

ঔপনিবেশিক  
বাংলায়

কষক

আন্দোলন

সম্পাদনা

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## ভঙ্গনামহল ও উনিশ শতকের আদিবাসী আন্দোলন

### শেখর শীল

অধ্যাপক, ঐতিহাসিক বিশ্ববিদ্যালয়, আজিপুরদ্বয়ার বিভাগ

এই রাজ্যের পশ্চিমাংশ সধারণভাবে ভঙ্গনামহল নামে পরিচিত। বঙ্গত, এই অঞ্চলের সাধারণতঃ আদিবাসী শ্রেণির দারিদ্র, অনুন্নয়ন প্রকৃতির বিপর্যয়ে যে আন্দোলন ও বিদ্রোহ-বিদ্রোহ সংঘটিত হয়েছিল, তার কারণ এই অঞ্চলে পশ্চিমবঙ্গের বর্তমান রাজনৈতিক মানচিত্রে একটি বিশেষ স্থান অধিকার করেছে। কিন্তু আদিবাসী জনগোষ্ঠী কর্তৃক এই আন্দোলন, মাত্র মূল্য আছে তাঁদের দীর্ঘদিনের স্বাধীনতা, সামাজিক ও অর্থনৈতিক বক্ষণ। এই অঞ্চলের ইতিহাসের শিকড় অতি প্রাচীন। তাই ঐপনিবেশিক এবং স্বাধীনতার পরেও এই ধরনের কৃষক আন্দোলন আন্দোলনকে নতুন করে তেমন ভাষায় তেমনি ইতিহাসের ধারাবাহিকতা বার বার বিলুপিত হয়েছে ভঙ্গনামহলে তৌগোলিক পরিভাষায়। সুতরাং যে বক্ষণ, অত্যাচারের কারণে একবিংশ শতাব্দীর সূচনা করে যে আদিবাসী আন্দোলনের সূত্রপাত হয়েছিল তার মূল্য আছে ঐপনিবেশিক শাসনকালের নিত্য নূতন সূত্রি রাজ্যে ব্যবস্থা—যা ছিল ভঙ্গনামহলের আদিবাসী ধর্মের পরিপন্থী। এই নতুন অর্থনৈতিক ও সূত্রি-ব্যবস্থার ফলস্বরূপ আদিবাসীরা যে ধরনের সংকটময় মুখোমুখি হয়েছিল তার-ই প্রতিফলিত স্বরূপ এই ভঙ্গনামহলে সব এক বিদ্রোহ মূল্য আছে আদিবাসী আন্দোলন থেকে শুরু করে। যার অনেকখানি পরিচয় আমরা ইতিহাসের পাতায় পাই। এখানে একটা বিষয় মনে রাখতে হবে যে এই সকল আদিবাসী আন্দোলনগুলি অনেকগুলো বলা-আন্দোলন বা কল-বিদ্রোহের রূপ গ্রহণ করেছিল। ভঙ্গনামহলে পশ্চিমবঙ্গের অর্থনৈতিক দারিদ্রতার কারণে আন্দোলন সীমাবদ্ধ ছিল না। এখন এই আন্দোলনকে যদি আন্দোলন পর্যালোচনা করতে হয় তাহলে অঞ্চলেই অসামান্যতঃ এর দ্রুত বিস্তারন করতে হবে। তাহলেই আমরা এই বিদ্রোহের সূচনা ও পরিচয় সম্পর্কে একটি সুনির্দিষ্ট ধারণা লাভ করতে পারব। যেহেতু এই আন্দোলন



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### জয়ন্ত পাণ্ডে

সহকারী অধ্যাপক এ.এম. কলেজ ঝালদা, পুরুলিয়া

মহাবিদ্রোহের ঠিক প্রাক্কালে ১৮৫৫-৫৬ খ্রিস্টাব্দে সংঘটিত হয়েছিল ঔপনিবেশিক ভারতের কৃষক আন্দোলনের ইতিহাসে সবচেয়ে ভয়াবহ ও রক্তাক্ত সংগ্রাম—সাঁওতাল বিদ্রোহ (ছল)। ১৮৫৭ খ্রিস্টাব্দের মহাবিদ্রোহের ছায়ায় সাঁওতাল বিদ্রোহ কিছুটা হলেও গবেষণার আলো থেকে বঞ্চিত থেকেছে—একথা বললে বোধহয় অত্যুক্তি হয় না। আমরা এই প্রবন্ধে সাঁওতাল বিদ্রোহের বিভিন্ন চেনা-অচেনা দিকগুলি (বিশেষত পরিবেশ সংক্রান্ত) সম্পর্কে আলোচনা করার চেষ্টা করব। তবে মূল বিষয়ে যাওয়ার আগে ঔপনিবেশিক ভারতের কৃষক আন্দোলন সম্পর্কে দু-চার কথা বলা প্রয়োজন। ভারতবর্ষে ব্রিটিশ শাসন প্রতিষ্ঠার পর থেকেই এদেশের কৃষক সমাজ শোষণমূলক রাষ্ট্রকাঠামোর বিরুদ্ধে বারবার বিদ্রোহমুখী হয়েছিল। নানা দুর্বলতা ও সীমাবদ্ধতা থাকা সত্ত্বেও বিদ্রোহগুলির মধ্য দিয়ে কৃষকদের ব্রিটিশ বিরোধী মনোভাব প্রকাশিত হয়েছিল। স্বাভাবিক নৃতাত্ত্বিক ক্যাথলিন গফ ব্রিটিশ ভারতে ছোটো বড়ো মিলিয়ে ৭৭টি উল্লেখযোগ্য হিংসাক্রমক কৃষক বিদ্রোহ তালিকাবদ্ধ করেছেন। তিনি এই কৃষক বিদ্রোহ গুলিকে কিছু সাধারণ বৈশিষ্ট্যের ভিত্তিতে পাঁচটি শ্রেণিতে বিভক্ত করেছেন।

- ১। পুনরুদ্ধার মূলক বিদ্রোহ (Restorative)
- ২। ধর্মান্বেষী বিদ্রোহ (Religious)
- ৩। সামাজিক দস্যুবৃত্তি (Social Banditry)
- ৪। জঙ্গি প্রতিহিংসামূলক বিদ্রোহ (Terrorist Vengeance)
- ৫। সশস্ত্র অভ্যুত্থান (Armed Insurrection)

আঠারো শতকের শেষ ও উনিশ শতকের গোড়ায় ইস্ট ইন্ডিয়া কোম্পানির নতুন ভূমি সংস্কার নীতি ও উচ্চহারে রাজস্ব নির্ধারণ ভারতীয় গ্রামীণ জনসমাজকে এমন

## আঞ্চলিক সংগীতের আলোকে মানভূম

### জেলার কৃষক আন্দোলন

#### শ্রীয়া রায়

অধ্যাপিকা শ্রীয়া রায়, অজয়ন কলকাতা, পূর্ববঙ্গিয়া

"চল বিহারী ভাই

তোরা রাখতে যারবি ভাত পেখাই"

ভক্তহরি মাথাত

"সুন্দরী পূর্ববঙ্গিয়া সুন্দরী পূর্ববঙ্গিয়া

কপে ঝরঝর

সকলীরে সজলীরে,

পূর্ববঙ্গিয়া বেবেকিবি তপ"

মানভূম ওষা পূর্ববঙ্গিয়ার প্রখ্যাত বিদ্রোহী শহীদ ভক্তহরি মাথাতের উপরোক্ত দুই গানটি থেকে এবং ষোল্লিখ মাথাতের উপনির্ভুক্ত সুন্দর গানটি থেকে নেওয়া যায় আমাদের জেলা মানভূম বা পূর্ববঙ্গিয়া একাধিকে যেমন একটি বিদ্রোহী জেলা, তেমনি এই জেলা শাস্ত্র-শিক্ষিত-পল্লীশে আচ্ছাদিত একটি সুন্দরী জেলা বা অপূরণে জায়াগা। পশ্চিমবঙ্গের অন্তর্গত এই রক্ত জেলাটি একদিনের যেমন তক্ত তেমনই অগ্যান্ডিকে এই জেলার আঞ্চলিক পরিবেশ অত্যন্ত মনোরম ও সুন্দর। প্রাকৃতিক পরিবেশে সুন্দর এই জেলাটির একাধিক নিজস্ব ঐতিহ্য ও সংস্কৃতি রয়েছে। এই যেমন দুই, ভারু, কলন, সুন্দর, জৈনাচ ও আরও কত কী। আর এই সংস্কৃতিগুলির মাধ্যমেই স্কটে উঠেছে নানা শিল্পিত্বিত্তে, নানা কারণে, বিভিন্নধরনের বিদ্রোহ ও বিদ্রোহী রেশনা মনোভাব। এই দুই, ভারু ও সুন্দর সঙ্গীতের মাধ্যমেই স্কটে উঠেছে মানুন্দের বিদ্রোহী মনোভাব এবং বিদ্রোহ ছড়িয়ে পড়েছে মানভূমের এক প্রান্ত থেকে অন্যপ্রান্তে।

তা-গোনো বিদ্রোহের মূল কেন্দ্রবিন্দু কৃষক, শ্রমিক, সিনামতুর খেটে কাওয়া

সম্পন্নকার মানুন্, যার সঙ্গে গভীরভাবে যুক্ত হয়েছে অধিবাসী সম্প্রদায়ের মানুন্। যারা ক্রীতদেয় চলার পথে বিভিন্ন ধরনের অনায়ায় অত্যাচার, লাঞ্ছনা, বঞ্চনার শিকার হয়েছেন। এরাও অনেকসময় অত্যাচার সহ্য করতে না পেরে বিদ্রোহের পথে পা দিয়েছেন। যার বহু দৃষ্টান্ত ইতিহাসে লেখা আছে। যেমন—নীল-বিদ্রোহ, হুগলি বিদ্রোহ, ঢোল বিদ্রোহ, হুতা বিদ্রোহ, হে-বিদ্রোহ, সাঁওতাল বিদ্রোহ, পাইক বিদ্রোহ ইত্যাদি। এই বিদ্রোহগুলি সারা পশ্চিমবঙ্গ কাঁদা হয়েছে পূর্ববঙ্গিয়া বা মানভূম এই বিদ্রোহগুলির প্রকার থেকে সুরে ছিল না। কেননা 'পশ্চিমবঙ্গের লক্ষণ-পশ্চিম সীমান্ত সীমানায় অবস্থিত ছোটো ছোটো উঁচু নিচু টিলা বা শৈলাশ্রেণিতে যেহা শাল-পিয়াল-হুতা আর রাজধানীর বেশ মানভূম যার বর্তমান নাম পূর্ববঙ্গিয়া, যেখানের অধিবাসে মানুন্ কৃষিজীবী এবং অধিবাসী সম্প্রদায়ের প্রভুত্বক' এই জেলা ছোটোমানপূর অঞ্চলের পূর্বাংশকে নিয়ে গঠিত। এখানে আমরা আঞ্চলিকভাবে নানান বৈশিষ্ট্য পেখতে পাঠি। এবং এখানকার মানুন্ হে আঞ্চলিক উপভাষায় কথা বলে তার নাম খাড়াভাড়া উপভাষা। আর এই গান উল্লেখিত রয়েছে অসাংখ্য সুন্দর গান, দুই গান, ভারু ও কলনগান। আর এই গান উল্লেখিত রয়েছে মানভূমে বসবাসকারী মানুন্দের আর্থ-সামাজিক অবস্থা ও সৈন্যদল জীবনযাত্রা। এই গানগুলির মাধ্যমেই বহিঃপ্রকাশ করতে আসিবাসী ও কৃষক সম্প্রদায়ের মানুন্দের ভেতরকার কষ্ট-মজ্জা ও চাপা গর্তনাম। এই সবকিছু একটি সুন্দর গান।

দিন আনে দিন ধাওয়া

মাড়ে-ভাতে দিন যাওয়া

কিঁকিঁটির বছরেই অকাল"

মানভূমের আধা আন্দোলনেও দুইগানেকে প্রয়োণ করা হয়েছিল। যা পূর্ববঙ্গিয়ার ইতিহাসে দুই সত্যপ্রব' নামে পরিচিত। হে আন্দোলনে অসাংখ্যকর ছিল, মানভূমের আপনায় জনতা, অসাংখ্য কৃষক, শ্রমিক, সিনামতুর। তবে যাদের ঐকান্তিক প্রচেষ্টায় এই বিদ্রোহ সংঘন হয়েছিল তারা হল নীওতাল ও কুর্কুলী সম্প্রদায়ের মানুন্। তাদের সাথে সাথে এই বিদ্রোহে স্থান পেয়েছিলেন জনসাধারণের সাধারণ দাবিদারেরা বিশেষ করে নিচুভিত্তে, কাছিত্তে, বহিষ্কৃত, শেখিত্তে অধিবাসী সম্প্রদায়ের ছিটিশ বরকার ও বিহার বরকারের বিরুদ্ধে পুঞ্জিত্ত জনবোধ্য ও বিজেতা। এরা দুই সঙ্গীতের মাধ্যমে বেনাখাতে চেষ্টাছিল যে ব্রিটিশ বরকারের থেকে তাদের শক্তি, তাদের লাভাই, তাদের সংগ্রাম, তাদের ঐক্যবদ্ধতা, তাদের বিদ্রোহী মনোভাব ও মানসিক চেতনা কোনে অসাংখ্য কমা নয়। এদের বিশ্বাস ছিল এরা জয়লাভ করবেই।

কমিশনতা নাভের পর মানভূম জেলা ছিল বিহারের অংশ। কিন্তু মানভূম ছিল

বাণেশ্বরভাষ্যার্থী অঞ্চল। এর বিরুদ্ধে অকলচয় শেখ, অকুলচয় শেখ, মালেশ্বরভাষ্য শেখ, ভক্তহরি মাভাট, সত্যকিঙ্কর নরু প্রমুখের নেতৃত্বে শুরু হয় ভাষা আন্দোলন।<sup>১</sup> কিছু এই আন্দোলনে অংশ গ্রহণ করেছিল হাজার হাজার আদিবাসী সম্প্রদায়ের মানুষ এবং তাদের অন্যই এই আন্দোলন গণ আন্দোলনে পরিণত হয়। এই আন্দোলনের একটি অন্যতম পলক্ষণ ছিল ‘চুঙ্গু সত্যায়ত’। বিহার সরকারের বিরুদ্ধে এই চুঙ্গু সত্যায়ত ২৯৫৪ সালের ২ জানুয়ারি থেকে ৮ ফেব্রুয়ারী পর্যন্ত অনুষ্ঠিত হয়েছিল। মূলত অনেক লোক একত্রিতভাবে বাণেশ্বর নিয়ে চুঙ্গুর গান গাইতে গাইতে পথ পরিভ্রমণ করেন। লোক সৈনিক সংঘের নেতা ভক্তহরি মাভাট, অকলচয় শেখ প্রমুখ চুঙ্গুগানের মাধ্যমে বিহার সরকারের অত্যাচারের চিত্র সাধারণ মানুষের আগায় ও সূত্রে তুলে ধরিতে শুরু করেন। সাধারণ মানুষের আগমনের ভয়ে বিহার সরকার জননিরাপত্তা আইন আরোপ করে মানসুখে চুঙ্গুর গান গাওয়া এবং সুসজ্জিত মিছিল নিয়ে পথ পরিভ্রমণ বন্ধ করার নির্দেশ দেয়। এর ফ্রািত্বাণে পুর্কলিয়ায় চুঙ্গু সত্যায়ত শুরু হয়। এইসময় গানভক্তির মূলকথা ছিল শির্ষ দিন ধরে বাংলারচারী মানুষের উপর বিহার সরকারের অত্যাচার, হিন্দী সাম্রাজ্যবাদী শক্তির বিরুদ্ধে ক্ষোভ ইত্যাদি। এইসময় সর্বাধিক জনপ্রিয় হয়েছিল ভক্তহরি মাভাটের লেখা চুঙ্গু গান ‘তল বিহারী ভাই’। তেঁরো কাণ্ডে জার্মি ভাঙ দেখায়।<sup>২</sup> গানটি এইসময় চুঙ্গুর গানে ‘মানসুখ’ বইটি ব্যাপক জনপ্রিয়তা লাভ করেছিল। পুর্কলিয়ার জালা আন্দোলন ও বাংলাতে তার অকৃত্তিকিত্ব পিছনে এই জেগার প্রাচীন সংস্কৃতি ‘চুঙ্গু’ গানের গুরুত্বপূর্ণ স্থানটি রয়েছে।<sup>৩</sup> শুধুমাত্র মানসুখের জন্য আন্দোলন ও পুর্কলিয়ার বঙ্গকৃতিই নয় চুঙ্গু সঙ্গীতের মাধ্যমে ফুটে উঠেছে মানসুখের আদিবাসীদের আর্থ-সামাজিক জীবনযাত্রা এবং মানসুখের আদিবাসী ও কৃষকবিদ্যোতের রূপরেখা।

শুধুমাত্র চুঙ্গু গানই নয় ধুমুহগানের মাধ্য দিয়েও প্রকাশ পেয়েছে মানসুখ তথা পুর্কলিয়ার কৃষক বিদ্যোত ও আদিবাসী বিদ্যোতের ইতিকথা। সারা পশ্চিমবঙ্গ তথা ভারতবর্ষের আদিবাসীরা যখন চুয়াড়, ধো, কোলা ও শাঁওতাল বিদ্যোতের উদ্ভাবন হয়ে উঠেছিল তখন মানসুখে কনকবন্দরী সাধারণ মানুষেরাও বিশেষ করে কৃষক ও আদিবাসীরা কোলাভাষ্যই পিছিয়ে থাকেনি। তারাও প্রকলক হয়ে বিদ্যোতী মনোভাব নিয়ে একত্রিতভাবে বিদ্যোতের কাণ্ডে পড়ে। চুয়াড় বিদ্যোতের নেতা অচল সিং (গেভেভা), বিঘন সিং, দুর্জন সিং, সুকলা সিং, কুইজঙ্গপল, জিলাপজায়া প্রমুখ সারিগা ঘাটোরাওগেলে ব্রিটিশ শক্তির বিরুদ্ধে সশস্ত্র সংগ্রাম করেছিলেন। শহরকেছিক ঝিলসংগে, ভোগাবাসী জীবন নয়, গ্রাম জীবনের প্রাণোদ্ধান, ধারণার ও প্রাণরত হয়ে উঠেছে ধুমুহের গানে। স্বরা কীর্তিত মানসুখ কাণ্ডেছিক বাস্তব কালকথা কুমুদিয়া কসিগা নিবৃত্তভারে প্রকাশিত করেছেন কুমুর গানভক্তির মাধ্যমে।<sup>৪</sup> এইরকম একটি কুমুরগানের পৃষ্ঠাছ

বিঘনগা পুর্কলিয়া, ধানময়ের ইকাতিকাক  
না তেরল চরিশাল সাল চেঁচু ফুটে গেল জলে  
গো মরি হয় হয়  
কি করি রে কই হয়ল আকাল।

বিদ্যোতের উপযুক্ত পরিবেশ না থাকলেও বিদ্যোতের উপযুক্ত যোগ্য নেতা না থাকে সত্ত্বেও বিদ্যোতের উপযুক্ত সাজ-সজ্জা ও যত্নপতির অভাব থাকলেও মানসুখের সাধারণ মানুষ ব্রিটিশ সরকারের বিরুদ্ধে হুঁসিগা আদিবাস, মহাজনদের বিরুদ্ধে বিদ্যোতের পলি গাওয়া আন্দোলনের জন্য, স্বাধীনভাবে মাথা উঁচু করে বেঁচে থাকার জন্য সংগ্রামের পথ অবলম্বন করে ছিল, যার জন্য তারা নিজেদের জীবন তির্যকন সিক্তেও পিছুপা হয়নি। তারা ‘সকলের জন্য সকলে’ এই বকম উল্লার মনোভাব নিয়ে আন্দোলনে কাঁপিয়ে পড়েছিল। যেখানেও স্বাধীনতা সংগ্রাম বা বিদ্যোত শুরু হয় সমাজের নীচুতলার, নিম্নবর্গীয়, চেটে খাওয়া, ব্যস্তিত, পোছিত, বঞ্চিত, সাধারণ মানুষ, কৃষক, শ্রমিক ও আদিবাসীদের সেক্ষ করে—পরে তা গণ আন্দোলনে পরিণত হয়। মানসুখ ও তার ব্যক্তিকম নয়। আন্দোলন জেলা মানসুখ বা পুর্কলিয়াতেও কৃষক ও আদিবাসীদের সেক্ষ করেই বিভিন্ন ব্রিটিশবিদ্যোতী আন্দোলনগুলি শুরু হত এবং এগুলির সূক্ষরভাবে বাস্তবকাশ ঘটত কুমুর সঙ্গীতের মাধ্য দিয়ে। মহাধাণাঙ্গির নেতৃত্বে এখন সমগ্র ভারতব্যাপী শুরু হয় (১৯১৯-২০) অহংসযোগ আন্দোলন, আইন জমানা আন্দোলন (১৯৩০) ভারত ছাড়ো আন্দোলন (১৯৪২), তখন এইসব আন্দোলনগুলির প্রভাব থেকে মানসুখও কিছু পিছিয়ে ছিল না। এখানকার জনসমধারণ এইসকল ব্রিটিশবিদ্যোতী আন্দোলনগুলিতে সক্রিয়ভাবে অংশগ্রহণ করে, বিশেষ করে মানসুখের আদিবাসী সম্প্রদায়ের মানুষেরাই সবচেয়ে বেশি অংশগ্রহণ করে আন্দোলনগুলিকে সক্রিয় গণআন্দোলন ও সফল করে তোলে। ভক্তহরি মাভাট, কানিকিঙ্কর নরু, সত্যকিঙ্কর নরু, দুর্জন সিং, বিঘন সিং, জিলাপজায়া প্রমুখ ব্যক্তিকগ ব্রিটিশ বিদ্যোতী আন্দোলনগুলিতে নেতৃত্ব দিয়েছিলেন।

চুঙ্গু ও কুমুর সঙ্গীত ছাড়াও বহু শাঁওতাল গানের মাধ্যমেও ফুটে উঠেছে মানসুখ তথা পশ্চিমবঙ্গের একধিক আদিবাসী বিদ্যোত ও কৃষক বিদ্যোতের চিত্র। এই সেশন শাঁওতাল বিদ্যোতের কথায় বলা যায়। শাঁওতাল বিদ্যোতের নেতা চিণ্ডু ও কনুর নেতৃত্বে ১৯৫৫ ছিটকো আন্দোলনগুলি মাঠে চাষাশে গ্রামের প্রতিবাদি হিসাবে আর ১০,০০০ শাঁওতাল একটি সত্যায়ত জন্মায়ত হয়েছিল। তাদের বিদ্যোত ইতিহাসে শাঁওতাল ছল নামে খ্যাত। তারা যে অঞ্চলে বসবাস করত তার নাম ‘পহিন-ই-কো’ বা পাহাড়ের জাঙ্গাল। আদিবাসী সম্প্রদায়গুলি আর সবাই শান্তিপূর্ণ। কিন্তু তাদের মাথায় শাঁওতালরা হল সবচেয়ে বেশি শঙ্ক-সরল ও শ্যাঙপ্রিয় উল্লেখ্য। শাঁওতাল বিদ্যোতের পথে না দিয়ে শান্তিপূর্ণ উপায়েই তাদের সমস্যার সমাধান করতে চেয়েছিল। সরকারের কাছে

ঘটিকারের আর্জি নিয়ে তর এক বিহিংসের আয়োজন করেছিল। এইরকম বিহিংসের নজির সম্ভবত উল্লিখ শতকের ইতিহাসে আর দ্বিতীয়টি দেখা যায় না। এরা প্রথমেই কোনো সরকার বিদ্রোহী আন্দোলন গড়ে তুলতে চায়নি বরং সরকারের সুবিচারের প্রতিই তাদের আস্থা ছিল। কিন্তু সরকারের প্রতি পুরোপুরি বিশ্বাস তাদের বিশ্বাস ভঙ্গ হল তখনই তারা এক স্বাধীন সীতলগঞ্জ সরকার স্বয়ং দেখতে শুরু করলো। তারা তাদের সেই অতীত দিনে বিদ্রোহ যেরূপ চাইছিল এখন তারা স্বাধীনভাবে বসবাস করত, যখন তারা কোনো খাজনা পিত না এবং যখন তাদের মাথার উপর কোনো উৎসাহিত্বের খাড়া ছিল না। যদিও সীতলগঞ্জ বিদ্রোহ শুধুমাত্র একটি উপজাতি বা আদিবাসী বিদ্রোহই ছিল না এবং এই বিদ্রোহের প্রভাব কেবলমাত্র সীতলগঞ্জ পরগণাগুলির মধ্যেই সীমাবদ্ধ ছিল না। যার স্মরণস্বরূপী প্রভাব পরেই সারা বাংলাদেশ বিশ্বয় করে মানস্কুম বা পুরুজিয়ায়। মানস্কুমে বসবাসকারী সীতলগঞ্জ ও এইসময় বিদ্রোহের আওলে ফলে উঠেছিল।<sup>১৭</sup>

সীতলগঞ্জ বিদ্রোহ যে কেবলমাত্র সীতলগঞ্জ উপজাতিবাহি আন্দোলন করেছিল তাই নয়, অর্থাৎ সীতলগঞ্জ বিদ্রোহ শুধুমাত্র একটি উপজাতি বিদ্রোহই ছিল না। এই বিদ্রোহ ছিল ব্রিটিশ সাম্রাজ্যবাদের বিরুদ্ধে শরীফ কৃষক ও শ্রমজীবীদের প্রতিবাদ। এই বিদ্রোহে যোগ দিয়েছিল স্থানীয় কুমোং, তোলি, কর্মকার, গোয়াল, মুন্সিয়, উতি, চামার, তেজ প্রভৃতি বিভিন্ন সম্প্রদায় ও নানা পেশার মানুষ। নগরহরি কবিবাজের মতে, এই বিদ্রোহ হয়ে উঠেছিল সব সম্প্রদায়ের নবীন জনগণের সুভিক্ষা। সীতলগঞ্জ বিদ্রোহ কেবল জামিদার বা মহাজনদের বিরুদ্ধেই গড়ে উঠেছিল তাই নয়, এটি ছিল একটি ব্রিটিশ বিদ্রোহী আন্দোলন। আর্থিক পর্যায়ে যদিও সীতলগঞ্জ মহাজন ও জামিদারদের বিরুদ্ধেই আন্দোলন শুরু করেছিল, কিন্তু পরবর্তীকালে খুব অল্প সময়ের মধ্যেই সীতলগঞ্জ বিদ্রোহ একটি ব্রিটিশবিদ্রোহী আন্দোলনে পরিণত হয় এবং এই বিদ্রোহের আওনে কেবলমাত্র নমিন-ই-কো বা ভাণসাজিহির মতোই সীমাবদ্ধ থাকেনি, এই বিদ্রোহের আওন সমগ্র বাংলাদেশ এমনকি মানস্কুমেও ছড়িয়ে পড়ে।<sup>১৮</sup>

এই বিদ্রোহে দীর্ঘ ও মাস ধরে ঔপনিবেশিক সরকার, জামিদার-মহাজন ও স্থানীয় মানুষের মধ্যে গভীর হাঙ্গামার সৃষ্টি করেছিল। বিদ্রোহের ফলে সেনাবাহিনী ও সরকারি কবচ বিলম্বিত হয়ে পড়ে এবং এই বিদ্রোহে প্রচুর অর্থ ও লোকসম্পদ হার, সরকারি রাজস্বের ওপরেও প্রচুর চাপ পড়ে। এই বিদ্রোহ কেবলমাত্র সীতলগঞ্জের মধ্যেই সীমাবদ্ধ ছিল না। স্থানীয়দের মতে, সীতলগঞ্জ ও স্থিৎ সম্প্রদায়ের মধ্যকারী আধা-আদিবাসী সেনা ও নিয়ন্ত্রণের দ্বিগুণ দৃষ্টিতে এই বিদ্রোহে লেগেছিল। নগরহরি কবিবাজ জানাচ্ছেন, আধা-আদিবাসী গণসংগ্রামের এক উজ্জ্বল পৃষ্ঠাভূমি সীতলগঞ্জ বিদ্রোহ। রূপশেষ মনুষ্যমানবের অভিমত এই যে, ১৮৫৭ খ্রিস্টাব্দের মাদ্রাসাভাঙকে যদি স্বাধীনতা সংগ্রাম বলি যায় তবে সীতলগঞ্জের এই সুকৃষ্টি সংগ্রামের স্বাধীনতা সংগ্রাম অর্ধাঙ্গাঙ্গ।

সুভাষণ দায় মনে করেন যে, "এই বিদ্রোহ সমগ্র ভারতবর্ষে ইংরেজ শাসনের ভিত্তি মূল পরিত্ত্ব কীপাইয়া দিচ্ছিল এবং ইহা ছিল ভারতের মুগাভকারী মধ্যবিদ্রোহের আধাপ্রসঙ্গ।"<sup>১৯</sup>

ঔপনিবেশের অত্যাচারে ভারতবর্ষে সংগঠিত বঙ্গবন্দন ও চিরধরা-অক্ষুণ্ণিত্যত্মক জেলা পরকলিয়া বা মানস্কুম হল এমন একটি জেলা যার একটি মূলত ইতিহাসমুখিত ইতিহাস রয়েছে। একাধিক কৃষক বিদ্রোহ ও আদিবাসী বিদ্রোহের জন্য এবং বিদ্রোহী মনোভাবনা শত্রুদের প্রাণবিরতনের জন্য বর্তমানে সিবো-কানোহা-বিরশা-বিশ্ববিদ্যালয়ের ইতিহাস পরিকল্পনার মধ্যে মানস্কুম তথা পুরুজিয়ার ইতিহাস একটি বিশিষ্ট স্থান পেয়েছে। মানস্কুম এমন একটি জেলা যার একাধিক নিজস্ব সংস্কৃতি রয়েছে। যেমন—চুপ, ভাদু, কুমুর, হৌনিচ, কন্ন-আড়া ইত্যাদি। এইসব সংস্কৃতিগুলির মাধ্যমে সুন্দরভাবে প্রকাশ পেয়েছে মানস্কুমে বসবাসকারী মানুষের সুখ-দুঃখ, ভালোবাসা-বিদ্বেষী মনোভাব ও বিপুলী তেতনা। একাধিক চুপ ও কুমুরগণের প্রকাশ পেয়েছে আদিবাসী ও কৃষক বিদ্রোহের অজনিহিত তাৎপর্য ও ক্রান্তরখা। আরোই এই প্রসঙ্গে উল্লেখ করা হয়েছে ভজহরি মাহাতের একটি চুপগান।

তোতা রাস্মতে নারবি ভাঙ দেখাই

"কন বিহরী আই

তোতা রাস্মতে নারবি ভাঙ দেখাই।"<sup>২০</sup>

#### তথ্যসূত্র

১. ড. প্রদীপ কুমার মজল, মানস্কুম জেলার ভাষা আন্দোলনের ইতিহাস, পুরুজিয়া, ২০১৩, পৃষ্ঠা-২০২
২. পুরুজিয়ার প্রখ্যাত বাস্তুশিল্পী গোবিন্দ মাহাতের কুমুর গানের ক্যাসেট থেকে শোনা নিজস্ব প্রতিজ্ঞা
৩. ড. প্রদীপ কুমার মজল, মানস্কুম জেলার ভাষা আন্দোলনের ইতিহাস, পুরুজিয়া, ২০১৩, পৃষ্ঠা-২০১
৪. সুশীল মাহাত, মানস্কুম কথা, ২০০৬, পৃষ্ঠা-১৩
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৮. সীতলগঞ্জ বিদ্রোহ সম্পর্কে নিজস্ব অভিমত।
৯. সুভাষণ দায়, সীতলগঞ্জ বিদ্রোহের ইতিহাস, কলকাতা, ২০০৮, পৃষ্ঠা-৫১
১০. তরুণ
১১. কৃষক ও আদিবাসী বিদ্রোহ নিজস্ব অভিমত।

# নদিয়ার শিল্প সাহিত্য সংস্কৃতি

সম্পাদনা

ভবেশ মজুমদার  
কবিরঞ্জন সাহা



বঙ্গীয় সাহিত্য সংসদ

NADIAR SHILPA SAHITYA SAMSKRITI

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প্রকাশক ও স্বত্বাধিকারীর লিখিত অনুমতি ছাড়া কোনো উপায়েই এই গ্রন্থের কোনো অংশের কোনোকণ  
পুনরুৎপাদন বা প্রতিলিপি করা যাবে না। এই শর্ত লঙ্ঘিত হলে উপযুক্ত আইনি ব্যবস্থা গ্রহণ করা হবে।

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## অদ্বৈত আচার্য ও শ্রীপাট শান্তিপুর

শান্তনু ভট্টাচার্য

শ্রীচৈতন্য শাখাদের মধ্যে সর্বজ্যেষ্ঠ অদ্বৈত আচার্য বৈষ্ণব সমাজে বিশেষ গুরুত্বপূর্ণ স্থানের অধিকারী। বলা হয়, সমাজের সাক্ষাৎ পরিস্থিতিতে যুগের দাবি তাঁর কণ্ঠস্বরের মধ্য দিয়েই প্রথম প্রকাশ পেয়েছিল এবং তাঁর আহ্বানেই স্বয়ং শ্রীকৃষ্ণ কলিমুগে চৈতন্যরূপে অবতীর্ণ হয়েছিলেন। শ্রীচৈতন্যের আবির্ভাবে অদ্বৈত আচার্যের আহ্বান ছিল একটি মুখ্য কারণ। এমনকি অক্ষয়কৃষ্ণ লীলা সংকরণও করেছিলেন অদ্বৈত আচার্যের প্রেরিত এক তরজার প্রেক্ষিতে বলে চৈতন্যজীবনী থেকে জানা যায়। ফলে বুঝতে অসুবিধা হয় না শ্রীচৈতন্যের জীবনে অদ্বৈত আচার্যের ভূমিকা কী ভীষণ পরিমাণে ছিল। বৈষ্ণব সমাজে শ্রীচৈতন্যের মতোই অদ্বৈত আচার্যকেও দেবত্বের আসনে প্রতিষ্ঠিত করে তাঁকে মহাবিক্রম অবতার রূপে চিহ্নিত করা হয়েছে। চৈতন্যচরিতামৃত থেকে জানা যাচ্ছে—

অদ্বৈত আচার্য গোস্বামী সাক্ষাৎ ঈশ্বর।  
মীমাংসক মতিমা নহে জীবের গোচর।।  
মহাবিক্রম সৃষ্টি করেন জগদাদি কার্য।  
তাঁর অবতার সাক্ষাৎ অদ্বৈত আচার্য।।

চৈতন্য ভক্তিবাদ ও তত্ত্ববোধ অদ্বৈত আচার্যের সহযোগিতায় জনসমাজে বিশেষ প্রচার লাভ করে। শ্রীচৈতন্য স্বয়ং পরম শ্রদ্ধা করতেন এই বায়োজ্যেষ্ঠ ভক্তকে। বৃন্দাবন দাস চৈতন্যভাগবতে অদ্বৈত আচার্যের মতিমা বর্ণনা করেছেন এইভাবে—

সেই নবধীপে বৈসে বৈষ্ণবাগ্রহণা।  
অদ্বৈত আচার্য নাম সর্বলোক ধন্য।।  
জ্ঞান-ভক্তি বৈরাগ্যের গুণ মুখ্যতর।  
কৃষ্ণ-ভক্তি বাখানিতে যে হেন শঙ্কর।।  
ত্রিভুবনে আছে যত শাস্ত্রের প্রচার।  
সকলই-বাখানে, কৃষ্ণভক্তি সার।।  
তুলসী মঞ্জরী সহিত গঙ্গাজলে।  
নিরবধি সেবে কৃষ্ণে মহা কৃত্তলে।।  
বহুবার করয়ে কৃষ্ণ আবেশের তেজে।  
যে করি ব্রহ্মাণ্ড ভেদি, বৈকুণ্ঠতে বাজে।।



# समकालीन हिंदी कविता के विविध आयाम

संपादक

डॉ. प्रदीप कुमार



मानव प्रकाशन  
कोलकाता

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# अनवरत सत्य का पीछा करती कविताएँ

गौतम सिंह राणा

“सत्य जानना चाहता है  
कि उसके पीछे हम कितनी दूर तक भटक सकते हैं।”

- विष्णु खरे

अनवरत सत्य का पीछा करने को कवि-कर्म माननेवाले हिंदी-कवियों की परंपरा में कबीर, निराला, शमशेर, नागार्जुन, मुक्तिबोध, रघुवीर सहाय, कुंवर नारायण, धूमिल, विनोद कुमार शुक्ल आदि के साथ विष्णु खरे का भी नाम आता है। 9 फरवरी, 1940 को छिंदवाड़ा, मध्य प्रदेश में जन्मे इस कवि-आलोचक-अनुवादक-पत्रकार का लेखन काल काफी लंबा रहा है। इनकी पहली कविता-संग्रह का प्रकाशन 'विष्णु खरे की बीस कविताएँ' नाम से अशोक वाजपेयी द्वारा संपादित 'पहचान' (1970), सीरीज की पुस्तिका के रूप में हुआ है। इसके बाद के छः संग्रहों का प्रकाशन लंबे अंतराल के बाद-बाद और काफी लंबे समय तक हुआ है- 'खुद अपनी आँख से (1978), सबकी आवाज के पदों में (1994), पिछला बाकी (1998), काल और अवधि के दरमियान (2003), लालटेन जलाना (2008) और अन्य कविताएँ (2017)। इनकी कविताओं की खासियत के बारे में बताते हुए मंगलेश डबराल कहते हैं- "इनके जीवन-काल में प्रकाशित सात कविता संग्रहों में केवल हमारे समय, उसके विभिन्न कायाकल्पों, समकालीन मनुष्य के हाल, सत्ताओं की बर्बरता और उसके प्रतिरोध के दृश्य और चेहरे ही दर्ज नहीं हुए हैं, बल्कि उनके विकल्पों की भी शिनाख्त मिलती है। ये ऐसी कविताएँ हैं जो 'अंधकार की शक्तियों' से समझौता नहीं करती।" किसी भी युग

में ऐसे प्रतिरोध के दृश्यों और चेहरों को दर्ज करना तथा उनके विकल्पों की शिनाख्त करना निरापद काम नहीं है; बावजूद इसके मुक्तिबोध को अपना सृजन-पिता माननेवाले विष्णु खरे अपने कविता-कर्म के दौरान यह खतरा बेखौफ होकर उठाते दिखते हैं, क्योंकि ये मुक्तिबोध और रघुवीर सहाय की रचनाओं की निर्मिति में निहित बेचैनियों और दुःस्वप्नों से काफी गहराई से जुड़े हुए रचनाकार हैं। इस संदर्भ में मंगलेश डबराल की ही उक्ति है- "असल में, विष्णु खरे का रचना-संसार बड़ी हद तक उन बेचैनियों और दुःस्वप्नों से निर्मित हुआ था जो मुक्तिबोध और रघुवीर सहाय की रचनाओं के केंद्र में थी।"<sup>2</sup>

विष्णु खरे का रचना-काल मूलतः समकालीन कविता का काल है। समकालीन कविता की एक अन्यतम प्रमुख विशेषता है कि यह सही काल पक्ष को संवेदित करती है। इसकी इस कालयात्रीपनता पर विचार करते हुए ए. अरविंदाक्षन ने कहा है- "समकालीन कविता हमारे अपने काल की कविता है। इस प्रस्ताव में कविता के दायित्वबोध की सूचना ही संकेतित है। कवि-दृष्टि की सार्थकता इसी बात में है कि वह सही काल पक्ष; टाइम एस्पेक्ट को संवेदित करे। समाज में अक्सर काल-निरपेक्ष स्थितियाँ बदलती रहती हैं। काल को पलटकर उसे जड़वत करने के तरीके उसके पास होते हैं। प्रायः ऐसा भी होता है कि काल का एक जड़ रूप पूरे वर्चस्व के साथ व्यापित होता है और सच का आभास देता रहता है। धीरे-धीरे उसे ही सत्य मानने की लाचारी बढ़ती है और काल का यही जड़ प्रारूप स्वीकृत होता है। समकालीन कविता ऐसे जड़ प्रारूप काल को तोड़ती है।"<sup>3</sup> विष्णु खरे की कविताएँ इसका अपवाद नहीं हैं; बल्कि ये और भी अधिक बेबाक-बेलौस-तीखे तेवर के साथ इस काम को अंजाम देती नजर आती हैं। आजादी के बाद से लेकर अब तक लगातार नित नवीन ढंग से ठगी जा रही सीधी सादी जनता की बदहाली के जिम्मेदार मुट्ठी भर मौकापरस्त लोग; सत्ता से साँठ-गाँठ कर अपना उल्लू सीधा करनेवाले लोग जब बड़ी चालाकी से अपना काम निकाल लेने के बाद आज सारा दोष ठगे लोगों पर ही मढ़ देते हैं तो 'अभिव्यक्ति के सारे खतरे/ उठाने ही होंगे/तोड़ने होंगे ही मठ और गढ़ सब' पर विश्वास रखनेवाले विष्णु खरे शोषक वर्ग के वास्तविक चरित्र को उजागर करने का एक अलग ही ढंग का व्यंग्यात्मक रूपक रचते हैं ताकि आभासी सत्य; जो कि वास्तव में झूठ है के अंदर निहित वास्तविक सत्य से लोग रूबरू हो सकें - "आज भी बितायी होगी लोगों ने एक शानदार जिंदगी/हुआ होगा अरबों का धंधा करोड़ों का नफा/अपने के सिवा किसी को भी परवाह नहीं की गयी होगी/जो संवाएँ जायदादें पहले ही बहुत खरीदी

जा चुकी है/उन्हें और खरीदा गया होगा/आज भी लोगों ने पूछा होगा असली गरीबी अब है कहाँ/कहा गया होगा कि पैदाइशी कामचोर गलीचों को कोई ऊपर ला नहीं सकता/जात-पात ऊँच-नीच तो कभी के खत्म हो चुके/आज नहीं है तो दस बरस में हो ही जाएगा/चूड़ों, चमारों, जंगलियों का राज/फिर भी हरामखोरों का रोना बंद नहीं होगा।”

विष्णु खरे शब्दों के सीमित केनवास पर बहुत गहरी और व्यापक दुनिया उकेरनेवाले समर्थ कवि हैं। इस संदर्भ में उनकी एक अपेक्षाकृत छोटी कविता 'एक कम' को देखा जा सकता है। यह कविता रघुवीर सहाय को भी बहुत प्रिय थी और खरे इसे सुनाने से पहले हमेशा इसका जिक्र किया करते थे। कविता सुनाने से पहले वे कहते थे- “पता नहीं, रघुवीर सहाय क्यों इसे बार-बार सुनाने के लिए कहते थे।” इस कविता में कवि आजादी के लंबे अंतराल के बाद भी मुट्ठी भर 'मालामाल होते' तबकों के बरक्स 'पच्चीस पैसे एक चाय या दो रोटी के लिए' हाथ फैलानेवाले अधिसंख्य लोगों की बदहाली के कारण; सीधापन और इमानदारिता का सत्यान्वेषण करता हुआ कहता है- “1947 के बाद से/इतने लोगों को इतने तरीकों से/आत्मनिर्भर मालामाल और गतिशील होते देखा है/कि अब जब आगे कोई हाथ फैलाता है/पच्चीस पैसे एक चाय या दो रोटी के लिए/तो जान लेता है/मेरे सामने इमानदार आदमी औरत या बच्चा खड़ा है।”

विष्णु खरे की कविताएँ यथार्थ के साथ जो संबंध बनाती है, वह हमेशा एक-सा सामान्य, इकहरा, सीधा और स्पष्ट नहीं होता; बल्कि वह जटिल और बहुआयामी या बहुस्तरीय ही अधिक होता है। इस संदर्भ में परमानंद श्रीवास्तव का कहना है- “विष्णु खरे की कविता यथार्थ के साथ बनी जटिल और बहुआयामी संबंध का तीखा अहसास कराने में सक्षम है। कविता चीजों को अनिवार्य; कभी अटपटी और भयानक तात्कालिकता में देखते हुए आदमी की नियति के बारे में किस तरह मार्मिक टिप्पणी बन जाती है- यह देखना विष्णु खरे के यहाँ दिलचस्प ही नहीं, सार्थक अनुभव है।” 'अंधी घाटी' कविता में व्यवस्था की भयानकता का डर दिखाकर उनकी चापलूसी करनेवाले सयानों की नियति पर की गई टिप्पणी इसका एक उदाहरण है- “यहाँ/नीचे/सयानों ने नयी अर्चना प्रारंभ कर दी है/वे दैत्याकार मकड़ियों को अर्घ्य देते हैं/जालों में झूलते हुए वे मक्खियों के अवशेष नहीं हैं/और पहरेंदार गिद्धों की छाया को चूमते हैं/वे स्वयं पीछे रहकर स्वतः को समर्पित करते हैं/और अंधी घाटी के देवताओं को जयकारते हुए/कगारों के पार जीवन नहीं है/कहकर मृत्यु को स्वीकारते हैं।”

आधुनिकता और बाजारवाद ने मानवीय संवेदना के तंतुओं को सबसे अधिक तार-तार किया है। इन्होंने मनुष्य के मन-मस्तिष्क में जीवन के लिए मानवीय संबंधों की तुलना में भौतिक सुख-सुविधाओं को अधिक महत्वपूर्ण तत्त्व के रूप में स्थापित कर दिया है। आलम यह है कि लोग भौतिक सुख को ही वास्तविक सुख मानने लगे हैं और उसे प्राप्त करने का एकमात्र साधन पूँजी के पोछे अंधे धुन में दौड़ रहे हैं; जबकि सच्चाई तो यह है कि पूँजीवाद ने अपनी सहूलियत के लिए मानवीय संवेदना को खत्म करने का जो मोहपाश तैयार किया है, उसमें लोग फँसते जा रहे हैं। इसका असर हर एक मानवीय संबंधों की तरह दाम्पत्य-संबंध पर भी पड़ चुका है। पूँजीवादी मानसिकता के कारण अपनी अतिस्वाभिमान ने दाम्पत्य-प्रेम के मधुर तंतुओं को तोड़ने का काम किया है, जिससे दाम्पत्य-संबंध टूटते जा रहे हैं। विष्णु खरे संबंधों के इस टूटन से काफी विचलित होने के बाद भी इस सत्य को मान चुके हैं कि यह प्रक्रिया अब रुकनेवाली नहीं है। वे अपनी 'अदावत' शीर्षक कविता में दाम्पत्य-विच्छेद के पश्चात् लड़की के माता-पिता के मार्फत युगल के बीच होनेवाले शुष्क भेंट और उसके पश्चात् की स्थिति का चित्रण करते हुए कहते हैं- "नीचे खड़ी थी वह अंधेड़ औरत उनकी बेटो/रूखी अनमनी और बेखबर/दरवाजा खोले गाड़ी का/जिसमें बूढ़ा-बूढ़ी एक-दूसरे को सहारा देते पीछे बैठे/फिर बाप ने उसे यंग लेडी कहा/ और पंद्रह बरस बाद फिर परिचय कराया/मीट दिस यंग मैन, रिमेंबर हिम/गाड़ी स्टार्ट करने से पहले/वह एक विरक्त अजिज मुस्कान मुस्कुरायी/तीनों एक युग पुराने उसके प्रेत/चले गये बैठकर ठंड की शाम की सूनी धुंधली सड़क पर/धीरे-धीरे जाती उस भुतहा गाड़ी में/मोड़ तक वे सब भूल चुके होंगे।"<sup>9</sup>

पूँजीवादी मानसिकता ने समाज में आदमी की पहचान के पारंपरिक ढंग को बदलकर कर रख दिया है। आज वल्लिद्यत; बुजुगों के नाम से आदमी की पहचान नहीं हो रही है बल्कि वसीयत और उसकी पहुँच से की जाने लगी है। साथ ही लोग फख्र भी वल्लिद्यत के बजाय वसीयत और पहुँच पर करने लगे हैं। ऐसी स्थिति में आम आदमी की पहचान संकटापन्न है क्योंकि सदियों से पूँजीवादी शोषण का शिकार वह आज भी दो वक्त की रोटी, तन ढंकने के लिए ठीक-ठाक कपड़े और सर पर एक मुकम्मल छत के लिए आजीवन संघर्षरत है। पूँजीवादी मानसिकता के तहत आदमी की पहचान को खत्म कर देने के इस षड़यंत्र का खुलासा विष्णु खरे 'और नाज मैं किस पर करूँ' शीर्षक कविता में करते हैं- "कई वजहों से अब वल्लिद्यत बतायी नहीं जाती/आज फख्र कुछ और बातों पर किया जाता है/किसके

पास कितना क्या है कौन किस-किस को जानता है/सब यही दरियाफ्त करते हैं अब।"<sup>10</sup>

पूँजीवादी विकास के बरक्स फैल रही मानवीय संवेदनहीनता का आलम यह है कि समाज और देश में पैरामीटर व पैराडाइम तेजी से बदल रहे हैं। क्लासिकी चिंतन, पारंपरीण भावुकताओं, आदर्शों, रणनीतियों पर चलनेवाले देश व समाज ने इनको त्यागना शुरू कर दिया है, जो मानवतावाद व विश्वमानवतावाद के लिए खतरे की घंटी है। विष्णु खरे पूँजीवादी विकास के आवरण तले छिपकर आ रहे इस खतरनाक दैत्य के कदमों के आहट को काफी तेजी से सुन पाते हैं और सबको सचेत करते हुए कहते हैं- "पैरामीटर बदल रहे हैं/स्थानांतर हो रहा है पैराडाइमों का/निम्नवर्ग होता जा रहा है निम्नमध्यवर्ग और मध्यवर्ग उच्चवर्ग/क्लासिकी चिंतन पारंपरीण भावुकताओं आदर्शों रणनीतियों से काम चलना बंद हो जाएगा/इंद्र समाप्त नहीं होगा उसकी बारीकियाँ बदलती जाएँगी/इतना तय है कि/अंदरूनी और बाहरी संशय संघर्ष और लड़ाइयाँ/जटिलतर कठिनतर हिंस्रतर होनेवाले हैं/हर नये दिन।"<sup>11</sup>

विष्णु खरे समसामयिक राजनीति पर पैनी दृष्टि रखनेवाले कवि रहे हैं। उन्होंने समसामयिक राजनैतिक प्रकाश के तले अपने पैर पसारते अमानवीय अंधकार को झोपड़ियों, अट्टालिकाओं, शरीरों, दिमागों, मंदिरों, मस्जिदों और कलीसाओं के भीतर तथा इर्द-गिर्द पहचान लिया है और उसकी चालाक गति के साथ अपनी गति मिलायी है ताकि उसके हर एक चाल को पकड़ा और समझा जा सके। समकालीन समय सत्ता और पूँजी के गठबंधन का काल है। इसने बड़ी चालाकी से भ्रूंडलीकरण-उदारीकरण के छद्मी प्रकाश के आड़ में एक ओर तो अधिकाधिक धन कमाने का व्यूह रच ही लिया है; साथ ही दूसरी ओर मानवीय संवेदना के जड़ों को भी खोदना शुरू कर दिया है। इससे एक ओर देश के अमीर बड़ी आसानी से और भी अधिक अमीर होते जा रहे हैं और देश की आम निरीह जनता दो जून की रोटी के लिए तरस रहे हैं तो दूसरी ओर मानवीय संबंध खंडहर में तब्दील होते जा रहे हैं। विष्णु खरे अपने समय के सजग प्रहरी हैं। वे इस घोर अमानवीय गठबंधन की कारस्तानियों को भली-भाँति समझते हैं और तात्कालीन सत्ता; नरसिम्हा राव की सरकार पर प्रहार करते हैं- "हर नया दिन नया कैदी नया गवाह तुम पर नये इल्जाम लेकर आ रहा है/लेकिन तुम पर दो सबसे संगीन आरोप ये हैं नरसिंह राव/कि तुमने खुलेपन और उदारीकरण का इंद्रजाल रच कर/देश में बीस लाख की गाड़ियों पाँच लाख की घड़ियों/और तीन हजार के जूतों का

बाजार खोला है/जबकि जानवरों से भी बदतर नसीब वाले चालीस करोड़ को/दो जून को रोटों भी नसीब नहीं हो रही।"12

एक समर्थ कवि की दृष्टि अपने काल के आवरण से बाहर जाकर भविष्य तक झाँक पाने में सक्षम होती है। इसी विशेषता के कारण उसकी स्थापनाएँ हर काल में प्रासंगिक हो उठती हैं। इस संदर्भ में हम विष्णु खरे को कबीर, मुक्तिबोध, रघुबीर सहाय जैसे सार्वकालिक कवियों की पॉत में खड़े पाते हैं क्योंकि एक लंबे समय तक देश की सत्ता द्वारा वोट की राजनीति करने के क्रम में अपनायी गयी अल्पसंख्यक तुष्टीकरण की नीति के खतरनाक प्रभाव को वे अपने समय में ही देख लेते हैं। वे इस नीति के तले मौजूद प्रतिपक्षी के लिए सुलभ बहुसंख्यक तुष्टीकरण की खतरनाक नीति को देख पाते हैं, जो भविष्य में देश और समाज के लिए काफी नुकसानदेह है। वे भारत जैसे धर्मनिरपेक्ष राष्ट्र की इस कुत्सित राजनीति से काफी चिंतित हो उठते हैं क्योंकि उन्हें स्पष्टतः लगता है कि प्रत्येक क्रिया के विपरीत एक समतुल्य प्रतिक्रिया जरूर होती है। वे देश के कस्बानुमा शहरों में सुबह घूमनेवाले मध्यवर्गीय सवर्ण पुरुषों में हरिओम पुकारने के ढंग को पकड़कर उसके तह में जाते हैं और वहाँ मौजूद इस भयानक तथ्य को हमारे समक्ष पेश करने के काम में जो कहते हैं; वह आज प्रासंगिक हो उठा है- "लेकिन अभी से ही उनमें जो रंजीदगी और थकान सुनता हूँ/उससे डर पैदा होता है/कि हिंदी वे हरिओम कहने को अनिवार्य न बनवा डालें इस सड़क पर/और फिर इस शहर में/और अंत में इस मुल्क में।"13

आजादी के बाद से लेकर काफी लंबे समय तक देश की सत्ता पर काबिज रहे नेहरू-गाँधी कुनवा एवं बीच-बीच में आई दूसरे राजनीतिक दलों की सरकारें देश का अपेक्षित विकास करने में नाकाम रही हैं। कांग्रेस कुनबे ने तो देश में एक ऐसा व्यामोह रचा है कि देश में जो भी विकास का प्रकाश आया है, वह उन्हीं का देन है। इस व्यामोह प्रकाश के तले देश में फैले अंधकार से अपने समय के प्रतिबद्ध कवि विष्णु खरे भली-भाँति परिचित हैं; साथ ही बीच-बीच में दूसरे दलों की आई सरकारों ने जो देश का अहित किया है उससे भी। इस संदर्भ में कवि का अब तक देश में काबिज सरकारों के प्रति मोहभंग हो चुका है और वे अपने देश के लोकतंत्र की रक्षा एवं उसके समुचित विकास के लिए देश की जनता को आगे बढ़कर आने का आह्वान करते हैं। उन्हें पूर्ण विश्वास है कि इस लोकतंत्र का सही में भला देश की जनता के प्रबुद्ध होकर आगे बढ़ने से ही संभव है- "बीच-बीच में नयी रोशनी के आए दीगर जादूगर/लेकिन इस अंधियारे को ही वे



कर गये दुबारा दूधर/हर दफा इसी कुनबे से गरचे हैं नयी रोशनी सारी/फिर भी बार-बार अंधकार क्यों हो जाता है भारी?/उनकी ऐसी रोशनी में जीवना जीना पड़ता है/यह क्लेश क्लेश में जंग लगे कीले-सा हर पल गड़ता है/क्या हमों नही मिलकर खींचे अपनी हाथों की रेखाएँ/पहचाने नित नयी रोशनी सबकी, उसे खुद लेकर आएँ?।”<sup>14</sup>

विष्णु खरे अपने समय की विडंबनाओं का चित्रण बहुत साफ और सीधे लहजे में करनेवाले कवि हैं। वे रघुवीर सहाय के जैसा रामदास के साथ हुए अन्याय के चित्रण के मार्फत लोगों में केवल संवेदना ही पैदा नहीं करते हैं, बल्कि वे उनसे आगे बढ़कर रामदास से दूर खड़े होकर खुद को खुशनसीब माननेवालों को उनकी नियति से रूबरू करवाते हैं। वे चुपचाप खड़े होकर भ्रष्टतंत्र के गंगा नाच को देखनेवालों को चेताते हुए कहते हैं- “इस देश में जब कुछ लोग/एक आदमी को घेरकर/सरेआम मार रहे होते हैं/उसे गालियाँ देते हुए/तो दूर खुशनसीब खड़े देखते हुए/तुम यह न समझो कि यह सब/सिर्फ उस लहलुहान अकेले आदमी पर/गुजर रही है/दरअसल वह तुम्हें ही नहीं/बल्कि वहाँ देखते खड़े/हर तुम जैसे अपनी हिफाजत में डरे हुए तमाशबीन को/खुली से खुली गालियाँ दे रहे होते हैं/उनके वह हाथ हथियार लात जूते/तुम जैसे हर चुप आदमी पर भी/चल रहे होते हैं।”<sup>15</sup>

देश में काबिज पूँजीवादी भ्रष्टतंत्र के विभिन्न पायदानों पर काम कर रहे कारीदों को यह बहुत ही अच्छी तरह से मालूम है कि एक लोकतांत्रिक देश में वे अपनी शक्ति एवं चालाकी पर कितना ही घमंड क्यों कर लें पर लोक-शक्ति की आँधी के समक्ष उनकी हैसियत एक सूखे पत्ते जैसा ही न्यून है। इससे निपटने का एक ही उपाय है और वह उपाय है- डर का साम्राज्य स्थापित करना। ऐसा करने से लोक शक्ति को कुछ समय तक संगठित होने से रोका जा सकता है और उस दरम्यान अपना काम निकाला जा सकता है। विष्णु खरे इन कारीदों के दर्प भरे व्यवहार के आवरण तले मौजूद इस डर की शिनाख्त करते हैं और लंबे समय से चले आ रहे इस तंत्र को समूल उखाड़ फेंकने हेतु लोक शक्ति का आह्वान करते हैं। वे डर के इस व्यापार को कलई खोलते हुए कहते हैं- “ताकतवर लोगों मुझे शालीन और संयत भाषा में/परामर्श न दो कि गुस्सा न करो/क्योंकि उससे मेरा ही नुकसान होगा/मैं तुम्हारे धीरोदात्त उपदेश में लिपटी चेतावनी सुन रहा हूँ/लेकिन सब कुछ चले जाने के बाद/यही एक चीज अपनी बचने दी गयी है/डॉक्टर तो सदाशय हैं भले-बुरे से ऊपर/लेकिन बुजुर्गों ग्रंथों ताकतवर लोगों/मैं जानता हूँ/आप एक सख्स के गुस्से से उतने चिंतित नहीं हैं/आपके सामने एक अदेशा है

सच्चा या झूठा/चंद लोगों के एक साथ मिलकर गुस्सा होने का।"<sup>16</sup>

समकालीन हिंदी कविता अन्तर्विरोधों को आरंभित करनेवाली मनुष्यधर्मी कविता है। साथ ही यह मानवीय संवेदना को बचाये रखने की कवायद करनेवाली प्रतिपक्षधर्मी कविता है। यह प्रतिपक्षधर्मिता आरंभित दृष्टि नहीं है, बल्कि स्वातंत्र्योत्तर भारतीय समाज और विश्व समाज के साथ मानवीय अवस्थाओं से प्रतिकृत होने रहने से उसकी जैविकता के अभिन्न अंग के रूप में विकसित हुआ है। इस संदर्भ में ए. अरविंदाक्षन का कहना है- "समकालीन कविता मनुष्यधर्मी है अर्थात् समकालीन कविता प्रतिपक्षधर्मी है। इसलिए मनुष्य को केंद्र में रखकर समकालीन कविता जब अपनी सहजता में प्रतिकृत होती है तो वह अपना प्रतिपक्ष स्वर ही व्यक्त करती है।"<sup>17</sup> विष्णु खरे की कविताएँ भी इससे इतर नहीं हैं। देश में किसानों-मजदूरों को आत्महत्याओं की खबर सुनकर विष्णु खरे केवल विचलित नहीं होते हैं, बल्कि वे प्रतिपक्षधर्मिता के हिसाब से इस समस्या का समाधान भी बेखौफ होकर पेश करने का जोखिम उठाते हैं। उनके विचार में इस परिस्थिति के जिम्मेदार देश के राजस्व अधिकारी, साहूकार, बैंकर, कंपनी मालिक-मैनेजर, अखबार चैनलों के मालिक, बुद्धिजीवी, अध्यापक, धर्मगुरु, पुलिस न्यायपाल, नेता के साथ-साथ रचनाकर्मी भी हैं। अतः किसानों-मजदूरों को धीरे-धीरे अपने साथ इनको भी खत्म करने का प्रण लेना चाहिए- "किसानों मजदूरों की आत्महत्या की खबरों से/मुझे भी हैरानी होती है/कि जब उन्हें खुदकुशी ही करनी है/तो वे राजस्व अधिकारियों साहूकारों बैंकरों कंपनी मालिकों मैनेजरो/अखबारों चैनलों के संचालकों पत्रकारों दौगर बुद्धिजीवियों/अध्यापकों रचनाकर्मीयों धर्मगुरुओं पुलिसवालों न्यायपालों/नेताओं अपराधियों विधायकों सांसदों मंत्रिमंडलों में से/कम से कम एक असली गुनहगार को मारकर क्यों नहीं मरते।"<sup>18</sup>

निष्कर्षतः यह कहा जा सकता है कि विष्णु खरे की कविताएँ आदमी के आस्तित्व और उसके सामने खड़े सारे संकटों को लेकर चिंता और प्रतिबद्धता, मानव होने के रोमांचक मामले में गहरी दिलचस्पी, जीवन और रिश्तों के अनंत वैविध्य के प्रति उत्सुकता और इन सबको अपनी भाषा और शैली में रख पाने की क्षमता से लेश अनवरत सत्य का पीछा करनेवाली कविताएँ हैं। 'सत्य' शीर्षक कविता में लिखित यह कथन उनकी कविताओं के संदर्भ में एकदम सटीक बैठता है - "जब हम सत्य को पुकारते हैं/तो वह हमसे परे हटता जाता है/जैसे गुहारते हुए युधिष्ठिर के सामने से/भागते थे विदुर और भी घने जंगलों में/सत्य जानना चाहता है/कि उसके पीछे हम कितनी दूर तक भटक सकते हैं"<sup>19</sup>

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# **WINGS OF LIFE**

**Genomics, Biodiversity  
and  
Life Processes**

**Edited by  
Asok Kanti Sanyal**

**THE ASIATIC SOCIETY**

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# CYANOBACTERIAL TAXONOMY : TRANSFORMATION FROM THE TRADITIONAL TO THE MODERN

SANDEEP CHAKRABORTY AND JOYDEEP MUKHERJEE

## Introduction

The existence of cyanobacteria, phylogenetically an old group of phototrophic organisms, was found in the early Precambrian and the wide diversity up to the present time signify their extraordinary and continual biologically and ecologically successful life strategies, with repeated rapid adaptations to various environmental conditions in different ecosystems which makes them phenotypically plastic in nature. The evolution of cyanobacteria without any sexual phase in their life cycle is due to the cause of horizontal gene transfer, which is a continual process (static evolution). The combination of these features along with the changes in their genomes to acclimate with the environmental conditions causes the diversification in their structural and molecular parameters. This leads to the discovery of new ecotypes and morphotypes. However these features cause their classification and taxonomic study much difficult.

It is estimated that there are approximately 40,000 species of algae have been reported out of which 1500 species belongs to 150 genera of cyanobacteria (Norton *et al.* 1996). Multiple approaches have been carried out for the classification of cyanobacteria by various researchers. Mainly these organisms were classified following the bacteriological approach and the botanical approach. The bacteriological approach put forward by Stanier *et al.* (1971) has been further supported by Rippka *et al.* (1979), Castenholz and Waterbury (1989), and Oren (2004). Botanical approach to classify cyanobacteria along with the other algae and plants was supported by Desikachary (1959) and Anagnostidis and Komárek (1985).

### Botanical approach for Cyanobacterial Taxonomy

Traditionally blue-green algae have been classified in the phylum Cyanophyta consisting of the class Cyanophyceae. Geitler (1932) was

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*Frontier Aspects of Natural Sciences*

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*Editors*

*Dr. Soma Mitra (Banerjee)*

*Dr. Subrata Sarkar*

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## **Preface**

This book is intended to serve as a rich collection of current research areas/topics of natural science for the students who have already completed their masters level in various disciplines and are about to start their research career. A variety of active research areas starting from atoms to galaxies, from biology to philosophy, from earth science to physical science have been covered up with specific applications. This book is not expected to provide basic text materials; rather, we think it may potentially serve as a vibrant source of ideas for new researchers. A student may not be interested in all these different fields but (s)he would surely find considerable overlaps with own areas of interests. This is particularly useful in motivating a student towards selecting a suitable reserach problem.

Emphasis has been given on simplicity of the underlying concepts and presentations. Mathematical symbols used are standard in scientific literature. The complex mathematical models and related calculations have been excluded as much as possible to make the book easy going for common students other than pure science origin.

Finally, the editors warmly welcome any kind of constructive criticism and suggestion for the improvement of the overall design of the book for possible modifications in future edition(s).

Subrata Sarkar  
Soma Mitra (Banerjee)

# Liquid Capillary Waves

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**Abstract:** In this chapter, a single capillary wave, which can be produced by throwing a pebble in water, is discussed. Now, imagine dropping of two such pebbles simultaneously at two nearby locations in a lake. Circular ripples, which propagate radially outward from each source point, would result in interfering waves on the water surface. Most textbooks [1, 2] on waves and optics include photographs of such interfering water waves while introducing superposition of waves but not discussing more about capillary waves and its characteristics. Hence, the aim of this chapter is to inform the readers the details about liquid capillary waves and its different recent research progress using diffraction of monochromatic light.

**Keywords:** Capillary waves; Rayleigh waves; Gravity waves; diffraction of light.

## Introduction:

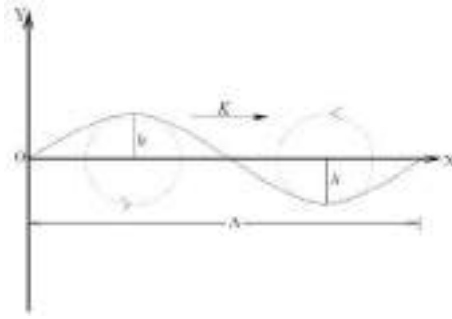
Suppose a marble is dropped on a liquid surface, say, in water. Transverse waves are produced, which travel outward along the radial direction (see Fig. 1) [3]. The phase velocity of the transverse wave on the liquid surface mainly depends on (a) the acceleration due to gravity ( $g$ ) and (b) the surface tension ( $\alpha$ ) of the liquid.



**Figure 1: Capillary waves on the water surface.**

Due to incompressibility of liquids, there is a high compression at the position of a trough and a hollow space under a crest. The continuity of

the liquid can only be maintained by the longitudinal vibration of the liquid molecules in the direction of propagation of the wave. Thus, the transverse vibration of the liquid molecules is always accompanied by the longitudinal vibration. The resultant of these two orthogonal vibrations (transverse and longitudinal) makes the molecule move in a circle, in an anticlockwise direction, if the wave propagates along the positive X-axis (see Figure 2).



**Figure 2: A schematic diagram of the propagation of surface capillary wave along the positive X-direction:  $K$ ,  $\Lambda$  and  $h$  are wavevector, wavelength and amplitude of the wave.**

The phase velocity of the transverse waves on the liquid surface is given by,

$$v_p = \sqrt{\frac{g\Lambda}{2\pi} + \frac{2\pi\alpha}{\rho\Lambda}} \quad (1)$$

Where,  $g$  is the acceleration due to gravity,  $\Lambda$  is the wavelength of the transverse waves (see Figure 2),  $\alpha$  and  $\rho$  are the surface tension and the density of the liquid, respectively. In the above Eqn. 1, when  $\Lambda = 0$  or  $\infty$ ,  $v_p = \infty$ . There exists a critical wavelength for which the velocity of the transverse wave is minimum, which is given by,

$$\Lambda_c = 2\pi \sqrt{\frac{\alpha}{\rho g}} \quad (2)$$

For example, the critical wavelength of the surface capillary wave for water is 1.73 cm. If ( $\Lambda > \Lambda_c$ ), the second term in Eqn. 1 is negligibly small and phase velocity becomes

$$v_p = \sqrt{\frac{g\Lambda}{2\pi}} \quad (3)$$

These waves of longer wavelength are only controlled by gravity and appropriately termed as gravity waves. The amplitude of the gravity wave is extremely small as compared to its wavelength. For the gravity wave, its phase velocity increases with wavelength – a behavior known as normal dispersion. On the other hand, when  $\Lambda < \Lambda_c$ , the first term in Eqn. 1 can be neglected and velocity becomes

$$v_p = \sqrt{\frac{2\pi\alpha}{\rho\Lambda}} \quad (4)$$

Such waves are of shorter wavelength and dominated by the effect of surface tension -commonly known as ripples or capillary waves or Rayleigh waves [4]. The phase velocity of capillary waves decreases with the increase in wavelength – a behavior known as anomalous dispersion. In this chapter, I shall concentrate on capillary waves.

### **Different reported works:**

It is worth summarizing some of the earlier work on capillary waves. The investigation began in 1871 when Lord Kelvin observed that the propagation of ripples depends on the surface tension of liquids [5]. Lord Rayleigh was the first to develop the stroboscopic method for the measurement of the surface tension of a liquid. The basic principle behind this technique was the following: the surface of water was periodically excited and then viewed by means of interrupted light. The flashes of light were isoperiodic with the waves [6]. Later, Dorsey, Smith and others used Rayleigh's method with more perfected apparatus [7-9] for the same measurement. Recent advances in related areas have been reported in literature. As for example, an introduction to light scattering by surface capillary waves is available in [10]. The quasielastic light scattering has been used to study thermally excited capillary waves on free liquid surfaces over a considerably wide range of wavenumbers: from  $190 \text{ cm}^{-1}$  to  $2000 \text{ cm}^{-1}$ . Using a typical photon correlation function, surface tension and viscosity of ethanol, water and aqueous solutions of both ethanol and tertiary-butyl alcohol are measured [11]. The coupling between capillary and dilational modes on the surface of dilute aqueous solutions of cetyltrimethyl ammonium

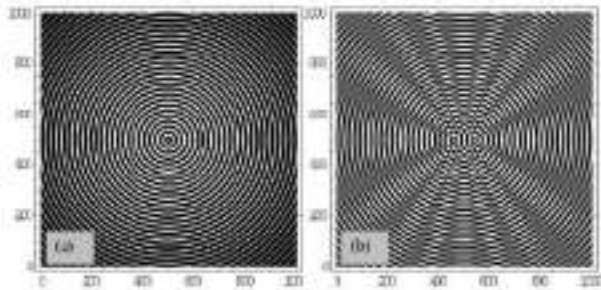
bromide and liquid gallium has been investigated using the above technique [12, 13]. Quasielastic light scattering spectroscopy has also been used to study the high frequency capillary waves at the surface of liquid gallium and the mercury liquid-vapor interface [13, 14]. Direct analysis of the spectra of the scattered light reveals the high sensitivity of this technique for the measurement of the viscoelastic modulus of liquid gallium [13]. The surface tension and viscosity of thermally excited liquid surface waves have been investigated in Ref. [15]. The spatial damping coefficient of low-frequency surface waves at air-water interfaces, using a heterodyne light-scattering technique (which has a wide dynamic range), has been measured [16]. For pure water, the measured value of the spatial damping coefficient agrees well with that obtained from linear hydrodynamic theory. Measurements, based on circular field of the capillary waves, have been reported to determine the decay coefficient of capillary waves in liquids covered with monolayers of stearic acid, oleyl alcohol and hemicyanine [17]. Martin et al. have measured the pressure-area compression isotherm in Langmuir monolayer films using the laser light diffraction from surface capillary waves [18]. The introduction of a Langmuir monomolecular layer to the water-air interface perturbed the surface tension and therefore the diffraction pattern. Analysis of the resulting diffraction pattern has been used to calculate the interfacial tension. A technique to study low-frequency liquid surface acoustic waves by means of optical diffraction and a real time characterization of amplitude and wavelength of circular ripples is available in [19]. Related works also can be found in [10]. If the wavelength of the surface capillary wave is small (say a fraction of a centimeter), it is not easy to see such waves with the naked eye. Sophisticated modern-day cameras can obviously detect these small-wavelength waves. But such cameras are expensive and not readily available. Therefore, to detect these capillary waves we need to find other ways, which also could provide valuable physical insight. Monochromatic laser light falling on the vibrating liquid surface gets diffracted and results in an intensity distribution with crucial characteristic features. In the simple single slit or grating experiments with a He-Ne laser we can infer the nature of the diffracting object from the intensity variation of the diffraction pattern.



Similarly, here, we can learn about the surface wave profile (which is the diffracting object).

**Conclusion:**

In this chapter, recent research and developmental works about liquid capillary waves is reviewed. Simple optics-based experimental technique is used with the necessary background theoretical formulation, to study the characteristics of surface capillary waves on liquids and also to measure the amplitude, wavelength and phase velocity of the interfering liquid capillary waves [20]. It is noted how the intensity of the diffraction pattern varies with the amplitude and also experimentally located the zeros of the Bessel function from the vanishing of various diffraction orders. This experimental method is used in International Physics Olympiad (*IPHO-2015*) examinations in 2015 as experimental question. On the whole, the experimental and theoretical results seem to demonstrate the capability of the setup in carrying out studies pertaining to capillary wave profile, liquid properties (*i.e.* surface tension and viscosity) and waves on liquid films on liquids [21]. Despite its limitations, the wide variety of information which can be obtained from such a simple setup makes it a tool worth improving upon for further investigations. The simulated surface capillary wave profiles using mathematica software for (a) single exciter and (b) two nearby exciters are shown in figure-3. If, anyone is interested to know more about capillary waves, then he/she can follow the references specially [20, 21] given below.



**Figure 3: Simulated surface capillary wave profiles for (a) single exciter and (b) two exciters.**

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# Fundamentals of Raman Spectroscopy

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**Abstract:** Raman spectroscopy is a powerful noninvasive tool to probe the structure and dynamics of a system at the molecular level. This technique can be used to study the molecular structure and stability on the basis of deformation/stretching of different vibrational bonds of molecules. The basic principle of Raman scattering and also the basic structure of spectrometer for the Raman measurements are discussed with a simple example. Raman spectroscopy is a unique tool, using which, the effect of drainage of water molecules and the amount of bound water phase present in Gillette shaving foam are detected by analyzing the characteristic spectral line profile.

**Keywords:** Raman scattering; Raman spectrometer; Stokes and anti-Stokes scattering; Raman spectrum; Foam; Water clusters; Water drainage.

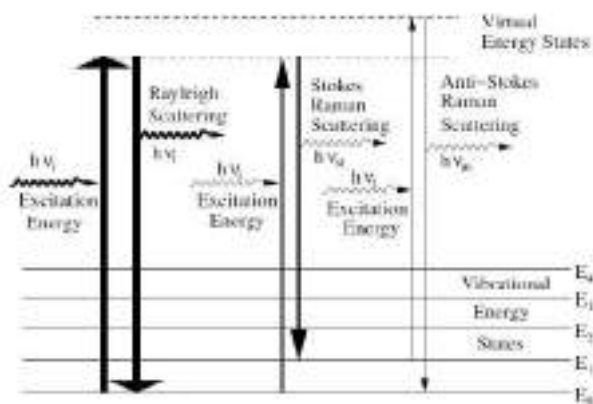
## Introduction:

When a beam of light interacts with a material, some part of the light is reflected, some part of the light is transmitted and the remaining part is scattered. In the scattered radiation most photons are elastically scattered and have the same energy (frequency) as that of the incident photons. This elastic scattering of light is known as Rayleigh scattering. However, a small fraction of light is inelastically scattered at optical frequencies different from the frequency of the incident photons. Raman scattering is the example of inelastic scattering of light. The inelastic scattering of light was first predicted in 1923 by A. Smekal [1]. However, it was not until 1928 that Sir C.V. Raman did the first set of experiments that confirmed Smekal's prediction and led to the Nobel Prize in 1930 [2].

Let us consider inelastic scattering of an incident photon of energy  $h\nu_i$  by a molecule in the initial energy state  $E_i$ . After scattering, the molecule is found in a final energy state  $E_f$  and a photon of energy  $h\nu_f$  is scattered. The difference in energy between the incident photon and the Raman scattered photon can be expressed as

$$h(\nu_i - \nu_f) = E_f - E_i = \Delta E \quad (1)$$

The energy difference,  $\Delta E$ , appears due to quasi-excitations. These excitations, for example, can be vibrational modes or rotational modes in a molecule. For Rayleigh scattering  $\Delta E = 0$ . If  $\Delta E > 0$ , the scattering is known as Stokes scattering. For anti-Stokes scattering,  $\Delta E < 0$ . A plot of intensity of the scattered light vs. the energy difference,  $\Delta E$ , is known as Raman spectrum. A semi-phenomenological treatment using quantum mechanics can be given if the incident electromagnetic wave is treated as a perturbation of the eigenstates of a molecule. The perturbation due to the incident radiation produces a time-dependent virtual state, as shown in Figure-1.



**Figure 1: A schematic for the virtual state description of Raman and Rayleigh scattering.**

The unperturbed states, which contribute most strongly to the Raman scattering efficiency, are those closest to the virtual state with the highest transition moments with both the initial and final states. Rayleigh scattering can occur from any stationary state and results in no net change in energy of the molecule. As shown in Figure-1, the Stokes scattering, with scattered frequency  $\nu_{st}$ , is a result of a net energy gain by the molecule, whereas the anti-Stokes process, with the scattered frequency  $\nu_{as}$ , the scattering carries away excess energy lost by the molecule. At room temperature, the thermal population of vibrational excited state is low, although not zero. Thus, the relative intensities of anti-Stokes lines are less than that of the Stokes lines. In

this chapter, all reported Raman spectra correspond to the Stokes scattering.

Classically, in vibrational Raman scattering the incident photon interacts with the electric dipole of the molecule and the molecular vibrations alter the polarizability of the molecule. When a molecule is subjected to the electric field amplitude  $\vec{E}_I = E_I \cos \omega t$  of the incident electromagnetic radiation, the dipole moment  $P$  of the molecule is given by equation no.-2 [3] -

$$\vec{P} = \vec{\mu}_0 + \tilde{\alpha} E_I, \quad (2)$$

where,  $\vec{\mu}_0$  represents a possible permanent dipole moment, while  $\tilde{\alpha} E_I$  is the induced dipole moment. The polarizability of a molecule is a tensor of rank two ( $\alpha_{ij}$ ). The structure of this tensor depends on the molecular symmetry. For small vibrational amplitudes, the normal coordinates ( $q_n(t)$ ) of the vibrating molecule can be approximated as -

$$q_n(t) = q_n(0) \cos(\omega_n t); \quad (3)$$

where,  $q_n(0)$  is the amplitude and  $\omega_n$  is the vibrational frequency of the normal mode. Using the Taylor series expansion (only upto the first term) of the permanent dipole moment and polarizability, the total dipole moment can be expressed as -

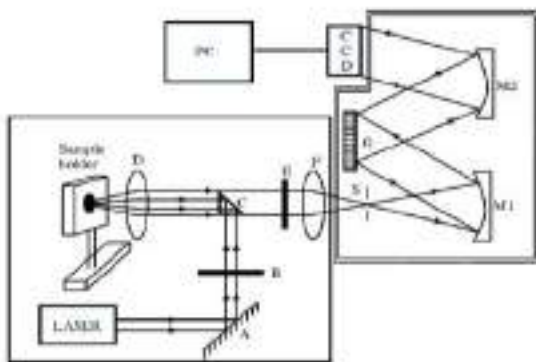
$$\begin{aligned} \vec{P} = & \vec{\mu}_0 + \alpha_{ij}(0) \vec{E}_0 \cos(\omega t) + \sum_{n=1}^Q \left( \frac{\partial \mu}{\partial q_n} \right)_0 q_n(0) \cos(\omega_n t) \\ & + \frac{1}{2} \vec{E}_0 \sum_{n=1}^Q \left( \frac{\partial \alpha_{ij}}{\partial q_n} \right)_0 q_{n0} [\cos(\omega + \omega_n) t + \cos(\omega - \omega_n) t]. \end{aligned} \quad (4)$$

The second term in Equation -4 describes Rayleigh scattering, the third term represents the infrared spectrum and the fourth term represents the Raman scattering process. Thus, for a mode of vibration of a molecule to be Raman active, the necessary criterion is  $\left. \frac{\partial \alpha}{\partial q_n} \right|_{q=0} \neq 0$ . Inelastically scattered component with frequency  $(\omega - \omega_n)$  corresponds to the Stokes scattering and the one with frequency  $(\omega + \omega_n)$  corresponds to the anti-Stokes scattering component.

### Basic Structure of Raman Spectrometer:

The Raman spectra are recorded from a back-scattering geometry using TRIAX550 single monochromator equipped with a notch filter and a

CCD detector. An Argon-ion laser of wavelength 488 nm and of power 30 mW on sample head have been used as an excitation source. The spot size of the excitation source is  $\sim 500 \mu\text{m}$ . Schematic of our Raman apparatus is shown in Figure -2. The collection optics is shown in the lower left. Using a mirror A, light from the laser is steered to the plasma filter B and then to a tiny right angle prism (C), where it bends by  $90^\circ$ . The light is then focussed on a quartz cell holder by a Nikon camera lens (D) of the focal length 55 mm. The actual size of the prism C is much smaller. The scattered light is then collected by the same lens and passed through a holographic notch filter (E), which cuts off the Rayleigh line from the scattered light. The output of the notch filter is then imaged on the entrance slit S of the monochromator using a collecting and focusing lens (F) of focal length 55 mm. The slit S is placed in the focal plane of the concave mirror M1. Mirrors M1 and M2 image the entrance slit on a CCD detector. The dispersive unit (G) uses a  $76 \times 76 \text{ mm}^2$  holographic grating (1200 rulings/mm) for dispersion of the spectral line. The CCD detector is interfaced with a computer (PC).

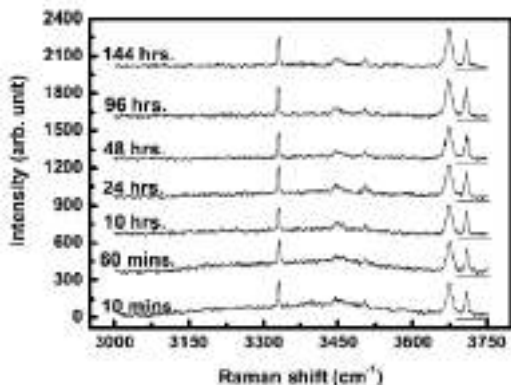


**Figure 2: A schematic of the Raman apparatus.**

### **Example of Raman spectra:**

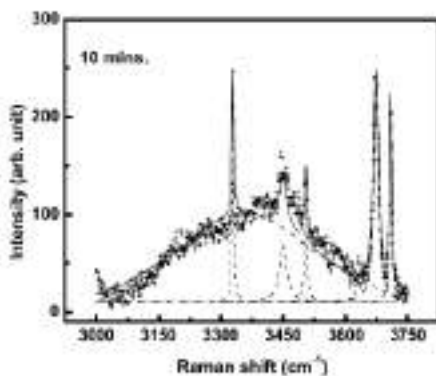
As for example of Raman measurements, a study of various -OH phases in Gillette shaving foam is shown here. This foam consists of a collection of gas bubbles surrounded by thin liquid films. The adjacent

bubbles coalesce if the liquid film becomes too thin. Foam evolves toward thermodynamic equilibrium by the coarsening process, which involves (i) rupturing of liquid films between bubbles and also (ii) growth of the bubbles through diffusive exchange of gas [4]. Characteristic Raman spectra, exhibiting the time evolution of -OH vibrational modes of water in foam, are shown in Figure-3. The spectra exhibit: (a) a broad band between 3100 and 3600  $\text{cm}^{-1}$  (at  $\sim 3350 \text{ cm}^{-1}$ ) and (b) relatively sharp features at 3330, 3450, 3504, 3670 and 3708  $\text{cm}^{-1}$ . While the spectral line profile in (a) is the fingerprint of free water molecules, connected in a network of higher density with a weaker hydrogen bond, the sharp features in (b) indicate the presence of bound water molecules – either in the form a cluster connected by strong hydrogen bonds or in the form of a complex with surfactant molecules in foam [5].



**Figure 3: Characteristic Raman spectra, showing the variation in –OH vibrational modes with time in Gillette foam. The intensity scale of all spectra is same. Horizontal line on the right of each spectrum shows zero intensity scale.**

Surfactant molecules possess hydrophilic heads and hydrophobic tails. Water molecules can be attracted to the hydrophilic heads of the surfactant and form a complex. It is to be noted that these sharp features are too intense to be overtones of low wavenumber Raman lines in foam.



**Figure 4:** The deconvoluted components (dashed lines) and net fitted spectrum (solid line) for the Raman spectrum recorded after 10 mins. (scattered points).

Each Raman spectrum has been fitted with six Lorentzian line shapes (five sharp Raman lines + one broad Raman line) keeping peak position, width and intensity of each component as free fitting parameters. This procedure ensures the proper estimation of these quantities. In Figure-4 we have shown the deconvoluted components (dashed lines) of the spectrum taken at 10 mins. The solid line is the net fitted spectrum to the data points (scattered points). The decrease in intensity of the broad feature in Figure-3, due to free  $-OH$  stretching vibration, indicates the drainage of free water molecules in foamy structure with ageing. It is interesting to note that the intensity of the sharp features do not get affected within the time-scale of our experiment. It is shown from the analysis of Raman spectrum ( see Figure-3 & Figure-4) in different time scale that along with free water molecules connected by weak hydrogen bonds, bound water clusters (in particular  $[H_2O]_4$  clusters) are also present in the system [4,6].

### **Conclusion:**

In this article, the fundamental knowledge about the Raman spectroscopy is discussed with a sample of Raman spectrometer and Raman spectrum of Gillette shaving foam. From this study, it is



concluded that if macroscopic and microscopic properties of any material are related, then the Raman line profiles can be used to probe the different properties of that material, indirectly, by studying its molecular behavior. In addition to free water molecules, which drain out with aging of foam, water clusters of only a few water molecules are also present in Gillette shaving foam [6].

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# Physical approaches for drug delivery: an overview

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## 1. Introduction

A major challenge in therapeutics is finding pathways for efficient delivery of therapeutic agents to the affected organs, tissues, or cells. For certain diseases (such as cancer), it is important to ensure all the cells affected by a condition are treated in order to avoid relapses [1,2]. Over the years, many techniques have been studied for drug delivery into cells based on various backgrounds. Viral and chemical vectors have developed extensively and many of them are undergoing clinical trials. Great interest has been shown in the application of viral vectors as gene-delivery agents, but their adverse effects pose significant safety risks to the host due to

their immunogenicity and toxicity [3]. Chemical methods such as liposome-mediated delivery are cell-specific and suffer from instability, uncontrolled delivery, and low transfection efficiency [4]. In the last few decades, physical methods for drug delivery have emerged due to their minimal adverse effects and controlled uniform delivery. Electroporation [5,6], mechanoporation [7], optoporation [8], and magnetoporation [9] are the main techniques that come under physical methods for drug delivery. Each of these techniques employs different physical energies to permeabilize cell membrane for intracellular cargo. As an advantage over current chemical methods for cell membrane permeabilization by using detergents, physical methods can

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control the pore size, number of pores, and density of pores on the cell membrane by means of physical energies and deliver cargo in a different cell type with high transfection efficiency and high cell viability [5,10]. Chemical agents can permeabilize cell membrane uniformly throughout the membrane surface, but in higher concentration they might create larger pores, leading to cell death by leakage of cytosol [11]. Using physical techniques, membrane pores could be created on localized or small regions of the cell membrane to avoid cell death after delivery [12]. Also, their size can be controlled based on the molecular size needed to be delivered into cells. Such precise control of the cell permeabilization parameters can be enabled by single-cell technology [13–17].

The main principle behind electroporation is using strong external electric fields to disrupt the cell membrane and create transient hydrophilic membrane pores to deliver cargo into cells [5]. Similarly, mechanoporation uses physical forces to create stresses on the cell membrane to form transient pores and deliver cargo into cells by a simple diffusion process [7]. In photoporation, the physical energy, such as laser, is exposed on metallic nanoparticles resulting in the formation of cavitation bubbles surrounding nanoparticles and thus cell membrane deforms and creates transient membrane pores to deliver cargo into cells [18].

This chapter begins by discussing a few key viral and chemical methods for drug delivery, highlighting their advantages with certain cargos and their drawbacks. This is followed by individual discussions on the major physical methods used for intracellular delivery with their potential clinical applications. We elaborate on the comparison between different physical techniques and their variations with cell types have been highlighted and special attention has been given to studies showing *in vivo* results. Following this, strategies employing a combination of two or more physical methods, termed “hybrid techniques,” are discussed due to their

promising results in terms of drug-delivery efficiency and cell viability after treatment. Finally, the various advantages and future prospects of different physical methods for drug delivery are highlighted.

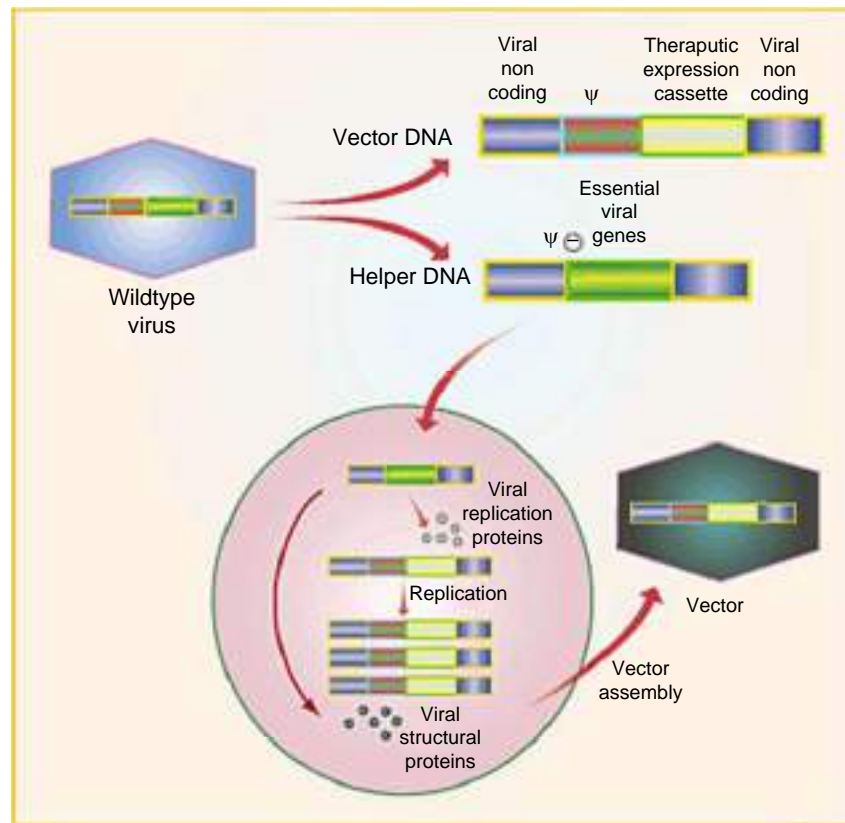
## 2. Overview of viral and chemical methods for drug delivery

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### 2.1 Viral methods

Viral methods involve delivery of drugs or genes using a virus as a vehicle (viral vectors) to transport nucleic acid coding for specific enzyme complexes into the targeted cell. The reliability of this procedure depends on the delivery of a substantial amount of therapeutic gene into the target cell without toxicity. Each viral vector is specified by a set of properties which is suitable for targeting specific cell types [19]. For converting a virus into a viral vector, a packaging consisting of a vector genome and viral genome is used. The viral genome is derived from the parental virus which encodes for a specific protein, whereas the vector genome contains a transgenic expression cassette and a *cis* acting element to help in gene encapsidation. Replication and expression of vector DNA happen from the packaging construct, which is incorporated into virus particles [20]. Fig. 7.1 depicts the engineering of a viral vector from wild-type virus [21]. The commonly used viral vectors in the clinical trials encompass retroviruses, adenoviruses, herpes simplex viruses (HSV), lentiviruses, and adeno-associated viruses (AAV). These viruses vary in the type of genetic material they use and their mechanism of attacking target cells. In some situations, the properties of these vectors are combined by developing hybrid viral vectors [20,22].

Retroviruses are lipid-enveloped particles consisting of homodimers of 7–11 kb of RNA genome. Their main advantage is the ability to integrate into the chromatin of target cells, hence



**FIGURE 7.1** The act of turning a virus into a vector; viral genes and viral noncoding genes are separated to form helper DNA and vector DNA, respectively. Separation is essential for the safety and efficiency of the viral method. The vector DNA contains a therapeutic expression cassette, *cis*-acting element, and packaging domain apart from noncoding genes. Once it enters into the cell, it leads to viral replication proteins and transducing of genetic information. *Reprinted with permission from Kay MA, Glorioso JC, Naldini L. Viral vectors for gene therapy: the art of turning infectious agents into vehicles of therapeutics. Nat Med. January 1, 2001;7(1):33–40. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/11135613>. Copyright © 2001, Springer Nature.*

effectively maintaining genetic information in the clonal outgrowth of stem cells and in self-renewing tissues [21]. Retroviral vectors have been successfully implemented for the treatment of leukodystrophies, immunodeficiencies, and globinopathies [23]. Adenoviruses have been used in clinical trials in targeting the epithelium of respiratory system, specifically to treat cystic fibrosis. If the adenovirus is taken intravenously, it aggregates in the liver, and if injected, it can transduce tissues such as skeletal muscle, liver, heart, lung, brain, tumors, and pancreas [21]. The targeting cells for lentiviral vectors include lymphocytes and they have been used to treat

immunodeficiencies and neurodegenerative disorders [24]. AAV and HSV vectors have been widely used in manipulation of gene expression in the brain [25]. Despite success in *in vivo* studies in treating diseases such as cancer, there are several issues with viral-based drugs. While transferring to the target location, unfavorable immune responses may arise or infections may occur due to targeting of healthy cells along with the lesion area. Transfer to the wrong location may also eventually cause mutation. Further, it possesses adverse effects such as carcinogenesis, broad tropism, immunogenicity, high toxicity, and inadequate DNA packaging [22].

Nonviral-based delivery using chemical methods has evolved to overcome these issues.

## 2.2 Chemical methods

Chemical-based drug delivery includes use of nonviral nanoparticles as vehicles for the purpose of drug delivery. In this approach, a gene or drug is adsorbed onto the surface of nanoparticles or it is encapsulated within the nanoparticle in a core–shell arrangement to form nanovectors. These nanovectors are modified by treating with targeting factors in such a way that they can bind to the target cell surface. During the process of cell granulation or endocytosis, gene or drug enters into the cell. These nanovectors are degraded due to cell lysosome enzymatic action to release the gene or drug, which then escapes into the cytosol by disruption of lysosomal membrane using chemical or physical means such as optical, electric, or magnetic fields. This enables targeted intracellular delivery of the desired cargo. The steps in gene editing using a chemical approach are presented in Fig. 7.2. Different nanoparticles have different sites of action, different release rates, and different biofilm permeabilities in vivo. Nanoparticles for drug delivery include inorganic nanoparticles, lipid-based nanoparticles, carbon nanotubes, quantum dots, silica nanoparticles, magnetic nanoparticles, polymer-based nanoparticles, and many others. Compared to viral methods, nanoparticle-based methods have shown better performance regarding improved gene stability, less immune issues, controlled chemical structure, mass production, and shielding of cargo from nuclease degradation [22].

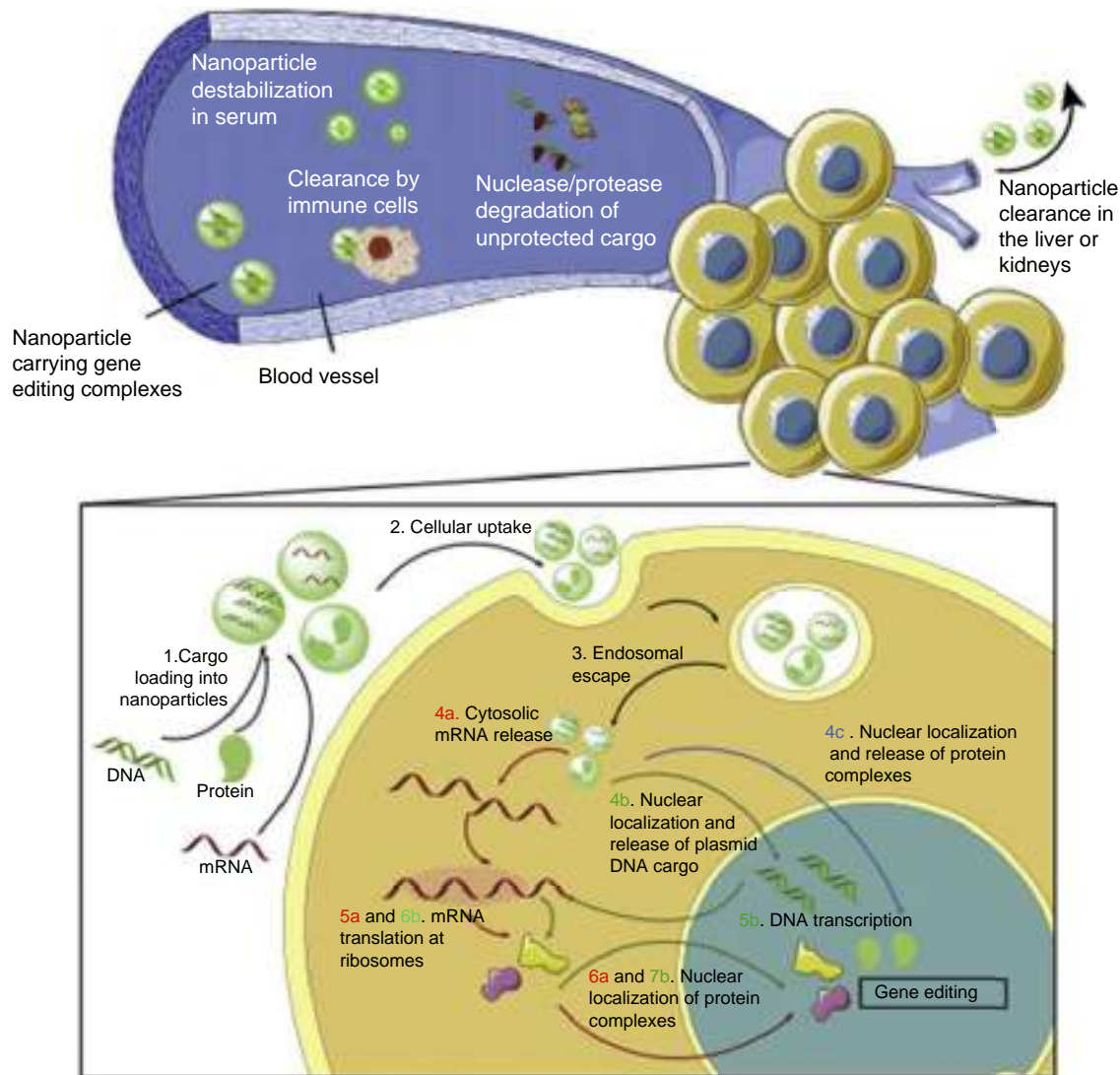
Multifunctional nanovectors are implemented by conjugating multiple targeting components to meet the results satisfactorily which prove to be a significant improvement over single-functional nanovectors. With this approach, fluorescence and magnetic resonance imaging of drug delivery are possible. For cancer therapy, the most

commonly used combinational approach is delivery of small interfering RNA (siRNA) and chemotherapeutic drug along with nanoparticles. Cationic trimethyl chitosan nanoparticles loaded with pDNA can treat infectious diseases. Tunable characteristics of nanoparticles can overcome the protective barriers in brain and deliver drugs into specific locations. Bioconjugated CdSe/CdS/ZnS quantum dots can be used in treating brain dysfunctional diseases [22]. Silica peptide conjugation facilitates targeted delivery by controlling environmental parameters such as pH, temperature, hypoxia, etc. [26]. Lipids, lipid materials, and polymers have been used in delivery of mRNA, pDNA, and oligonucleotides into cells. A multicomponent delivery system approach has been adapted for gene editing using polymeric materials [19]. Major applications of nanovehicles in biomedicine include treatment of infectious and brain dysfunctional diseases and cancers [22]. The major concern in designing nanovectors for drug delivery is to maintain a viable balance between safety and delivery efficiency. Nanoparticles should degrade after their action to avoid accumulation in organs which might be harmful toward vital body functions. Many nanoparticles have been reported to cause adverse effects such as hepatotoxicity, neurotoxicity, renal toxicity, reproductive dysfunction, and pulmonary injury [22]. In spite of advances in chemical methods for intracellular delivery, they face limitations such as low delivery efficiency (10%), nonuniform in vivo delivery, and uncontrolled uptake of cargo by cells. Physical methods for delivery offer an avenue for overcoming these limitations.

## 3. Physical methods for drug delivery

### 3.1 Electroporation

Electroporation is a process in which an electric field is applied to change the permeability of the cell membrane. In 1754, electrical sparks



**FIGURE 7.2** Pictorial representation of the sequence of events in gene editing in tissues of liver or kidneys using nanoparticles: (1) nanovectors are formed by encapsulating protein or nucleic acid with nanoparticles, (2) entry of encapsulated cargo through endocytosis, (3) escape from endolysosomal part of intracellular region, (4a) mRNA release in cytosol in order to occur (5a) protein synthesis/translation in ribosomes, (5a) delivery of plasmid DNA cargo after nuclear localization for successful (5b) DNA transcription, (6b) mRNA moves into cytosol for protein synthesis, and (6b), (7b) synthesized protein enters into the nucleus for gene editing. Reprinted with permission from Rui Y, Wilson DR, Green JJ. *Non-viral delivery to enable genome editing. Trends Biotechnol March 2019;37(3):281–93. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/30278987>* © 2018 Elsevier Ltd.

were applied across human and animal cells [5]. Later several experiments were conducted over different cells and bio-systems by employing an electric field. Finally, in 1982, electroporation was used to transfect mouse lymphoma cells, thus establishing it as a successful poration technique [27].

On application of electric field higher than the transmembrane potential barrier of cell membrane, the phospholipid structure of the membrane can be disrupted. This can create temporary hydrophilic openings which allow transport of molecules across the membrane

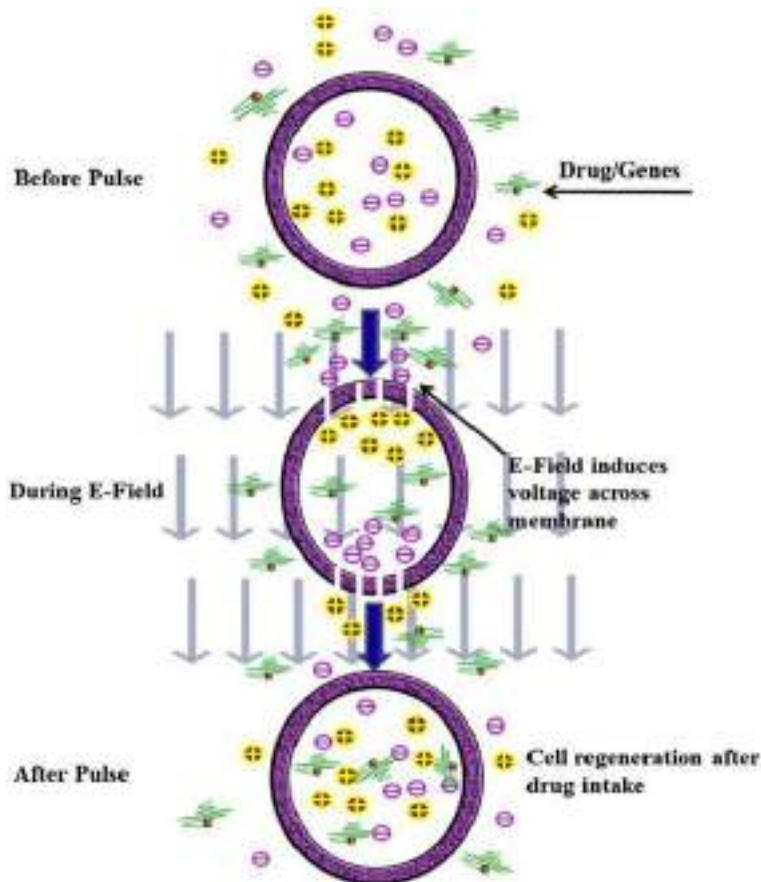


FIGURE 7.3 Schematic showing the mechanism of electroporation. Reprinted with permission from Lakshmanan S, Gupta GK, Avci P, Chandran R, Sadasivam M, Jorge AES, et al. *Physical energy for drug delivery; poration, concentration and activation. Adv Drug Deliv Rev* 2014;71:98–114. Copyright © 2013 Elsevier.

(Fig. 7.3). The size of the pore created as well as its density are dependent on the amplitude, time and frequency of the electric field applied, electrode design, extracellular medium, and presence of different molecules in the surrounding area [5].

Initially, the electroporation technique was called bulk electroporation (BEP), and employed electrodes placed millimeters to centimeters apart to apply a very high electric field (kV/cm) across millions of suspended cells. This technique was replaced by single-cell electroporation (SCEP) to achieve uniform drug delivery, increased cell viability, and to maintain the cell lineage. These factors prove beneficial in

downstream omics studies and *ex vivo* gene therapy applications. With the developments observed due to SCEP, localized single-cell electroporation (LSCEP) was introduced. This technique focuses on engineering the device design to fabricate nanoelectrodes that can locally permeabilize the cell membrane. Cell death due to a resistive heating effect, creation of cavitation bubbles, and generation of metal ions at electrodes can be minimized in LSCEP [29].

### 3.1.1 Bulk electroporation (BEP)

BEP can be involved in transfection to multiple cells simultaneously. However, there is no control on the uniformity of delivery as well as

the efficiency being low. The pore generation on each individual cell is a function of its location in the cell suspension. Fig. 7.4 shows a cell suspension inside an electroporation cuvette with electrodes placed along the walls. Reduced electrode gap (bottom part of the cuvette) can decrease electric field nonuniformity. This results in spatial variation of electric field intensity in the cell suspension. The cells in the central zone of the electroporation cuvette show better delivery efficiency compared to the cells near the electrode. On increasing the applied voltage across the suspension, the delivery rate can be increased at the cost of decreased cell viability due to irreversible electroporation.

### 3.1.2 Single-cell electroporation (SCEP)

For SCEP, the electrode is scaled down to a size comparable to the dimension of a single cell. This can attain a uniform electric field across each single cell, which can be further tuned to control pore density and pore size. A single cell is positioned between each pair of electrodes using dielectrophoretic force or microfluidic channels. Microfluidic device-based single-cell isolation can be used for almost all cell types,

whereas dielectrophoretic single-cell isolation depends on the electrical properties of the cell, which vary from cell to cell [14,27].

In a design proposed by Xiaoliang Guo et al. the cells can be positioned with quadruple electrodes by applying dielectrophoretic force and a pair of electrodes in the center is used for electroporation (Fig. 7.5). The quadruple electrodes are connected to out-of-phase alternating current sinusoidal dielectrophoretic voltage sources with the same amplitude and frequency used for positioning the cells on top of the center electrodes. The electrical properties of the cell and the medium govern the strength of the dielectric force acting upon the cell. This varies from cell to cell, resulting in a varying motility rate for the same intensity of electric field. Once the cells are aligned to be seeded on the top of the central electrodes, voltage is applied in particular combination to electroporate an individual cell. Using this technique different cell types can be selectively aligned and hence delivered, due to their varying dielectric constants and other electric properties. Although electroporation efficiency is greater than 90%, the device throughput is low [30].

Electroporation can deliver drugs with high efficiency, however, to attain higher throughput and cell viability, modifications in device design are required. One such device fabricated by Santra et al. can transfect 10 million cells/min using a 1 cm<sup>2</sup> size massively parallel single-cell electroporation platform (MSEP). MSEP is based on microfluidic isolation of individual cells using an array of through holes that can allow passage of only a single cell at a time. Each hole is lined with Au electrodes on parallel edges (Fig. 7.6) that can create an electric field across the micro-hole. An optimized concentration of cell and cargo mixture is pumped from the reservoir with an appropriate flow rate to achieve a transfection efficiency greater than 90% [31]. Based on the device design, suspended cells can be delivered, which has a direct application in gene therapy.

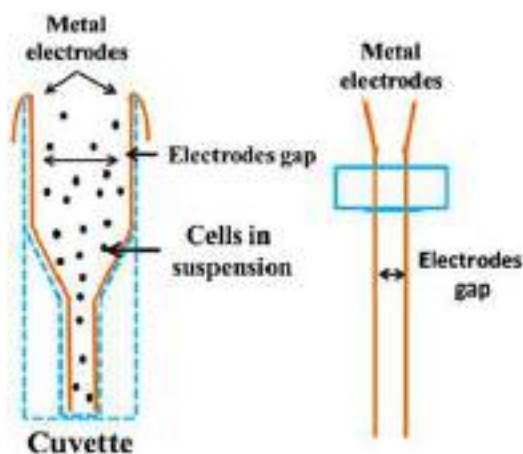
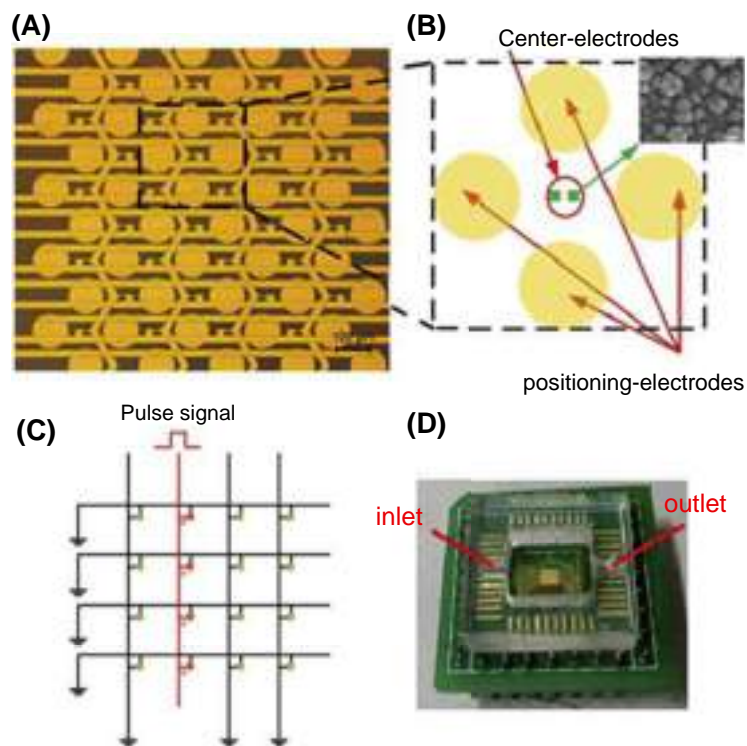


FIGURE 7.4 Schematic showing bulk electroporation. Reproduced from Santra T, Tseng F, Santra TS, Tseng FG. *Recent trends on micro/nanofluidic single cell electroporation*. *Micromachines* September 6, 2013;4(3):333–56. Available from: <http://www.mdpi.com/2072-666X/4/3/333>.





**FIGURE 7.5** (A) Electrode array. (B) Schematic representation of the quadruple electrodes used for cell positioning and pair of electroporation electrodes. (C) Schematic of pulse application connections to the central electrodes for controlling single cell electroporation. (D) Image of the final device prototype. *Reproduced from Guo X, Zhu R. Controllable in-situ cell electroporation with cell positioning and impedance monitoring using micro electrode array. Sci Rep November 10, 2016;6(1):31392. Available from: <http://www.nature.com/articles/srep31392>. Copyright © 2016.*

### 3.1.3 Localized single-cell electroporation (LSCEP)

LSCEP is a technology used for locally electroporating the cell membrane in a nano-scale region, by reducing the gap between the electrodes to a few tens of nanometers [32–34]. Thus, only a small region of the cell membrane experiences an intense electric field and undergoes poration. In SCEP, the entire cell is placed in the electric field, as a result, the pores created are nonuniformly distributed all over the cell membrane. In order to deliver larger molecules, the pore size has to be increased. This cannot be achieved if the pore density is higher, which would lead to cytosol leakage and in turn cell death, on increasing the pore diameter [35].

LSCEP can give better control of cell membrane poration and uniform drug delivery. Santra et al. designed an LSCEP device that can successfully electroporate the cells seeded on an electrode gap. The electrodes are made from indium tin oxide (ITO), a transparent conductive material, to allow better visualization of the electroporation process [36]. The device proposed was first fabricated with a 500 nm gap, which was later reduced to 60 nm.

The device structure shown in Fig. 7.7 uses SiO<sub>2</sub> as a passivation layer upon ITO electrodes in order to prevent direct contact between cells and electrodes to avoid undesired poration in the cell membrane [38]. Furthermore, the passivation layer imposes better control over bubble generation and joule heating [10]. To construct

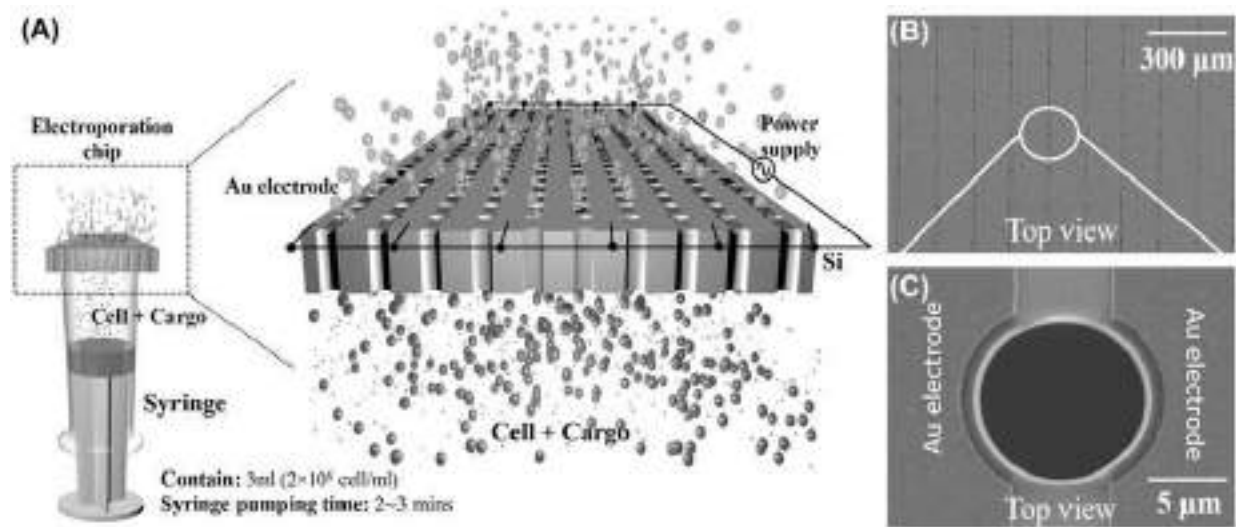


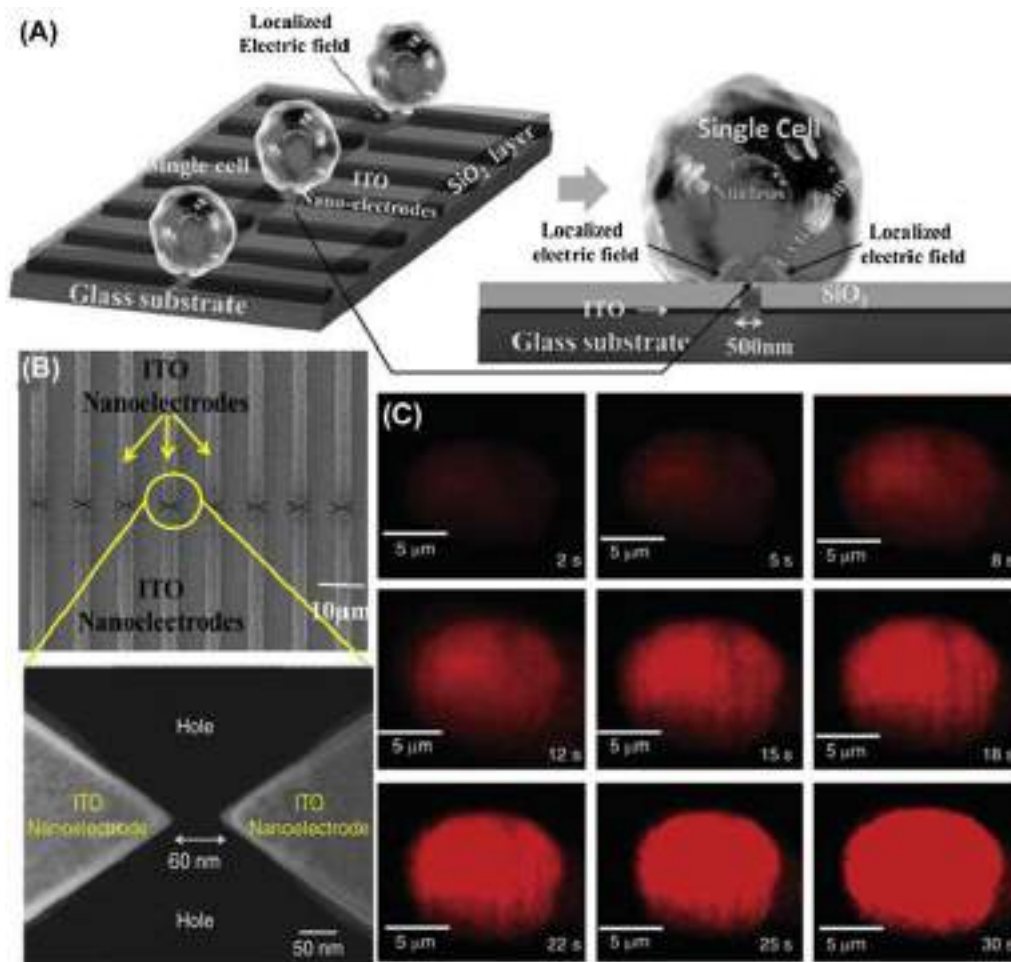
FIGURE 7.6 Massively parallel single-cell electroporation platform (MSEP). (A) Schematic representation of the MSEP showing cells and cargo are pumped with a syringe through the MSEP connected to the power supply and transfected cells are collected at the top. (B) Scanning electron microscopy (SEM) image of the MSEP. (C) SEM image of the microhole with parallel Au electrodes along its edges. *Reproduced from Device for massively parallel high throughput single cell electroporation and uses there of. August 9, 2017; Available from: <https://patents.google.com/patent/US20180066222A1/en>.*

the final submicron range channel-focused ion beam (FIB) technology is used to cut both ITO electrodes and the  $\text{SiO}_2$  layer. The chip enables biomolecule delivery through the holes in the submicron-channel from the base of the device. The triangular edge electrode design generated a more confined electric field for achieving ultra-localized electroporation where cell viability was found to be around 90%–95% for plasmid delivery [37,39].

Although electroporation can achieve efficient delivery, use of intense electric fields in combination with using nanoelectrodes can cause electrode degradation, forming nanoparticles that can enter cells. Also, metal ions and oxides are formed in the presence of high electric fields, which can be toxic and reduce cell viability. Selection of electrode material and optimization of electric parameters is essential in successful delivery of chemotherapeutic agent to viable cells.

### 3.2 Optoporation

Optoporation is the phenomenon of using light energy to induce nano/micropores in the cell membrane. In the initial development, an objective lens was used to focus a laser beam on the cell membrane. The concentrated laser energy displaced cell membrane phospholipids, thus creating a passage for extracellular molecules to enter the cell. This was termed as optoinjection and was a contactless controlled single-cell delivery technique. It can also be used to deliver cargo into cells in transparent microfluidic chambers. Despite its advantages, the optoinjection technique suffers from low throughput. In order to overcome this limitation, a technique named optoporation was introduced. This technique enables simultaneous drug delivery into a large number of cells in the presence of a photosensitizer to harness laser energy. The photosensitizer can convert or amplify laser



**FIGURE 7.7** (A) Schematic of LSCEP technique with a single cell seeded on electrode gap. (B) SEM image of the ITO electrodes with 60 nm electrode gap. (C) Fluorescence image showing uniform delivery of propidium iodide (PI) dye into single cell. (A) Reproduced from Santra TS, Wang PC, Chang HY, Tseng FG. Tuning nano electric field to affect restrictive membrane area on localized single cell nano-electroporation. *Appl Phys Lett* December 2, 2013;103(23):233701. Available from: <http://aip.scitation.org/doi/10.1063/1.4833535>. (B) Reprinted with permission from Santra TS, Borana J, Wang PC, Tseng FG. Nanoelectroporation and controllable intracellular delivery into localized single cell with high transfection and cell viability. In: 2014 IEEE 27th International Conference on micro Electro mechanical systems (MEMS) IEEE; 2014 865–8. Available from: <http://ieeexplore.ieee.org/document/6765778/>. Copyright © 2014, IEEE. (C) Reprinted with permission from Santra TS, Kar S, Borana J, Wang PC, Tseng FG. Nanolocalized single-cell-membrane nano-electroporation: for higher efficiency with high cell viability. *IEEE Nanotechnol Mag* 2014;8(1):30–4. Copyright © 2014, IEEE.

energy to create shock waves in the surrounding medium. These shock waves create transient pores in the cell membrane.

### 3.2.1 Mechanism of optoinjection

In optoinjection, the laser beam is tightly focused over a very small region of diameter

about 5–8  $\mu\text{m}$ . An objective lens is used for focusing the beam to obtain an energy density as high as  $2 \times 10^7 \text{ W/cm}^2$ . The minimum distance between the cell and objective lens can cause cell apoptosis whereas, for distances above a threshold value, no pores are formed [40]. Further, a pulsed laser is used to reduce the

exposure time to tens of nanoseconds. When a spatially and temporally compressed laser beam is irradiated on water, it exhibits nonlinear optical absorption resulting in the creation of atomic ions. The laser beam further accelerates the ions and free electrons, causing collision with other atoms to create a plasma of temperature  $\sim 10^4$  K in order. This can instantaneously vaporize the surrounding media forming plasmonic microbubbles lasting for about a few hundred nanoseconds. The microbubbles expand and collapse to create very strong shock waves in the medium, causing displacement of the cell membrane phospholipids, creating a membrane pore [41].

### 3.2.2 Mechanism of optoporation

In optoporation, usually metal nanoparticles or carbon nanoparticles are used as light sensitizers. When these nanoparticles are irradiated with a laser beam of a wavelength corresponding to their respective peak absorption wavelengths, surface plasmon polariton (SPP) is created. SPP formation induces oscillatory motion to the free surface electrons of the nanoparticles. This oscillatory motion generates lattice heat. The rate at which heat is generated is very high, causing a sudden rise in temperature of the nanoparticle. The metal nanoparticle has lower specific heat capacity causing sudden (within a few picoseconds) and continuous dissipation of high energy to the surrounding medium. This causes the formation of cavitation bubbles in the surrounding medium. The expansion and collapse of these cavitation bubbles create shock waves. In this case, a highly focused beam is not required. A laser beam of diameter 2–5 mm can be used to produce this phenomenon. However, based on the pulse duration of the laser beam, the sizes of the cavitation bubbles formed vary, which in turn affects the spatial extent and strength of its impact [18]. The effect can also be optimized by tuning the shape and

structure of the nanoparticles used, such as corrugated gold nanoparticles [42].

The above-mentioned phenomena can be broadly classified as the photoporation technique. The photoporation experiments are carried out with four different types of laser sources, including continuous wave, nano-, pico-, and femtosecond pulsed lasers.

### 3.2.3 Continuous wave (CW) laser irradiation

The laser source emits a tightly focused high-intensity beam continuously for a given time interval, causing localized heating of the cell membrane. This phenomenon is used in optoinjection. Besides optoinjection, CW lasers can also be used for optoporation. However, due to very low absorption coefficient of water for the visible spectrum of light, CW laser sources that emit a visible spectrum of light need appropriate photosensitizers for cell poration. In the case of near-infrared (NIR) wavelength sources, for which water shows a higher absorption coefficient, the laser power has to be optimized to avoid a boiling effect causing cell apoptosis. Also, heating of media and cells can cause cell stress due to hyperthermia decreasing the cell viability after exposure.

### 3.2.4 Pulsed laser irradiation

The pulsed laser irradiation can be of three types—nano-, pico-, and femtosecond—based on the individual pulse width. The nano- and pico-second pulsed lasers induce the formation of cavitation bubbles in the presence of a plasmonic photosensitizer or at a specific temperature and pressure conditions. The femtosecond pulsed laser can induce plasma formation in medium by a nonlinear absorption phenomenon which leads to cavitation bubble formation. Femtosecond pulsed lasers induce the least medium heating effect due to the process of heat transfer taking longer than the duration of single-pulse irradiation [43].

### 3.2.5 Nanoparticle (NP)-based delivery

#### 3.2.5.1 Bioconjugated NPs

Bioconjugation is a chemical process of attaching a biomolecule to another molecule by forming a stable covalent link between them. Bioconjugation of NPs is done for multiple reasons, such as to avoid clustering of NPs, to load drug molecules on the NP, to interface DNA or RNA on the NP, to interface targeting antibody, or as a protective coating to avoid chemical action on the NP. In an *in vivo* study on rats reported by Wilson et al., antibody binding to surface receptors of target cells was conjugated with gold (Au) nanoparticles (AUNPs) to deliver siRNA or dextran by optoporation of retinal ganglion cells (RGCs) using a femtosecond pulsed laser. The AUNPs were intravitreally injected along with siRNA or dextran molecules after administering anesthesia. The intravitreal administration provides the highest access to the retinal cells due to its close proximity to the vitreous humor. After 3 h of settling time, the NIR (800 nm) femtosecond pulsed laser was irradiated on the RGCs with a pulse width of 100 fs and 80 MHz repetition rate. Fig. 7.8 shows a schematic of the drug-delivery mechanism using bioconjugated AUNPs. Upon observing the cells for toxicity after irradiation, there was no significant loss of cell viability in RGCs, thus proving the nontoxic nature of the process. Thus, this technique can be used for therapeutic applications [44].

#### 3.2.5.2 Upconverter nanoparticles (UCNPs)

UCNPs have become popular due to their photon upconverting property. They have multiple metastable states that allow absorption of multiple lower energy photons from an NIR laser source to obtain higher energy photons in the visible range. The UCNPs are composed of lanthanide ions doped in a transition metal lattice, which allows them to attain multiple metastable states. The energy obtained from

the multiple photons is summed up and a higher energy photon is emitted. This phenomenon is distinct from other multiphoton excitation or second harmonic generation as it shows a much higher shift in the excitation-emission wavelengths. In a recent study, Cho et al. demonstrated the use of UCNPs in delivering drugs to urinary bladder cancer cells. The UCNPs are conjugated with gold nanorods (AuNR) and are collectively bioconjugated with antibodies targeting the overexpressed epithelial growth factor receptors (EGFRs) in bladder cancer cells. This forms a nanocluster of UCNP-AuNR highly specific in targeting bladder cancer cells. NIR radiation has higher tissue penetration as compared to visible light. Also, it is less harmful to cells as compared to visible light. This makes the use of UCNPs advantageous over other metal NPs. The antibodies are used for actively targeting the cancer cells. The UCNP-AuNR nanocluster selectively gets attached to the cancer cell plasma membrane. After irradiation with femtosecond pulsed laser, AuNR creates cavitation bubbles to disrupt the cell membrane. Cisplatin (a chemotherapy drug) enters the cell by diffusion through the pores formed. The UCNP–AuNP nanoclusters also exhibit a photoluminescence phenomenon on irradiation with NIR laser. This is useful in bioimaging to distinguish cancerous cells from noncancerous cells, thus allowing targeted delivery to cancerous cells. As a result, a much lower dosage of cisplatin was required for treatment [45].

#### 3.2.6 Device-based optoporation

Device-based optoporation techniques are used for *ex vivo* drug-delivery applications. They consist of immobilized metal nanostructures on a substrate. Cells are usually cultured on these substrates and then irradiated with laser for optoporation experiments.

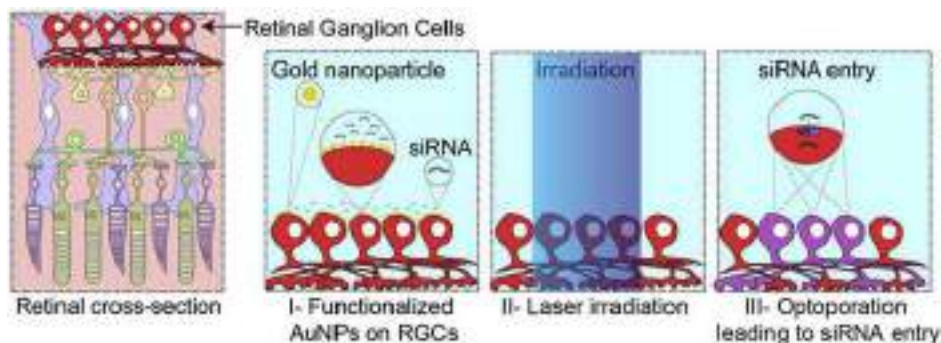


FIGURE 7.8 Schematic showing the interaction between RGCs, AuNPs, and siRNA for delivery of siRNA into RGCs by the optoporation technique. Reprinted with permission from Wilson AM, Mazzaferri J, Bergeron É, Patskovsky S, Marcoux-Valiquette P, Costantino S, et al. *In vivo laser-mediated retinal ganglion cell optoporation using KV1.1 conjugated gold nanoparticles*. *Nano Lett.* 2018; 18(11):6981–8. Copyright © 2018, American Chemical Society.

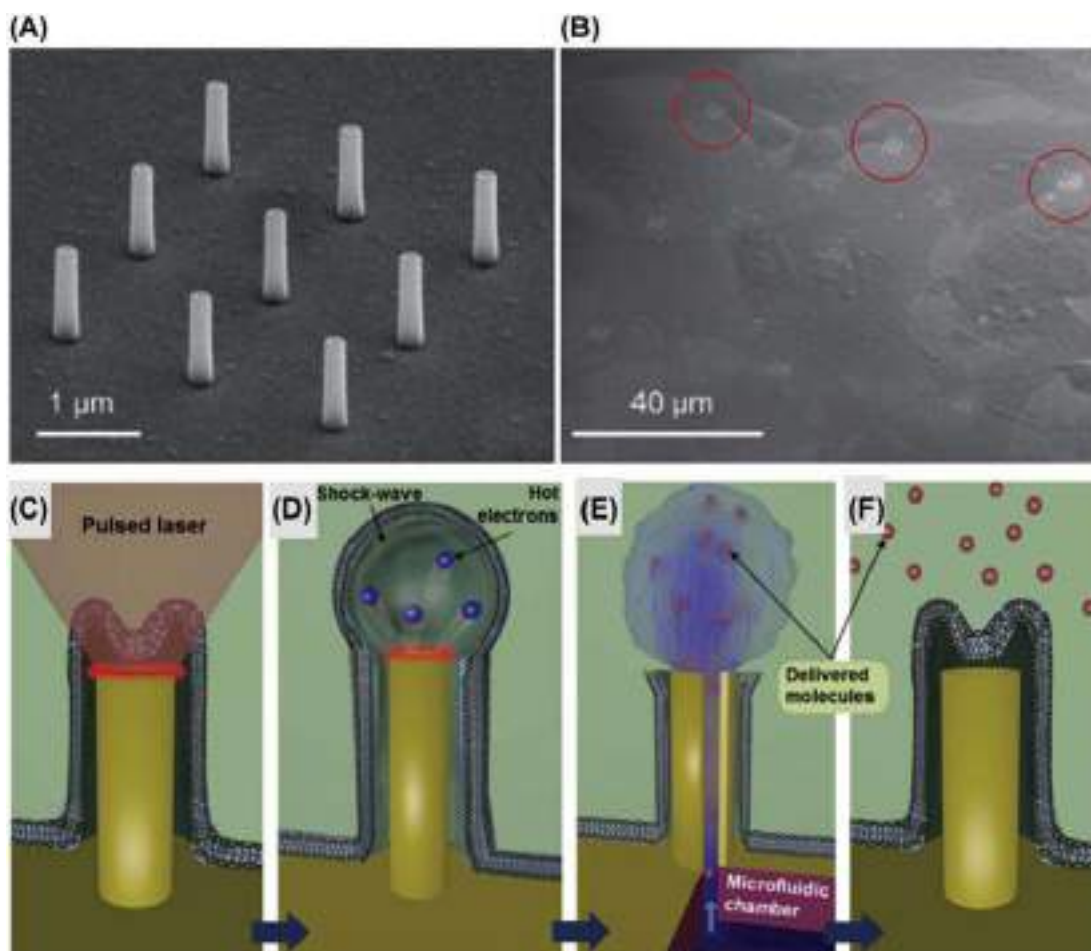
### 3.2.6.1 Gold nanotube (AuNT)-embedded microfluidic platform

G. Messina et al. developed a microfluidic platform for targeted delivery of individual cells using pulsed laser irradiation on AuNTs. The device consists of a  $3 \times 3$  array of AuNTs fabricated periodically with through holes (180 nm) on a silicon nitride surface (Fig. 7.9A,B). A microfluidic channel is connected to the AuNTs to carry the drug. Cells are cultured on top of AuNTs. Irradiation of NIR pico-second pulsed laser resulted in generation of optical hotspots at the top edges of the AuNTs, forming cavitation bubbles in the surroundings that locally disrupted the cell membrane. Following laser exposure, the drug loaded in the AuNT through a microfluidic channel diffuses into the cells (Fig. 7.9C–F). The pores formed on the cell membrane resealed completely within 5–10 min. Based on the flow rate of the drug molecules and the time for which they are being taken up, the exact amount of drug delivered into the cell can be calculated. Another important feature of the device is that it does not allow the contents of the medium to enter the cell. This is possible as the cell membrane creates an envelope over the nanotube during its attachment to the surface to segregate the nanotube opening from the culture medium. Thus, it allows only the drug from

the microfluidic channel to enter the cell cytoplasm after pore creation. This technique is independent of the type of molecule to be delivered. A mixture of drug with variable concentration can be delivered using this device. Although the delivery efficiency is high ( $\sim 95\%$ ), the throughput of this device is low as compared to nanoparticle-based delivery [8].

### 3.2.6.2 Biophotonic laser-assisted surgery tool (BLAST)

This tool is developed to deliver large drug molecules, simultaneously, into a large number of cells using a nano-second pulsed laser. This device consists of a  $\text{SiO}_2$  substrate with perforations for cargo passage. Each perforation is lined with 100-nm thick titanium metal. Cells are cultured on top of the substrate. The entire device surface is scanned within 10 s, with a 6-ns pulsed laser. As a result of laser–metal interaction, cavitation bubbles are created that cause localized disruption of the cell membrane near the substrate perforation. After the laser irradiation, drug is actively pumped from the reservoir placed below the substrate using a polydimethylsiloxane (PDMS) pump. This pushes the drug through the perforated substrate into the cell via membrane pores (Fig. 7.10). The major advantage of this device is the use of an



**FIGURE 7.9** (A) SEM image of the  $3 \times 3$  array of AuNTs on silicon nitride surface. (B) Red circles show the periodic arrangement of the array of AuNT. (C), (D), (E), and (F) show a schematic of the drug-delivery process by an AuNT-embedded microfluidic platform. Reprinted with permission from Messina GC, Dipalo M, La Rocca R, Zilio P, Caprettini V, Proietti Zaccaria R, et al. *Spatially, temporally, and quantitatively controlled delivery of broad range of molecules into selected cells through plasmonic nanotubes*. *Adv Mater* November 1, 2015;27(44):7145–9. Available from: <http://doi.wiley.com/10.1002/adma.201503252> © WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

active pumping mechanism instead of diffusion for drug loading. This gives better control over the amount of drug delivered and enhances delivery efficiency. Also, homogeneous delivery can be obtained. It is possible to deliver healthy bacteria of size up to  $1 \mu\text{m}$  into cells with this device. Thus, the size of the pore can be controlled from nanometer range to up to a micron, to deliver variable-size drug molecules. The device can give high delivery efficiency

( $\sim 90\%$ ) and high cell viability ( $>90\%$ ) with a laser fluence of  $55 \text{ mJ}/\text{cm}^2$  [46].

Thus, optoporation can be a useful technique for delivery into peripheral tissues as well as tissues forming the lining of body cavities. Also, the techniques discussed above show a lot of promise for developing in vivo and ex vivo gene therapy with the capability of delivering large cargo molecules.

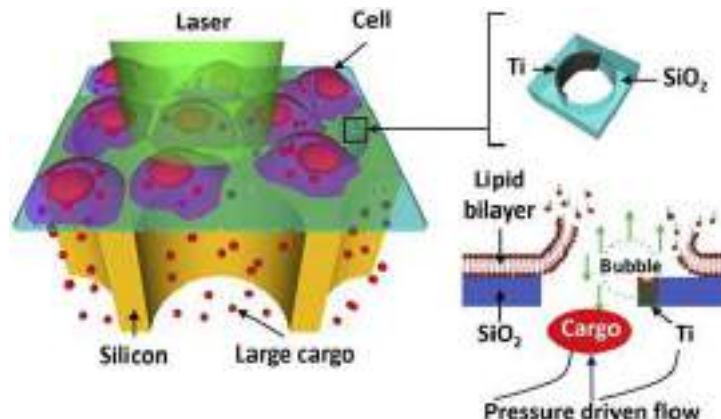


FIGURE 7.10 Schematic of a drug-delivery technique using BLAST. Reprinted with permission from Wu YC, Wu TH, Clemens DL, Lee BY, Wen X, Horwitz MA, et al. Massively parallel delivery of large cargo into mammalian cells with light pulses. *Nat Methods*. May 6, 2015;12(5):439–44. Available from: <http://www.nature.com/articles/nmeth.3357>. Copyright © 2015, Springer Nature.

### 3.3 Mechanoporation

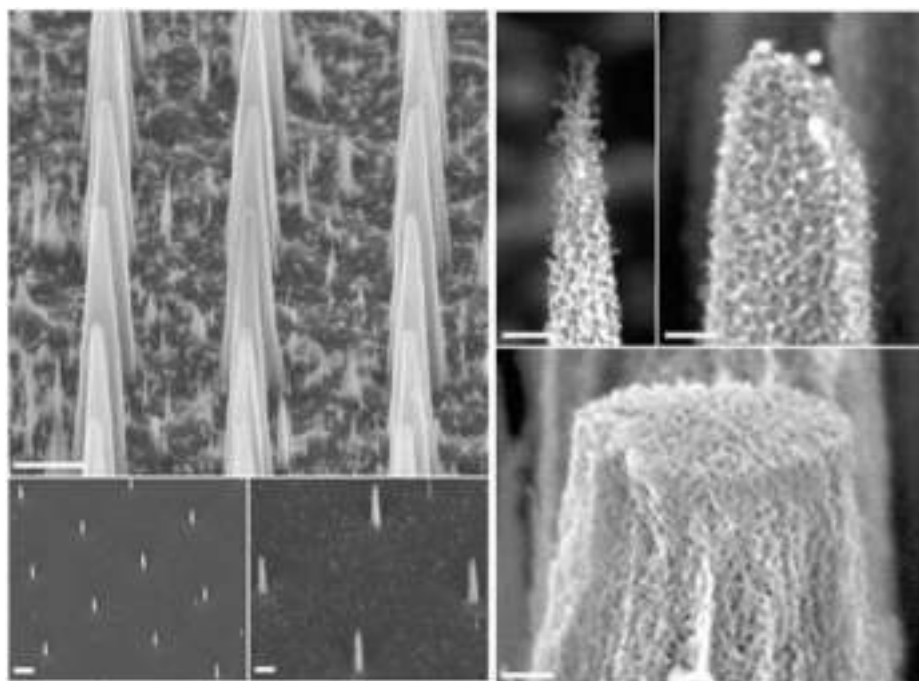
Application of appropriate mechanical stresses to cell membrane can break it open to form pores. If these pores are small enough, the cell is able to reseal them without cytosol leakage. There are several methods of applying mechanical stresses of such magnitude to the cell membrane. One of the earliest techniques of inducing physical stresses in the cell membrane was manual microinjection. In this technique, a single cell impinges with a microneedle and the desired cargo is delivered. If the needle's dimensions are too large, the cell is unable to recover from the impingement [47]. However, for optimized design parameters, microinjection shows very high delivery efficiency. However, this technique can only be performed by skilled operators and suffers from very low throughput. There have been many attempts to automate this process of microinjection or come up with techniques for performing many single-cell microinjections simultaneously [48–50]. One of these techniques is by using nanoneedle arrays for impingement of a large number of cells at the same time, thus enabling high throughput.

#### 3.3.1 *In vivo* mechanoporation using nanoneedle array

Chiappini et al. [51] used porous biodegradable silicon nanoneedles to achieve transfection into cells both in vivo and in vitro (Fig. 7.11). The porous nanoneedles were fabricated by metal-assisted chemical etching and reactive ion etching of silicon substrates. The system reported more than 90% efficiency of DNA and siRNA delivery in vitro.

Two approaches were followed for in vitro delivery: (1) Seeding cells on the nanoneedles and allowing them to be naturally impinged by the nanoneedles as they proliferate and (2) forcing the nanoneedle array into a monolayer of cells, thus achieving immediate impinging. Assays revealed there was no leakage of intracellular contents upon impinging. Codelivery of green fluorescent protein (GFP) plasmids and glyceraldehyde-3-phosphate-dehydrogenase (GAPDH)-siRNA and delivery of siRNA alone were performed separately using the cell seeding approach. Up to 80% silencing in GAPDH expression was observed by the delivery of GAPDH siRNA into cells through the nanoneedle array.





**FIGURE 7.11** SEM images showing the morphology of the porous nanoneedles fabricated by Chiappini et al. Reprinted with permission from Chiappini C, De Rosa E, Martinez JO, Liu X, Steele J, Stevens MM, et al. *Biodegradable silicon nanoneedles delivering nucleic acids intracellularly induce localized in vivo neovascularization*. *Nat Mater* May 30, 2015 ;14(5):532–9. Available from: <http://www.nature.com/articles/nmat4249>. Copyright © 2015, Springer Nature.

In vivo delivery was tested and optimized by pressing nanoneedle arrays, having 50 nm diameter nanoneedles loaded with fluorescent dyes and 2  $\mu\text{m}$  pitch, onto the skin and muscles of live mice. The concentration of the dye in the local area of application was observed even up to 48 h after treatment. In comparison, using a flat chip showed low retention and patchy distribution. When compared with a microneedle array, the distribution of dye in the local area was much more uniform using a nanoneedle array, due to the high density of nanoneedles per unit surface area.

Finally, expression of human vascular endothelial growth factor-165 plasmid DNA (pVEGF165) was observed by its delivery into the muscles of mice through the proposed nanoneedle array as well as through direct injection. Real-time PCR analysis of the mice muscle cells showed mice treated with nanoneedle arrays

had a higher rate of pVEGF165 expression than mice treated with a direct injection. The muscles treated with the nanoneedles showed high neovascularization in proximity to the surface and showed greater blood pooling than direct injection. This indicated the formation of new immature, leaky capillaries—a major identifier of VEGF expression. Thus, nano-injection showed successful local gene expression in vivo and holds promise for future clinical applications.

### 3.3.2 Pressure-based mechanoporation

Zhang et al. [52] proposed a pressure-based device for cell capture and subsequent cell membrane deformation. The chip described consists of an array of solid silicon microneedles, each lying in a hemispherical well and surrounded by four elliptically shaped through holes. Positive or negative pressure is applied through these holes to release or capture cells from the

fluid. When a negative pressure is applied, the cells get pulled toward the well. Upon applying pressure high enough, the cells get impinged by the needles and are captured in the wells. Following this, a positive pressure is applied through the holes to release the cells from the needles. Drugs present in the cell suspension now diffuse into the cell through the temporary pore formed by impingement. The schematic representation of the device's working is shown in Fig. 7.12. The flow-rate requirements through the elliptical holes to impinge and release cells were derived from the studies conducted by Adamo and Jensen on impingement of cells by glass microneedles [53]. Zhang et al. used K652 cells for their studies. Propidium iodide was added to the cell suspension after treatment with the chip to check for the formation of pores on the cells. Flow cytometry results showed dye staining in 15% of treated cells. Thus, pressure manipulation can be an effective means for poration of cells by mechanical structures such as microneedles.

### 3.3.3 Constriction-based mechanoporation

Aside from impinging cells with micro/nano-needles, delivery of particles into cells can also

be promoted by deforming the cells to an extent which causes small transient pores to form in the cell membrane. These pores are nanometers in diameter and are quickly healed by the cell. The deformation is produced by passing the cells through a chip having constrictions that are micrometers in size. The fluid surrounding the cells is filled with the target particles to be transfected into the cells. Once these pores are formed, given they are sufficiently large, the particles from the surrounding fluid diffuse into the cells (Fig. 7.13).

Szeto et al. [54] used the CellSqueeze, a microfluidic and pressure device, for passing cells through microconstrictions to study different characteristics observed in antigen loading through mechanoporation. B cells suspended in media were passed through the CellSqueeze device in the presence of 3 kDa dextran, 40 kDa dextran, or excess ovalbumin (OVA) in the fluid. Chips containing 30- $\mu\text{m}$  long channels in parallel having one constriction per channel of 4  $\mu\text{m}$  width were found to be highly efficient for delivery into B cells. The efficiency of delivery into B cells was found to be between 75 and 90 times for 3 kDa dextran and about 25 times higher for 40 kDa dextran in comparison to simple

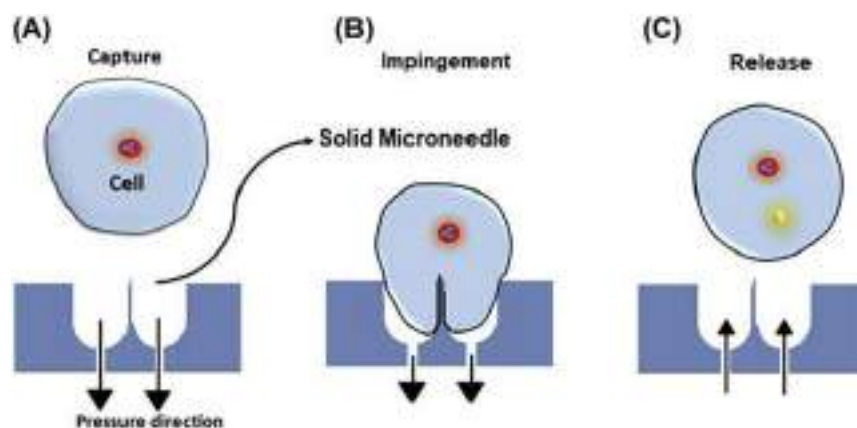
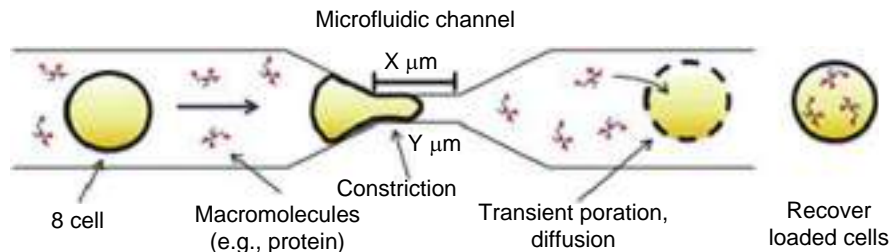


FIGURE 7.12 Schematic representation of the working mechanism of the high-throughput microinjection device operated by pressure manipulation. Reprinted with permission from Kumar A, Mohan L, Shinde P, Chang H, Nagai M, Santra TS. *Mechanoporation: toward single cell approaches*. Copyright © 2018, Springer Nature Singapore Pte Ltd.



**FIGURE 7.13** Schematic representation of the cells passing through microconstrictions of the CellSqueeze device and getting deformed, leading to formation of transient pores on the membrane. *Reproduced from Szeto GL, Van Egeren D, Worku H, Sharei A, Alejandro B, Park C, et al. Microfluidic squeezing for intracellular antigen loading in polyclonal B-cells as cellular vaccines. Sci Rep 2015;5(April):1–13. Available from: <https://doi.org/10.1038/srep10276>.*

endocytosis control experiments. The viability of the B cells after passing through the CellSqueeze platform was observed to be  $\sim 95\%$ .

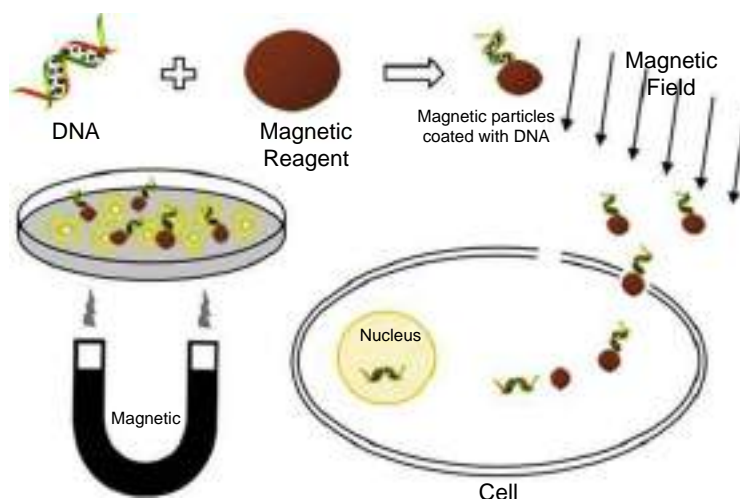
B-cell receptors are known to take up the proteins/antigens into their endolysosomes [major histocompatibility complex (MHC)-II presentation pathway] for activation of  $CD4^+$  T-cells. Due to this, B cells are unable to cause activation or proliferation of  $CD8^+$  T-cells which require the MHC-I pathway. The MHC-I pathway presentation involves loading of antigens or proteins into the cell cytosol instead of being taken up into endolysosomes. Szeto et al. loaded B cells with OVA using the CellSqueeze device. These treated cells were then cocultured with carboxyfluorescein succinimidyl ester (CFSE)-labeled  $CD8^+$  T cells. The  $CD8^+$  T cells used were OVA-specific. It was observed that the B cells promoted the proliferation of  $CD8^+$  T cells. From this, Szeto et al. came to the conclusion that the OVA was delivered into the cytosol of the B cells and not trapped into endosomal compartments. For further verification, the treated B cells were cocultured with OVA-specific  $CD4^+$  T cells. It was observed that the B cells did not promote the proliferation of the  $CD4^+$  T cells, thus further suggesting that the B cells followed the MHC-I pathway for antigen presentation.

They also tested whether the squeezed B cells would prime the antigen-specific  $CD8^+$  T cells in vivo. CFSE-labeled OT-1  $CD8^+$  T cells were

adoptively transferred into mice. This was followed by injection of resting or squeezed B cells into the mice after 1 day. It was found that both activated and inactivated squeezed B cells caused significant proliferation of T cells in the spleens and lymph nodes. Around 40% of injected T cells proliferated in the spleen upon introduction of squeezed B cells. This indicates a lot of promise in the use of B cells loaded with mechanoporation in the development of cellular vaccines.

### 3.4 Magnetoporation

Manipulation of the magnetic field has come up as a promising physical means for cell transfection due to its noninvasive nature. Magnetoporation is also known as magnetic drug targeting (MDT) due to the phenomenon of releasing drug at a specific location after applying a magnetic field [55,56]. The basic principle of magnetoporation is shown in Fig. 7.14. Exogenous biomolecules are attached to the magnetic nanoparticles in order to form a magnetic reagent complex (MRC). It is possible to direct the movement of MRCs with an external continuous magnetic field toward the target location. This can be implemented by applying a gradient of magnetic field from the point of injection to the targeted location. MRCs can be concentrated by applying a uniformly distributed magnetic field across the target tissue.



**FIGURE 7.14** Basic mechanism of magnetoporation. Reproduced from Du X, Wang J, Zhou Q, Zhang L, Wang S, Zhang Z, et al. *Advanced physical techniques for gene delivery based on membrane perforation. Drug Deliv* January 3, 2018;25(1):1516–25. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/29968512>.

Once all MRCs reach the site of action the continuous magnetic field strongly sediments them on the cell surface to increase their interaction and probability of cellular uptake. In the presence of other vectors to permeabilize the cell membrane, the transfection efficiency of the overall system shows a considerable increase. Further, temperature gradient-based release of biomolecules due to an increase in the MRC temperature to up to 45°C in the presence of an alternating magnetic field could be implemented. This increased temperature can also induce hyperthermia and hence cell death, which was found useful on targeting cancerous cell receptors with antibody-functionalized MRCs [9].

MRCs in the presence of an external magnetic field ensure controlled uniform distribution of the drug to the site of action through in vivo blood capillaries, which is advantageous over nonmagnetic core NPs that have few means of control on their distribution to target site. In addition, they need a long incubation time without exhibiting uniform particle dispersion inside the body. The MRCs can resist and overcome hydraulic pressure induced by blood flow and do not depend on passive effects such

as enhanced permeability and retention for their mode of action [28].

The cellular uptake could be induced by receptor-mediated endocytosis or by controlling cell permeabilization in the presence of an electric field induced by an alternating magnetic field or due to heat generation by eddy current formation. Application of repetitive magnetic pulses over a single magnetic pulse could enhance the effective cellular uptake of biomolecules [57].

### 3.4.1 Magnetofection by magnetic nanoparticles

Plank et al. [58] discussed the use of magnetic nanoparticles (MNPs) for intracellular delivery of nucleic acids. The technique employed by them involves the binding of these MNPs with naked nucleic acids or desired vectors. These functionalized MNPs are introduced into a cell medium containing adhered cells at the bottom. A magnetic plate is placed under the culture dish which drives these MNPs toward it. Due to this, the MNPs try to penetrate the plasma membrane of the adhered cells, which are at the nearest location to the magnetic plate in the entire

culture dish. If the applied magnetic field is high enough, the MNPs are taken up by the cells along with the bound vector.

### 3.4.2 Transfection by applying a varying magnetic field

Kardos et al. [59], introduced a technique for contactless permeabilization of cells by applying a varying magnetic field. They applied the concept of inducing an electric field in a region for poration by applying a strong change in the magnetic field. They highlighted the disadvantages of contact-based electroporation, such as direct contact to electrodes, cell toxicity, and problems with in vivo electroporation, such as pain caused by delivery of electric pulses and insertion of electrodes. They used monophasic and biphasic magnetic fields for poration and subsequent GFP expression in skin flaps of hairless guinea pigs. Magnetic field pulses of 4 T in strength and with a rise time of 700 ns were used for experiments, producing a rate of change of 5.2 MT/s in the magnetic field near the skin. Biphasic magnetic pulses proved to be about as effective as electropermeabilization, while also being more effective than monophasic pulses. Thomas et al. highlighted the potential of this technique for in vivo delivery due to its highly treatment-friendly nature in comparison to electroporation, as it generates no cell toxicity, and pain caused due to insertion of electrodes is avoided.

### 3.4.3 Magnetoporation using a rotating magnetic field

Liu et al. [60], devised a technique employing a weak rotating magnetic field for inducing magnetoporation in cancer cells. When polymer-coated multiwalled carbon nanotubes (MWCNTs) are uniformly dispersed in an aqueous solution and observed under a rotating magnetic field, the MWCNTs get magnetized. They start rotating individually and form visible MWCNT aggregates in the solution. The rotation and aggregate formation are faster when the

metal impurity concentration is higher in the MWCNTs. The addition of cell suspension to the above setup causes an increase in cell permeability due to the MWCNTs penetrating the membrane. Upon application of stronger magnetic fields, the rotation of the MWCNTs can also lead to cell rupture and death. The experiments conducted by Liu et al. showed that some of the cells resealed following treatment with the MWCNTs. This was proven by adding PI dye to the suspension before and 10 min after treatment in separate experiments (Fig. 7.15). Roughly 20.2% of the cells showed PI staining when PI dye was added before treatment under a 75 mT magnetic field and only 10% cells showed PI staining when the dye was added after the same treatment. Hence, this technique can enable intracellular drug delivery through transient membrane pores and can be used for cell lysis also by applying higher magnetic fields.

## 3.5 Hybrid techniques

The techniques involving two or more different physical drug-delivery approaches in

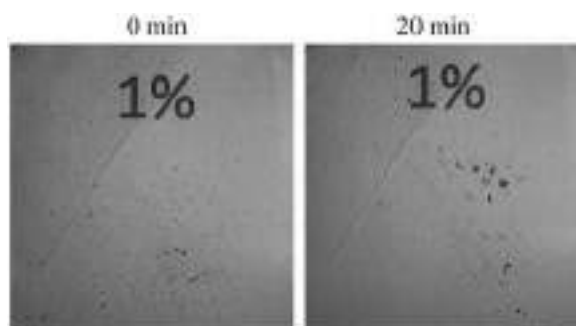


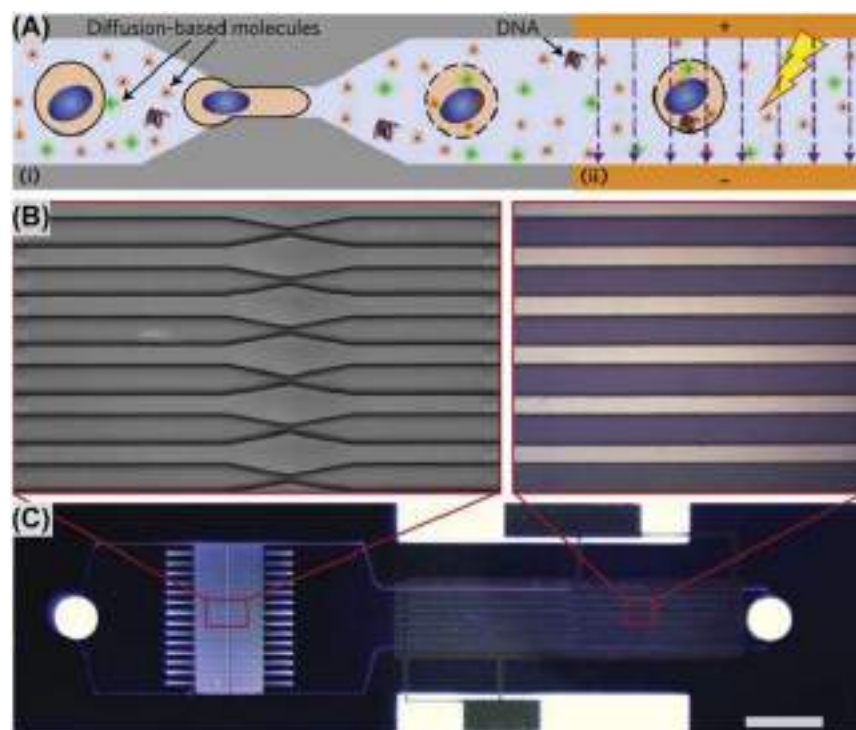
FIGURE 7.15 Images were taken at 0 and 20 min showing the aggregation of MWCNTs upon aqueous dispersion in a solution under the action of 75 mT rotating magnetic field. Reprinted with permission from Liu D, Wang L, Wang Z, Cuschieri A. Magnetoporation and magnetolysis of cancer cells via carbon nanotubes induced by rotating magnetic fields. *Nano Lett.* 2012;12(10):5117–21. Copyright © 2012, American Chemical Society.

order to increase delivery efficiency and cell viability can be classified as hybrid techniques.

### 3.5.1 Mechano-electroporation

So far, several different techniques have been discussed for drug delivery into cells, including discussions on their various advantages and disadvantages. While mechanoporation allows for cytosolic delivery while maintaining high cell viability, it is not very efficient in the delivery of materials to the nucleus of cells. Thus, the expression efficiency of materials such as DNA and RNA after mechanoporation in cells remains low. However, since DNA is negatively charged, an electric field might be used to drive it further inside the cell.

Ding et al. [61] tried nuclear delivery of plasmid DNA using a microfluidic device with a region of channels containing microconstrictions for first delivering the DNA inside the cell followed by an electric pulse region (Fig. 7.16). This electric pulse region enables the DNA to be delivered in larger populations and deeper into the cells, even into the nucleus of cells. Green fluorescent protein plasmid DNA was delivered into HeLa cells to easily check for DNA transfection and expression after treatment. The device parameters such as applied voltage, constriction length, and width were optimized through multiple experiments to achieve the best balance between cell viability and GFP expression efficiency. Ding et al. tested



**FIGURE 7.16** The hybrid delivery device proposed by Ding et al. (A) Schematic representation of cells getting squeezed in the microconstrictions before passing through the applied electric field. (B) Magnified images of the microfluidic channels showing the constrictions and region where the electric field is applied. (C) Optical image of the fabricated device. Reprinted with permission from Ding X, Stewart MP, Sharei A, Weaver JC, Langer RS, Jensen KF. High-throughput nuclear delivery and rapid expression of DNA via mechanical and electrical cell-membrane disruption. *Nat Biomed Eng* March 9, 2017;1(3):0039. Available from: <http://www.nature.com/articles/s41551-017-0039>. Copyright © 2017, Springer Nature.

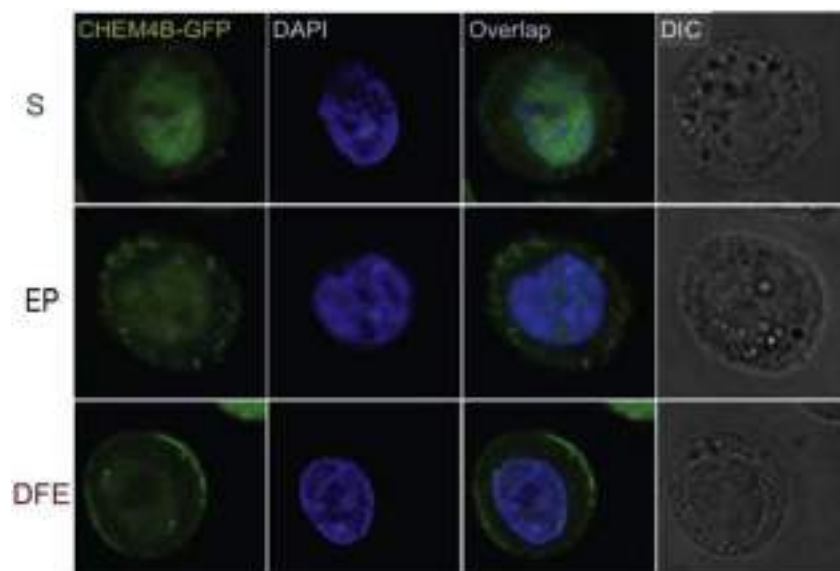
the performance of their device against other delivery strategies such as electroporation, lipofection, and microinjection. Green fluorescence due to the GFP plasmids was observed in 80% of cells within the first hour of microinjection, which is expected as microinjection is known to be efficient in direct delivery into cell cytoplasm and nucleus. The majority of cells treated by electroporation began showing fluorescence between 4 and 48 h after treatment. Cells treated by the proposed device also showed similar expression kinetics as microinjection, thus suggesting the device was able to enhance DNA delivery and expression in the nucleus of cells.

The delivery mechanism of the constrictions and electric field device was further studied by delivery of Cy3-labeled plasmid DNA into HeLa cells using the proposed device, only squeezing and only electroporation with optimized parameters. In the case of only electroporation, sharp fluorescence of Cy3 was observed

in spots on the plasma membrane of cells, whereas in the case of only cell squeezing, Cy3 fluorescence was absent in the cytoplasm (Fig. 7.17). However, in the cells treated by the proposed device, fluorescence spots were observed on the plasma membrane, cytoplasm, and nucleus of cells. This suggested that the device followed a mechanism different from only electroporation or squeezing alone.

Ding et al. hypothesized the possible explanations for DNA expression in the nucleus and cytoplasm upon treatment of cells by their device involved either: (1) Degradation of DNA in the cytoplasm leading to diffusion of Cy3 toward the outer regions of the cells after detachment from DNA or (2) a high amount of DNA being trapped in the nucleus of cells rather than the cytoplasm when the DNA moves through the cell under the influence of the externally applied electric field.

Charged multivesicular body protein 4B (CHMP4B) is an important subunit of the



**FIGURE 7.17** Image showing staining of cells after different treatments by Ding et al.: S (squeezing only), EP (electroporation), and DFE (disruption and field enhanced). A high amount of overlap was observed in DFE treatment. Reprinted with permission from Ding X, Stewart MP, Sharei A, Weaver JC, Langer RS, Jensen KF. High-throughput nuclear delivery and rapid expression of DNA via mechanical and electrical cell-membrane disruption. *Nat Biomed Eng* March 9, 2017;1(3):0039. Available from: <http://www.nature.com/articles/s41551-017-0039>. Copyright © 2017, Springer Nature.

endosomal sorting complex required for transport-III (ESCRT-III). This complex plays a role in rapid repair of ruptures in the plasma membrane and the nuclear envelope [62]. Microinjection clearly induces accumulation of CHMP4B-GFP at the site of wounding in the nuclear envelope.

Similarly, Ding et al. observed many transient spots of CHMP4B-GFP at both the nuclear membrane and the plasma membrane of cells. From this, they came to the hypothesis that their device induces transient pore formation in the nuclear membrane as well as the plasma membrane of cells. Thus, they were able to enable

delivery of materials such as DNA plasmids and mRNA to a much larger extent by employing a combination of mechanical disruptions and electrical disruptions, than by electroporation or cell squeezing alone.

### 3.5.2 Dielectrophoretic transfection using mechanoporation

Similar to the above strategy, Meacham et al. [63] fabricated an acoustic shear poration (ASP) device that combined with electrophoresis for delivery of DNA into the nucleus of cells (Fig. 7.18).

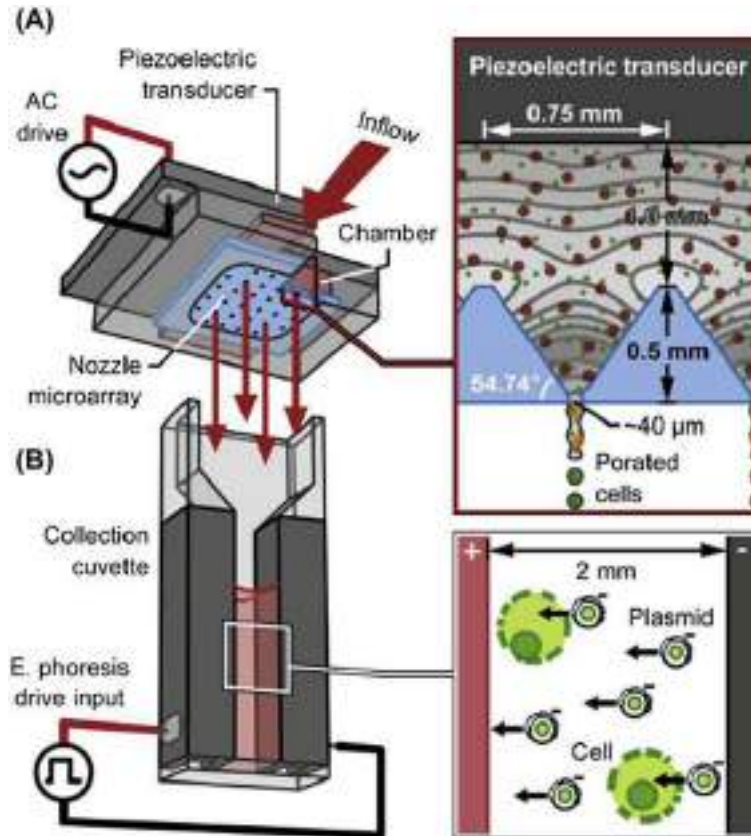
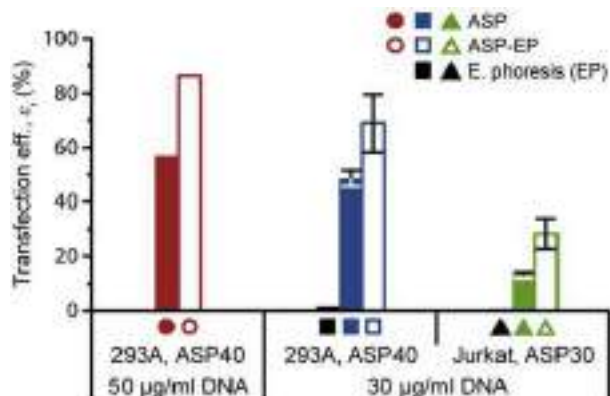


FIGURE 7.18 (A) Schematic representation of the device proposed by Meacham et al. and visualization of the fluid and particle flow in the device. (B) Representation of the electric field in the channels through which the cells are passed. *Reproduced from Meacham JM, Durvasula K, Degertekin FL, Fedorov AG. Enhanced intracellular delivery via coordinated acoustically driven shear mechanoporation and electrophoretic insertion. Sci Rep December 27, 2018;8(1):3727. Available from: <http://www.nature.com/articles/s41598-018-22042-0>.*





**FIGURE 7.19** Transfection efficiency of various methods experimented by Meacham et al. *Reproduced from Meacham JM, Durovasula K, Degertekin FL, Fedorov AG. Enhanced intracellular delivery via coordinated acoustically driven shear mechanoporation and electrophoretic insertion. Sci Rep December 27, 2018;8(1):3727. Available from: <http://www.nature.com/articles/s41598-018-22042-0>.*

HEK293A, Jurkat, and peripheral blood mononuclear cells were used for all studies. The ASP device consists of a chamber that is filled with fluid containing the suspended cells and cargo. In the device, a piezoelectric transducer is also present in the chamber along with pyramidal nozzles. Focused acoustic waves can be generated at particular resonant frequencies by the transducer. These waves create a pressure gradient that drives the cells suspended in the fluid toward microorifices at the nozzle apices. When the cells pass through these orifices, they experience shear forces which cause transient nanopores to form on the plasma membrane.

However, since DNA particles are large in size, it is difficult for them to diffuse into the cells through these pores. This mixture of treated cells and cargo is further passed through a region generating an electric field, which causes the DNA to move via electrophoresis but is not large enough to further disrupt the cell membrane or nuclear membrane. Thus, the DNA particles are able to enter deep into the cells.

The main parameters to be optimized for the cell treatment were the exposure time of cells to the orifices and the shear rate experienced by the cells when they pass through the orifices. These parameters can be controlled by varying the lengths and diameters of the orifices.

Meacham et al. found the optimal diameter for the orifices to be 2–3 times the size of the cells being passed through them (Fig. 7.19). They compared the performance of their hybrid device against a simple electroporation or simple mechanoporation device. It was found that their hybrid device showed better results as it was able to deliver much larger macromolecules than the other two techniques. The hybrid device improved delivery efficiency from 13%–57% to 28%–87% compared to pure mechanoporation alone. The ASP device combined with EP was able to deliver dextran molecules of up to 2 MDa in size into the chosen cells.

From the two devices discussed in this section, it is possible to envision the use of hybrid devices in the future due to their significant advantages in overcoming the shortcomings of the pure physical delivery techniques discussed (Table 7.1).

#### 4. Challenges and future prospects

With the advancement of micro/nano-fabrication techniques, it is possible to achieve highly controlled drug-delivery environments. Localization of the membrane pores to achieve wider pores, for delivery of larger size cargo

TABLE 7.1 Overview of the physical delivery techniques.

S. no.	Technique for drug delivery	Cell type transfected	Advantages	Disadvantages	References
1	SCEP	AGS cancer cell line	Higher cell viability and transfection efficiency	Nonuniform distribution of pore on cell membrane	[35]
2	MSEP	HeLa cells, THP-1 acute myeloid leukemia cells, U87 glioblastoma and Lncap prostate cancer	Useful for transfection of cells in suspension with high throughput and single-cell delivery	Complex fabrication	[31]
3	LSCEP	HeLa cells	Larger molecules can be delivered	Complex fabrication, degradation of electrodes on application of an intense electric field	[12]
4	Nano-electroporation	CHO–K1 and NIH-3T3 cells	Nano-sized cargo can be delivered into the cells cultured in vitro with minimal harm	Complex fabrication process and electroporation parameters depend on cell type and size	[64,65]
5	Upconverter NP	Urinary bladder cancer cells	Increased penetration depth for in vivo application	Enhanced permeability and retention effect can be observed	[45]
6	BLAST device	HeLa cells, normal human dermal fibroblasts, peripheral blood monocyte-derived macrophages, tubule epithelial cells	High throughput, large cargo delivering potential	Intricate fabrication, delivery efficiency varies with cell type	[46]
7	Biodegradable nanoneedles	HeLa cells and in vivo treatment of mice	High transfection efficiency in vitro and possibility of in vivo treatment	Low expression efficiency in vivo	[51]
8	Microconstriction channels	B cells	High throughput, applicable for various cell types, gives good results for hard-to-transfect cells	Low efficiency with delivery of plasmid DNA	[54]
9	In vivo magneto-permeabilization	In vivo treatment of hairless female Guinea pigs	Potential to treat at anatomical location in vivo	Intensity variation of magnetic field may generate an electric field across a small portion of the skin. Parameter optimization depends upon many factors such as age, skin structure, etc.	[59]
10	Magnetoporation using MWCNTs	MCF-7 cells	Can be used for treatment of cells in suspension	Low transfection efficiency	[60]
11	Hybrid techniques	HeLa, HEK293A, Jurkat and peripheral blood mononuclear cells	Enables nuclear delivery and much higher DNA expression than standalone physical techniques	A novel and developing field; needs more research before any clinical trials	[61,63]

followed by active pumping is an excellent approach to prevent cell death due to leakage of cell contents [11]. However, research has to be carried out to standardize pore formation by different techniques. Uniform cargo delivery to various cell types with high efficiency and high cell viability is still a challenging task. Besides, any technique could be limited to certain cell types due to its design constraints. The most challenging task is *in vivo* drug-delivery applications. For conventional or BEP-based cellular transfection, accurate external applied voltage, pulse duration, and number of pulses need to be controlled and it depends on fulfilling many requirements. The applied external voltage needs to be high enough to overcome the threshold membrane potential in order to create membrane pores. These pores need to transform to hydrophilic in nature, from initially formatted hydrophobic pores, which depends upon the applied pulse duration and the number of pores formed. The biomolecules can be delivered successfully at this stage. Finally, membrane should be able to reseal to maintain cell viability without any mechanical rupture or any kind of injury to the cell membrane. This highly depends upon the external applied voltage and generated heat during the electroporation process. Thus, upon precise control of these parameters, electroporation can be widely used for cell transfection without any technical difficulties and there are almost no limitations on cell type and size [5]. However, due to the use of large electrodes in the BEP process, a larger surface area reacts with the medium to induce a toxic environment, which decreases cell viability. In recent years, due to rapid development of micro/nanotechnology, the electrode formation can be achieved at a micro/nano-scale level, which reduces the electrode surface area and enables precise single-cell electroporation (SCEP) with high transfection efficiency as well as high cell viability in comparison with BEP. However, SCEP is currently in the *ex vivo* stage for cellular therapy and analysis. Parallel high-throughput

single-cell transfection techniques need to be developed, where the same number of biomolecules can be delivered to millions of cells together, to open up a new pathway for cellular research and regenerative medicine purposes. Electroporation is widely used for clinical applications where drugs and genes were transferred to various areas of the human body [66]. The *in vivo* DNA (pSV2-CAT gene) was introduced into mammalian cells in the presence of an electric field with a transfection efficiency of 100–1000 times in comparison to introduction without an electric field [67].

Intravenous injection of nanoparticles followed by optical treatment could be used to achieve *in vivo* drug delivery. However, limitations lie in the penetration depth of the optical energy applied. Body organs with a cavity could be irradiated with an optical fiber embedded catheter, but irradiating deeper tissues still remains a challenge. The development of *ex vivo* gene therapy could form pathways to overcome the limitations of physical techniques for *in vivo* delivery application. Distribution of the cargo once delivered in the cytoplasm is yet to be studied. On account of the transient nature of the cell pores, its visualization is difficult. However, efforts are being made in this direction using fluorescent molecules.

In comparison with BEP, magnetoporation is a promising noninvasive technique, where external magnetic energy is used to deform the cell membrane on a precise location within the body and deliver drugs. For successful magnetoporation, magnetic nanoparticles needed to bind with targeted drugs and then due to application of external magnetic field, nanoparticles bound with drugs can be transported to the desired location in the body and finally the drug can be released with the influence of an external magnetic field. However, to achieve high efficiency in magnetoporation, there are many crucial parameters to optimize, such as the size and property of magnetic nanoparticles, physiochemical properties of the drug which binds

with magnetic nanoparticles, penetration of particles into the tissue, particle aggregation, etc. Mechanoporation is another technique where transient pores are formed on the cell membrane for the purpose of intracellular delivery. Mechanoporation devices tend to show high efficiency regardless of the type of cells chosen for drug delivery. However, the mechanism of membrane deformation and pore formation by mechanical stresses is still not fully understood. Although there are simulation studies of membrane deformation and breakdown under mechanical forces [68], it is difficult to observe the same in real-time experiments. Mechanoporation-based devices seem to be able to deliver cargo directly into the cytosol of cells, but transfection of material such as DNA or RNA, which requires delivery into the nucleus, shows poor results with these devices compared to electroporation.

In the 21st century, due to rapid development of microfluidic or bio-MEMS technology, integration with a micro-total analysis system can provide high-throughput data with limited assay complexity. Reagent utility has been tremendously scaled down. These developments open up a new path toward understanding cellular mechanisms precisely. However, there are significant challenges in the fabrication of such sophisticated devices. Highly skilled technicians are required in the field for intricate device design and fabrication for precise cellular delivery and analysis. As a result, bulk manufacturing has its own implementation challenges.

The current tools available in the market for cellular therapy and diagnostics have a wide gap as per the requirements. To commercialize the newly developed devices, there is a need to focus on integrating ease of usage along with high performance, reliability, and good reproducibility. The device must be able to integrate into platforms with high-level automation requirements, which could then be easily operated by nonspecialized technicians as well.

## 5. Conclusions

In this chapter, we have discussed the advancement of different physical techniques for drug delivery on different cell types with high transfection efficiency and high cell viability, which is potentially applicable for biological cell research and therapeutic development. The significant advantages of these techniques over viral and chemical methods have been highlighted. Some of the physical techniques were tested on animals, while others were tested on cell lines. Physical techniques offer high-throughput parallel delivery with high transfection efficiency, which is potentially applicable for clinical trials and for regenerative medicine. Looking into the future, the physical techniques for drug delivery show emerging prospects over viral and chemical methods. Hybrid techniques seem to offer a path to combine the multiple physical techniques to achieve high-throughput delivery on different cell types with high efficiency and cell viability. However, being recently developed, they require further investigation before they can proceed to clinical trials.

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# বাংলার ইতিহাস

## ঐতিহ্য ও সংস্কৃতি

(সম্পূর্ণ ইতিহাসের সাংক্ষিপ্ত বিবরণে লেখকের ইচ্ছা অনুযায়ী)

ইতিহাসের অধ্যয়ন বাংলায় সর্বদা  
আত্মপ্রসিক্ত ও প্রাচীনতম আকারে  
কল্যাণের নৈতিকতা-এর কারণে ও  
কেন্দ্রে ইতিহাস-লেখকগণের ইচ্ছা-  
শক্তি-স্বপ্নের ও সত্য-বাহিনী-স্বপ্নের  
উপস্থাপন। অধ্যয়ন বাংলায় সর্বদা  
আত্মপ্রসিক্ত ও প্রাচীনতম আকারে  
কল্যাণের নৈতিকতা-এর কারণে ও  
কেন্দ্রে ইতিহাস-লেখকগণের ইচ্ছা-  
শক্তি-স্বপ্নের ও সত্য-বাহিনী-স্বপ্নের



ইতিহাস-লেখকগণের ইচ্ছা-  
শক্তি-স্বপ্নের ও সত্য-বাহিনী-  
স্বপ্নের উপস্থাপন। অধ্যয়ন  
বাংলায় সর্বদা আত্মপ্রসিক্ত  
ও প্রাচীনতম আকারে  
কল্যাণের নৈতিকতা-এর  
কারণে ও কেন্দ্রে ইতিহাস-  
লেখকগণের ইচ্ছা-শক্তি-  
স্বপ্নের ও সত্য-বাহিনী-  
স্বপ্নের উপস্থাপন।

### সম্পাদনা

ড. মহীতোষ গায়েন  
সমরকান্তি চক্রবর্তী  
কৌশিক দত্ত

ইতিহাস-লেখকগণের ইচ্ছা-  
শক্তি-স্বপ্নের ও সত্য-বাহিনী-  
স্বপ্নের উপস্থাপন। অধ্যয়ন  
বাংলায় সর্বদা আত্মপ্রসিক্ত  
ও প্রাচীনতম আকারে  
কল্যাণের নৈতিকতা-এর  
কারণে ও কেন্দ্রে ইতিহাস-  
লেখকগণের ইচ্ছা-শক্তি-  
স্বপ্নের ও সত্য-বাহিনী-  
স্বপ্নের উপস্থাপন।



RANGALAR ITIHASHI : SWAMI O'SANSKRITI

Edited By Mahatosh Goyen, Sonnu Kanti Chakraborty, Kaushik Dutta

(অনুশীলনা স্বাক্ষরিত সাংস্কৃতিক বিবেচনায় স্বকীয়চিত ইতিহাস ক্রিয়াকৰণ)

প্রথম প্রকাশ

২০২০

মুদ্রণ : শংকরচন্দ্র

পৃষ্ঠাভিঃ :

ড. মধীন্দ্রনাথ গাঙ্গুলি, দ্বিটি অসেন, সত্যেন্দ্র গগৈ মল্লিকী, অমৃতানন্দ মেধোবিনোদ সেনগুপ্ত,  
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অধ্যাপক ড. শ্রীকান্ত চন্দ্রনাথ অমৃতানন্দ, মল্লিকী মধীন্দ্রনাথ চন্দ্রনাথ, বসু সত্যেন্দ্রনাথ গগৈ মল্লিকী, সেনগুপ্ত অমৃতানন্দ মেধোবিনোদ, গগৈ কৌশিক, গগৈ মালতী, গগৈ সত্যেন্দ্রনাথ, গগৈ মল্লিকী, গগৈ চন্দনা বসেন, গগৈ মালতী।

প্রকাশক

শংকরচন্দ্র

মুদ্রণ : শংকরচন্দ্র

মুদ্রণস্থলী, পোঃ খলিফাবাদ, গুৱাহাটী-৭৮১০০৮

স্বতন্ত্র প্রকাশক

শ্রীমতিস্বামী : ২০০ বিহারী সার্বী, কলকাতা-৭০০ ০০৮

স্বতন্ত্র : ২০০২০৮২২২২

অধ্যাপক

শ্রীমতিস্বামী

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মুদ্রণ

শ্রীমতিস্বামী

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উৎসর্গ

অধ্যাপক গাওঁ দত্ত

অধ্যাপক হরি শংকর বাসুদেবন

অধ্যাপক উভাশীষ বিশ্বাস

শ্রীমতিস্বামী

ব্রজব্রাহ্মণ অংগজ ইতিহাস বিভাগের অধ্যাপক ড. এ.এফ.কাহ্নিয়ার-উস্টিন আহমেদ, অধ্যাপক মহেশ্বর সানাজিউস্টিন ও অধ্যাপক শরমল কাহ্নি দত্তক (বিশিষ্ট কবি ও ভাষাবিজ্ঞানী, সিনেট, বাংলাদেশ)। প্রথমেই ইতিহাসের ছাত্রী না হওয়াও যেভাবে গ্রন্থটি রূপায়নে কেহে বিভিন্ন পর্বে সাহায্য সহযোগিতার হাত বাড়িয়ে গ্রন্থটিকে সর্বাঙ্গীনমূলক করতে সাহায্য করেছেন তার জন্য অংশে ধন্যবাদ জানাই সীমিত। বলাচী মতল দত্তক। আঞ্চলিক ধন্যবাদ জানাই রূপালী শাক্তিকেশনের অংশক মাননীয় সূর্যকুমার ভট্টাচার্য মহাশয়কে। বইটির অংশে বিন্যাসের কেহে মাননীয় অর্পণ ভট্টাচার্যের অকুণ্ড সাহায্য ও সহযোগিতা ছাড়া এই বইটিকে এতটা নির্ভুল করা যেত না। কারণ, এই গ্রন্থটিকে সর্বাঙ্গমূলক করার জন্য তাদের সৌন্দর্য ও নিষ্ঠারই ছাড়া অন্য কোনো উপায় নেই।

পত্রিশতের আশাকরি যে, যাদের জন্য এই গবেষণামূলক গ্রন্থ প্রকাশ করা হল, সেই নব্য গবেষক ও সুরক্ষামূলক ছাত্র-ছাত্রীসকল যদি এর ছাত্র উপকৃত হয়, তাহলেই আমাদের মনে সার্থক বলে বিবেচিত হবে।

সম্পাদক মহতী  
ড. মহীতের পায়েন  
সহকারী ড. চন্দ্রকান্তী  
কৌশিক দত্ত

সূচিপত্র

□ ছবি/ক/1-iv

□ ক গ্রন্থসমূহ, সমাজ, সংস্করণ ও পরিবেশের ইতিহাস

- পুরুনিত্য জেলার নারক জাতির সেকাল একালের সামাজিক ইতিবৃত্ত- মঙ্গল/১
- ঊনবিংশ শতক : নীওজাল বিদ্রোহ ও অধঃসামাজিক-বিশুদ্ধতার যোয/১০
- অধঃসামাজিক নারী শিক্ষার উপর পরিবেশের প্রভাব ও বিকল্প জীবনযাত্রা: সুলভকালের যোগ্যমনা ছাত্রের উপর একটি সমীক্ষা- অধঃসামাজিক সুলভক/২০
- ইতিহাসের যোগ্যপটে কড়াভাষা সংস্করণ- বিপাকের যোয/২৯

□ খ দেশ, রাজ, শহর, গ্রামের ইতিহাস

- দেশভাগ ও উৎসাহ জীবনের চাকচিক্য- মঙ্গল রে খেয়/৩৯
- আশার শহর-কন্যাচার- ভাষণে বিশ্বাস/৫০

□ গ সাহিত্য- ইতিহাস

- কাছী নজরুল ইসলামের কাব্য সৃজন ও সাহিত্য চেহেলার সামান্য একই জটিলতাবল : একটি ইতিহাসিক পর্যবেক্ষণ- ড. মহীতের পায়েন/৫৯
- কবীজনাদের কবিতায় নারী চরিত্রের বিবর্তন- ড. তপন কুমার বর্মা/৭২
- বাংলা ভাষাচর্চায় ধারার দুই কিংবদন্তী : আভ্যন্তরীণ ও শ্যামপ্রাসাদ সুরোপাধায় - সৌন্দর্য পোকার ও শিবানী মতল/৯০

- অধীনতা উত্তর আনন্দ্রহের পোকপাহিত্য  
(লোকগান ও কুসুর) - অসীম কুমার মুখার্জী/১০১

#### ঘ) শিক্ষা, শিল্প ও সংস্কৃতির ইতিহাস

- অভিব্যক্তি : আশ বাংলার এক শিল্পচর্চা কেন্দ্র- সমর কান্তি চক্রবর্তী/১১২
- পুরুলিঙ্গার জনপ্রিয় লোকসংস্কৃতি ও জনজীবন-সংগ্রহ মাথাত/১২৪
- বলাপাড়ের কীর্তিয্যবাহী নৌশিল্পের ইতিহাস- উৎকলিকা সাধ/১৩৫
- ভারতের স্থাপত্য ভাস্কর্য চিত্রকলায় বিবর্তন :  
একটি সমীক্ষা- ড. টিকেদে নারায়ণ সরকার/১৪৬

#### ঙ) জীবনী ইতিহাস

- চারধকরি মুকুন্দদাস ও যশেন্দ্রী যুগের ব্যক্তিগত- কৌশিক দত্ত/১৫৪
- ইতিহাসের আলোকে শ্রীচৈতন্যদেব- ড. অশোক চন্দ্র সরকার/১৭৪
- নৃত্যচিত্রশিল্পের স্মৃতির অভিব্যক্তি- জীবনস্মৃতিতে নিহিত বাস্তবীতি ও  
অর্থের আত্মপরিচয় - অর্পণ দেবনাথ/১৮২
- দেশভাগ ও উদ্বাস্ত জীবনের দুই বিতর্কিত ব্যক্তিত্ব : শ্যামসুন্দর মুখোপাধ্যায়  
ও যোগেন্দ্রনাথ মজুমদার- পণ্ডিত মজুমদার/১৯১
- সাধক মূল্যায়ন বাবার কথা ও কিংবদন্তী- জনন বর্মান/২০১

#### ভূমিকা

সারা শৃংখলাতে আজ কঠিন সময়। ভয়ঙ্কর কলননা আবার সবই নিশ্চয়ই। এই  
গভীর অতিমারী সংকটকালে ইতিহাস, সাহিত্য, সংস্কৃতি চর্চায় মারাত্মক অস্বাভাবিক  
গাথতে আমরা ইতিহাসের কাছে আশ্রয়বোধ করি। এই লম্বা পথকেই বহু প্রতীক্ষায়  
এর অগত্যাতে শীতের পরশ মাথা ইতিহাসের কাজ বেলাতে প্রকাশিত হলো "বাংলা  
ইতিহাস : সমাজ ও সংস্কৃতি" গ্রন্থটি। এটি একটি অর্ধশৃংখলা সম্বন্ধিত বিশ্লেষণ  
শাস্ত্রীয় (Peer Reviewed)। ইতিহাস বিষয়ক গবেষণা প্রবন্ধ সম্বন্ধিত গ্রন্থ।  
আমাদের এই গবেষণা গ্রন্থের মূল প্রতিপাদ্য হলো সমাজ ও সংস্কৃতির  
অন্যকালে গবেষণা ইতিহাস চর্চা এবং তা করতে গেলে প্রথমেই সংস্কৃতি প্রসঙ্গে  
চিন্তা করতে নেতৃত্ব প্রয়োজন।

সমাজ, সমাজ, জীবনের সবকিছুই ইতিহাসের অধিক্ষেপে প্রতিস্থাপিত। আর  
সেই জীবনের মূল্যবান অভিব্যক্তি হলো সংস্কৃতি। সংস্কৃতির উৎসে নিহিত আছে  
মানুষের জীবনব্যাপী ও জীবিতকাল পদ্ধতির মধ্যে। শুধু তাই নয় সামাজিক অর্থ,  
সাংস্কৃতিক ও আর্থিক অর্থ, সামাজিক প্রয়োজন অর্থের সমন্বয়ে গড়ে ওঠে  
এক-একটি সংস্কৃতি। সংস্কৃতি হচ্ছে প্রবর্তমান নীতির স্রোতের মত। এই প্রসঙ্গে  
প্রথম বিশ্ববিদ্যালয়ের বিশিষ্ট অধ্যাপক ড. চিত্তাবিন্দু আহম্মদ শেরীফ তার "সংস্কৃতি  
আমরা" বইয়ে বলেছেন "সংস্কৃতি কোনো উৎপাদিত শব্দ যা নির্দিষ্ট নাহা  
নয়। সংস্কৃতি ব্যক্তির ও সমাজের প্রতি মুহূর্তের তার চিন্তা-কর্ম-আচরণে অভিব্যক্ত  
মানসিক চেতনা ও জীবনচারণের অর্থকর্ম এবং নির্দিষ্ট সর্বকালের ব্যক্তিগত প্রয়োজনের  
ও চোখ-উল্লেখ্য বস্তু। এই সংস্কৃতিবাহী প্রবর্তমান ও বিকাশমান।" সমাজ  
ও সংস্কৃতির সেই শাশ্বত রূপ-নির্ধারণের সন্ধানে আমাদের এই ইতিহাস চর্চা।  
ইতিহাসবিদ অসীম মল্লভট্টের কথ্যে বলা যায় ইতিহাস মানুষের মনের  
মনের অঙ্গ প্রবেশ কলাতে পরিণত না। সাহিত্য চিত্রকলাই এই কাজটি করে  
করে। আর সেই কাজে রতী হয়ে আমরা এই গবেষণা গ্রন্থে ১৯টি প্রবন্ধ  
সমাপ্তকালে ও বিষয়ের উপর ওরফে দিয়ে ক্রম সাজিয়েছি এবং প্রবন্ধগুলিকে



# বাংলার ইতিহাস

## ঐতিহ্য ও সংস্কৃতি

লেখকগণের অন্যান্য গবেষণা পত্রিকার পত্রিকার ইতিহাস বিবরণে দেখা।

১৯১৬-১৯১৭ খ্রিঃ বাংলার সংস্কৃতি  
 সামাজিক ও রাজনৈতিক অর্থব্যবস্থা  
 রবীন্দ্রনাথ - নতুন কথা - জননী ১১  
 মেসার্স উদ্ভাস কল্যাণ ১১  
 শ্রী (কল্যাণ) ১১  
 ১৯১৬-১৯১৭ খ্রিঃ বাংলার সংস্কৃতি  
 সামাজিক ও রাজনৈতিক অর্থব্যবস্থা  
 রবীন্দ্রনাথ - নতুন কথা - জননী ১১  
 মেসার্স উদ্ভাস কল্যাণ ১১  
 শ্রী (কল্যাণ) ১১



লেখক প্রথম পর্বের মুদ্রণের ফোটার  
 ১৯১৬-১৯১৭ খ্রিঃ বাংলার সংস্কৃতি  
 সামাজিক ও রাজনৈতিক অর্থব্যবস্থা  
 রবীন্দ্রনাথ - নতুন কথা - জননী ১১  
 মেসার্স উদ্ভাস কল্যাণ ১১  
 শ্রী (কল্যাণ) ১১

সম্পাদনা

ড. মহীতোষ গায়ের  
 সমরকান্তি চক্রবর্তী  
 কৌশিক দত্ত

১৯১৬-১৯১৭ খ্রিঃ বাংলার সংস্কৃতি  
 সামাজিক ও রাজনৈতিক অর্থব্যবস্থা  
 রবীন্দ্রনাথ - নতুন কথা - জননী ১১  
 মেসার্স উদ্ভাস কল্যাণ ১১  
 শ্রী (কল্যাণ) ১১

BANGALUR ITIHASHI - SWMAJ O SANSKRITI  
Edited By Mahinash Gyeken, Samar Kanti Chakrabarty, Kaushik Dutta  
(অতীতকালীন সমসাময়িক সাংস্কৃতিক বিশেষজ্ঞ শাস্ত্রীয় ইতিহাস বিষয়ক গ্রন্থ)

প্রথম প্রকাশ  
২০২০

গ্রন্থস্বরূপ : সম্পাদকমণ্ডলী

সম্পাদনা :

ড. মহীত্বোষ গায়েন, সিটি কলেজ, সমর কান্তি চক্রবর্তী, অক্ষয়রাম মেমোরিয়াল কলেজ,  
কৌশিক দত্ত, শ্রী চৈতন্য কলেজ, হাবড়া

সম্পাদকমণ্ডলী

অধ্যাপক ড. শরীফ উদ্দিন আহমেদ, নর্থ-সাউথ ইউনিভার্সিটি, ঢাকা, সহ সভাপতি এশিয়াটিক  
সোসাইটি, ঢাকা, অধ্যাপিকা মহম্মা সরকার, যাদবপুর বিশ্ববিদ্যালয়, অধ্যাপক ড. সৈয়দ তনভীর  
নাসরিন, ডিরেক্টর- ভারতীয় সংস্কৃতি কেন্দ্র, মালদ্বীপ, অধ্যাপক প্রদীপ চট্টোপাধ্যায়, বর্ধমান  
বিশ্ববিদ্যালয়, অধ্যাপক ড. আনওয়ারুল করিম, প্রাক্তন উপাচার্য ইসলামিক বিশ্ববিদ্যালয়, বাংলাদেশ,  
অধ্যাপক মেসবাহ কামাল, ঢাকা বিশ্ববিদ্যালয়, অধ্যাপক অনিল সরকার, কল্যাণী বিশ্ববিদ্যালয়।

প্রকাশক

রূপালী

সূর্যেন্দু ভট্টাচার্য

সুভাষপল্লী, পো: খালিসানি, চন্দননগর ৭১২১৩৮

থেকে প্রকাশিত

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এল.আর.ইনফোটেক

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মুদ্রণ

নিউ কালীমাতা প্রিন্টার্স

১৯এ/এইচ/২ গোয়াবাগান স্ট্রিট, কলকাতা-৭০০০০৬

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- স্বাধীনতা উত্তর মানসময়ের লোকসাহিত্য  
(লোকধাম ও কুমুর)- অসীম কুমার মুখার্জী/১০১

#### খ) শিক্ষা, শিল্প ও সংস্কৃতির ইতিহাস

- অভিব্যক্তি : সাত বাংলার এক শিল্পচর্চা কেন্দ্র- সমর কান্তি চক্রবর্তী/১১২
- পুরুনিয়ার জনপ্রিয় লোকসংস্কৃতি ও জনজীবন-সম্ভাব্য মাহাত/১২৪
- বলাগড়ের ঐতিহ্যবাহী নৌশিল্পের ইতিহাস- উৎকলিকা সাহ/১৩৫
- ভারতের স্থাপত্য ভাস্কর্য চিত্রকলার বিবর্তন :  
একটি সমীক্ষা- ড. টিকেজ নাথ সরকার/১৪৬

#### ঙ) জীবনী ইতিহাস

- চারনকবি মুকুন্দদাস ও স্বদেশী যুগের বরিশাল- কৌশিক দত্ত/১৫৪
- ইতিহাসের আলোকে শ্রীচৈতন্যদেব- ড. অমল চন্দ্র সরকার/১৭৪
- 'লিভিংস্টোনের স্মৃতির অভিযান 'জীবনস্মৃতি'তে নিহিত রাজনীতি ও অধরের আত্মপরিচয়'- অর্ণব দেবনাথ/১৮২
- দেশভাগ ও উদ্বাস্ত ভাবনায় দুই বিতর্কিত ব্যক্তিত্ব : শ্যামাপ্রসাদ মুখোপাধ্যায়  
ও যোগেন্দ্রনাথ মণ্ডল- পলাশ মণ্ডল/১৯১
- সাধক ধুলিয়া বাবার কথা ও কিংবদন্তী- চন্দন বর্মণ/২০১

## স্বাধীনতা উত্তর মানভূমের লোকসাহিত্য (লোকগান ও কুমুর)

অসীম কুমার মুখার্জী\*

জঙ্গলমহলের গর্ভ থেকে জন্ম হয় মানভূম জেলার (১৮৩৩)। ধানবাদ, পুরুলিয়া এবং বাঁকুড়ার কয়েকটি পরগণা এবং ধলভূম মহকুমা নিয়ে নবগঠিত মানভূম জেলার বিস্তৃতি। এই জেলা ভেঙে যে বাংলা ভাষাভাষি এলাকাগুলি পশ্চিমবঙ্গের সঙ্গে যুক্ত হয়ে নূতন জেলারূপে আত্মপ্রকাশ করে তার নাম পুরুলিয়া (১৯৫৬)। লোকগানের স্বর্গরাজ্য পুরুলিয়া। সাহিত্য সংস্কৃতিতেও অগ্রণী ভূমিকায় সফল অংশীদার গীতি কবিতা ও লোকগানেই সমৃদ্ধ ছিল মানভূমের সাহিত্যসংস্কৃতির পরিমন্ডল। কুমুর গানের মধ্যেও মানভূমবাসী খুঁজে পেয়েছিল শুধু আনন্দই নয়, বেঁচে থাকার নিবিড় প্রত্যয়। অনেকের মতে মানভূম ছিল 'গানভূম', সঙ্গীতের কেন্দ্রভূমি।

মানভূমের লোকজীবনের হাসিকামা, সুখদুঃখের জীবন কাহিনী সব থেকে বেশী ধরা পড়ে যে গানে তা হল পুরুলিয়ার অতি জনপ্রিয় টুসুগান। বাঙালীর জাতীয় উৎসব যদি দুর্গাপূজা হয় তাহলে মানভূম তথা পুরুলিয়া বাসীর জাতীয় উৎসব অবশ্যই টুসু। প্রকৃত অর্থেই টুসু পরব এ জেলার মহামিলনের পরব। হাজারে হাজারে, লাখে লাখে মানুষের প্রাণের স্বতোৎসারিত আনন্দের প্রকাশ টুসু পরবে যেভাবে প্রকাশিত হয় অন্য কিছুতে হয় কিনা সন্দেহ। এখানকার মানুষের ভাষায় 'এহে জন্যে পরবটাকে পুষ পররবও কহথিগ। ই সময়টায় ঘারেক ঘাইহরে যারা আহাৎ বেসন পরে গেলাহাৎ তারাও ঘরে আওয়াৎ। সবাইকার সঙ্গ বাইকার দেখা হেন। এহে জন্যেই পরবটাকে মহামিলনকে পরব কহা যাইগ।'<sup>২</sup>

স্বাধীনতা উত্তর মানভূমে ভাষাধ্বন্দ্ব এক ভয়ংকর রূপ ধারণ করে। মাতৃভাষা বাংলা ভাষার অস্তিত্ব রক্ষার জন্য এবং ভাষাভিত্তিক প্রদেশ গঠনের দাবিতে সারা জেলায় শুরু হয় মরণপণ লড়াই ও গণ-আন্দোলন। এই ভাষা আন্দোলনেও

\* স্টেট এডেড কলেজ টিচার, অচ্চুরাম মেমোরিয়াল কলেজ, ঝালদা, পুরুলিয়া, পশ্চিমবঙ্গ, ভারত



# সৃজনে ও মননে : শিশু-কিশোর

সম্পাদনা  
কঙ্কনু সহিস

প্রজ্ঞাবিকাশ

৯/৩, রমানাথ মজুমদার স্ট্রিট  
কলকাতা-৭০০০০৯

Srijane O Manane ; Shishu-Kishor  
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ড. অরুণাভ মুখার্জী

"সব দেবতার আদরের ধন

নিত্যকালের তুই পুরাতন,

তুই প্রভাতের আলোর সমবয়সী।" -রবীন্দ্রনাথ

—শৈশব আমাদের জীবনে মহার্ঘ। বারে বারে আমাদের ইচ্ছে করে এই স্বপ্নের জগতে ফিরে যেতে। কিন্তু সবাই তা পারে না। কেননা শিশু সুলভ মন স্বর্গীয় সুস্মার ধারক। তবে কেউ কেউ পারে এই শৈশবের অভিযাত্রী হতে। কাজী নজরুল ইসলাম সেই রকমই এক পরিণত বয়স ও মননের চিরশিশু; তাঁর অনেক রচনাতেই ছড়িয়ে আছে শিশুসৌরভ। বঙ্গত ছোটদের নজরুল ভালোবাসতেন। তাই যখন যেটুকু সময় পেয়েছেন, ছোটদের জন্য ছড়া লিখেছেন, গান বেঁধেছেন, নাটিকা লিখেছেন, গল্প শুনিয়েছেন। কচি ও কিশোরদের জন্য কবির দরদী মনের এই পরিচয় ছড়িয়ে রয়েছে তাঁর বিভিন্ন রচনায়।

কাজী নজরুল ইসলাম একাধারে যেমন বিদ্রোহের কবি, প্রেমের কবি, সামের কবি, সাধনার কবি; তেমনই ছিলেন প্রাণোচ্ছল, ফুঁটিবাজ দিলখোলা মানুষ। সর্বোপরি তাঁর মধ্যে ছিল এমন এক শিশুসত্তা, যা তাঁকে উন্মাদের মতো তুরীয়ানন্দে ছুটে চলতে যেমন প্রভাবিত করেছে, তেমনই করে তুলেছে "চির শিশু, চির-কিশোর/... যৌবন-ভীতু পল্লীবালার আঁচর কাঁচুলি নিচোর।" বঙ্গত নজরুলের সমস্ত সৃষ্টির মধ্যেই রয়েছে এক ধরণের প্রাণোচ্ছলতার দীপ্তি। শিশু-কিশোরদের জন্য লেখাগুলিতে তাঁর এই প্রাণোচ্ছলতার উদ্ভাস লক্ষ্য করা যায়।

নজরুলের শিশুসৌরভ ছড়িয়ে রয়েছে তাঁর যে সব শিশুতোষ রচনা সমূহে, সেগুলি হল 'পুতুলের বিয়ে' (নাটিকা-১৯৩৩, এপ্রিল, ১৩৪০ চৈত্র প্রথম প্রকাশ), 'ঝিঙেফুল' (কাব্যগ্রন্থ-১৯২৬), 'সঞ্চয়ন', 'সংকল্প', 'মুক্তব সাহিত্য', 'নতুন চাঁদ', 'ঝড়' প্রভৃতি। এইসব রচনায় যে বৈশিষ্ট্যগুলি প্রধানভাবে লক্ষ্য করা যায়, তা হল—

ক) চিরায়ত বাংলা লোক সাহিত্যের আন্তরিকতার স্পর্শ।

খ) শিশুর ক্রম বিকাশমান মানবসত্তা।

গ) শিশুর কল্পনা প্রতিভার স্বাভাবিক বিকাশ।

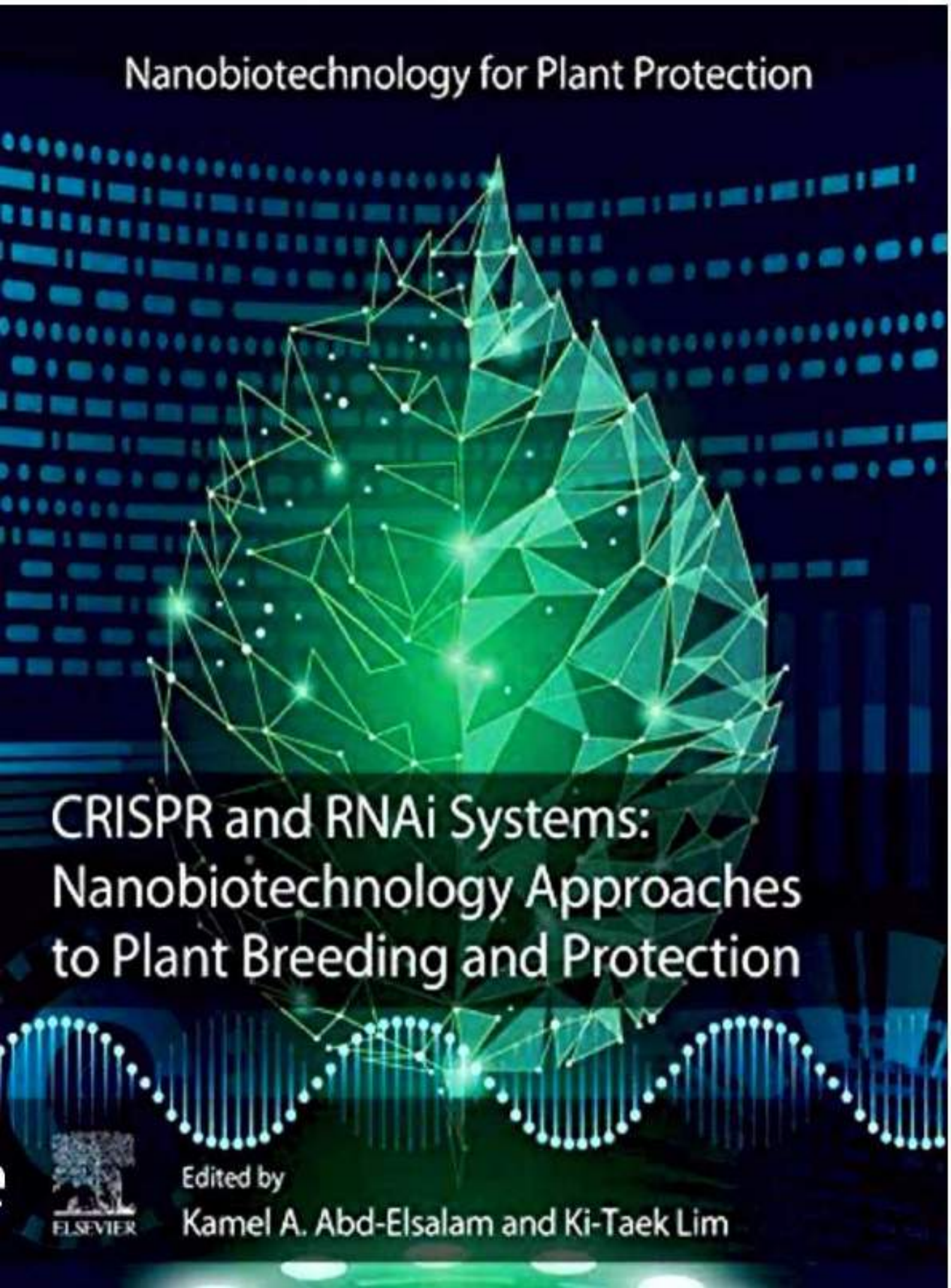
ঘ) আনন্দ লাভের সঙ্গে সঙ্গে জ্ঞান আহরণ।

ঙ) সাধারণ জিনিসকে অসাধারণত্ব দান।

চ) কৌতুক ও হাস্যরস পরিবেশন।

এছাড়াও নীতিশিক্ষা, মনের জাগরণ, সৌন্দর্য সৃষ্টি, দেশপ্রেম, সেবা, অভিযান, ব্যঙ্গরস প্রভৃতি বৈশিষ্ট্যও তাঁর শিশু সাহিত্যে মূর্ত হয়ে উঠেছে। বিশেষত নজরুল

Nanobiotechnology for Plant Protection



CRISPR and RNAi Systems:  
Nanobiotechnology Approaches  
to Plant Breeding and Protection



Edited by

Kamel A. Abd-Elsalam and Ki-Taek Lim

Nanobiotechnology for Plant Protection

# CRISPR and RNAi Systems

Nanobiotechnology  
Approaches to Plant Breeding  
and Protection

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ELSEVIER

# ARE CRISPR/CAS9 AND RNA INTERFERENCE-BASED NEW TECHNOLOGIES TO RELOCATE CROP PESTICIDES?

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## 4.1 INTRODUCTION

Pests are the primary cause of the huge destruction of crops worldwide. Insects, plants, bacteria, fungi, weeds, molluscs, birds, mammals, fish, nematodes (roundworms), and other organisms which has economic impacts on crops and compete with humans for food that may be considered as pests (Dayan et al., 2009; Yadav et al., 2015). Pesticides are the only apparent measures to ensure food safety and crop protection, which in turn increase food productivity (McClung, 2014). According to Jeyaratnam, 1990, pesticides are any substance or can be a mixture of various substances having the properties to kill, prevent, or destruct any pest. As pesticide is a general term, it must be classified into various groups for detailed studies. Pesticides can be classified in various ways. Pesticides may be classified by their mode of entry, composition, or type of pests they killed (Drum, 1980). Based on the mode of entry, the pesticides may be classified as systemic, contact, stomach poisons, fumigants, and repellents. Systemic fungicides are those which can be transported to the untreated parts of crops via conducting tissue (Buchel, 1983). On the other hand, nonsystemic or contact pesticides act via direct interaction with the pests and do not translocate to other parts of crops. Fumigants can kill the pest by vaporization. Moreover, a repellent does not kill but destruct the pests (Yadav and Devi, 2017).

Pesticides also classified as herbicides, insecticides, fungicides, rodenticides, molluscicides, and nematocides based on organisms they kill (Agrawal et al., 2010). Pesticides also classified by their chemical composition. Excessive and worldwide use of pesticides harms nontargeted organisms, the environment as well as on human beings. The pesticides may be volatized after use and affect other organisms (Majewski and Capel, 1995). Herbicides may be washed off from crop fields and incorporate in the aquatic ecosystem and kill herbs, which lowers the productivity of oxygen in the aquatic body and imparts overall effect on aquatic organisms (Helfrich et al., 2009). Pesticides may also reach and contaminate groundwater (Pesticides in Groundwater, 2014). Humans can also be affected

by pesticides. Each year, about 3,000,000 cases of pesticide poisoning and 220,000 deaths have been reported worldwide (Lah, 2011).

In most cases, humans are affected by the consumption of pesticides contaminated foods (Hayo and Werf, 1996). The effect of pesticides in humans includes various physiological and mental disorders (Lah, 2011), damages the immune system (Culliney et al., 1992), etc. The relationship between pesticides and Parkinson's disease and Alzheimer's disease was also established (Casida and Durkin, 2013). The deleterious effect of pesticides is of great concern over the past few decades. The first solution regarding the lousy effect of chemical pesticides is the use of biopesticides. The principal of biopesticides is the use of living organisms to reduce the population of other harmful organisms or pests (Bale et al., 2008). Biopesticides are developed by various biocontrol organisms, which can be fungi, bacteria, viruses, nematodes, predatory parasites, insects, mites, etc., and also may be developed by the natural product isolated from them which are helpful in protection of plants or animals (Bettiol, 2011). The search for new techniques for plant pest management is a prime concern from time to time. Generally, pest management also depends on the resistance power of crop, so the incensement of resistance power with new techniques is always a new concern. The use of RNA interference (RNAi) to control pests is of a new concern over the past few years. In plants, the double-strand RNA (dsRNA) is processed by several enzymes and machinery to produce small interfering RNA (siRNA), which can silence any RNA having similarity with the dsRNA (Baulcombe, 2004; Borges and Martienssen, 2015). The RNAi works via mRNA degradation or chromatin modulation. A dsDNA molecule of ~21–25 bp and with ~2-nt 3' overhangs processed with an RNase III enzyme DICER into siRNAs. Subsequently, these RNAs incorporate with an Argonaute protein to produce RISC complex, which in turn can degrade the mRNA molecule having complementary to the guide strand of RISC complex (Christiaens et al., 2014; Carthew and Sontheimer, 2009). It is found that RNAi is effective against insects belongs to Coleoptera and sometimes against viruses (Baum et al., 2007). The dsDNA, which targets the functional mRNA of pests after ingestion, downregulates the genes of pests, which results in reduced growth or death of the pest feeding on it (Klumper and Qaim, 2014). In this chapter, we will focus on the comparison between conventional pesticides and RNAi-mediated crop protection and the limitation of the RNAi method. We will also try to find out if the RNAi is a new tool for relocating conventional crop pesticides.

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## 4.2 CONVENTIONAL PESTICIDES: PRESENT STATUS AND CHALLENGES

For the betterment and improvement of agricultural yield and quality, pesticides are surely a solution in modern times (Damalas, 2009). The need and evolution of pesticides have a long history. Primary uses and explosion of pesticides were seen after World War II. Some essential pesticides like Dieldrin,  $\beta$ -benzene hexachloride (BHC), chlordane and endrin, 2,4-dichlorophenoxyacetic acid (2,4-D), Aldrin, dichlorodiphenyltrichloroethane (DDT), etc. was discovered that time (Delaplane, 2000). Although the use of pesticides reaches a peak in 1961, it drastically fell after 1962 for seeing its hazardous effects (Jabbar and Mallick, 1994). But the introduction of “integrated pest management” (IPM) in the late 1960 open a new era in pesticide research (Delaplane, 2000). From the past few years, the careless use of pesticides violating safety norms and other standard protocols affects the environment severely and also causes health risks of humans as well as other organisms (Carvalho,



2017). Synthetic pesticides are considered as most hazardous for having harmful effects on human beings. Initial exposure having various health issues like convulsions, headache, nausea, irritation, diarrhea, and breathing discomfort. Pesticides like organophosphate upon showing respiratory effects give symptoms like wheezing and asthma (Sharma et al., 2020). Using chemical pesticides in the wild also make insects and other pests as pest resistance (Sparks and Nauen, 2015). The search for new alternatives always the primary concern in the research field of pesticides. The conventional pesticide industry and market also underwent significant changes over time to time (Pelaez and Mizukawa, 2017).

One of the significant practices to replace conventional chemical pesticides is the use of biopesticides. Any substances which derived from animal, plants, microbes, or their products and use for pest control are considered as biopesticides (EPA, 2020). The global market is creating with a rate of 10% per year worldwide, as it appears to be a good substitution of chemical-based pesticides. Many microorganisms like fungus and bacteria are used for this purpose. The bacterium *Bacillus thuringiensis* (Bt) is used as the production of more than 90% microbial biopesticides (Kumar and Singh, 2015). Fungus *Talaromyces flavus* is used to control anthracnose caused by *Glomerella cingulata* in the nursery (Ishikawa, 2013). Extract of the species *Clitoria ternatea* shows an inhibitory effect on *Helicoverpa*, which shows a toxicity effect on *Helicoverpa* spp (Mensah et al., 2014). Products of the fungus *Trichoderma harzianum* show a very striking effect against *Fusarium* root rot bacterium (Kirk and Schafer, 2015). *Lactobacillus casei* strain LPT-111 (Tivano) shows effectiveness against angular leaf spot, caused by *Xanthomonas fragariae* (Dubois et al., 2017). Stilbenes isolated from grapevine extracts caused acute mortality of *S. littoralis*. A crop pest (Pavela et al., 2017). *Bacillus thuringiensis* produces endotoxins and causes lysis of insect guts; *Agrobacterium radiobacter* used to control crown gall (Quarles, 2011). Many critical secondary metabolites of plants-like Citronella oil, garlic extract, neem extract, datura, orange oil, tea tree extract, basil, lemongrass, apple mint, mustard, castor, Mahogany, and sesame are used to control the pest. Neem oil and pyrethrins (extracted from *Chrysanthemum cinerariaefolium*) are the two most widely used compounds used in pest control (Chandler et al., 2011). Pesticides may affect humans employing occupational exposure like industrial workers, distributors, dealers and farmers, and nonoccupational methods. Exposure through consuming contaminated foods, vegetables, etc. (Sabarwal et al., 2018). Exposure of pesticides to humans causes some serious health issues and disorder includes Hodgkin's disease, nonHodgkin lymphoma (Luo et al., 2016). Parkinson's disease (Brouwer et al., 2017) endocrine disruption, respiratory, and reproductive disorders (Kirkhorn and Schenker, 2002). Biopesticides are considering as safest over conventional chemical pesticides, as this is much safer and fewer detritus and most effectively efficiently affect only target organisms. On the other hand, biopesticides need in a minimal amount and do not leaves any detritus residue.

Nevertheless, it seems that the biopesticides did not completely replace the chemical pesticides as some drawbacks and lack of collaborative research. It is recommended that the chemical and biopesticides must go together to ensure better protection. Extensive research also needed in this field (Damalas and Koutroubas, 2018). Another new way to get a ride from the adverse effects of pesticides is by using nanotechnology. Nanotechnology can help by protecting the biopesticides as an encapsulating agent and also by protecting the degradation of many compounds (De Oliveira et al., 2014). Nanoparticles found effective in protecting neem oil from degradation (Mishra et al., 2017).

### 4.3 ADVANCEMENT IN GREEN REVOLUTION: THE RNAI TOOLKIT

Although RNAi is a perfect tool for functional gene analysis in vivo and in vitro (Trivedi 2010), it now also effectively used in crop pest control, particularly against insect pest (Huvenne and Smagghe, 2010). The RNAi method may be implanted in the field by either host-induced gene silencing (HIGS) or virus-induced gene silencing (VIGS). The HIGS aims of the expression of dsRNA in crops specific to a pest or pathogen. Gene duplication thought to be a factor for increasing expression of RNAi in coleopteran. It was also proved by Davis-Vogel et al. (2018) that RNAi efficiency varies among different groups of insect orders for which mRNA expression of core machinery genes is also responsible (Christiaens et al., 2019). The first known experiment was reported by Bettencourt et al. (2002), by silencing a gene named *Hemolin* with RNAi technology, which is essential for larval production and embryonic development in *Hyalophora cecropia* has been stopped and causes early death of larva. A knockdown of zygotic genes in offspring was observed when dsDNA was injected in the mother's hemocoel of *Tribolium castaneum* (Bucher et al., 2002). One of the best examples is the development of genetically modified (GM) maize, which expresses vATPaseA dsRNA for control of *Diabrotica virgifera*, the western corn rootworm (Yan et al., 2019). Another evidence came from *Tribolium*, where induction of RNAi in the larval stage gives a functionless adult stage (Tomoyasu and Denell, 2004), which suggests the application of RNAi in a particular stage may affect to another stage. It is found that insects lack RNA-dependent RNA polymerase (RdRP), which suggests insects care not depends on RDRP-based gene silencing, instead maybe adopt another method, but it has to uptake dsRNA continuously (Gordon and Waterhouse, 2007).

An effective way is making transgenic plants that can supply dsDNA continuously. Evidence of reduction of corn root damage was found in a study by Baum et al. by the production of (V-ATPase) dsRNA after infection with corn rootworm (Baum et al., 2007). After feeding on transgenic *Arabidopsis thaliana* or *Nicotiana tabacum* expressing dsRNA specific to a cytochrome P450 gene (*CYP6AE14*), the level of the gene was knocked down in insect gut causing reduced larval tolerance toward gossypol-containing food (Mao et al., 2007). A new way for the implementation of RNAi also found as spray induces gene silencing method. Koch et al. showed that *Arabidopsis* and barley express a dsDNA which can disrupt the fungal membrane integrity by targeting CYP51 genes which were necessary for expression of cytochrome P450 lanosterol C14 $\alpha$ -demethylase (Koch et al., 2013) Later on a study, spraying with 791-nt long CYP3-dsRNAs on detached barley leaf was effective against the fungal pathogen (Koch et al., 2016). Similar disease control was also observed in various studies. Wang et al. reported that applying dsRNAs and small RNAs was also successfully suppressed *Botrytis cinerea* from attacks (Wang et al., 2016a,b). Translocation of sRNA in the distal untreated part also reported, and taking up of external dsDNA and sRNA by fungal pathogen was also reported (Wang et al., 2016a,b). Cotton bollworm *Helicoverpa armigera* tolerates gossypol is a polyphenolic compound found in cotton, although it is very toxic to animals. It was found that the gene CYP6AE14 detoxify gossypol after a construct targeting CYP6AE14 was made the cotton worm feeding on transgenic leave found a limited growth (Mao et al., 2007). Several species of Coleoptera, like *Tribolium castaneum*, *Leptinotarsa decemlineata*, and *Diabrotica virgifera*, are found very useful to RNAi (Tomoyasu et al., 2008). Some other successful approaches, including GM crops expressing

dsDNA, are GM cotton against *Tetranychus cinnabarinus*, GM tobacco against *Myzus persicae*, and GM potato against *Leptinotarsa decemlineata* (Yan et al., 2019). Transplastomic crops show high efficiency in RNAi-mediated gene transfer, which allows the accumulation of a large amount of stable dsDNA (Yan et al., 2019). Table 4.1 briefly summarizes some of the examples of successful HIGS in plant pathogens.

RNAi may be used either by making transgenic plants or by using products with dsRNA. The delivery method of RNAi is the most crucial concern. One successful method of delivery is making transgenic crops, although it seems to be practically difficult in many aspects, so the tropical application of dsRNA is now considered as an alternative way (Baum et al., 2007; Joga et al., 2016). As RNA can translocate within the whole plant, the tropical application seems to be very useful, two types of pests took after dsRNA from previously treated citrus leaves proves this fact (San Miguel and Scott, 2016). Although the problem may arise during the delivery of naked RNA, which can be overcome by using clay, a type of specialized nanosheets which protects the naked RNA (Mitter et al., 2017), another effective method is VIGS, where a nonpathogenic engineered virus is produced

**Table 4.1 List of some conventional RNAi-based techniques for knocking down insect-specific genes.**

Species	Genes	Phenotype	Reference
<i>Acyrtosiphon pisum</i>	<i>C002</i>	100% mortality after 8 days	Mutti et al. (2006)
<i>Bactericera cockerelli</i>	Actin, v-ATPase	82%–92% mortality	Wuriyangan et al. (2011)
<i>Cimex lectularius</i>	<i>cpr</i>	Increased deltamethrin sensitivity	Zhu et al. (2012)
<i>Laodelphax striatellus</i>	Disembodied	Reduction in EcR expression; impaired development; and decreased survival	Wan et al. (2014)
<i>Lygus lineolaris</i>	<i>PG1</i>	No phenotypic effect observed	Walker and Allen (2010)
<i>Myzus persicae</i>	<i>C002</i>	Reduction in fecundity	Walker and Allen (2011)
<i>Nephotettix cincticeps</i>	<i>PGRP12</i>	95% mortality after 10 days	Tomizawa and Noda (2013)
<i>Nilaparvata lugens</i>	<i>Hsp70, Argk</i>	Decreased mortality after triazopos exposure	Ge et al. (2013)
<i>Oncopeltus fasciatus</i>	Hunchback	Parental RNAi and disrupted embryonic development	Liu and Kaufman (2004)
<i>Pyrrhocoris apterus</i>	<i>Met, kr-h1</i>	Disturbed metamorphosis and development	Smykal et al. (2014)
<i>Rhodnius prolixus</i>	Nitrophorins1–4	Discolouration of salivary glands	Araujo et al. (2009)
<i>Sogatella furcifera</i>	Disembodied	Reduction in EcR expression; impaired development; and decreased survival	Wan et al. (2014)
<i>Triatoma brasiliensis</i>	Brasiliensin	Reduction in blood feeding	Araujo et al. (2007)

pest-specific RNAi inducer sequence. After exposure of this engineered virus to the pest, the target mRNA becomes silenced (Nandety et al., 2014). One vital aspect of RNAi technology that the cost is reduced day by day, for example, the cost to produce 1 g of dsRNA using NTP synthesis was USD 12,500 in 2008, which is now USD 100 in 2016, and to USD 60 in the present. (Andrade and Hunter, 2016). Another cost-effective (USD 4 per 1 g), the method is using HT115(DE3), a strain of *Escherichia coli*, which lacks dsRNA degrading enzymes that can be used for the production of a large amount of dsRNA which can be used anytime (Andrade and Hunter, 2016). Ingestion of dsRNA targeting *16D10* dsRNA in root-knot nematode results in reducing nematode activity (Huang et al., 2006).

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#### 4.4 ADVANTAGES AND DISADVANTAGES OF RNAI-BASED METHODS

The first primary concern is the delivery of dsRNA; various strategies like modification of dsRNA, using various useful vehicles are of present concern. A straight forward way of delivery is micro-injection. Although this is an easy and efficient method for delivery of dsRNA, it seems to be possible only in laboratory conditions and unsuitable for field conditions because it is very laborious and ineffective for a large-scale delivery. Another critical concern regarding RNAi-based pest control is degradation (Christiaens et al., 2014); degradation may occur due to either unstable pH condition or dsRNA degrading enzymes. Lipid-based nanoparticle formulation may help to overcome these situations (Zhang et al., 2010). Use of viruses that upon infection to pest express dsRNA is also helpful for this purpose (Hajeri et al., 2014). Another factor for the success of the RNA-mediated pest control is the presence of proper RNAi machinery components; a variation of this machinery has been found, sometimes even under the same phylum (Miller et al., 2012). An example of Sid1-like genes may be taken into consideration, and this gene varies among different insect species (Bansal and Michel, 2013). A previous report came from *Drosophila* that the Flock house virus (FHV) B2 protein can bind to long siRNA duplexes and inhibits it from forming of RISC complex (Chao et al., 2005), this is an example of suppression of RNAi mechanism by a virus which is also a significant concern as the virus has anti-RNAi defense mechanism (Haasnoot et al., 2007).

Furthermore, the delivery system and other problems many more limitations to be addressed, like its effectiveness, biosafety measures, and ecological safety. Table 4.2 briefly demonstrates the application of dsRNA based on the mode of insect feeding on plants. Several questions like the part of plants where the expression is done, the concentration needed for the purpose should be addressed. When compared to conventional insecticides, the cost, effect, pollution aspects, stability, and uptake rate should be improved for its better acceptance (Zhang, 2012). Details study of length of RNA, sequence, life stage of target insect, and procedures are very complex and need more study (Terenius et al., 2011). A report came from recent studies in *Euschistus heros* that by using EDTA, the stability of dsDNA and RNAi, efficiency may be increased (Castellanos et al., 2019).

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#### 4.5 ADVANTAGES OF CRISPR/CAS9-BASED SYSTEMS

CRISPR/Cas9 is a modern gene-editing tool that has created a new way to study genome editing and various diseases. It stands for clustered regularly interspaced short palindromic repeats (CRISPR)–

**Table 4.2 Formulation technique of various dsRNAs during insect feeding on plants.**

Species	Genes	Method of application	References
<i>Leptinotarsa dceclineata</i>	$\beta$ -Actin; protein transport protein sec23	Feeding (larvae)	Zhu et al. (2011)
<i>Phyllotreta striolata</i>	Odorant receptor ( <i>PsOr1</i> )	Injection (adult)	Zhao et al. (2011)
<i>Lygus lineolaris</i>	Inhibitor of apoptosis gene ( <i>LIAP</i> )	Injection	Walker and Allen (2011)
<i>Riptortus pedestris</i>	Circadian clock genes period; cycle	Injection (adult)	Ikeno et al. (2011a, b)
<i>Myzus persica</i>	<i>MpC002</i> and <i>Rack-1</i>	Transgenic plant	Pitino et al. (2011)
<i>Athalia rosae</i>	<i>Ar</i> white gene	Injection (eggs)	Sumitani et al. (2005)
<i>Schistocerca americana</i>	Eye color gene vermilion	Injection (nymph)	Dong and Friedrich (2005)
<i>Gryllus bimaculatus</i>	<i>Delta</i> ; <i>Notch</i>	Injection (eggs)	Mito et al. (2011)
<i>Gryllus bimaculatus</i>	Insulin receptor; insulin receptor substrate; phosphatase and tensin homolog; target of rapamycin; PRS6-p70-protein kinase; fork head box O; and epidermal growth factor receptor	Injection (nymph)	Dabour et al. (2011)

CRISPR-associated gene Cas9. Genome editing with CRISPR–Cas9 is very stable compare to the RNAi method. Some examples of pests on which CRISPR–Cas9 gene knockout has performed include *Helicoverpa armigera*, *Spodoptera litura*, *Plutella xylostella*, and *Spodoptera littoralis* (Zhu et al., 2016; Wang et al., 2016a,b; Huang et al., 2016). CRISPR–Cas9 has a great success in editing insect genome. Choo et al. demonstrated the mutagenic effect through CRISPR–Cas9 in a crop pest *Bactrocera tryoni* by frameshift-mutation in an ATP-dependent binding cassette transporter (Choo et al., 2017). Therefore the genome editing using site-specific nucleases (SSNs) helps us to understand the transgene experiments that can be carried out in an efficient and precise manner. There are four major classes of SSNs that can be used effectively to edit the genomes, for example, mega-nucleases (MEGA), zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and CRISPR. Fig. 4.1 shows an overview of three major types of genome editing strategies that are used frequently for viral resistance (Zaidi et al., 2016a).

It is interesting to note that this RNA-based guiding technique is cheaper and easier to engineer and one can manipulate a wide range of possible target sequences without error. Despite of gaining significant success in genome editing, it remains to be uncleaned whether this technique could actually work under natural conditions in open field trails or not (Zaidi et al., 2016b). Therefore more detailed and precise analysis of these technologies (CRISPR/Cas9 and RNAi) will eventually led to the development of novel disease resistant crops in the upcoming years.

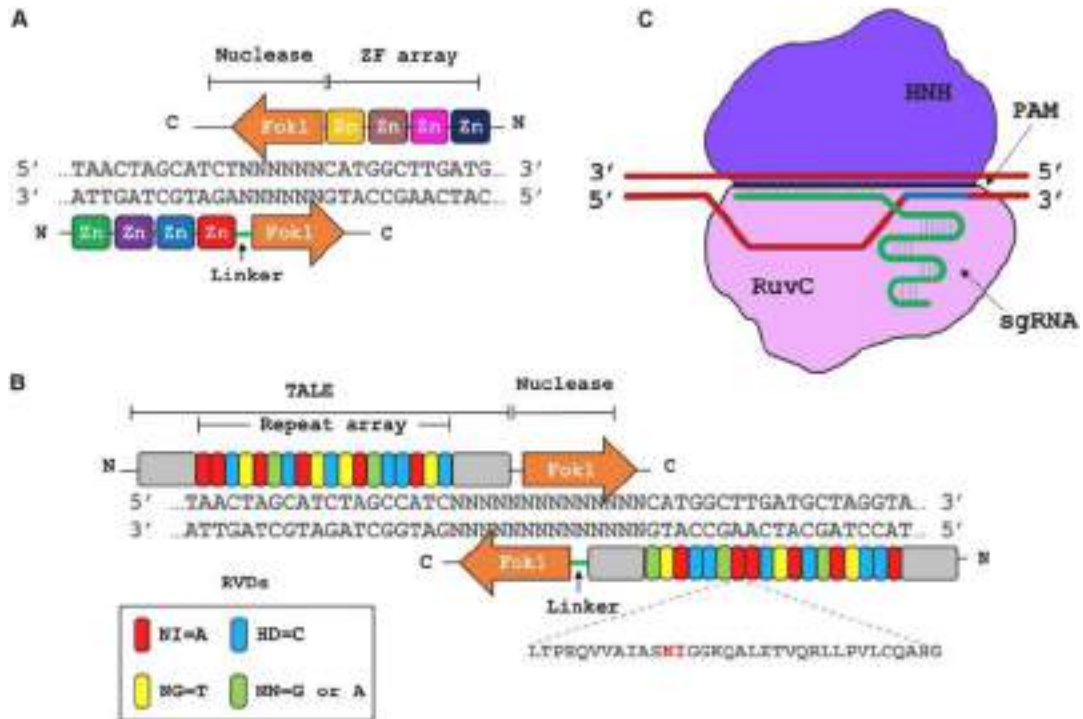
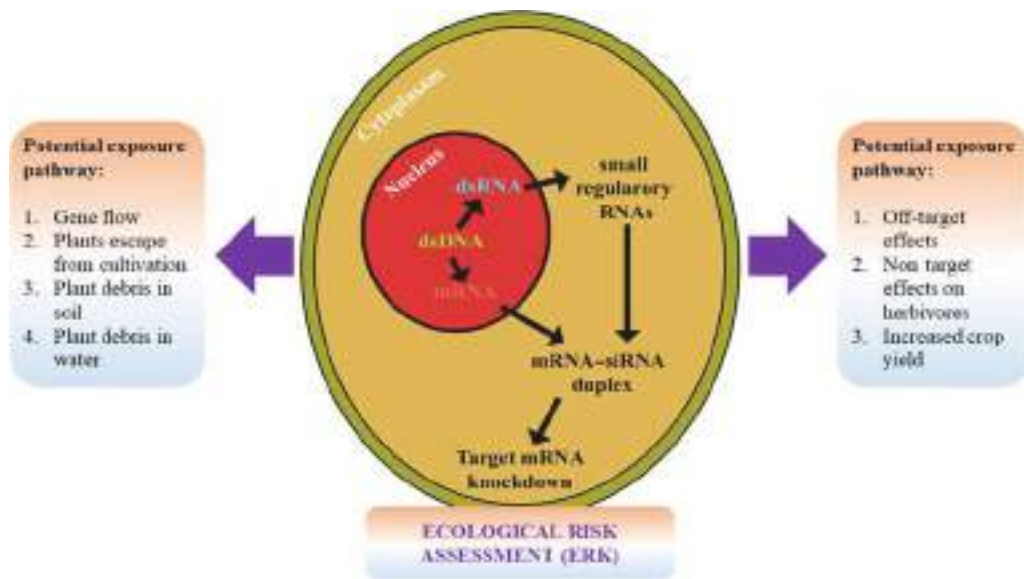


FIGURE 4.1

The major types of CRISPR/Cas9-based genome editing platforms. The proposed structure of site-specific nucleases (SSNs). (A) Zinc-finger nucleases (ZFNs). (B) Transcription activator-like effector nucleases (TALENs), and (C) CRISPR. *CRISPR*, Clustered regularly interspaced short palindromic repeats; *Cas9*, CRISPR–CRISPR-associated gene.

## 4.6 CONCLUSIONS AND FUTURE PROSPECTS

The crop improvement using traditional pesticide or herbicide-resistant traits or improving the biocompatibility of biopesticides is time-consuming and labor-intensive. Most of the cases, the biopesticides are found inactive environmental conditions or impede the growth and development of agronomic crops. To eliminate such difficulties, the researchers are now switching towards RNAi-based biotechnological technologies for quality traits with enhanced protection against pathogens. However, the critical question comes; for example, can it be effective against the pathogens for a long time? Is it possible to extract and identify the microRNAs in a small volume? Or is there sufficient knowledge about the detailed mode of action of RNAi-based techniques? (Fig. 4.2). Based on these common aspects, the RNA-based technologies remain challenging over conventional pesticides or insecticides that are produced on a large scale. In reality, most of the genetically modified crops approved for commercial use are mainly designed to produce toxic proteins that are harmful to insects. However,



**FIGURE 4.2**

A hypothetical model demonstrating the ecological risk assessment of RNA-based crop protection.

there is no proper explanation or resources that could support the significant impact of using this new technology for crop improvement. Furthermore, the crop regulatory agencies and risk assessment analysts need to become familiar with this RNAi-based toolkit and its proper application during filed trails. The proper knowledge and understanding of the mode of action in various aquatic and terrestrial ecosystems will be a crucial part of the characterization of these RNAs. Novel diagnostic tools will probably eliminate these problems regarding the successful application of RNAi and genome editing tools soon.

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संपादक

डॉ. जगदीश भगत



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## संस्कृति और व्यवस्था के तानों-बानों में दम तोड़ती दलित जीवन की गाथा

(संदर्भ : एस. आर. हरनोट कृत 'हिडिम्ब')

श्री गौतम सिंह राणा

समकालीन हिंदी कथाकारों में एस. आर. हरनोट एक जाना-पहचाना नाम है। ये हिमाचली पार्वत्य-पृष्ठभूमि पर विपुलता के साथ लिखनेवाले एक महत्वपूर्ण कथाकार हैं। बीसवीं सदी के नवें दशक से निरंतर सृजनरत इस कथाकार के अब तक कुल आठ कहानी संग्रह, एक उपन्यास; हिडिम्बद्ध एवं हिमाचल की संस्कृति और जनजीवन पर पाँच महत्वपूर्ण पुस्तकों का प्रकाशन हो चुका है। हिमाचल प्रदेश के चनावग गाँव (जिला-शिमला) में जन्मे इस कथाकार ने हिंदी-पाठकों के मन को अपनी कथाओं के मार्फत बहुत ज्यादा आंदोलित किया है क्योंकि बचपन से लेकर अपनी समझदारी की उम्र तक इन्होंने जिस नैसर्गिक-सौन्दर्य-संपन्न पहाड़ी जीवन को जिया और साथ ही उसके खुरदुरे यथार्थ को अनुभूत किया, उसे इन्होंने जस का तस बड़ी कोमलता के साथ अपनी कथाओं में रख दिया है। तिस पर हिमाचली पार्वत्य समाज में टीस से भरे जीवन जीने को बाध्य दलितों की दूरदशा के कारणों की परत-दर-परत पड़ताल करने में उनकी लेखनी की तीव्र धार तो देखते ही बनती है।

हरनोट जी ने अब तक कहानियाँ ही ज्यादा लिखी हैं और उनकी अधिकांश कहानियों का विषय या अंतर्विषय हिमाचली पार्वत्य समाज से संबंधित दलितों के शसद जीवन के उत्तरदायी तत्वों; व्यक्ति तथा व्यवस्थाद्ध की कलाई खोलना रहा है। उनकी कहानियों के दलित प्रसंगों से गुजरते हुए हर एक सहृदय पाठक को अनायास ही इस अकृलाहट से गुजरना पड़ता है कि कहीं न कहीं कुछ कसक रह गई। संभवतः अपनी कहानियों के स्वपाठ ने लेखक को भी इसी स्थिति में डाल दिया; जिसका परिणाम 'हिडिम्ब' के रूप में पाठकों के सम्मुख प्रस्तुत हुआ। इस उपन्यास में उन्होंने बड़े दृष्टिकोण से विकास और संस्कृति की आड़ में व्यवस्था को हथियार की तरह इस्तेमाल

कर अपना उल्लू सीधा करनेवाली उन ताकतों का पर्दाफाश किया है जिसने हिमाचली समाज में दलितों को नारकीय जीवन जीने के लिए बाध्य किया है।

'सिद्धिम्ब' की कथा की बुनाहत हिमाचली समाज में संस्कृति व परंपरा के नाम पर लंबे अर्से से चली आ रही 'काहिका' उत्सव के बहाने वहाँ के दलित नड़ जाति के लोगों पर होते आ रहे अमानवीय अत्याचार व शोषण को चित्रित करने के क्रम में हुई है। कथा के केंद्र में शावणु नड़ का परिवार है। इस परिवार में शावणु के अतिरिक्त उसकी पत्नी सुरमा देई, बेटी सूमा एवं बेटा कांसी राम है। इस परिवार की सबसे बड़ी खासियत है कि यह पूरे परगने का एकमात्र नड़ परिवार है। एकमात्र इसलिए क्योंकि इस समाज में 'काहिका' उत्सव के बहाने इस समुदाय के लोगों को बली चढ़ाने एवं साथ ही कठोर जीवन यापन के कारण इस समुदाय के लोगों का दूसरे सहूलियत वाले प्रदेशों में चले जाने का काम काफी लंबे समय से होता आ रहा है। शावणु के पिता भी 'काहिका' उत्सव की बली चढ़ चुके हैं और बालक शावणु ने संस्कृति के नाम पर हुए मौत के निर्मम नृत्य को अपनी आँखों से देखा है। 'काहिका' में बलि चढ़ जाने के एवज में प्राप्त जमीन पर खेती बारी एवं पशुपालन कर शावणु का परिवार पल रहा होता है। इतने में मंत्री जी की लोलुप दृष्टि शावणु के जमीन पर पड़ती है और वह उसे येन-केन-प्रकरेण पाने के हथकंडे अपनाता है। शावणु और उसके परिवार को मानसिक रूप से तोड़ वहाँ से चले जाने को बाध्य करने के लिए मंत्री उसके बेटे को जहर देकर मार डालता है। इसका प्रभाव सबसे अधिक सुरमा देई पर पड़ता है। वह मानसिक रूप से विक्षिप्त होकर घर छोड़कर कहीं मर खप जाती है। ऐसी परिस्थिति में शावणु न चाहते हुए भी अपनी बेटी को मंत्री के कारिंदों से बचाने व उसके जीते जी कुछ समय के लिए ही सही दाम्पत्य सुख में जीते देखने के लिए पहाड़ पर काम करने आये एक ऑस्ट्रेलियन युवक से कार्टेक्ट मैरेज कर देता है। व्यवस्था तंत्र की इतनी ताकत लगाने पर भी जब उसे सफलता नहीं मिलती है तब वह अपने तंत्र की शक्ति का उपयोग संस्कृति को हथियार के रूप में प्रयोग करने के लिए करता है। एकमात्र बच्चे इस नड़ परिवार के खात्मे के उद्देश्य से वह असमय ही 'काहिका' उत्सव का आयोजन करता है। शावणु 'काहिका' उत्सव के सामाजिक दबाव से बाध्य होकर उसमें शरीक तो होता है पर ऐन वक्त पर वह अपने घर भाग आता है और मंत्री से छुपते-छुपाते अपनी जमीन को एक चौरिटेबल अस्पताल बनाने के लिए संस्था को दान में दे देता है। इस प्रकार वह बुढ़ापे में घर और भूमिहीन होकर अपना शेष जीवन अकेले ही जीने को बाध्य होता है।

"संस्कृति की आड़ लेकर धर्म का आडम्बरपूर्ण कर्मकांडी रुग्ण पक्ष जिस शक्ति आक्रामकता के साथ अपने को ईश्वर, अवतार, और उद्धारक के रूप में प्रस्तुत कर



अपनी प्रकृति पाता है, वह किसी भी सुसंस्कृत प्रबुद्ध समाज के लिए घातक है। लेकिन 'अग्रवाल' के घटाटोप में लिपटे पाखंड को बेनकाब करने का जुर्म कोई कैसे करे? संस्कृति व्यक्ति को मनुष्य के रूप में सिरजने का संस्कार है, और फिर अपने से किन्नार दूसरे को तमाम लौकिक-भौतिक भेद भुला कर मनुष्य के रूप में पहचानने की साधना। चूंकि परम्पराएँ समय के साथ नष्ट नहीं होती, बल्कि हर परिवर्तनशील पल के साथ अपने रूप को सुविधानुसार बदल कर वक्त के भीतर मानीखेज हस्तक्षेप करने की ताकत रखती है, इसलिए एक-दूसरे के तालमेल में अपना उल्लू सीधा करते विकास और संस्कृति के मूल मन्तव्यों को जानना भी बेहद जरूरी हो जाता है।" "ब्रह्मोत्तम जी रोहिणी अग्रवाल के इस कथन से शत प्रतिशत सहमति रखनेवाले कथाकार हैं। वे भी प्रबुद्ध समाज के प्रति प्रतिबद्ध कथाकार होने के नाते अपना लेखकीय दायित्व बलि-प्राप्ति समझते हैं। यही कारण है कि वे 'काहिका' उत्सव के दौरान नड़ जाति के प्रति होनेवाले अच्छे व्यवहार को सबर्णों का सांस्कृतिक ढोंग समझते हैं और उसके पीछे के काले सच को बयां करते हुए शावणु के बारे में कहते हैं— "वह जानता था कि उसकी 'नड़' जाति ऐसी है जिसकी जरूरत क्षेत्र के लोगों को कभी सात, कभी बारह तो कभी बीस-तीस बरस बाद 'काहिका' के लिए पड़ती है। जो नड़ इस उत्सव का मुख्य पात्र होता उसकी बुलंदी अचानक बर्फ ढकी चाटियों से भी ऊँची हो जाती। किन्नर, कैलाश, मणिकर्णिका और श्रीखण्ड महादेव से भी भव्य। वह ब्राह्मण हो जाता और फिर देवता बन जाता। यानी सर्वेसर्वा। शायद ईश्वर। जिसके पिदे देवता तक चलते। उनके पुजारी और गूर चलते। कारकुन चलते। गाँव-बेड़ और परगना चलता। बड़े बुजुर्ग चलते। बच्चे और जवान चलते। मंत्री और संतरी चलते। उसका यश आसमान में पहुँच जाता। वह नर से लेकर देवता तक के कष्टों और पापों का संहारक हो जाता। लेकिन जब जब उसकी जरूरत नहीं होती, तो वह अछूत, चंडाल बन जाता। गाँव-बेड़ के पिछवाड़े का एक आबारा कुत्ता। पूजा-पाठ करते हुए ब्राह्मण देख लें तो हजारों मन गालियाँ देने लगे। पानी छू ले तो अपवित्र हो जाए। देवता हो स्पर्श कर ले तो गुनहगार, अपराधी और कड़े दंड का अधिकारी।"

वर्तमान समय राजनीतिक भ्रष्टता एवं अवसरवाद का समय है। भारत जैसे जनतांत्रिक देश, जहाँ की अच्छी आबादी आज भी अशिक्षित है; में स्थिति और भी अधिक भयावह बनी हुई है। जनता के प्रतिनिधियों ने बड़ी आसानी से पुरी व्यवस्था पर अपनी मजबूत पकड़ बना ली है। न्याय व्यवस्था के प्रति जनता की आस्था बनी हुई रहने के बावजूद उसकी समयसाध्यता के कारण जनता परेशान व दिशाहारा बनी हुई है। ऐसी परिस्थिति में भारतीय समाज जहाँ सदियों से वर्ण-व्यवस्था की मानसिकता की चक्की तले दलित पिस रहे हैं; वहाँ तो उनकी स्थिति काफी कारुणिक बनी हुई

है। आजादी के इतने समय बाद भी नेता-मंत्री इनका शोषण बड़ी आसानी से व्यवस्था-तंत्र को अपना हथियार बनाकर कर पाने में सक्षम बने हुए हैं। हालाँकि कुछ प्रदेश इसके अपवाद भी हैं, जहाँ की जनता प्रबुद्ध समाज गढ़ने के लिए प्रतिबद्ध एवं जागरूक है। हानोट भी अपने समय के जागरूक व प्रतिबद्ध कथाकार हैं। इन्होंने इसी प्रतिबद्धता-निर्वहन के क्रम में इस उपन्यास के कतिपय स्थलों पर इन घट्ट व अवसरवादी जनप्रतिधियों के चेहरे को बेनकाब किया है एवं उनके द्वारा बुनी गई घट्टतंत्र के प्रत्येक तंतु को चिन्हित भी किया है। उपन्यास के एक स्थल पर जहाँ मंत्री को शावणु की जमीन पा लेने की क्षुधा जागती है, वहाँ कथाकार ने ऐसा ही विवरण प्रस्तुत किया है- "जमीन की खूबियाँ उसके मन में बैठ गई। तीव्र अभिलाषा हुई कि किसी भी किमत पर वह जगह हासिल हो जाए। वह उद्विग्न होने लगा। मन अस्त-व्यस्त हो गया। पागलपन के सघन नशे ने उसे जैसे अंधा कर दिया हो। उसी तरह जैसे कभी किसी सुन्दर पहाड़ी यौवना को देख लेता और मन उसे भोगने के लिए व्याकुल हो उठता। तब तक चूँन से न बैठ पाता जब तक लड़की उसके शयन कक्ष में न पहुँचाई जाती। उसके लिए वह किसी भी अवरोह को पार कर जाता। ऐसे कार्यों में उसके चमचे बराबर साथ देते। सभी इन्तजाम कर लिया करते। ये लोग कई तरह के मुछौटे पहने साथ होते। कहीं निजी स्टाफ के रूप में। कहीं क्षेत्र के छोटे-मोटे नेता या प्रधान के रूप में। कहीं कलक्टर, तहसीलदार और पटवारी के वेश में तो कहीं जनसेवकों के रूप में।" आगे जब नर हथियारों की जमीन एवं गायों से गोशाला-निर्माण द्वारा अपनी धर्मात्मा छवि बनानेवाले इन नेता-मंत्रियों के घोर अवसरवादी चरित्र का पर्दाफाश करते हुए कथाकार कहते हैं- "सभी गायों की पीठ पर मंत्री ने अपनी पार्टी का निशान खुदवा लिया। उनकी पीठ पर से बाल काटे गए और एक आधुनिक मशीन से उस जगह पार्टी का चिन्ह अंकित कर दिया गया। यह सिलसिला लगातार चलता रहा। अवसरवादी नेता ने जब भी दल बदला, या सरकारें बदलीं, तभी गायों की पीठ से पुराना निशान मिटा कर नया चिन्ह खुदवा लिया जाता।"

विभिन्न आर्थिक स्तरों पर जी रहे अमूमन एक समुदाय के लोगों के बीच के मनोवैज्ञानिक खिंचाव को नकारा नहीं जा सकता पर जब बात नौकरी, पद, प्रतिष्ठा बचाने की हो तो न चाहते हुए भी एक व्यक्ति के लिए अपने ही समुदाय के अन्य लोगों पर हो रहे अन्याय का विरोध कर पाना मुश्किल हो जाता है। उस उपन्यास में यही स्थिति धानेदार की है। वह भी दलित समुदाय का है। बावजूद इसके वह शावणु को 'काहिका' से भाग आने के कारण मंत्री के षडयंत्र के तहत मूर्ति के गहनों की चोरी के झूठे आरोप में गिरफ्तार कर धाने की कोठरी में बंद कर देता है। यहाँ मामला केवल दलित समुदाय से संबंध रखने का नहीं है बल्कि उससे भी बढ़कर इस भ्रष्टतंत्र

वं खहरधारियों की दुर्दमनीय शक्ति के सम्मुख नतमस्तक होने को बाध्य हो जाने का है। शावणु को उसके ही समुदाय के शोभा द्वारा जमानत पर लुहा ले जाते समय थानेदार का हवलदार मनीराम को दिया वक्तव्य इसी मामले की ओर संकेत करता है; जहाँ वह कहता है- "बई मनीराम! देखा तैने...उन दो बूढ़ों को...। हम साले पुलिसवाले बुत्ते से भी बदतर होते हैं। ...पर तु बता मनीराम, हम कर भी क्या सकते हैं...हमारे उपर जो ये साले खहरधारी बैठे हैं न, सारे खटमल हैं खटमल। हमारा ही खून बूसेंगे और हमारे ही बिस्तर में दुबक जाएंगे...लाख दूँडो...नहीं मिलते साले...। इनकी न तुनो तो बदली...। तु बता मनीराम मैं जैसा इस वर्दी में दिखता हूँ भीतर से भी वैसा हो हूँ? नहीं मनीराम नहीं...मैं वैसा नहीं हूँ...मैं...मनीराम...तेरी तरह हूँ...। सब मनीराम जब उस बूढ़े को मैंने कल शाम गालियाँ दीं तो मन से नहीं दी...।"

हरनोट जी एक विनम्र कथाकार हैं, लेकिन समय की कुरता को वे अपनी कथाओं में बड़ी सख्ती से पकड़ने की काशिश करते हैं। इनकी सबसे बड़ी खासियत है कि इन्होंने अपनी कथाओं में पहाड़ पर पहुँची मशीनी सभ्यता के बरक्स वहाँ के प्राकृतिक, सामाजिक एवं सांस्कृतिक वातावरण में आए क्षरण और उसके कुप्रभाव को बड़ी शिद्दत के साथ प्रस्तुत किया है। दैत्याकार मशीनों ने पहाड़ का सीना चीरकर जितना प्राकृतिक असंतुलन पैदा कर दिया है, उससे कहीं अधिक इसके साथ पहुँची नशाखोरी ने युवा पीढ़ी को बर्बाद किया है। इस नशाखोरी का दंश सबसे अधिक वहाँ के औसतन कम शिक्षित व कम जागरूक दलित समुदाय को झेलना पड़ा है। एक ओर इसने दलित युवाओं के भविष्य को चौपट तो किया ही है, दूसरी ओर नेता-मंत्री को इसे अपना हथियार बनाकर अपना स्वार्थ आसानी से साध लेने की सुविधा भी मुहैया करवा दिया है; जिससे दलितों का जीवन और भी अधिक कष्टमय बना है। इस उपन्यास में दलित पात्र शोभा के एकमात्र पुत्र का नशाखोरी के कारण मर जाना और नशाखोरी को हथियार बनाकर मंत्री द्वारा शावणु के पुत्र की हत्या का प्रसंग इसी बात की गवाही देता है। इन सब कारणों से पहाड़ में जो भयावह अजनबीयत की स्थिति बनी है, उसका चित्रण करते हुए कथाकार उपन्यास के एक स्थल पर कहता है- "शावणु को अब इधर-उधर आते-जाते लगने लगा था कि वह किसी अजनबी जगह पर आ गया है। यहाँ न पगडंडियाँ अपनी है न हाट-घराट। इस घाटी के गाँव-बेड़, जमीन-मिट्टी में एक अजनबीपन पसर गया है। नदी, घाटी, खेत-खलिहान की सुगंध जो हर तरफ फैली रहती उसमें भौंग-सुलफे की बास घुस गई है। न अपनापन, न अपनी बोली। देखते-देखते सब कुछ बदल गया है।"

हरनोट जी इस उपन्यास के मार्फत हिमाचली पार्वत्य समाज के प्रेम में हमारे पक्ष की बदनूमा सच्चाई को पिरोने का काम करते हैं। इस क्रम में वे हिमाचली

सामाजिक संरचना में दोहरा अभिशाप झेल रही स्त्रियों की दशा का भी चित्रण करते हैं। कट्टर जातिवादी मानसिकता के कारण हिमाचली समाज में जी रही दलित स्त्रियों की कारुणिक दशा का पता उपन्यास के स्त्री पात्रों- सूरमादेई और सूरमा से चलता है। पुत्रवियोग का दंश झेलती सूरमादेई अपना मानसिक संतुलन खोकर घर और समाज से दूर घली जाती है, तीस पर लोग उसके मर-खप जाने का अदेशा लगाकर उसकी सुधी तक नहीं लेते हैं। सूरमा को घर पर अकेला छोड़कर जाने और मंत्री के कारिदों के भ्रष्ट चरित्र की बात सोचकर शावणु भी उसे खोजने दूर तक निकल नहीं पाता है। सूरमा की स्थिति तो उससे भी अधिक दयनीय है। विवाह के योग्य उम्र तक पढ़ाने के बावजूद उस परगने में एकमात्र नड़ परिवार की आत्मजा होने के कारण उसका विवाह तक नहीं हो पाता है। मंत्री से बिगाड़ होने के कारण उसके कारिदों से उसकी ईज्जत बचाने के लिए शावणु एक आस्ट्रेलियन युवक से उसका कार्टेक्ट मैरेज करवाने के लिए बाध्य हो जाता है। न चाहते हुए भी परिस्थिति के आगे बाध्य होकर सूरमा को बेसहारा शावणु को बुढ़ापे में अकेले ही छोड़कर आस्ट्रेलिया जाना पड़ता है। किस प्रकार संस्कृति और व्यवस्था की मिलीभगत समाज में स्त्रियों को नारकीय जीवन जीने को बाध्य करता है, सूरमादेई तथा सूरमा का चित्रण इसका दृष्टांत है।

इस प्रकार हम देखते हैं कि 'हिडिम्ब' उपन्यास में हरनोट जी ने एक प्रबुद्ध अन्यायविहीन समाज के निर्माण के प्रति अपनी प्रतिबद्धता के बरक्स उसके मार्ग में रोड़ा बने हुए जनतंत्र एवं संस्कृति के पहरेदारों की कलाई परत दर परत खोला है और साथ ही हिमाचली समाज में जीनेवाले दलितों के नारकीय जीवन के मूल कारणों को मनुष्य की मनोवृत्तियों में खोजने का महत्वपूर्ण कार्य किया है। इसके कारण उनका यह उपन्यास संस्कृति व व्यवस्था के तानों-बानों में दम तोड़ती टीस से भरी दलित जीवन की गाथा के रूप में हमारे समक्ष प्रस्तुत हुआ है।

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Tuhin Subhra Santra  
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# Nanomaterials and Their Biomedical Applications

# **Springer Series in Biomaterials Science and Engineering**

Volume 16

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The Springer Series in Biomaterials Science and Engineering addresses the manufacture, structure and properties, and applications of materials that are in contact with biological systems, temporarily or permanently. It deals with many aspects of modern biomaterials, from basic science to clinical applications, as well as host responses. It covers the whole spectrum of biomaterials—polymers, metals, glasses and ceramics, and composites/hybrids—and includes both biological materials (collagen, polysaccharides, biological apatites, etc.) and synthetic materials. The materials can be in different forms: single crystals, polycrystalline materials, particles, fibers/wires, coatings, non-porous materials, porous scaffolds, etc. New and developing areas of biomaterials, such as nano-biomaterials and diagnostic and therapeutic nanodevices, are also focuses in this series. Advanced analytical techniques that are applicable in R&D and theoretical methods and analyses for biomaterials are also important topics. Frontiers in nanomedicine, regenerative medicine and other rapidly advancing areas calling for great explorations are highly relevant. The Springer Series in Biomaterials Science and Engineering aims to provide critical reviews of important subjects in the field, publish new discoveries and significant progresses that have been made in both biomaterials development and the advancement of principles, theories and designs, and report cutting-edge research and relevant technologies. The individual volumes in the series are thematic. The goal of each volume is to give readers a comprehensive overview of an area where new knowledge has been gained and insights made. Significant topics in the area are dealt with in good depth and future directions are predicted on the basis of current developments. As a collection, the series provides authoritative works to a wide audience in academia, the research community, and industry.

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# Nanomaterials and Their Biomedical Applications

 Springer



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# Preface

Nanomaterials are defined based on their size, which is one-billionth of a meter ( $10^{-9}$  m) in any one of its dimensions. In other words, “the materials with any external dimension or having an internal structure or surface structure in the nanoscale range.” In such extremely small size, materials exhibit unique and spectacular performance due to an increment of the surface to volume ratio. Materials, usually in the size range of 1–100 nm, show different physicochemical properties from their bulk. In the past two decades, several engineered nanomaterials have been established for different application purposes. After the rapid development of micro and nanotechnologies, fabrication of nanoscale structures and devices with exceptional sights of the supramolecular association has grown interest into a systematic way, and this has enhanced their perspective for an innovative connection in a huge variety of research areas, such as biology, chemistry, physics, engineering, computer science, etc. Nanoscale materials are progressively creating a foremost influence on human health, and they are used increasingly further for therapeutic and diagnostic applications. Nanotechnology plays a vital role in the current technological developments and plays an important role in diagnosing diseases, drug delivery, designing drugs, etc. This book intends to bring science and advanced nanotechnology together and their applications in cell biology and biomedical engineering. From a nanoscale and nanomaterial perspective, it highlighted different nanostructured material design, synthesis, processing, characterization, and potential applications. This book also covers different nanoscale and nanostructured materials for biomedical applications such as therapeutics, diagnostic, prosthesis, implant, drug discovery, and drug delivery, etc. An overview of nanomaterials’ progress and prospects and its biomedical applications are discussed with a series of reasoning and practical considerations.

This book contains 17 chapters, covering an extensive range of the critical aspects of nanomaterials for biomedical applications. Each chapter is contributed by professionals in their fields, and these chapters deliver technical information based on their valuable knowledge and skills. Possible glitches and challenges, as well as potential keys, are also deliberated with importance on prospects. Chapter “[Nanomaterials: An Introduction](#)” narrates brief advancement of nanotechnology to date. The different health-related problems that arise due to the application of

nanotechnology in medicine, food, agriculture, etc., are reported. Environmental nano pollution and its effect on society, social–economic disruption due to the rapid use of nanotechnology, safety and security of nanotechnological developments, and its future direction is also discussed. Chapter “[Metallic Nanoparticles for Biomedical Applications](#),” discusses the top-down and bottom-up approach and current trends in the synthesis of *metallic nanoparticles* for biomedical purposes. Further, it describes how the parameters can be tuned to get metallic nanoparticles with the desired shape, size, and crystallinity. Chapter “[Size and Shape-Selective Metal Oxide Nanomaterials: Preparation, Characterization and Prospective Biomedical Applications](#),” describes the different preparation methods for *metal-oxide nanomaterials* (MONMs), characterization techniques, and MONMs usage in different biomedical applications. The mechanism of interaction between nanomaterials and internal structures of microorganisms and institutes working on the nanomaterials standardizations is deliberated. Chapter “[Nanofibers and Nanosurfaces](#)” discusses the different synthesis routes associated with the development of nanofibers for cartilage regeneration. The fabrication and effect of nanosurfaces on metallic implants for enhanced chondrocyte conductivity are also highlighted. Chapter “[Nanoceramics: Synthesis, Characterizations and Applications](#),” narrates in detail the nanoceramics, their preparation methods, available characterization techniques, their unique properties, and their widespread biomedical applications arising due to their excellent properties. Chapter “[Biomedical Applications of Carbon-Based Nanomaterials](#),” discusses briefly carbon-based nanomaterials like Nanodiamonds (NDs), Carbon nanotubes (CNTs), Buckminsterfullerene (C<sub>60</sub>), Carbon quantum dots (CQDs), Carbon nanohorns (CNs), and its biomedical applications. Chapter, “[Solution Combustion Synthesis of Calcium Phosphate-Based Bioceramic Powders for Biomedical Applications](#),” gives an overview of the solution combustion synthesis of pure and doped hydroxyapatite powders and their characterization. This chapter also discusses the solution combustion synthesis of plasma sprayable hydroxyapatite powder, fabrication of coating, and characterization of the developed plasma-sprayed coating. Chapter “[Nanomaterials in Medicine](#),” outlines the various types of nanomaterials and their applications in the field of nanomedicine. The clinical applications of the nanomaterials in sepsis therapy, chemotherapy, and applications of nanomaterials in heart, kidney, lungs, brain diseases, etc., are discussed. Chapter “[Hydrogels: Biomaterials for Sustained and Localized Drug Delivery](#),” illustrates the synthesis, functionalization, tailoring mechanism of hydrogel matrix, followed by *in-vitro*, *ex-vivo*, and *in-vivo* characterization and drug loading/delivery efficiency. The different classifications of the hydrogel, along with its crosslinking chemistry, hydrogel nanocomposites biomedical perspective, and hydrogel applications ranging from lab scale to industrial level, are also discussed. Chapter “[Nanomaterials: Versatile Drug Carriers for Nanomedicine](#)” highlights the recent advancements and applications of nanocarriers for drug delivery in medicine, especially wound healing therapeutics and also different approaches to enhance drug cargo capacity, to improve cell entry efficiency, to avoid host immune systems and to achieve specific tissue targeting. Chapter “[Nanomaterials for Medical Implants](#),” discusses the general consideration of using nanomaterials in implantable devices, dental implants/prostodontics,

spinal orthopedic implants, and hip and knee replacements, cardiovascular implants, others—phakic intraocular lens and cosmetic implants. Chapter “[Fabrication of Nanostructured Scaffolds for Tissue Engineering Applications](#)” addresses different categories of biomaterials used to fabricate nanostructured scaffolds for tissue regeneration applications. The desired properties required for various tissue engineering scaffolds and its fabrication methods, merits and demerits, current development, and future directions of these methodologies are discussed. In addition to that, the special emphasis given on three dimensional (3D printing) technologies to manufacture tissue engineering scaffolds using various nanomaterials are also discussed in this chapter. Chapter “[Nanomaterials for Medical Imaging and In Vivo Sensing](#),” is devoted to nanomaterials for medical imaging techniques. The extensive information about the current developments in imaging systems, its advantages & disadvantages, the science behind individual imaging systems and the basic instrumentation, how the nano-based contrast agents are helpful in various biomedical applications are systematically discussed. Chapter “[Nanomaterials: Surface Functionalization, Modification, and Applications](#),” presents the various surface modifications and functionalization of nanomaterials, including metallic nanoparticles, carbon nanomaterials, nano-ceramics, and self-assembled materials for biomedical applications. Chapter “[Laser-Induced Micro/Nano Functional Surfaces on Metals for Biomedical Applications](#)” emphasizes the recent research works on laser processing such as selective laser melting (SLM), laser surface melting (LSM), laser surface patterning of various metallic implant materials and surface characteristics, and biomedical applications of processed surfaces are summarized. Chapter “[Surface Nanostructuring of Metallic Materials for Implant Applications](#),” provides detailed coverage of surface mechanical attrition treatment (SMAT) of stainless steels, Ti alloys, Ni-Ti alloy, CoCrMo alloy, and how the nanostructured surface enables an improvement in the characteristic properties that are suitable for biomedical applications. Chapter “[Tailoring the Surface Functionalities of Titania Nanotubes for Biomedical Applications](#),” deliberates the key electrochemical factors that control the nanotube geometry and demonstrate various surface functionalization approaches for tailoring the surface properties of TiO<sub>2</sub> nanotubes to develop new functional biomaterials for biomedical applications.

We hope this book can be pleasant reading material and, at the same time, a handy resource for students, scientists in academia, and professionals in industries working on various traits of nanomaterials.

Chennai, India  
Toyohashi, Japan

Tuhin Subhra Santra  
Loganathan Mohan

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# Nanomaterials: An Introduction



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**Abstract** Nanotechnology offers a significant advantage in science, engineering, medicine, medical surgery, foods, packing, clothes, robotics, and computing from the beginning of the twenty-first century. As the potential scientific discovery always contains some good and bad effects on human civilization and the environment, nanotechnology is not an exception. The major drawbacks include economic disruption along with imposing threats to security, privacy, health, and environment. The introduction of the chapter discusses the historical background of nanotechnology. Later it also discusses the advancement of nanotechnology to date with its benefits. Major drawbacks of nanotechnology arise in human health due to the enormous involvement in medicine, food, agriculture, etc. This chapter also deals with environmental nano pollution and its effect on society, highlighting the social-economic disruption due to the rapid use of nanotechnology. Nano pollution affects not only human beings but also other living beings like microorganisms, animals and plants, which are briefly reviewed. This chapter also demonstrates the safety and security of nanotechnological developments, current policy and regulation status, challenges, and future trends. Finally, it is concluded, while nanotechnology offers more efficient power sources, faster and modern computers and technologies, life-saving medical treatments, but due to some negative impacts, it bounds us to think twice before any further advanced technological applications.

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## 1 Introduction

Nanotechnology is an emerging field of science and technology with numerous applications in biomedical and manufacturing engineering [1–3]. In the last two decades, nanotechnology integrates with mechanical and electronic engineering to develop Micro/Nano-electromechanical systems (MEMS/NEMS) devices, which have diverse applications in different fields of science and engineering. These devices are potentially applicable for various sensing, actuating, and biomedical analysis purposes [4–13]. Recently, quantum dots have increased much attention in biological fields due to their unique size, tunable light absorption, and emission properties [14]. Further, biocompatible nanomaterials have many applications in biomedical purposes such as orthopedic, cardiovascular, contact lenses, catheter, prosthetic replacement, etc., [15–21]. Among noble metals, Ag and Au nanoparticles synthesis via marine algae are used as a broad-spectrum antimicrobial agent towards a variety of pathogens in the biomedical field [22]. Nowadays, nanomaterials are produced by industries for commercial applications with enormous benefits. While there lies a vast potential of nanomaterials for fulfilling individual requirements, it also represents potential risks to human health [23].

The green synthesis of nanoparticles attracts many researchers and industries. Many microorganisms are utilized for the synthesis of nanoparticles. Biosynthesis of nanoparticles has been reported using photoautotrophic microorganisms such as cyanobacteria, eukaryotic algae, and fungi. The biogenic fabrication of nanoparticles via microalgae is a non-toxic, and eco-friendly, green chemistry method with a large variety of compositions and physicochemical properties. Biosynthesis of nanoparticles by plant extracts is currently under exploitation. Plant extracts are a better source of nanomaterials compared to the various biological processes often considered eco-friendly substitutes of chemical and physical methods [1, 17]. Seaweeds contain different organic and inorganic substances that can benefit human health [24]. The green seaweed is used widely in agriculture, pharmaceutical, biomedical, and nutraceutical industries for its presence of a high amount of vitamins and minerals [25]. Among several genera of microalgae, *Spirulina platensis* is blue-green algae of the cyanobacteria family grown in temperate water in the whole world. A blue-green alga has served as food with high protein content and nutritional value from ancient times [26]. The algae produce novel and potentially useful bioactive compounds [27, 28]. The bioactive materials have gained significant attention in recent years and have been used considerably in developing new pharmaceutical products, food products, renewable bio-energy, and biomedical applications [29–31]. However, a new global health problem has been arisen as in discriminant antibiotic use and the remarkable ability of bacteria to acquire resistance to lower these drugs' effectiveness via genetic



mutation or gene acquisition. Therefore, new classes of antibiotics with novel structures are needed to combat this trend. Food preservation is now dealing with the severe concern of microorganisms mediated spoilage and fall in quality and nutrition worldwide [32]. Hence, increasing the continuous demand for pathogen control measures to combat resistant microorganisms against multiple antimicrobial agents. However, nanoparticles own large surface area to volume ratio, unique quantum size, magnetic properties, heat conductivity in addition to some catalytic and antimicrobial properties [33]. In this regard, nanomaterials, including metal nanoparticles, carbon nanotubes, quantum dots, and other active nanomaterials can be used to develop biosensors against a broad spectrum of microorganisms for the formulation of a new generation of antimicrobial agents.

## 2 Historical Background of Nanotechnology

The first experiment of nanotechnology was shown in 1857 when Michael Faraday introduced 'gold colloid' samples to the Royal Society. He added phosphorous to a solution of gold chloride and, after a short while, noted that the blue color of the solution changed to a ruby red dispersion, without knowing the actual cause of color changing. Indeed, the resulting suspension of nanosized gold particles in solution appeared transparent at some frequencies, but others could look colored (ruby, green, violet, or blue). Since then, many experiments and theoretical studies have been carried out to explain similar systems' unique properties, which in today's terminology are called low-dimensional systems. Nearly after 100 years, in 1959, Richard Feynman inspired the field of nanotechnology in his lecture at the American Physical Society (APS) meeting, Caltech, saying the meaningful words "There's Plenty of Room at the Bottom." From the late 1980s, we find there is a growth of activity on these low dimensional materials. In general, low dimensional systems are categorized as follows: (a) two dimensional (2D) systems, in which the electrons are confined in a plane (e.g., Layered structures, quantum wells and superlattices); (b) one dimensional (1D) systems, in which electrons are free to move only in one dimension (e.g., linear chain-like structures, semiconductor quantum wires), and (c) zero-dimensional (0D) systems, where electrons are confined in all three dimensions (e.g., quantum dots, clusters, and nanosized colloidal particles) [34–41].

The dimension of these materials in the direction of confinement lies in the nanometer scale, given the name nanomaterials. In this length scale, classical physics fails to explain the behavior of these materials. Instead, one needs quantum mechanical concepts. Interestingly, due to quantum effects, the physical properties of nanomaterials change drastically from their corresponding bulk behavior. This unique feature of nanomaterials has been exploited by modern technology in various applications. The link between human life and nanotechnology is as old as Ayurveda, a 5000-year-old Indian medicine system.

Moreover, twenty-first century modern science marks the beginning of nanoscience, while it existed from ancient times of Vedas, much before even the

term “nano” was coined [42, 43]. As per strict nanometer terminology, any objects with dimensions in the nm range can be termed as a nanoparticle or a “nano” object, as TiO<sub>2</sub> dust in the study mentioned above [44]. Nanotechnology not only combines engineering, physics, and chemistry but also integrates with biology [45]. A physicist generally tries to identify and quantify nanomaterials’ fundamental interactions with different surrounding systems such as the thermodynamics, the interface of the nanoparticles with the liquid, and the role of mechanical properties (e.g., stiffness, elasticity, adhesion), etc.

Past three decades, extensive work has been performed to develop new drugs from natural products, because of the resistance of microorganisms to the existing drugs [46]. Researchers from the Indian Institute of Technology Bombay, India, have discovered that the age-old complementary medicines of Homeopathic pills and Ayurvedic Bhasmas are having metal nanoparticles such as gold, silver, copper, platinum, tin, and iron [46, 47]. Metallic nanoparticles (mainly silver and gold) have unique optical, electrical, and biological properties, that have attracted significant attention due to their potential use in many applications, such as catalysis, ultra-sensitive chemical and biological sensors, bio-imaging, targeted drug delivery and nanodevice fabrication [13, 48–57]. Recently, various industries like electronics, aerospace, cosmetics, textile, and even food use nanoparticles. Consequently, the chance of human exposure to nanoparticles rises, heading towards the time when nanoparticles are eventually present in blood circulation and interacting with immune blood cells.

Nanoparticles can be synthesized via various chemical and physical routes such as chemical reduction, [58–60] photochemical reduction, [61–65] electrochemical reduction, [66, 67] heat evaporation, [68, 69], etc. In all the above-mentioned methods, the reagents can be from different properties, i.e. inorganic such as sodium or potassium borohydrate, hydrazine, and salts of tartrate, or organic ones like sodium citrate, ascorbic acid, or amino acids, capable of getting oxidized. Various options are also available to work as a stabilizing agent. Several studies have reported shape and size dependency of silver nanoparticles formation on capping agents such as dendrimer, [70] chitosan, [71] ionic liquid, [72], and poly (vinylpyrrolidone) PVP [73]. These capping agents control the nanoparticle growth via reaction confinement within the matrix or preferential adsorption on specific crystal facets. Since these approaches are costly, hazardous, toxic, and non-environment friendly, hence, evaluation of the risk of these nanoparticles to human health becomes critical. Multiple studies have shown the increase in the number of leukocytes, mainly neutrophils, in the lungs and bronchoalveolar lavages during airway exposure of nanoparticles *in-vivo* models of inflammation. The neutrophil counts act as biomarkers for inflammation. Therefore, the selection of a synthesis route that minimizes the toxicity and increases nanoparticle stability leads to enhanced biomedical applications of silver and gold nanoparticles. The development of better experimental procedures for the synthesis of nanoparticles employing a variety of chemical compositions and controlled polydispersity offers considerable advancement [74]. Methods of nanoparticle production through different physical and chemical routes, as stated above, have their demerits as they produce enormous environmental contaminations

and hazardous byproducts. Thus, there is a need for “green chemistry” that ensures clean, non-toxic, and environment-friendly nanoparticles production [75].

In recent years, environment-friendly approaches have been developed to fabricate stable nanoparticles with well-defined morphology and configured constricted sizes [76]. Additionally, owing to the high demand for precious metals (like silver and gold) and metal oxides in electronics, catalysis, medical, and other industrial applications, its recovery from primary and secondary sources is of considerable significance and interest. Biological recovery of these precious metals by preparing their nanoparticle is a green alternative to the conventional physical and chemical methods [77, 78]. Bio-inspired synthesis of nanoparticles is an advanced, cost-effective, environment-friendly approach over chemical and physical processes, without any inclusion of high pressure, energy, temperature, and toxic chemicals [79]. For example, the plant leaf extract is used for the biosynthesis of silver and gold nanoparticles for pharmaceutical and biomedical applications, without employing any toxic chemicals in the synthesis protocols [80]. An environmentally acceptable solvent system, eco-friendly reducing and capping agents are considered to be an essential element for an ultimately “green” synthesis [81]. The green synthesis techniques are generally utilizing relatively non-toxic chemicals to synthesize nanomaterials. The fabrication process also includes the use of non-toxic solvents such as water, biological extracts, biological systems, etc. In this technique, generally, microwave maintains a constant temperature of solvent systems. The conventional extraction technique using hexane, ethanol, and water was used to collect bioactive molecules [82]. However, they are immensely problematic due to instability as well as environmental and health hazards [83]. To overwhelm this problem, researchers developed a new approach, i.e., supercritical fluid (SCF) extraction technology for avoiding toxic organic solvents in green technology. SCF possesses physical properties intermediate between CO<sub>2</sub> gas and a liquid at a temperature and pressure above its critical point. Since supercritical CO<sub>2</sub> is non-polar, non-toxicity, non-flammability, and low critical temperature.

### 3 Benefits of Nanotechnology

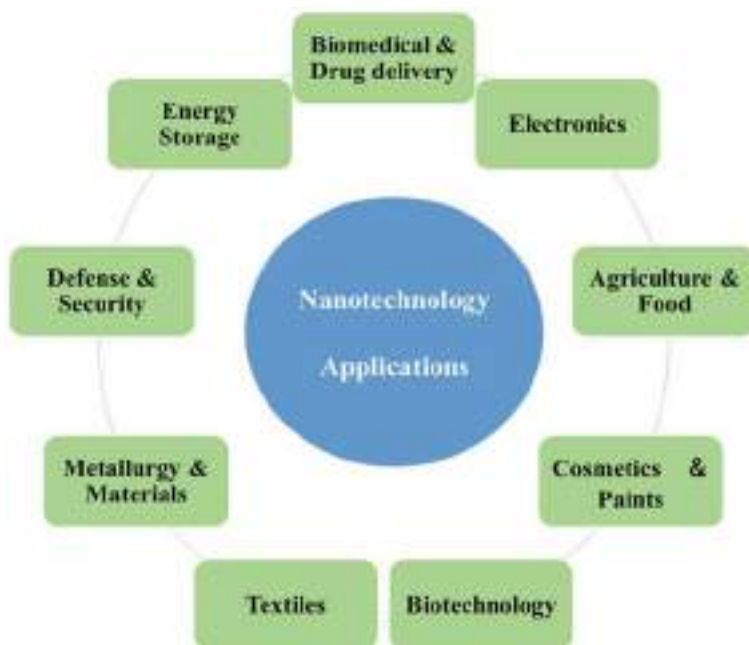
Recently, research and development in nanotechnology have seen exponential growth due to advantages in different fields, i.e., drug delivery, cell imaging, material improvement, and medical devices for diagnosis and treatment. More powerful computers are being designed using nanomaterials in a smaller size, faster in speed, and consuming very less power, having long-life batteries. Circuits consisting of carbon nanotubes can maintain the computer system advancement. Carbon nanotubes are also commercially used in sports equipment, to increase their strength while maintaining a low weight. Nanoparticles or nanofibers in fabrics improve the water-resistance, stain resistance, and flame resistance, without putting on extra weight, stiffness, or thickness of the material. Nanoparticles are used in medical products for dermal, oral or inhalation applications, and pharmaceuticals. These are

also used in various consumer products, including cosmetics, food, and food packaging. The nanomaterials having potential uses in cosmetics include nanosilver, nanogold, nanoemulsions, nanocapsules, nanocrystals, dendrimers, fullerenes, liposomes, hydrogels, and solid lipid nanoparticles. Smaller the size, corresponding to the higher surface area of nanomaterials offer greater strength, stability, chemical, physical, and biological activity. Nanomaterials present in the human environment can be primarily classified into four categories: carbon-based nanomaterials, metal-based nanomaterials, dendrimers, and composites. The carbon-based nanomaterials (fullerenes and nanotubes) are employed in thin films, coatings, and electronics.

The metal-based nanomaterials (i.e., nanosilver, nanogold, and metal oxides (i.e., titanium dioxide ( $\text{TiO}_2$ )) are useful for food, cosmetics, and drug-related products. The dendrimers are nano-polymers, an ideal candidate for drug delivery. Composites such as nanoclays are formed with a combination of nanoparticles with other nanosize or larger particles. Many beverage bottles are made up of plastics with nanoclays. The nanoclay reinforcement increases permeation resistance to oxygen, carbon dioxide, moisture, and thus retaining carbonation, pressure with increased shelf life by several months. Nanoclays are also being used in packaging materials.

Different classes of nanomaterials are composed of nanoparticles with different shape, size, and chemistry and biology. Nanotechnology helps to improve vehicle fuel efficiency and corrosion resistance by building vehicle parts from Diamond-Like-Nanocomposite (DLN) materials that are lighter, stronger, and more chemically resistant than metal [84–88]. The DLN film exhibits biocompatibility in nature, which has potential applications as a coating material for biomedical purposes [89, 90].

A few nanometers wide water filters can remove nanosized particles, including virtually all viruses and bacteria, which can revolutionize the water filtration method. These cost-effective, portable water-treatment systems are ideal for the improvement of drinking water quality in developing countries. Nowadays, most sunscreens also contain nanoparticles for effective absorption of light, including the more dangerous ultraviolet range and passing the other wavelengths, which is healthy for the skin. Recently, nanosensors can be programmed to detect a particular chemical at low levels, such as a single-molecule detection, out of billions of molecules. This capability is ideal for security systems and surveillance at labs, industrial sites, and airports. In medical science, the detection of single biomolecules has tremendous DNA/RNA sequencing and disease analysis applications. The nanobiosensors can be used to precisely identify particular cells or substances in the body for different diagnostics purposes. Current research is focused on preparing the smaller, highly sensitive, and cost-efficient biosensors. The new biosensors are updated to even detect odors specific diseases for medical diagnosis, pollutant detection, and gas leaks for environmental protection. Figure 1 shows the technological tsunami that occurs due to nanotechnology in energy storage, defense & security, metallurgy & materials, electronics, optical engineering & communication, biomedical & drug delivery, agriculture & food, cosmetics & paints, biotechnology, textile, etc. [91]. According to Zion market research analysis in 2017 [92], there is a rapid increase of global nanomaterials market volume (in kilo tons) and revenue (in USD Billion), which is estimated from 2014 to 2022, is shown in Fig. 2a. Other statistical surveys



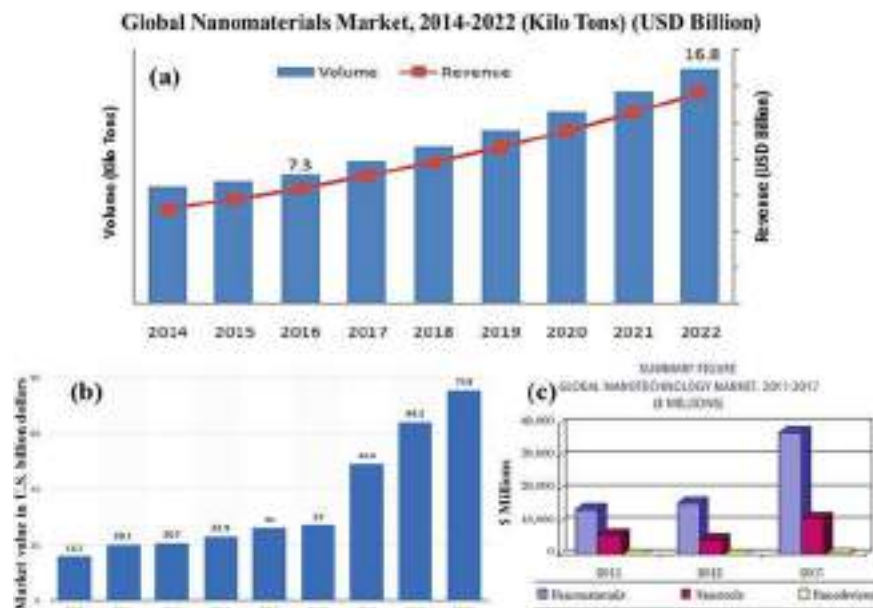
**Fig. 1** Technological tsunami due to nanotechnology. Redrawn from [91]

from two different agencies (see Fig. 2b and c (BCC research)) also confirmed the rapid increase of the global nanotechnology market of nanomaterials, nanotools, and nanodevices, etc. [93, 94].

## 4 Nanotechnology in Health

### 4.1 *Potential Routes for Nanomaterials to Enter into the Human Body*

Nanomaterials can enter into the human body in various ways. Potential routes nanomaterials enter the human body are ingestion, inhalation, and skin absorption [95–97]. Many nanomaterials are employed in drug transport or cell imaging via intravenous entry to the human body. In the body, nanomaterials are translocated throughout the body by blood circulation. For the purpose, the nanoparticles must fulfill the requirement of permeability across the barrier of the blood vessel wall. Absorption through the skin serves as an alternate route of entry for nanoparticles inside a human body. The skin is the largest organ of the human body, provides a large surface area for interactions with the external environment.  $\text{TiO}_2$  nanoparticles can take either



**Fig. 2** a Rapid increase in global nanomaterials market volume (Kilo Tons) and revenue (USD Billion) for the period of 2014–2022 [92]. *Source* Zion market research analysis, 2017. b The global market value of nanotechnology from 2010 to 2020 (in Billion USD) [93]. c Global nanotechnology review for nanomaterials, nanotools, and nanodevices market from 2011 to 2017 (in Million USD). *Source* BCC Research [94]

route for entry, i.e., the lungs or gastrointestinal tract. Nanomaterials can enter the body through the skin for various reasons, such as the use of medicine, cosmetics, ointments, and use of clothes containing nanomaterials, occupational contact in the industry, etc. Soaps, shampoos, toothpaste, hair gels, creams, and some cosmetics containing the nanosilver, which can enter into the body through the skin.

Cream or solution containing Silver nanoparticles is used to treat wounds, burns, etc. to prevent infections and damaged skin. The penetrating ability depends on the size of the nanoparticles. The smaller the nanoparticle, has the more exceptional penetrating ability. The inhaled particulate matter gets accumulate in the human respiratory tract, while one significant portion of those inhaled particles gets deposited in the lungs. Nanoparticles also can travel across the placenta in pregnant women to the fetus along with other organs, i.e., brain, liver, and spleen. The effects of inhaled nanoparticles in the body may include lung inflammation and heart disease problems [95]. The pulmonary injury and inflammation resulting from the inhalation of nano-sized urban particulate matter appear due to the oxidative stress imposed by these particles in the cells [98–101]. The first reported nanoparticle is nanosilver, which can damage DNA molecules. Silver nanoparticles have the most harmful effects on the most sensitive biological groups [98, 102–105]. This nanoparticle can enter into the blood through the skin. Silver binds with the thiol group of some proteins. If

silver complexes with thiol groups are located near-skin region, it gets readily available to get reduced either by visible or UV light into metallic nanosilver particles. Therefore, the immobilization of silver nanoparticles takes place in the skin. Further, the effect of nano copper-induced renal proximal tubule necrosis in kidneys has been reported by Liao and Liu [106].

## ***4.2 Nanomaterials for Therapy and Diagnostics***

Nanoparticles in pharmaceutical products facilitate improved absorption within the human body and easy delivery, often in association with medical devices. For example, magnetite, a metal oxide, has high potential applications in nanomedicine. Nanoparticles can assist the targeted delivery of chemotherapy drugs to specific cells, i.e., cancer cells. Superparamagnetic iron oxide nanoparticles (SPIONs) and ultra-small superparamagnetic iron oxide (USPIO) have also proved its significance for targeted drug delivery [107]. Nanoparticles improve the solubility of poorly water-soluble drugs, increase drug half-life, modify pharmacokinetics, improve bioavailability, diminish drug metabolism, assist controlled and targeted, and combined drug delivery [98, 108–111]. According to the International Agency for Research on Cancer (IARC) data, estimates of nearly 13.1 million deaths due to cancer by 2030. It is evident that the low survival rate occurs not because of the scarcity of potent, natural, or synthetic antitumor agents but owing to inadequate drug delivery systems. Hence develops the requirement of technology advancement to establish carriers and delivery systems capable of targeted and efficient delivery of the chemotherapeutic agents without unwanted systemic side effects [112]. The solid lipid nanoparticles and nanoemulsions are the most employed lipid-based drug delivery particles. However, nanosilver based commercial products are capturing the market. The newly developed nanomaterials for theranostics are being employed alone or in association with “classical” drugs, e.g., cytostatic drugs, or antibiotics. Theranostics is a combined term for nanomaterials with diagnostic and therapeutic properties [111].

## **5 Drawbacks of Nanotechnology**

Nanomaterials are being employed in different industries and everyday life. Therefore, the interplay of nanomaterials and social surroundings is worth scientific exploration. Nanomaterials with several benefits can be toxic. Various studies also confer the effects, as mentioned above, indicating the potential toxicological effects on the human environment [98]. Different toxic and hazardous effects of nanotechnology are briefly discussed below.

## 5.1 Toxicity of Nanomaterials

Greater human exposure of nanomaterials presents in the environment; more significant is the harmful effect on human health. The assessment of the cytotoxicity of nanomaterials assists in the proper elucidation of the biological activity. Gerloff et al. reported the cytotoxicity of various nanoparticles, such as zinc oxide (ZnO), SiO<sub>2</sub>, and TiO<sub>2</sub>, on human Caco-2 cells [113]. Shen et al. [114] showed the human immune cells are prone to toxicity due to ZnO nanoparticles [115]. The ZnO nanoparticles damage mitochondrial and cell membranes in rat kidney, ultimately leading to nephrotoxicity [115]. Generally, the nanomaterial toxicity mechanism comprises reactive oxygen species formation and genotoxicity. However, as described earlier, the toxicity of ZnO nanoparticles mainly affects immune cells. Various nanomaterials with their diverse sizes alter mitochondrial function. For example, ZnO nanoparticles generate Zn<sup>2+</sup> ions, which disrupts charge balance in the electron transport chain in the mitochondria and therefore triggers reactive oxygen species generation. Nanosilver particle has a genotoxic effect. A 20-nm nanosilver has a genotoxic effect on human liver HepG2 and colon Caco2 cells. It has also increased mitochondrial injury and the loss of double-stranded DNA helix in both cell types [116]. Inhalation of TiO<sub>2</sub> nanoparticles resulted in pulmonary overload in rats and mice with inflammation [117, 118]. The cytotoxic and genotoxic effects of TiO<sub>2</sub> nanoparticles on the human lung were reported by Jugan et al. [119]. TiO<sub>2</sub> nanoparticles are genotoxic, and it can induce pathological damage of the liver, kidney, spleen, and brain. Du et al. reported cardiovascular toxicity of silica nanoparticles in rats [120]. The surface coating of quantum dots causes toxicity to the skin cells, including cytotoxicity and immunotoxicity [121]. Nanosilver is used in wound dressings, affects both keratinocytes and fibroblasts. Fibroblasts show higher sensitivity towards nanosilver than by keratinocytes. Again, iron oxide nanoparticles rapidly get endocytosis on cultured human fibroblasts and interrupt the function. Citrate/gold nanoparticles have shown toxicity on human dermal fibroblasts [122]. Carbon nanotubes have high toxicity and produce harmful effects on humans. The nanoparticles can penetrate the lungs, then reached the blood and acted as a barrier for the circulation of blood into the brain. They can also enter inside other organs like bone marrow, lymph nodes, spleen, or heart. Sometimes, nanoparticles can incite inflammation, oxidant and antioxidant activities, oxidative stress, and change in mitochondrial distribution. These effects depend on the type of nanoparticles and their concentrations [101]. Copper nanoparticles (diameters 40 nm and 60 nm) harm brain cells at low concentrations. It activated the proliferation of the endothelial cells in brain capillaries. Ag nanoparticles (25, 40, or 80 nm) influenced the blood-brain barrier, causing a pro-inflammatory reaction, which might induce a brain inflammation with neurotoxic effects [123]. Smaller Ag nanoparticles (25 nm and 40 nm diameter) can induce cytotoxic effect at a higher rate than larger nanoparticles. Nanoparticles also have harmful effects on the brain cell of the mouse and rat. The high concentration of nanoparticles can affect brain blood fluxes, with consequent cerebral edema. Pathogenic effects of Ag-nanoparticles (25, 40, and 80 nm diameter), Cu-nanoparticles (40 and 60 nm), and Au-nanoparticles

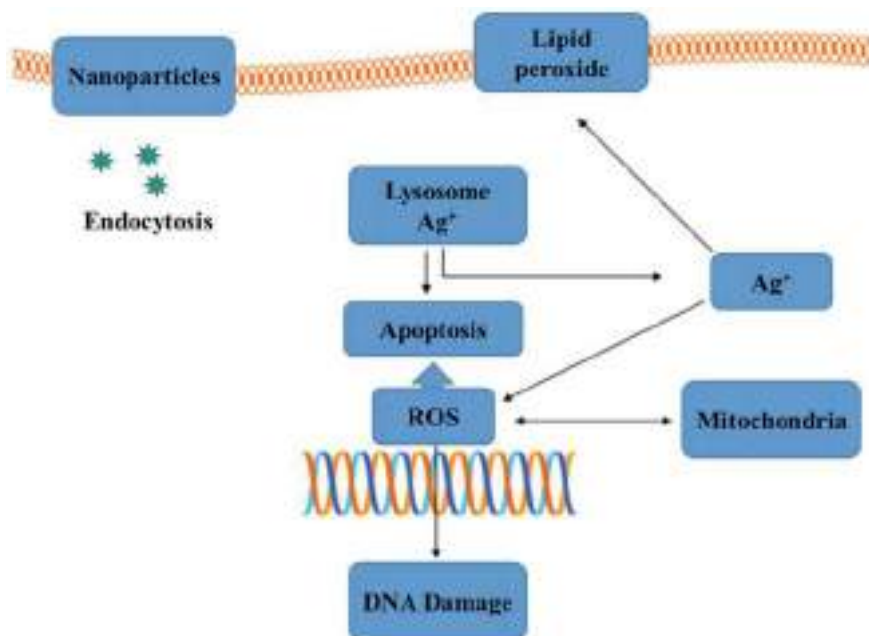


(3 and 5 nm) on the blood-brain barrier of the pig have been reported [124]. Silver nanoparticles (45 nm) influenced the acetylcholine activity via nitric oxide generation; it induces hyperactivity of rat tracheal smooth muscle [125]. It is also reported that Ag- nanoparticles (25 nm) produced oxidative stress after the injection into the mouse. The nanoparticles were aggregated in the kidneys, lungs, spleen red pulp, and the nasal airway, with no observable morphological changes apart from the nasal cavity [126].

Very few cells do not undergo morphological changes after withstanding the air-liquid interface culture for an extended duration. Au-nanoparticles (5 nm and 15 nm diameter) penetrated the mouse fibroblasts, where they remained stocked. Only the presence of 5 nm Ag-nanoparticles disrupted cytoskeleton resulting in narrowing and contraction of cells. Many engineered nanomaterials, such as TiO<sub>2</sub>, magnetite iron, CeO<sub>2</sub>, carbon black, SWCNTs, and MWCNTs, also might cause different levels of inflammatory reactions, including enhanced pro-inflammatory cytokines expression, target inflammation-related genes, and micro-granulomas formation [127, 128]. The intra-tracheal administration of MWCNTs with variable length and iron content in hypertensive rats led to the lung inflammation with increased blood pressure and lesions in abdominal arteries along with accumulation in multiple organs i.e., liver, kidneys, and spleen post seven days and 30 days exposure [129]. Maneewatttanapinyo et al. studied acute toxicity of colloidal silver nanoparticles administered in laboratory mice and observed no mortality any acute toxicity symptoms after a limited dose of 5.000 mg/kg post 14 days of oral administration. No differences could be observed among groups after hematological and biochemical assessment and the histopathological study. The instillation of silver nanoparticles at the concentration of 5.000 ppm developed a transient eye irritation for 24 h. The application of these nanomaterials on the skin did not produce any micro or macroscopic toxicity [130]. The schematic mechanism of silver nanoparticle's toxicity in the human body is shown in Fig. 3 [131]. The liver and spleen are maximum exposed organs to nanomaterials owing to the prevalence of phagocytic cells in the reticuloendothelial system. Also, the organs with high blood flow, such as kidneys and lungs, can be affected.

## ***5.2 Health Hazards in Human***

Despite having many benefits and using nanomaterials, it may cause health hazards to humans due to a tiny size. The broad absorption surface of the lung, the thinner air-blood barrier, and comparatively less inactivation of enzymes leads to faster entry for particles into the systemic blood circulation at higher drug concentrations. Additionally, intended uptake, exposure of airborne particles from the environment, and nanoparticles released during the manufacturing process may also cause health hazards for humans. Usually, nanomaterials' biological effects are based on their size, composition, shape, and even on their electronic, magnetic, optical, and mechanical



**Fig. 3** Mechanism of silver nanoparticles toxicity (Abbreviations: NPs—nanoparticles; ROS—reactive oxygen species; Ag+—silver ions) Redrawn from [131]

properties. Presently, the influence of nanotechnology on human health and the environment is still controlled. Most of the studies assessed the outcomes of unintentional and accidental exposure (inhalation, medical procedures, or accidental ingestion) and focused only on local effects [98, 99]. Though, along with introducing nanomaterial-based biomedical methods, it is mandatory to analyze their toxicity at a systemic level. Centuries before, Paracelsus said, “everything is a poison, and nothing is a poison, it is only a matter of a dose.” For nanomaterials, it is applicable in both the aspects of dose and particle size [100]. There is a massive demand for nanomaterials in various applications, ranging from diagnostic technology, bio-imaging, to gene/drug delivery [132–145]. Therefore, intended or unintended human exposure to nanomaterials is unavoidable and has higher prospects of exposure. Thus, a branch of science is developing, named “nanotoxicology”, the study of the toxicity of nanomaterials. Nanotoxicology assesses the role and safety of nanomaterials on human health. Several anthropogenic sources, like power plants, internal combustion engines, and other thermo-degradation reactions also generate nanoparticles and develop the need to assess them [101].

### **5.2.1 Hazards in Nanomedicine**

The nanomaterials represent a variety of biomedical applications. However, there is some potential risks factor related to the toxic issue. For example, oxidative stress, cytotoxicity, genotoxicity, and inflammation have been reported on in vitro and in vivo models for testing nanoparticles. The difference in the size of nanomaterial and bulk comes with the differences in properties and toxicity. Nanomaterials are tremendously beneficial yet can be toxic. Ag, ZnO, or CuO nanoparticles are frequently used as bactericides [102]. Nevertheless, waste disposal in the environment can also negatively affect non-target organisms.

### **5.2.2 Hazards in Medical Instrumentation**

Nanomaterials are involved in medical interventions like prevention, diagnosis, and treatment of diseases. More functional and accurate medical diagnostic equipment are being designed for easy and safe operation. The lab-on-a-chip technology facilitates real-time point-of-care testing, enhancing the standards of medical care. Nanomaterial based thin films on implant surfaces improve the wear and resist infection. However, until now, these medical nanodevices are not 100% hazard free due to manufacturing processes, not following guidelines of nanotoxicity, and operating without the assessment of long term effects of nanotoxicity.

### **5.2.3 Hazards in Food Product**

Nanotechnology is used to produce advanced food products and smart packaging technology [146–148]. In this way, the possibility of direct exposure to nanomaterials with human beings is enhanced, and different types of long-term or short-term toxicity may occur [149–151]. Nanoparticles and diamond-like nanocomposite (DLN) thin films are used in food packaging to reduce UV exposure and prolonged shelf life. Due to very few articles being reported in this area, further research is needed to fully explore the potential use of these nanoparticles for food products and medical treatments.

## **6 Environmental Nanopollution and Its Effect in Society**

Environment conservation is a challenging task. Its vastness and complexity make this even more difficult. As nanomaterials' production is growing, multiple issues concerning nanotechnology arise as environmental pollution and industrial exposure. Nanoparticles serve as pollutants in diesel exhaust or welding fumes, presenting new toxicological mechanisms [152, 153]. It also makes us face pollution in macro, micro,

and nanoscale. New branches of electronics are also creating new sources of occupational exposure hazard. The circumstances produce new challenges for both classical toxicology and nanotoxicology. Though nanotechnology improves the living standard, a simultaneous increase in water and air pollution has also occurred. As the origin of this pollution lies in nanomaterials hence termed “Nanopollution.” Nanopollution is exceptionally lethal to both underwater flora and fauna and organisms living on soil. The pollutants can enter the human body in multiple ways. Cellular mechanisms can get affected by nanomaterial toxicity, which mainly comprises reactive oxygen species generation and genotoxicity [153–155]. The nanoparticle’s exposure on humans can occur accidentally by environmental particles (e.g., air pollution) and intentionally because of a variety of consumer products, cosmetics, and medical products containing nanoparticles. The release of nanoparticles during the manufacturing process may result in exposure to workers via dermal, oral, and inhalation routes. Exposure to air pollutants, such as ultrafine particles, is known to cause inflammatory airway diseases and cardiovascular problems in humans [156]. Pope et al. [157] stated that even low levels of ambient nanoparticle exposure have a significant effect on mortality. To decrease nano pollution, scientists and researchers used nanotechnology to develop nanofilters, eliminating almost all airborne particles [158].

## **7 Social-economic Disruption Due to Rapid Use of Nanotechnology**

As the speed of nanotechnology development is growing, as a consequence, the job opportunities are decreasing, arising the problem of unemployment in fields like industrial sector, manufacturing, and traditional farming [159, 160]. Nanotechnology-based devices and machines have replaced humans to furnish the job more rapidly and efficiently, which has pointed out the importance of human resources in practical work. Increasing growth and instant performance of nanotechnology have compromised the worth of commodities like diamond and oil. As an alternative technology, i.e., Nanotechnology has a detrimental effect on demand as substitutes have more efficiency and do not need fossil fuels. Diamonds are losing the worth due to greater availability from nanotechnology-based fabrication methods. Currently, manufacturing companies are equipped to produce the bulk of these products at a molecular scale, followed by disintegration to create new components.

At present, nanotechnology involves high investment technologies, raising the cost daily. The high price is the result of intricate molecular structure and processing charges of the product. The whole process makes it difficult for manufacturers to produce dynamic products using nanotechnology randomly. Currently, it is an unaffordable business owing to the massive pricing of nanotechnology-based machines. Hence, nanotechnology can also bring financial risks as manufacturers have to invest a large sum of money for setting up nanotech plants. The manufacturers have to

face a considerable loss if, by any chance, the manufactured products fail to satisfy the customers. Alternate options such as the recovery of the original product or maintenance of the nanomaterials are also a costly and tedious affair.

Further, nanotechnology does not leave any byproducts or residues, generally based on small industries, therefore creating a considerable risk of extinction for small scale industries. As an outcome, the quantity of sub-products of coal and petroleum is deteriorating. Another massive threat, like the Covid-19 pandemic situation, may be born with the arrival of nanotechnology. It can make the easy accessibility of biochemical weapons or nano-bio engineered biological weapons. Nanotechnology is making these weapons more powerful and destructive. Unauthorized criminal bodies or corrupt politicians can steal the formulations and may reach these dangerous weapons easily, and they can quickly destroy our civilization [161].

## **8 Effect of Nanotechnology on Microorganisms, Animals, and Plants**

Some nanomaterials are hazardous to human beings and are also harmful to the existence of different microorganisms, animals, and plants. Human-made nano pollution is very unsafe for living microorganisms, animals, and plants under the water or on the earth. As a result, many of microorganism's families have entirely disappeared from the world. Due to the rapid application of nanotechnology in the agriculture sector without proper nanotoxicological analysis, many plants are directly exposed to nanotoxicity, and animals are indirectly exposed. Thus, in the last two decades, a vast number of valuable plants and animals are entirely disappeared from our world.

## **9 Safety and Security of Nanotechnological Developments**

Nanotechnology is an extensively expanding field. Researchers, scientists, and engineers are getting high success in producing nanoscale materials and taking advantage of enhanced properties, such as higher strength, lighter weight, increased electrical conductivity, and chemical reactivity compared to their larger-scale equivalents [162, 163].

Human health concerns are also growing due to nanomaterials. The attempts of technological manipulations raise the vocational risk to the workers in case of accidental exposures. The ethical issues regarding the poisoning of mass material are processed at a nanoscale, causing adverse effects on the health and industry. Mass poisoning occurs in the case of toxic micro particles coatings on the products. These microparticles penetrate inside the brain, while in contact with humans. Academic and industry experts suggest that there exists ambiguity regarding the toxic effects of releasing nanoparticles into the environment. It is also noteworthy that there is a lack

of knowledge of nanoparticles interactions with humans and the environment. Similar to most of the emerging technologies, nanotechnology, and nanochemistry industries have both benefits and challenges. To obtain maximum benefits, the problems must be overcome, managed, and endured. In combination with other inorganic or organic counterparts, mesoporous silicates have been extensively explored for targeted drug delivery and cancer treatment. Even though the long-term toxicity of the nanoparticles is subjected to controversies and doubts, the use of gold and silver nanoparticles have provided more advantages in comparison to other actual alternatives (cytostatics).

Consequently, there is a growing interest in developing *in vitro* assays for nanotoxicology study [164]. It is strongly encouraged to use primary human cells as a source for *in vitro* study with nanoparticles since different origins of cancerous cell lines complicate data interpretation for human risk evaluation. Till now, the environmental effects and the toxicity of nanomaterials to organisms are in the infancy state. The evaluation methods need to be cost-effective rapid, and quantity efficient.

## 10 Current Policy and Regulation Status

The social implications of nanotechnology comprise many fundamental aspects like ethics, privacy, environment, and security. Occasionally, the negative impacts on the environment are too averse to handle that the people simply give up. However, nanoscience researchers are still optimistic about seeing the light of hope on the other side of the tunnel. Environmental clean-up is possible via the design and manipulation of the atomic and molecular scale of materials. It would develop cleaner energy production, energy efficiency, water treatment, and environmental remediation. Nanoscale fluid dynamics decipher the flow of nanoparticles in the environment as a result of interactions with biological and ecological systems. Researchers are keen to understand the transportation of nanomaterials in association with environmental contaminants through groundwater systems. For food authenticity, safety, and traceability, every food company should need to use smart labels at more robust and innovative functional lightweight packaging. Each developed and developing countries have a separate policy and regulation for the use of nanotechnological products and applications. Explicit initiatives on nanotechnology must be needed to promise that the opportunity provided by nanotechnology is not misused, and research does not become fragmented. The uncertainty, complexity, and diversity of nanotechnology mean that any initiative should not be a strictly preconceived closed program. Flexibility will be needed to stay side by side of development as they arise.

## 11 Challenges and Future Trends in Using Nanomaterials in Humans

Nanotechnology-based production uses minimal human resources, land, maintenance, and it is cost-effective, high productivity with modest requirements of materials and energy. The extensively growing field offers scientists and engineers an excellent opportunity to manipulate or alter the nanoscale materials to yield benefit of enhanced material characteristics like increased strength, lightweight, higher electrical conductivity, and chemical activity in comparison to their large-scale counterparts. However, for biomedical applications, the toxicity evaluation of nanomaterials should be performed. Broadly, detailed physicochemical characterization of nanomaterial should be performed before and during any toxicity study. Essential properties can control nanomaterial-induced toxicity, including size and shape of the nanomaterials, coating, chemical composition, crystal growth, nanomaterials purity, structure, surface area, surface chemistry, surface charge, agglomeration, and solubility should also be taken care. Measurements should be performed in a sufficiently stable state of nanomaterials in the most suitable test medium, i.e., aggregation status and ion release from metallic nanomaterials. Various engineered materials should be tested for their multidisciplinary tiered toxicity using diverse models and experiments [165, 166]. Therefore, the first step in genotoxicity is an assessment of the physicochemical properties of nanomaterials. The validation of the proposed tiered approaches still waits for the future. The researchers are continuously trying to increase the relevant database with an increasing number of publications (papers, reviews, or even patents) every year [167], particularly the market share of the nanotechnology products is also growing up to thousands of billions of Euros [168]. Balanced use of the nanotechnologies/nanomaterials must be arranged to optimize the opportunities/risks factors.

Further studies related to the influence of size and shape, capping agents, receptors immobilization onto the metal nanoparticles are still necessary. Varying sizes can tune surface plasmon resonance, the shape of the nanomaterials and different surface functionalization of both silver and gold nanoparticles can reduce the toxicity and enhance a variety of biomedical applications in the future. For example, CNT toxicity can be reduced via functionalization, surface coating, and stimulation of the autophagic flux. The amino functionalization decreases the CNT toxicity to the cells [169] and albumin coating for SWCNTs [170]. We have summarized some comparative points about the advantages and disadvantages of nanotechnology discussed throughout our review in the form of the following Table 1.

## 12 Conclusions

Nanoparticles can enter and get distributed around the human body very easily. After entering into humans, it moves within the body and creates cellular toxicity. Then it attacks the respiratory system, cardiovascular system, brain, skin, gut, and other

**Table 1** Comparative discussion about advantages and disadvantages of nanotechnology

Advantages	Disadvantages
Early-stage detection of some diseases	Still at its infancy stage
Reduction of the size of any material, machine or equipment	More research and developmental work need to be done
Reduction of the amount of energy and resource	Expensive technology till now
Helps to clean up the existing nano-pollution	Creates environmental nano pollution
Able to secure the economy once it can be fully implemented	It can create social-economic disruption in society
Applicable and implementable to most of the applications ever existed	The huge initial cost for implementation
Can alter the basis of technology for human, in its matured phase	Resistance from a culture perspective, activists, journalists and even within the government
Improvement of the therapeutic drug index by increasing efficacy and/or reducing toxicities	Knowledge limitation from many industries and misperception among many fields about its capabilities.
Targeted delivery of drugs in a tissue-, cell- or organelle-specific manner	The government does not regulate nanomaterials
Enabling sustained or stimulus-triggered drug release	Requirement of significant investment and research but yield is still a limiting factor
More sensitive cancer diagnosis and imaging	Some nanoparticles may be toxic to humans
Better pharmaceutical properties (i.e. stability, solubility, circulating half-life and tumor accumulation) of therapeutic molecules	Nanotechnology made weapons are more powerful and more destructive by increasing the explosion potential
Provision of new approaches for the development of synthetic vaccines	Lack of employment in the fields of traditional farming, manufacturing, and industrial sector

organs. Some nanomaterials kill harmful bacteria within the body, and some kill good bacteria and live-cells of the human body. Nanoparticles with different substances are used in SIM cards of cell phones or sunscreens. When these are used, free nanoparticles get released in the environment (air, water, or soil). Engineering fields like civil and electronics also create new occupational health risks, making new, potentially toxic nanomaterials. The toxicity of nanoparticles depends on their shape, size, and chemical composition. Centuries before, Paracelsus quoted, “everything is a poison, and nothing is a poison, it is only a matter of a dose.” In regards to nanomaterials, the quotes hold value for both dose and particle size. The new interdisciplinary investigations explore the potentially harmful effects of these useful NPs and help in environmental preservation. Owing to a smaller size, the inhalation of nanomaterials imposes an adverse impact on human health. The inhalation causes severe injury to the lungs and can also become fatal. The deterioration of lungs can be observed even after the 60s of nanoparticle inhalation. Therefore, for sustainable nanotechnology development, it is mandatory to evaluate and spread knowledge about the short term and long term exposure benefits and hazards for nanomaterials.



To conclude, nanotechnology has the potential to impact society, both positively or negatively. Its consumers, producers, and dealers include all the community members and all stakeholders, so we should collectively raise the voice in its various growth and commercialization phases. Nanotechnology is currently in its infancy stage, with a significant lack of awareness about its effects on humans and the environment. As civilization moves forward, the vital query is: how should we manage the risks and uncertainties of this emergent technology? Is anyhow the COVID-19 pandemic situation human-made? If not, we can face such circumstances due to the careless application of nanotechnology in different fields.

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# Forest Resources Resilience and Conflicts



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# Effects of Sonajhuri (*Acacia auriculiformis*) plantation on soil health in Purulia district, West Bengal, India

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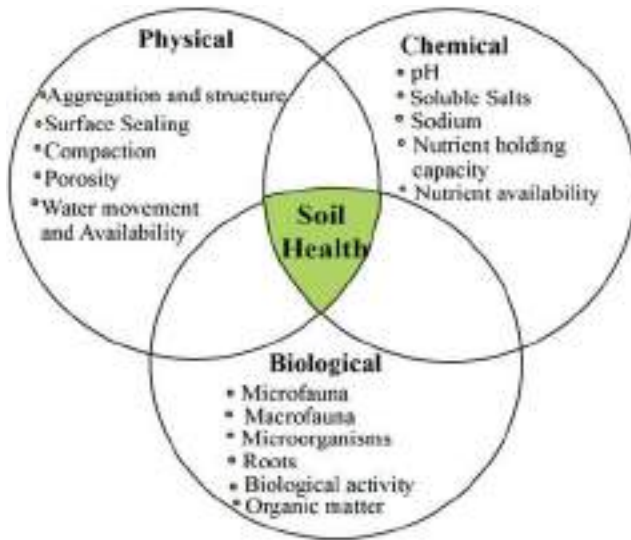
## 1 Introduction

Due to their multifarious uses, Australian *Acacia auriculiformis* (Sonajhuri) has been widely introduced across the tropics (Tassin, Rangan, & Kull, 2012; Dubliez, Freycon, Marien, Peltier, & Harmand, 2018) for the last 50 years (PROTA, 2016). *A. auriculiformis* species are planted as forestry and agroforestry to increase the soil fertility (particularly nitrogen) to integrate carbon and to restore soil nutrient in the degraded forests and degraded lands (Bernhard-Reversat, 1993; Franco et al., 1994; Parrotta & Knowles, 1999; Fuentes-Ramirez, Pauchard, Cavieres, & Garcia, 2011; Bouillet et al., 2013; Sitters, Edwards, & Venterink, 2013; Permadi, Burtona, Pandita, Walker, & Race, 2017). One of the fastest growing tree species, *A. auriculiformis* is planted for agroforestry, commercial forestry (ISC, 2020), well decoration purposes, fuel, charcoal, and supply of wood (Sitters et al., 2013; Permadi et al., 2017). The presence of nitrogen-fixing species (NFS) similar to the Australian acacias usually increases forest production and crop production at nitrogen deficiency sites (Binkley, 1992; Khanna, 1998; Bouillet et al., 2013; Nambiar & Harwood, 2014; Paula et al., 2015; Dubliez et al., 2018). The Australian *A. auriculiformis* has the ability to sequester carbon in both biota and soil that also involved in climate modification (Binkley, 1992; Kaye, Resh, Kaye, & Chimner, 2000; Resh, Binkley, & Parrotta, 2002; Lee, Ong, King, Chubo, & Su, 2015; Forrester, Pares, O'Hara, Khanna, & Bauhus, 2013). However, in some cases, soil carbon storage by this species may not be ensured (Voigtlaender et al., 2012; Oelofse et al., 2016). *A. auriculiformis* species has been most dangerous for soil health and forest ecosystem through reduction of soil moisture, soil fertility, and under growth in Purulia district.

Soil health is considered as an important factor for the improvements of agricultural production (Sarvade et al., 2019). According to FAO (2015), soil health is continued capacity of soil to existing living system, which preserved the biological productivity, environmental excellence, and promotes the plant and animal health. Healthy soil helps to maintain soil biota and plant life, decompose organic matter, amassment and cycle of water and nutrients, neutralize toxic compounds, soothe microbes, and conserve the quality of water (Slavich, 2001). Due to rapid growth of human population and reduction in land holding, soil health is depleting through overexploitation of land resources and nutrient (Sarvade, Singh, Prasad, & Prasad, 2014).

Agroforestry is considered as a sustainable land use system as it can conserve soil and enrich various properties of soil (physical, chemical, and biological) through multifunctional mechanism (Pandey, 2007; Das, Deb, & Arunachalam, 2011; Anju & Koppad, 2013; Mandal et al., 2013; Sarvade et al., 2014; Guleria et al., 2014; Nair, 2014; Sarvade & Singh, 2014; Berhe & Retta, 2015) (Fig. 27.1). In the tropics, Agroforestry systems can converse land degradation problem through their positive effects on soil (Tornquist, Hons, Feagley, & Hagggar, 1999). The amount of litter accumulation, class of litter, frequency of decomposition, and improvement of soil properties are controlled by the kind of tree species, their age, and density. (Isaac & Nair, 2006; Nair, 2007; Xiong, Xia, Li, Cai, & Fu, 2008; Sarvade et al., 2014).

Some of the exotic species, such as *A. auriculiformis*, are more risky among a variety of plant species that can degrade soil health (Kidanu, Mamo, & Stoosnijder, 2005). *A. auriculiformis* competes with different plants to obtain the moisture of soil (Kidanu et al., 2005; Forrester, Theiveyanathan, Collopy,



*Balance between Soil components and Soil Health*

FIGURE 27.1 Relation between soil components and soil health.

& Marcar, 2010; Albaugh, Dye, & King, 2013) and acquires topsoil nutrients (Gupta, 1993; Guo, Sims, & Horne, 2002). Therefore, these species adversely affect biodiversity and can reduce plant diversity (Huttel & Loumeto, 2001). This tendency of plants represents as allelopathy (Lisanework & Michelsen, 1993; Paul, Polglase, Nyakuengama, & Khanna, 2002; Hartemink, 2006; EDDMapS, 2016). Modifications in the structural variety of soil microorganisms (Mycorrhizal fungi and Rhizobia) interrupt the growth of innate plants in Purulia district. *A. auriculiformis* establishes strongly optimistic plant–soil reactions that are essential systems for its further annexation (Gaertner et al., 2014) and indicates the competitive ability as a threat compared to the native plants (Rodríguez-Echeverría, Afonso, Correia, Lorenzo, & Roiloa, 2013). *A. auriculiformis* have also harmful effects on fixates of soil nutrients and neighboring plant species (Liu et al., 2017; Meira-Neto et al., 2018). Often in some water-limited or drought-prone areas, the introduction of exotic NFS species similar to the Australian *A. auriculiformis* can change the seasonal water availability of the soil (Rascher, Grobe-Stoltenberg, Maguas, & Werner, 2011; Siddiq & Cao, 2016).

## 2 Materials and methods

### 2.1 Study area

Bounded by the latitudes of 22°40'N to 23°42'N and the longitudes of 85°49'E to 86°54'E, in eastern fringe of the Chota Nagpur Plateau (Fig. 27.2), funnel-shaped Purulia district is located in the westernmost part of the West Bengal. The district is bounded by the state of Jharkhand in north, west, and south; and in eastern part by the districts of Bardhaman, Bankura, and Jhargram of West Bengal, India.

The geological structure of the region has been adorned with various stratigraphic units from the earliest Precambrian (Archeans) period to younger Tertiary–Quaternary period (Dunn, 1929). From the topographical point of view, this region is very much diversified as it is endowed with numerous dome-shaped inselbergs, escarpments, spurs, undulating upland, and erosional plain (Mahato & Jana, 2019). The elevation of different parts of Purulia ranges between 78 and 699 m above the mean sea level with its much more diversity of the polycyclic landscape through the undulating Archean plateau (Dunn & Dey, 1942). As the Purulia district is a part of the Chota Nagpur granite-gneiss tract, it has not felt any severe diastrophic movement in its prolonged geological history, but it has been greatly affected by the orogenic forces (Dunn, 1929; Singh, 1969; Ray, 1982; Ghosh, 2012). The study area occupies on the eastern edge of the Precambrian granite-gneiss tract of the Chota Nagpur Plateau (Singh, 1969).

Climatologically, Purulia district is characterized by subtropical monsoon type of climate with very high day temperatures during the summer months reaching up to 46°C, whereas the minimum temperature drops to 3°C during the winter months and the region feels the plentiful cool (Bhattacharya et al., 1985; Datta & Chakraborty, 2017). The evaporation rate of the district is very high during the summer months due to mean monthly average temperature of 32°C, while the average monthly temperature in winter months is 11°C. The average long-term annual rainfall between the periods of 1960–61 and 2014–15 is 132 cm of which 80% rainfall occur during June to September (Bhattacharya et al., 1985; Datta & Chakraborty, 2017). The soil of the area is infertile laterite and red gravelly type, which is characterized by infertile, unproductive, erosion prone, lack of soil nutrients, and lower water holding capacity (NBSS & LUP, 2010).

### 2.2 *Acacia auriculiformis* and its distribution in the district

*A. auriculiformis* is widely introduced as a commercial plantation to supply different yields such as firewood, charcoal, pulp, and construction equipment; moreover, it is used for soil conservation and ecological restoration (Awang & Taylor, 1993; Franco & de Faria, 1997; Otsamo, Adjers, Hadi, Kuusipalo, & Vuokko, 1997; Midgley & Turnbull, 2003; Eyles et al., 2008; Kull & Rangan, 2008; Coetzee et al., 2011; Hai, Duong, Toan, & Ha, 2015). This tree species was brought to India from Australia in 1946 (Kushalapa, 1991) and planted for forestry to extended monoculture tree plantations. *A. auriculiformis* has been widely cultivated in Purulia district by government and private initiatives for its ability to grow in poor soils. At present, *A. auriculiformis* has been planted in Purulia over an extensive area for vegetation restoration, reduction of

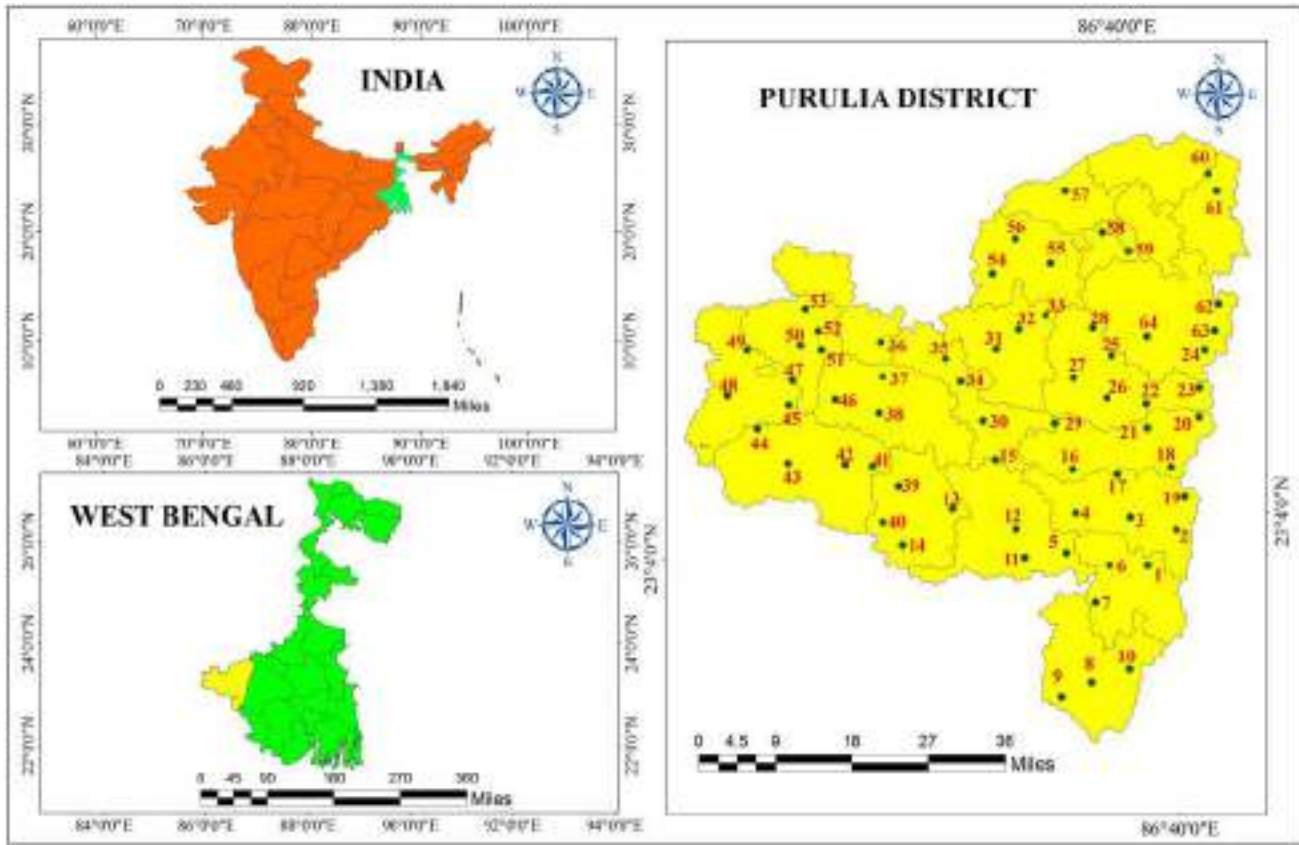


FIGURE 27.2 Location of the study area with 64 soil-sampling sites.

wastlands, conservation of soil, production of pulp, wood, firewood, construction materials, and ornamental purposes (Fig. 27.3 and Table 27.1).

Government and private organizations have taken initiatives for the plantation of *A. auriculiformis* in most of the fallow lands and wastelands of the district for environmental sustainability and its multipurpose uses, but this initiative did not properly address the district's indigenous environment. This species becomes harmful to environment for reduction of soil nutrients, soil moisture, soil fertility, atmospheric moisture, and undergrowth, but recently the rate of *A. auriculiformis* plantation is constantly increasing (Table 27.1).

### 2.3 Sampling design

Soil samples were taken during November to December 2019 using a 4-cm diameter auger. Samples were collected randomly from four sites under <5, 6–10, 10–15, and >15 years old *A. auriculiformis* plantation area (AG <5, AG 6–10, AG 11–15, and AG >15, respectively) and two sites under the inexistence of *A. auriculiformis* species such as

scrub grassland sites and native forest sites. All these sites were selected for exhaustive analysis of the altered chemical properties of topsoil (0–20 cm) and subsoil (20–40 cm). Aboveground litter layer removed before the collection of samples. Samples have been collected from the top layer of soil because this layer is very much affected by the growing vegetation cover (Jobbagy & Jackson, 2001). In total, 64 sample sites [(AG <5)-10, (AG 6–10)-10, (AG 11–15)-10, (AG >15)-10, scrub grassland sites-9 and native forest sites-15] were selected in the study area for testing and validation of chemical characteristics (Fig. 27.2 and Table 27.2). At each site, two samples were taken such as one from topsoil and another from subsoil ( $n = 2$ ); therefore, total number of sample is  $64 \times 2 = 128$ . All the selected sites are located on homogeneously well-drained and sandy soils of the rolling plateau fringe and characterized by a gentle to moderately inclined topography (Elevation 157–182 m).

### 2.4 Analytical methods

Air-dried fine soil samples were taken for testing and analysis of chemical characteristics and charge properties

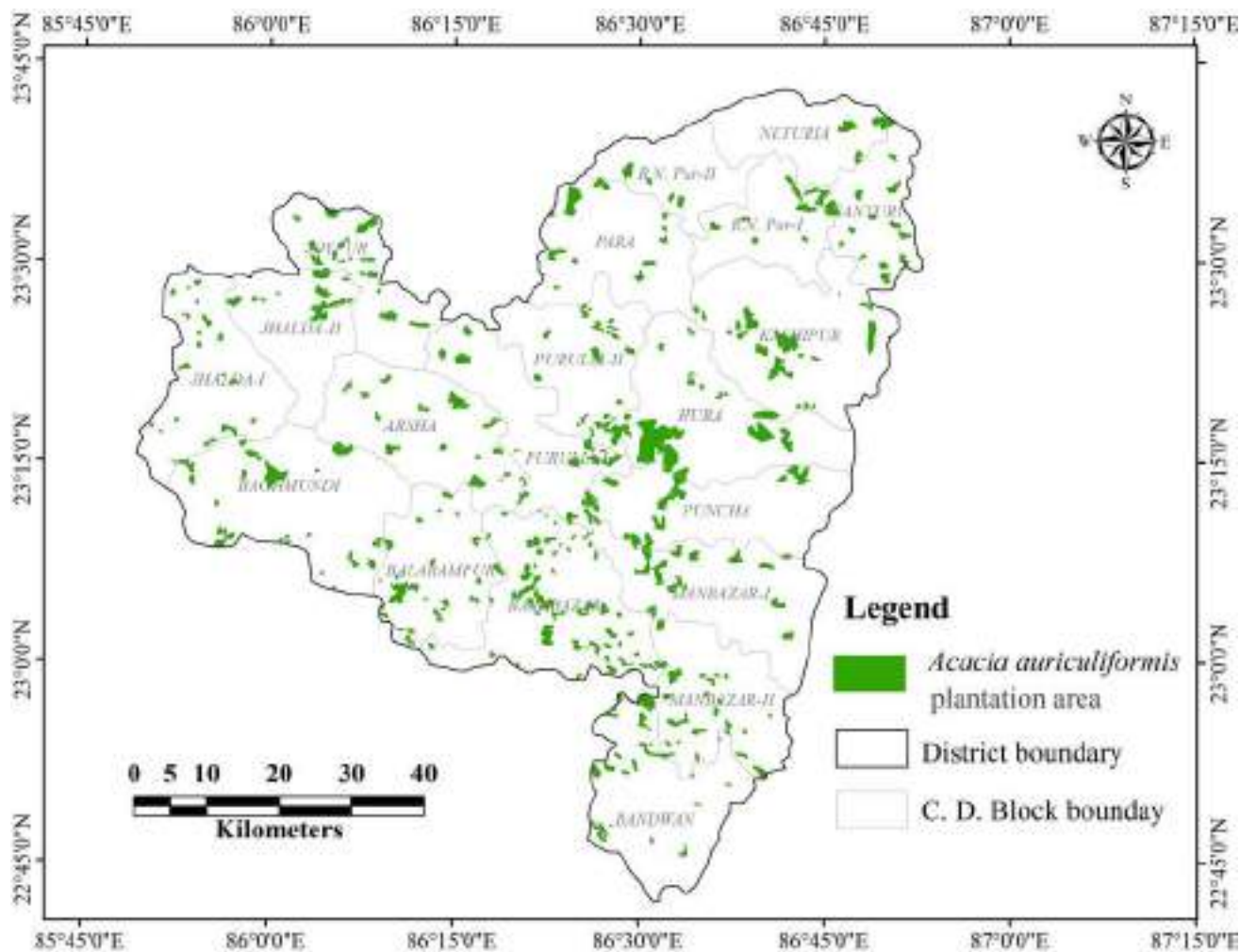


FIGURE 27.3 Spatial distribution of *Acacia auriculiformis* plantation in Purulia district using SOI topographical sheet, new edition in 2010 with the help of Arc-GIS 10.4 software assigning UTM, WGS 1984, 45°N zone projection system.

**TABLE 27.1** *Acacia auriculiformis* plantation area and total plantation area of Purulia district during 2004–05 to 2014–15.

Year	Plantation area (ha)	<i>A. auriculiformis</i> plantation area (ha)	PS	GR
2004–05	514	381	74.12451362	13.39421613
2005–06	375	260	69.33333333	-31.75853018
2006–07	451	346	76.71840355	33.07692308
2007–08	745	620	83.22147651	79.19075145
2008–09	843	657	77.93594306	5.967741935
2009–10	802	569	70.94763092	-13.39421613
2010–11	971	815	83.93408857	43.23374341
2011–12	1098	746	67.9417122	-8.466257669
2012–13	897	705	78.59531773	-5.495978552
2013–14	1024	768	75.00	8.936170213
2014–15	1105	873	79.00452489	13.671875

Data source of plantation area and *A. auriculiformis* plantation area is Forest Department of Purulia, 2017. The present authors have computed PS and GR. PS—Percentage share of *A. auriculiformis* plantation area to plantation area, that is,  $PS = \frac{A. auriculiformis \text{ plantation area}}{\text{plantation area}} \times 100$ ; GR—growth rate of *A. auriculiformis* plantation area, that is,  $GR = \frac{\text{present} - \text{past}}{\text{past}} \times 100$ .

**TABLE 27.2** Design of field sampling in Purulia district of West Bengal, India.

Sample sites	Geographical location		Soil weight (g)		Types of sample sites					
	Latitude (N)	Longitude (E)	Ts	Ss	<i>Acacia auriculiformis</i> planting Sites				Scrub and grassland sites	Native forest sites
					AG <5	AG 6–10	AG 11–15	AG >15		
1	22°57'22.476"	86°38'51.368"	371	346			√			
2	23°01'52.773"	86°41'33.841"	320	334					√	
3	23°07'52.073"	86°37'21.563"	311	309						√
4	23°04'58.115"	86°30'06.583"	327	353				√		
5	23°00'02.364"	86°26'24.135"	380	311						√
6	22°58'13.109"	86°34'18.301"	357	329					√	
7	22°54'48.643"	86°30'54.435"	314	367	√					
8	22°48'14.342"	86°31'56.891"	375	340			√			
9	22°46'17.605"	86°28'08.645"	305	304		√				
10	22°51'03.517"	86°37'10.034"	317	347				√		
11	23°00'46.845"	86°23'30.119"	388	357	√					
12	23°05'14.227"	86°23'42.137"	330	349			√			
13	23°06'38.342"	86°18'01.664"	342	320		√				
14	23°03'37.221"	86°12'00.389"	315	326					√	
15	23°10'07.309"	86°20'39.941"	365	367				√		
16	23°08'24.174"	86°29'58.420"	314	340						√
17	23°07'51.145"	86°35'04.169"	309	304			√			
18	23°06'57.701"	86°40'29.036"	327	347	√					
19	23°05'02.327"	86°43'49.187"	325	350						√
20	23°10'24.152"	86°43'39.512"	364	382				√		
21	23°09'51.361"	86°37'50.401"	340	342		√				
22	23°12'48.126"	86°40'01.353"	365	373					√	
23	23°14'00.991"	86°44'00.416"	318	360						√
24	23°17'25.256"	86°44'10.039"	355	330			√			
25	23°18'00.953"	86°37'39.114"	320	342						√
26	23°24'48.655"	86°32'19.540"	334	305	√					
27	23°16'39.607"	86°29'31.733"	350	314				√		
28	23°20'42.943"	86°33'39.206"	382	317		√				
29	23°13'22.258"	86°25'58.307"	342	330	√					
30	23°14'26.722"	86°19'49.858"	373	357						√
31	23°18'28.074"	86°22'56.381"	360	375					√	
32	23°22'14.154"	86°24'47.954"	324	380	√					
33	23°25'55.163"	86°28'01.280"	303	388						√
34	23°18'47.439"	86°17'03.911"	329	320				√		
35	23°21'09.167"	86°16'02.229"	357	313		√				
36	23°23'09.234"	86°11'05.357"	349	367					√	
37	23°19'13.458"	86°11'42.407"	320	351			√			
38	23°14'50.621"	86°11'08.856"	326	344						√
39	23°09'04.375"	86°11'54.502"	310	360						√
40	23°06'24.307"	86°08'05.148"	330	394	√					
41	23°11'40.825"	86°07'51.453"	364	411			√			

(Continued)

**TABLE 27.2** Design of field sampling in Purulia district of West Bengal, India. (Cont.)

Sample sites	Geographical location		Soil weight (g)		Types of sample sites					
	Latitude (N)	Longitude (E)	Ts	Ss	Acacia auriculiformis planting Sites				Scrub and grassland sites	Native forest sites
					AG <5	AG 6–10	AG 11–15	AG >15		
42	23°12'01.004"	86°04'00.579"	345	356				√		
43	23°11'54.908"	85°58'57.388"	351	308					√	
44	23°15'19.642"	85°56'02.173"	322	354						√
45	23°15'56.027"	85°59'57.834"	318	396		√				
46	23°17'00.683"	86°05'51.081"	366	302	√					
47	23°18'17.514"	86°00'03.558"	326	374				√		
48	23°18'38.696"	85°52'58.331"	387	354						√
49	23°23'29.097"	85°56'01.922"	316	405		√				
50	23°21'56.341"	86°01'07.989"	389	327			√			
51	23°20'42.139"	86°05'17.505"	335	338						√
52	23°23'21.877"	86°04'44.112"	305	340	√					
53	23°26'39.972"	86°02'50.542"	322	362			√			
54	23°28'33.156"	86°23'11.934"	370	384						√
55	23°28'39.093"	86°31'52.739"	346	320				√		
56	23°31'01.972"	86°28'00.383"	334	348			√			
57	23°37'00.521"	86°33'56.149"	309	350		√				
58	23°31'48.227"	86°36'04.306"	353	355					√	
59	23°29'40.607"	86°39'52.911"	311	349	√					
60	23°36'08.192"	86°47'01.101"	329	324			√			
61	23°33'03.541"	86°49'54.834"	367	316				√		
62	23°24'44.077"	86°47'39.553"	340	346						√
63	23°20'48.233"	86°46'04.417"	304	305		√				
64	23°20'39.068"	86°40'11.105"	347	385					√	

Ts, Topsoil; Ss, subsoil; AG, age of *A. auriculiformis* species; √, selected sites for sampling.

with the help of standard procedures followed (Kasongo, Van Ranst, Verdoost, Kanyankagote, & Baert, 2009). The samples were analyzed for the distribution of particle proportions by pipette method as well as estimation of organic carbon content ( $C_{org}$ ) by Walkley and Black method, pH (water and KCl extracts 1:2.5), and total nitrogen content ( $N_{tot}$ ) by macro-Kjeldahl method. Whereas exchangeable base cations ( $1_M NH_4OAc$  at pH 7) and cations exchange capacity ( $CEC_7$ ) were ascertained on combined soil samples as prescribed by Van Ranst, Verloo, Demeyer, & Pauwels (1999). Uehara and Gillman (1980) method has been applied to determine field pH,  $pH_0$ , and charge properties of litter samples, and Gillman and Sumpter (1986) improved this method following for  $pH_0$  ascertained, the soil component was  $Ca^{2+}$  impregnated and paddled to equilibrium with  $0.002_M CaCl_2$ . The pH is standing to various values in the range from 4.0 to 7.0. In stable condition, the pH assessed and labeled as  $pH_{0.002}$  (ratio of soil from solution 1:2.5), where the similar soil sample counterweighted with

a  $2_M CaCl_2$  solution and labeled as  $pH_{0.05}$ . As the pH reacts with the determination of changes in negative and positive charges, the soil is again filled with  $Ca^{2+}$  and equilibrated with  $0.002_M CaCl_2$ .

Structural proportion of pH ( $H_2O$ ), pH (KCl),  $C_{org}$  (%),  $N_{tot}$  (%), and C/N represents in different sites along with successive age of *A. auriculiformis* species.

## 2.5 Statistical analyses

Major variations in the chemical properties of the soil have been recorded in the *A. auriculiformis* plantation sites of different ages, scrub grassland sites, and native forest sites, identifying by the one-way ANOVA analysis. The variances between the treatments mean values at  $P < .05$  significant find out by least significant difference (LSD) test. Pearson's correlation coefficients ( $PCC = r^2 + \_$ ) have been calculated to ascertain the correlations between the specific soil characteristics.



### 3 Results and discussion

#### 3.1 Chemical characteristics of soil

The mean chemical properties of topsoil and subsoil in *A. auriculiformis* plantation areas are shown in Tables 27.3A and B represent the average chemical properties of topsoil and subsoil in scrub grassland sites and native forest sites. Table 27.3A shows that the pH (H<sub>2</sub>O) and pH (KCL) of topsoil and subsoil significantly decrease according to different successive ages of plantation field (Fig. 27.4A). Within 10 years, *A. auriculiformis* trees influence a clear acidification of the topsoil of the study area. The average topsoil pH(H<sub>2</sub>O) of the 15-year-old *A. auriculiformis* forest is about 5.26, whereas it is about 6.40 under scrub grasslands and about 6.15 under the native forests (Fig. 27.4D).

The main reasons for the soil acidification with decrease in soil pH are organic acids generating from litter and corrosion products of the root or litter extractives (Kasongo et al., 2009). In addition to neutralizing the effects of enhanced N mineralization by nitrification, this study is

influenced by the low-solubility macromolecular elements formed by the acidity reduction processes generated beneath the acacia forest. For example, it is seen here that the amount of C<sub>org</sub> of organic matter in the acacia forest has decreased significantly from 2.92% to 1.94% during the early 6 years of the plantation.

The chronological sequence of *A. auriculiformis* species also highlights an important and uninterrupted decline in C<sub>org</sub> and N<sub>tot</sub> content over a period of 15 years (Fig. 27.4B and C). As estimated, the availability of organic components is mostly influenced in the topsoil, as a result about 252% decreases of the C<sub>org</sub> content following 15 years of *A. auriculiformis* plantation. A major fluctuation in the C<sub>org</sub> matters of together the topsoil (2.92%) and subsoil (1.31%) is existent during 5 years. During 6–10 years old *A. auriculiformis* fields, the C<sub>org</sub> matters double to achieve moderately high heights in the topsoil (around 1.94%), while more than 15 years oldest *A. auriculiformis* fields are characterized by low C<sub>org</sub> matters (1.16% and 0.77% in the topsoil and subsoil, respectively).

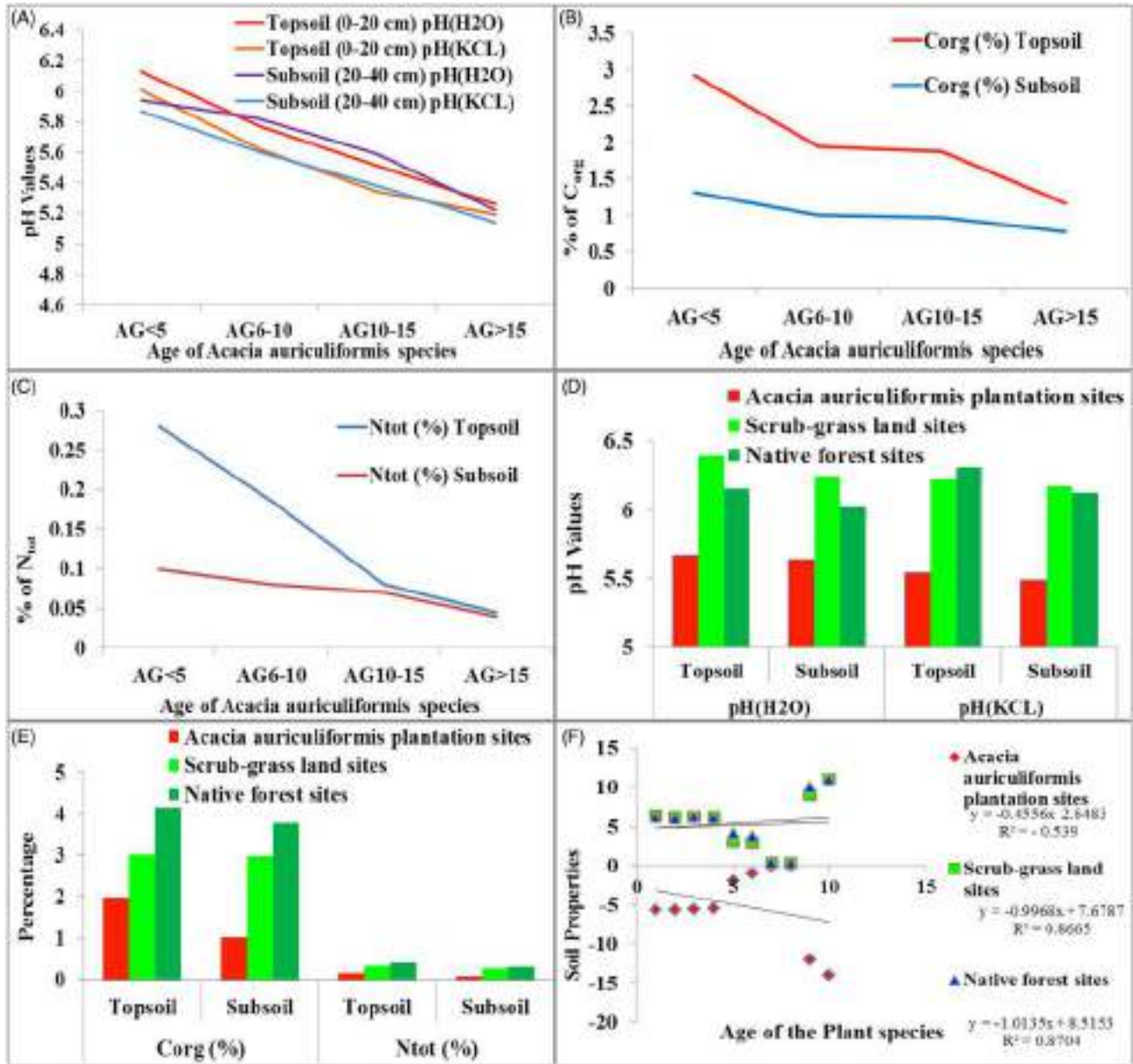
**TABLE 27.3(A)** Average pH (H<sub>2</sub>O), pH (KCL), C<sub>org</sub> (%), N<sub>tot</sub> (%), and C/N ratio of topsoil and subsoil under the *Acacia auriculiformis* plantation sites of cumulative age.

Soil situation	Age of the plant species	<i>A. auriculiformis</i> plantation sites				
		pH(H <sub>2</sub> O)	pH(KCL)	C <sub>org</sub> (%)	N <sub>tot</sub> (%)	C/N
Topsoil (0–20 cm)	AG <5	6.13c	6.01b	2.92d	0.280d	10a
	AG 6–10	5.77b	5.62ab	1.94c	0.186c	10a
	AG 10–15	5.51ab	5.34ab	1.87b	0.080b	11b
	AG >15	5.26a	5.19a	1.16a	0.045a	15c
	Average	5.67a	5.54ab	1.97c	0.148c	12b
Subsoil (20–40 cm)	AG <5	5.94b	5.87b	1.31c	0.100b	13a
	AG 6–10	5.82ab	5.60ab	1.00b	0.080b	13a
	AG 10–15	5.59ab	5.38a	0.97b	0.080b	12a
	AG >15	5.22a	5.14a	0.77a	0.040a	19b
	Average	5.64ab	5.49a	1.01b	0.075b	14a

**TABLE 27.3(B)** Average pH(H<sub>2</sub>O), pH(KCL), C<sub>org</sub> (%), N<sub>tot</sub> (%), and C/N ratio of topsoil and subsoil under the scrub grassland sites and Native forest sites.

Soil situation	Scrub grassland sites					Native forest sites				
	pH (H <sub>2</sub> O)	pH (KCL)	C <sub>org</sub> (%)	N <sub>tot</sub> (%)	C/N	pH(H <sub>2</sub> O)	pH(KCL)	C <sub>org</sub> (%)	N <sub>tot</sub> (%)	C/N
Topsoil (0–20 cm)	6.39c	6.22c	3.02e	0.341e	9a	6.15c	6.31c	4.15e	0.414e	10a
Subsoil (20–40 cm)	6.24c	6.17c	2.97d	0.284d	11a	6.02c	6.12c	3.78e	0.311e	11a

pH (H<sub>2</sub>O) and pH(KCL)—pH of water and KCL extracts 1:2.5; C<sub>org</sub>—organic carbon content; N<sub>tot</sub>—total nitrogen content. All the values followed by different letters are statistically significantly different ( $P < .05$ ).



**FIGURE 27.4** Graphical representation of various soil properties of different sites. (A) pH (H<sub>2</sub>O) and pH (KCL) status of topsoil and subsoil in different ages of *Acacia auriculiformis* sites; (B) decreasing C<sub>org</sub> in topsoil and subsoil of different ages of *A. auriculiformis* sites; (C) decreasing N<sub>tot</sub> in topsoil and subsoil of different ages of *A. auriculiformis* sites; (D) comparison of pH values between different sites; (E) comparison of C<sub>org</sub> and N<sub>tot</sub> content between different sites; (F) correlation between ages of different plantation sites and chemical properties of soil.

The amounts of C<sub>org</sub> and N<sub>tot</sub> content in the scrub grass-land sites and native forest sites are significantly higher than *A. auriculiformis* sites (Fig. 27.4E). The average C<sub>org</sub> content of *A. auriculiformis* sites of topsoil and subsoil are 1.97% and 1.01%, respectively, where scrub grassland sites are 3.02% and native forest sites are 4.15%. On the other hand, the N<sub>tot</sub> content of topsoil in scrub grassland sites are 0.341% and native forest sites are 4.15%, which are specifically better than the *A. auriculiformis* sites. The pH values

of native forest sites and scrub grassland sites are characterized as neutral (Fig. 27.4D).

In all soil samples, the pH (H<sub>2</sub>O) values are higher than the pH(KCL) signifying a clear adverse charge. Besides, the C<sub>org</sub> matters is very ominously ( $P < .01$ ) absolutely interrelated with the cation exchange capacity (Pearson product moment correlation values are *A. auriculiformis* sites,  $r^2 = -0.539$ ; scrub grassland sites  $r^2 = 0.8665$ ; native forest sites  $r^2 = 0.8704$ ; (Fig. 27.4F), which aids from the

supplementary supply of pH-dominated charged colloidal measurable.

### 3.2 The effects of density and canopy of *Acacia auriculiformis* species on soil C and N

Increasing density of *A. auriculiformis* species is associated with the soil nitrogen (N) and carbon (C) (Belsky, Mwonga, Amundson, Duxbury, & Ali, 1993; Ludwig, de Kroon, Berendse, & Prins, 2004; Hagos & Smit, 2005; Sitters et al., 2013) (Fig. 27.4; Tables 27.3A and B). The abundance of *A. auriculiformis* is the root cause of decreases in  $C_{org}$  and  $N_{tot}$  contents, which is also the cause of variances in soil nutrients. Primarily, the topsoil underneath in tree canopies of acacia is depriving the  $C_{org}$  and  $N_{tot}$  in all sites, which would expect given that all sites were of different ages. On the other hand, the relationship among the soil C and N and tree thickness outside the canopy of *A. auriculiformis* is significantly positive; it reflects the reality that the distance to the adjacent tree decreases with increasing density. Second, general decreases in  $C_{org}$  and  $N_{tot}$  along the density incline of acacia forest, and the soil  $C_{org}$  and  $N_{tot}$  values indicate decreasing ratio of soil C and N generating from the trees.

Binkley (2005) suggested that N-enhancement by N-fixing plants could cause fluctuations in the slow-moving soil-microbial community of organic matter; this process can account for the addition of C along the density gradient of the tree. In the scrubs and native forestlands, the N enhancement processes stabilized in this effect, but *A. auriculiformis* species become oppositely effects on microbial community. Therefore, the present authors have strongly standardized that the density and canopy of scrubs and native forest is better than the *A. auriculiformis*.

### 3.3 Effect of *Acacia auriculiformis* in Purulia

The widespread invasion of *A. auriculiformis* in different parts of the world has caused an overall conflict of focus on the positive and negative effects of the species (Kull & Rangan, 2008; Richardson & Rejmanek, 2011; Wilson et al., 2011; Tassin et al., 2012; Ismael & Metali, 2014; Aguiar, Barbosa, Barbosa, & Mourao, 2014; Souza, Chaves, Barbosa, & Clement, 2018). The multipurpose use of this species is socially and economically very much important (ISC, 2020). In spite of several described benefits of *A. auriculiformis* in forestry, agroforestry, and agricultural systems, there is growing evidence for the causes of its detrimental properties, as this species can have penetrating negative effects on biodiversity, soil health, and human well-being (Richardson & Rejmanek, 2011; Attias, Ferreira Siqueira, & de Godoy, 2013; Koutika & Richardson, 2019). However, *A. auriculiformis* have restrictions for enhancing forest productivity, restoring C and N, and soil fertility and

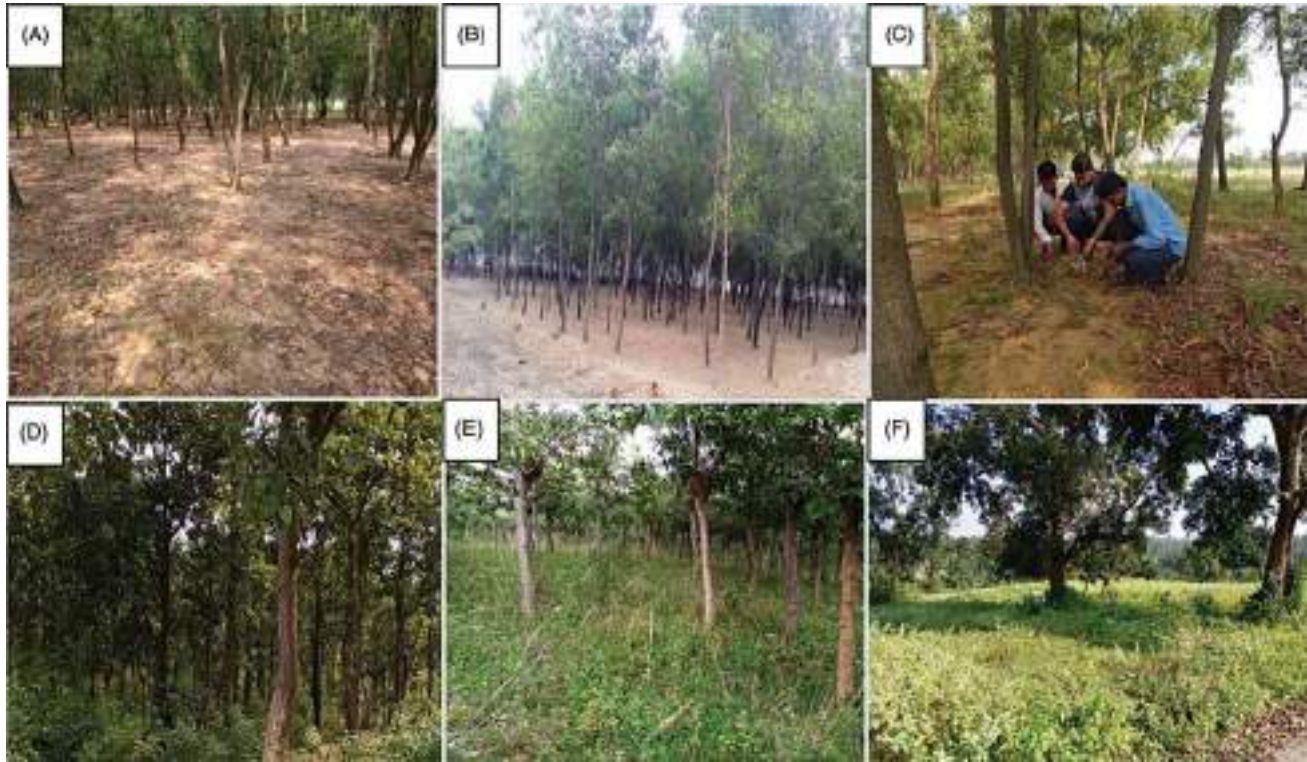
controlling the degraded land restoration (Koutika & Richardson, 2019). The authors did not endorsed *A. auriculiformis* for reclamation of degraded land in Purulia, because of its restricted performance with reference to most of the variables that have been measured. In the same way, Parrotta and Knowles (1999) suggested that the defective capability of fast growing species (such as acacia and eucalyptus species) does not support in the successional processes of Brazil (Koutika & Richardson, 2019).

Initiatives have been taken for the cultivation of *A. auriculiformis* species to reclaim wastelands and fallow lands in Purulia, but these initiatives are not reducing the wastelands rather accelerates the same. This species becomes harmful for the environment of Purulia due to destroyed ecosystem facilities, habitat variation, monoculture formation, reform of successional arrangements, infrastructure damage, reduced natural biodiversity, damage of native species, and risk to endangered species. A huge plantation of fast-growing Australian acacia species on the wastelands of Purulia has omitted internal breeding of bird species (Chowdhury, 2019). *A. auriculiformis* plantation in Purulia is greatly reducing the number of native plant species (Mallick, 2018). Such findings show that extensive plantation of Australian *A. auriculiformis* is harmful in outside their native range, such as Purulia.

#### 3.3.1 Negative effects on soil

Variations in the capable variability of microorganisms existing in soil (rhizobia and mycorrhizal fungi) inhibiting the growth of native flora species, while restoring wastelands and degraded lands in Purulia district with Australian *A. auriculiformis*. The other Australian acacia species of the district are *Akashmoni* and *Australian babul* (ISC, 2020), recognized optimistic plant-soil responses, which are significant materials for its additional annexation (Gaertner et al., 2014), indicated a tough antagonistic capability comparative to the native plant species. Australian *A. auriculiformis* has deleterious effects soil nutrients absorptions by neighboring plants (Liu et al., 2017; Meira-Neto et al., 2018). In early incursion stage, *A. auriculiformis* is capable to absorb the nitrogen in both soil and leaf, enhance canopy layers, and facilitate an extensive range of light difference that is helped by the nitrogen received and shifted to neighboring plants (Meira-Neto et al., 2018).

Planting of *A. auriculiformis* and native mixed tree species [like *Butea frondosa* (Palash), *Bassia latifolia* (Mohul), and *Shorea robusta* (Sal)] in the wastelands and degraded forestlands of Purulia district, soil N, C, and P accessibility declined in the topsoil of pure acacia sites compared to native mixed forest at the completion of the first 10-year cycle. In Purulia, native tree accumulated greater amounts of P and N via litter, although the opposite picture can be seen in *A. auriculiformis* (Santos, Balieiro, Fontes, & Chaer, 2017) (Fig. 27.5). In subtropical Purulia, the NFS



**FIGURE 27.5** Field photographs exhibiting different kinds of canopy cover. (A) More than 10-year-old acacia forest of Kulabahal mouza under the Racab reserve forest, (B) *Acacia auriculiformis* plantation in Kantadih mouza of Balarampur forest range, and (C) collection of soil sample during from 10 to 15-year-old acacia forest in Simni mouza of Kotshila forest range. A–C represent alien species with no undergrowth under the canopy layer. (D) Sal forest of Ajodhya protected forest, (E) Arjun plantation in Seja mouza of Hura forest range, and (F) high scrub and undergrowth under the native Kusum tree in Kalimati mouza of Baghmundi forest range. D–F are native species, showing high undergrowth and balanced plant ecology under the forest.

such as *Albizia lebbek* (Siris), *B. frondosa* (Palash), *Terminalia arjuna* (Arjun), and *Lagerstroemia parviflora* (Sidha) have higher P storage ability rather than non-NFS (Begum, Pramanick, Mukhopadhyay, & Majumdar, 2020). These studies may reveal the potential risk of fluctuating from N limitation to soil P restraint in long term involved in reduc-

ing forest productivity. It is to be mentioned that *A. lebbek*, *B. frondosa*, *L. parviflora* plantations will be mostly benefited for the subtropical climate and nutrient-poor soil of Purulia (Fig. 27.6B), wherein N is the utmost inadequate nutrient and P accessibility is attenuate by forcible exploitation because of the huge quantities of Al and Fe oxide



**FIGURE 27.6** Different forest ecosystem of Purulia district. (A) *Acacia auriculiformis* Plantation on Maguria Pahar (hill) in Hura C. D. Block. This type of plantation promotes soil erosion and increases rocky field. (B) *Butea frondosa* (Palash) in Shyamalota mouza of Hura C.D. Block is an indigenous species of the study area. Palash is beneficial as it promotes undergrowth, increases soil moisture, soil organic matter. In Purulia, lac is cultivated in Palash tree, but the hard reality is that this tree is gradually being replaced by *A. auriculiformis*.

in maximum of subtropical soils. *A. auriculiformis* species help to increase the erosion rather than conservation (Fig. 27.6A) of soil in the study area due to reducing water availability of soil layers and absence of undergrowth.

### 3.3.2 Negative effects on biodiversity

In Purulia, the diversity and density of macroinvertebrates in the topsoil of native forests deliberate as moderate to lower (Begum, Pramanick, Mukhopadhyay, & Majumdar, 2020), and changes in other forms of land use in this ecosystem can drastically change their population. The macroinvertebrates of soil is an impressive indicator of natural systems and management, and it has a greater copiousness and multiplicity in the agroforestry methods compared to the other types of agricultural land use. Forestry and agroforestry plantations are mostly established in wastelands and degraded forestland of Purulia district that are extremely vulnerable to invasions of exotic trees. Australian *A. auriculiformis* can easily invade the degraded native forests that are suffering from water shortage and drought condition (Osunkoya, Othman, & Kahar, 2005). Attack of *A. auriculiformis* is supplementary with the modifications of biodiversity (ISC, 2020).

The spread of the *A. auriculiformis* trees on the native plants is identified as a specific threat to some infrequent species and their homes in Purulia. This species has invaded degraded forestlands, wasted areas, forestlands, and scrub in Purulia district and changed plant communities by shifting native plants. However, *A. auriculiformis* planting is taking place extensively across the district resulting in declining of soil moisture and rapid rise in temperature, which significantly effects on soil macrofauna community. This species is causing serious damage to lac insects and lac cultivation in the district. Lac insects require certain specific plant species (Modak & Basu, 2011) like *B. frondosa* (Palash), *Schleichera trijuga* (Kusum), and *Zizyphus xylopyra* (Kul) to survive. This species has an extensive range of effects on ecosystems, which is increasing with time and instability and habitually transforming into ecological activities, in that way changing and decreasing the delivery of ecosystem services.

### 3.3.3 Negative effects on water availability

In various parched and water inadequate parts of the tropics, initiating exotic NFS such as Australian *A. auriculiformis* may change patterns the seasonal water use (Rascher et al., 2011; Siddiq & Cao, 2016). The introduction of fast growing species *A. auriculiformis* and eucalyptus consumes abundant water rather than other native trees and forests. The roots of the *A. auriculiformis* tree can absorb water from far below the soil layer and have a higher rate of transpiration than other native trees. As a result, in the *A. auriculiformis* fields of the district, both the topsoil and

subsoil layers exposed to this water crisis, which complicates the survival of the native species. Therefore, the 10-year-old fields of this species do not have any types of undergrowth (Fig. 27.5A–C). The *A. auriculiformis* species reduces the amount of moisture in the lower air, so the number of microscopic fauna species and different birds in these fields is much lower.

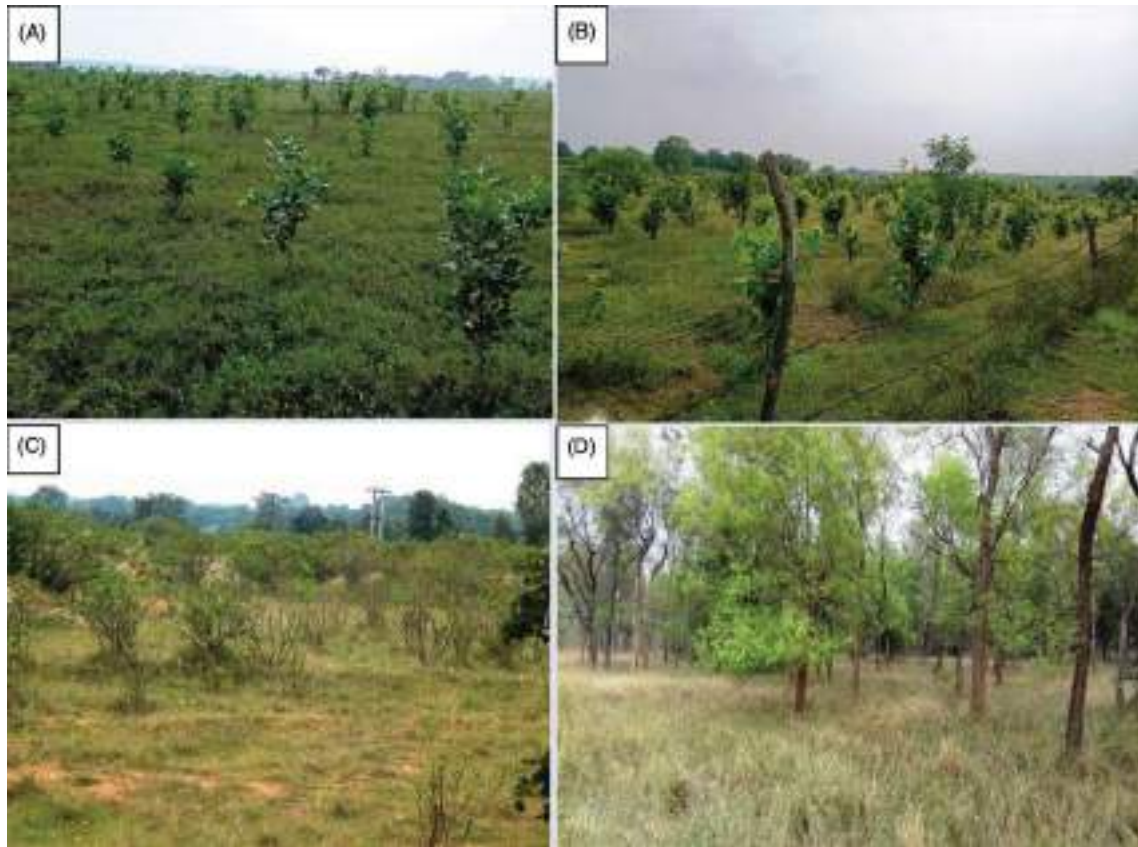
## 4 Risk assessment and remediation

Species such as the Australian *A. auriculiformis* have been extensively planted outside their native range for decades, which have become aggressive and have the negative impact on the environment. Attacks and related impacts naturally manifest only several decades after planting this species in large scale (Richardson, Le Roux, & Wilson, 2015; Koutika & Richardson, 2019). Outside of the native environment, this species has a definite detrimental effect on ecosystem and biodiversity (Wilson et al., 2011; Low, 2012; Attias et al., 2013; Sampaio & Schmidt, 2013; Aguiar et al., 2014; Richardson et al., 2015; Nambiar, Harwood, & Mendham, 2018).

From the experience of long history of planting *A. auriculiformis* in Purulia district, three key issues will need careful attention while considering *A. auriculiformis* invasive and management issues: (1) the role of habitation time and offensive debate, (2) harmful chemical effects of the environment, and (3) biological control.

Proper management of plantation can control invasions of *A. auriculiformis* into subtropical forests of Purulia and observing of soil seed stores, but no such evidence is found there. However, it is possible to maintain the nutrition balance and sustainability of the environment through appropriate remediation in the areas affected by *A. auriculiformis*.

- The principal remediation would be to develop practices to limit the damage of most important nutrient properties from the agroforestry scheme. The branches and bark of *A. auriculiformis* contain significant amount of nutrients, particularly Ca, C, and N (Louppe, Ouattara, & Oliver, 1998; Mendham, O'connell, Grove, & Rance, 2003; Nambiar & Harwood, 2014). Therefore, those parts have to be left in the cutting sites for process of decomposition, which will provide nutrients to the soil.
- A second remediation is the residue obtained after charcoal burning will have to be returned to the *A. auriculiformis* fields. This practice has been observed in some of the degraded fields after cutting the acacia trees, which are now being promoted to recover the physical and chemical properties and improve the efficiency of tropical soils. For the positive role on the physical and chemical properties of the soil, it is necessary to use charcoal in acacia fields (Glaser, Lehmann, & Zech, 2002), which is also increased the water holding capacity of soil (Glaser et al., 2002; Glaser & Birk, 2012).



**FIGURE 27.7 Forestry of native species.** (A) *Carissa spinarum* (*Karamcha*) plantation in Dumdumi mouza of Purulia-I C.D. Block, (B) *Shorea robusta* (*Sal*) plantation in Chepua mouza of Manbazar-I C.D. Block, (C) *Jatropha* plantation in vast wasteland of Kulabahal mouza of Purulia-II C.D. Block for the reduction of wasteland and improvement of soil properties, (D) *Dalbergia sissoo* (*Shisham*) trees with undergrowth in Durmut mouza of Raghunathpur-I C.D. Block, which is gradually becoming rare in Purulia. These trees can be grown up in less amount of water.

- The restoration of minor biomass parts (leaves, twigs, and small branches) for the tree growing and production during the second tree rotation.
- In the second rotation of planting, instead of the *A. auriculiformis*, native species such as *Dalbergia sissoo* (*Shisham*), *B. frondosa* (*Palash*), *S. trijuga* (*Kusum*), *Z. xylopyra* (*Kul*), *B. latifolia* (*Mohul*), *S. robusta* (*Sal*), and *Carissa spinarum* (*Karamcha*) should be planted (Fig. 27.7), which can survive with less water. These native plants can increase biodiversity and conserve soil nutrients.
- Initiatives are needed for the genetic improvement of the *A. auriculiformis* trees that can genetically modify the seeds so that they provide nutrients to the soil and does not destroy native plants.

## 5 Conclusion

A valuable fast-growing species, *A. auriculiformis* has obvious benefits in economic and social perspectives for fuel wood, charcoal, timber, and ornamental purposes, but the species has the major negative effects on biodiversity and

ecosystem functioning when it becomes more than 10 years old. In Purulia, with the increasing age, the *Acacia* species becomes increasingly detrimental to soil health. However, it is possible to bring back the soil nutrients in the acacia field through use of charcoal ash. As a result, the balance between soil physical, chemical, and biological components will be maintained and water-holding capacity will be increased. Finally, the authors have suggested that the most important way to protect the soil health and reclaim the wasteland in Purulia district is afforestation and reforestation of native plant species.

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## ঔপনিবেশিক মানভূম: জমির হাতবদল, পরিবেশগত পরিবর্তন ও জনজীবনের ওপর তার প্রভাব

জয়ন্ত পাণ্ডে

আদিবাসী অধ্যুষিত মানভূম জেলায় ঔপনিবেশিক হস্তক্ষেপ গুরুত্বপূর্ণ আর্থ-সামাজিক পরিবর্তনের সূচনা করেছিল। সাধারণভাবে জল, জঙ্গল, জমি- এই তিনের ওপর নির্ভর করেই আদিবাসী জীবনযাত্রা আবর্তিত হত। ভারতবর্ষে ব্রিটিশ শাসনের প্রতিষ্ঠা অন্যান্য অঞ্চলের মতো মানভূমের আদিবাসীদের সহজ সরল জীবনযাত্রায় ছেদ ঘটায়। তাদের ধীরে ধীরে শোষণমূলক ঔপনিবেশবাদের আওতায় নিয়ে আসা হয়। আদিবাসীদের পুরোনো ভূমিব্যবস্থা বাতিল করে তাদের ওপর নতুন ভূমিরাজস্ব ব্যবস্থা আরোপ করা হয়; যা ভূমি সম্পর্কের ক্ষেত্রে গুরুত্বপূর্ণ বদল নিয়ে আসে। অন্যদিকে মানভূমের বিশাল প্রাকৃতিক সম্পদের ওপর ঔপনিবেশিক নিয়ন্ত্রণ স্থাপনের প্রয়াস, পরিবেশগত অবনমনের পথ প্রশস্ত করে। ভূমি সম্পর্কের ভোলবদল ও পরিবেশগত পরিবর্তন মানভূমের আদিবাসী জনজীবনকে গভীরভাবে প্রভাবিত করেছিল। তাদের স্বাভাবিক জীবনযাপনের চেনা ছন্দটাই নষ্ট হয়ে যায়।

উনিশ শতকের ত্রিশের দশকে জঙ্গলমহল জেলা থেকে মানভূম জেলা (বর্তমান পুরুলিয়া) তৈরী করা হয়।<sup>১</sup> ভৌগোলিক দিক দিয়ে এই অঞ্চলটি ছোটনাগপুর মালভূমির অংশ। ঔপনিবেশিক জনসংখ্যাগত তথ্য অনুযায়ী মানভূম ছিল প্রধানত একটি আদিবাসী অধ্যুষিত এলাকা। সাঁওতাল, ওরাঁও, কোড়া, মুন্ডা, কোল, ভূমিজ প্রমুখ আদিবাসী সম্প্রদায়ভুক্ত মানুষ এই অঞ্চলে বসবাস করত। পাশাপাশি শবর, বীরহোড়, খেড়িয়ার মতো অরণ্যবাসী আদিম জনজাতিরও উল্লেখযোগ্য উপস্থিতি ছিল।<sup>২</sup> এলাকাটি ছিল একান্তভাবেই কৃষির ওপর নির্ভরশীল। প্রাক ঔপনিবেশিক সময়কালে আদিবাসীরা ব্যাপকভাবে জঙ্গল পরিষ্কার করে কৃষিযোগ্য জমি প্রস্তুত করেছিল। আদিবাসী কৃষকদের সঙ্গে স্থানীয় রাজাদের একটা সুন্দর বোঝাপড়ার সম্পর্ক গড়ে উঠেছিল। তাদের



Arup Kanti Konar

**Reconstruction of  
Hydraulic Keynesianism for  
Macroeconomics of Sustainability**



**RECONSTRUCTION OF  
HYDRAULIC KEYNESIANISM  
FOR MACROECONOMICS OF  
SUSTAINABILITY**

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## Reconstruction of Hydraulic Keynesianism for Macroeconomics of Sustainability

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Arup Kantil Konar

## ABSTRACT

The nature and role of macroeconomics is determined by or dependent on context. This means that macroeconomics is contextual or context-dependent. "Sustainability macroeconomics", "macroeconomics for sustainability" and "macroeconomics of sustainability" (MOS) are interchangeably used. MOS is the eventual outcome of its contextualization. Though the effective life of MOS started since the second half of the 1990s, it has remained in the stage of infancy because of continuous process of (re)construction. The intensification of (re)construction for its further development is being observed since the beginning of the 21st century. Reconstruction of Hydraulic Keynesianism (HK), coined by the English economist Alan Coddington (1941-1982 A.D.), in the context of realizing sustainability, is needed in order to contribute to the emerging MOS. Keynes's General Theory (1936) has acquired revolutionarily varied interpretations, reinterpretations and/or misinterpretations, which had been classified by Coddington into three different groups: (i) Hydraulic Keynesianism (HK), (ii) Fundamentalist Keynesianism and (iii) Disequilibrium Keynesianism, while each group includes many analogous/homologous Keynesian models. It needs reiteration that Coddington was the originator of the foregoing categorization, but not the originator of any Keynesian model, which can be put in any one of the foregoing three groups. It is worthy to recall that HK consists of four constituent Keynesian macroeconomic models: (i) Simple Keynesian



Model, (ii) Special Keynesian Model, (iii) More General Keynesian Model or IS-LM Keynesian Model and (iv) Generalized Keynesian Model. Though HK was introduced in the context of exploring only the "causes, consequences and cures" of the "persistent problem of economic instability" in the capitalist world, yet its reconstructed version can be used to tackle the emerging problem of "ecologically socially unsustainable" or "ecologically unsustainable social instability" through the gradual development "dual capitalism", which implies the coexistence of "ecological capitalism" and "social capitalism". "Ecologically socially unsustainable" or "ecologically unsustainable social instability" is renamed as simply "unsustainability".

Against the foregoing backdrop, this thesis seeks to overcome the ingrained inadequacies of the conventional HK through the compositional transformation of the conventional equilibrium equations of the two models of HK such as (i) Simple Keynesian Model and (ii) IS-LM Keynesian Model. For that purpose, this thesis incorporates the relevant macro-ecological and macro-social/sub-social variables along with the new policy measures and applications into them in the reconstructed version of HK. Since the term "social" consists of various "sub-socials", an initiative is undertaken to describe how the "ecologically 'sub-social sustainability'" or "ecologically sustainable 'sub-social stability'" can be achieved through the desired reconstruction of conventional HK in order to realize the "ecologically socially sustainability" or "ecologically sustainable social stability" which is renamed as simply "sustainability".



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## **Reconstruction of Hydraulic Keynesianism for Macroeconomics of Sustainability**



## 1. Introduction

The economy is a hydraulic machine (Morgan & Boumans, 2004).

Extraterrestrial intelligent life in the form of human, superhuman or subhuman may exist elsewhere beyond the earth in the universe. The following newspaper report will confirm the foregoing statement:

### **Alien fever: Scientists believe in an exodus from Mars**

**By Danielle Bochove**

*Asian Age*

**Chicago, October 9, 1996**

As “alien fever” continues to sweep the United States – and the TV networks – more and more people are becoming convinced that intelligent life exists beyond earth, including some who believe alien lifeforms have already set up housekeeping on the planet.....Humans have an image in the galaxy. It’s not right now but it will be worse if we turn our backs on our neighbours in need. ....Such “neighbours” include a handful of Martians already on Earth who are waiting for a more welcoming climate before bringing an entire refugee population here. ....According to a Harris poll conducted in August (1996), 53 per cent of adult Americans believe there is intelligent life elsewhere in the universe and 40 per cent believe it exists within our solar system. And even the skeptics say those numbers are going to increase as the coming millennium conjures visions of apocalypse and television and film studios capitalize on the intrinsic appeal of characters like “ET”.....Quite clearly, there hasn’t been any change at all in the scientific evidence to support any claim of extraterrestrial visitations by aliens.....Some US insurance companies have even begun profiting from the wave of “alien fever” by offering policies covering abduction by aliens. One British broker recently (before 9 October 1996) began selling insurance against alien impregnation. Even politicians are not immune. Florida politician Lynne Plaskett recently risked political suicide with her announcement that space aliens cured her of cancer in 1975. Such tales are nothing new. ....It is modern folklore.....(*Asian Age*, 10 October, 1996).

But, surprisingly, we have no evidence to support the aforesaid newspaper report. Hence, we should/can claim that the earth is the only tiny little islet of life amid the boundless ocean of lifelessness.

Looking at the earth from the outer space, one realizes how infinitesimally small our world is – both we ourselves and our beautiful planet. We love our native lands – our cities, our villages, our steppes, our forests. But what about the whole of our native planet? We should love our remarkable, our one and only earth.....Indeed, there is no end of happiness to live on our planet. It is no end of happiness for people to have such a wonderful, comfortable planet. At

times I feel like exclaiming: “People, save the earth! It is so small, fragile, delicate, vulnerable! There is no other planet like it!.....Our planet, fragile and delicate, is a product of the indomitable forces of nature. It is populated by human beings with their boundless possibilities, with minds capable of grasping the laws of the universe. Why do humans love and hate, laugh and cry, do what they do? We have created a great deal, but has everything been done correctly? The question is difficult to answer, and the answer would hardly be unambiguous. Save our earth! (Rebrov, 1989, pp. 7-8).

By any criterion, the earth is going through the worst phase of dual instability: social instability and ecological instability. While social instability is persistent since the birth of the primitive society, ecological instability is emerging since the inception of industrial revolution in the 1770s in Britain. Such dual instability is based on the following four *ceteris paribus* assumptions:

- (1) Extraterrestrial intelligent life (ETI) in the form of human, superhuman or subhuman may exist elsewhere beyond the earth in the universe. But such ETI has no impact on or intrusion into our earth. This means that ETI is not responsible for the foregoing dual instability of the earth.
- (2) Solar stability is exogenously and autonomously given.
- (3) Natural stability indicated by the persistent equilibrium or homeostasis of the various life support systems is also exogenously and autonomously determined.
- (4) Natural instability indicated by the natural catastrophes (e.g. river floods, earthquakes, volcanic eruptions, hurricanes, typhoons, tsunamis, landslides, collision with asteroid or fall of large meteorite) is also exogenously and autonomously determined.

Social instability consists of multitude of “sub-social instabilities” (e.g. economic instability, political instability, cultural instability, religious instability, ethical instability, moral instability, sexual instability, marital instability, gender instability, familial instability). Social instability is indicated by poverty, starvation, malnutrition, inequality, illiteracy, backwardness, terrorism, kidnapping, human trafficking, prostitution, assassination, killing, lynching, child labour, child marriage, exploitation, etc. On the other hand, ecological instability is indicated by degradation, depletion or destruction of ecological or natural resources or capital.

Hence, under the *ceteris paribus* assumption, the coexistence of persistent social instability and emerging ecological instability gives rise to “ecologically unsustainable social instability”, which is renamed as simply “unsustainability”. On the contrary, the coupling of social stability with ecological stability *ceteris paribus* implies “ecologically sustainable social stability”, which is renamed as simply “sustainability”. Noteworthy that social stability or

sustainability and ecological stability or sustainability are interdependent, neither independent, nor dependent at the cost of other.

In order to reduce or rule out the unsustainability (or restore sustainability), innumerable interdisciplinary and/or multidisciplinary means, measures, methods, or mechanisms are being adopted by numerous scientists. Economics of sustainability is being constructed to tackle the problems of unsustainability. Since (un)sustainability is a macro level or global phenomenon, so the construction of “macroeconomics of sustainability” (MOS) is eventually inevitable. Reconstruction of Hydraulic Keynesianism by appropriate, adequate and/or apposite means is an attempt to contribute to the MOS.

In this context, the following remark of Roderick T. Long may be more relevant:

We can begin with the beliefs we have and move forward making adjustments as we find inconsistencies and learn new information (Richman, 2011).

The “explication” of Long’s remark (Richman, 2011), as stated below, is indispensable, because this remark should/may be treated as the “strategic starting point” of any (critical) research:

*We* (as practitioners of, specialists in, or contributors to, an academic discipline/a field of knowledge) *can begin* “research” (that means “search for new truths”, which may be invention of uniquely new ideas, new perspectives on old ideas, new inconsistencies/errors, or new developments on the preexisting/received ideas) *with the beliefs we have* in the “established truths” *and move forward* (that is, proceed or advance) *making adjustments* (that is, executing/performing new developments or progressive improvements) *as we find inconsistencies* (which may be criticisms, limitations, inadequacies, deficiencies, ambiguities or errors) in the “established truths” and *learn new information* (that is, “new truths”).

But the “search” for “new truths” against the “established truths” should be directed/guided by the suggestion of Paul A. Samuelson (the first American to receive a Nobel Prize in Economics in 1970) that there is the “anthropomorphic sin” of judging older writers by the canons of modern theory, but there is also the “sophisticated-anthropomorphic sin” of not recognizing the equivalent content in older writers (Blaug, 1983).

The significance of the search for new truths against the established truths can/should be judged by any one, two, ....., or all of the following ten points:

- (1) In practice, we all start our own research from the work of our predecessors, that is, we hardly ever start from scratch. Analysis has to start somewhere. There has to be something to analyze. That something is given by a pre-analytic cognitive act, which is renamed as vision (Schumpeter, 1954).
- (2) We do not start from nothing. The contributions of previous scholars or schools of thought are there to help (Pasinetti, 2005).
- (3) A new idea does not come forth in its mature scientific form. It contains logical ambiguities or errors. It is highly probable that the great new ideas of any period will have found an earlier and neglected statement. It is simply impossible for men to apprehend and adopt wholly unfamiliar ideas (Stigler, 1955).
- (4) The successful scholar is always the one, who adds some marginal improvement to the dominant theories, to which everyone is accustomed. Hence, it is essential to subject established truths constantly to a critical analysis without indulgence (Allais, 1997).
- (5) Every contributor to any field of knowledge stands on the shoulders of his/her predecessors. Specialists in any field of knowledge know that no one ever single-handed invented anything. In a sense, there are no “revolutionary discoveries” (Hansen, 1947).
- (6) Mark Blaug (1994) argues that great theories in economics, as in other subjects, are path dependent, that is, it is not possible to explain their occurrence without considering the corpus of received ideas, which led to the development of that particular new theory; had the body of received ideas been different, we would have arrived at a different theory at the culmination of that development (Snowdon & Vane, 2005).
- (7) The search for new truths does not ignore the thoroughly forgotten past, and so it is worth digging into the past again to disclose the faults and misjudgements of our forerunners to arrive at new truths (Konar, 2011).
- (8) “New knowledge tends to develop simultaneously through the works of many researchers in different places” (Ogburn, 1922). Thus, almost simultaneous and independent invention of an (identical) idea in different places may not be impossible in any academic discipline. Hence, a true researcher should be acquainted with the past inventions of the same or similar idea (Konar, 2011).

(9) The Nobel laureate (1995) Chicago University economist, Jr. Robert Lucas, argues that our responsibility is to create “new knowledge” by pushing “research” into “new” and hence, necessarily “controversial territory” (Snowdon & Vane, 2005).

(10) New developments of/on anything become needless, when it acquires completeness or perfection. The German mathematician, Carl Friedrich Gauss (1777 - 1855 AD), who is known as the prince of mathematicians, remarked that “When a fine building was finished, the scaffolding should no longer be visible” (Konar, 2011). By analogy, it can be pointed out that if the constituent/compositional components/elements of an academic discipline (e.g. theories, models, and methodologies) assume their finished form, why are they subject to recurrent developments? The answer to this question is that such developments occur owing to the operation of the “principle of informed ignorance”, coined by the German Cardinal, mathematician, experimental scientist and influential philosopher, Nicholas of Cusa (1401-1464 AD), in his *On Learned Ignorance* (1440). Such principle implies that the more we know, the more aware we will be of our ignorance and the further we penetrate into the informed ignorance, the closer we come to the truth itself (Konar, 2011).

## **1.1. New Developments on the Critical Fronts**

There is hardly any/an academic discipline, which is free from, or devoid of “lurking inconsistencies”. Needful to note that the term “lurking inconsistency” was coined by Alfred North Whitehead (1862–1947 AD) in *Science and the Modern World* (1925, p. 76). The persistence of lurking inconsistency in academic disciplines is evident from the remark of Herman Daly (2013):

“Economics too suffers from the lurking inconsistency”.

Daly’s (2013) remark implies that as in other academic disciplines, in economics also, there are “fronts”, in which “lurking inconsistencies” are congealed or embedded, and such fronts can be designated as “critical fronts”. Hence, new developments on the critical fronts in the theory of economics are inevitable for the realization of new truths against the established truths.

In the theory of macroeconomics, the “critical front”, which needs new developments, has been discovered/disclosed by this thesis: Coddington’s (1976, 1983) Hydraulic Keynesianism (HK).

Noteworthy that new developments on HK to adapt to different contexts (e.g. different dimensions of sustainability) have previously been executed by the following twenty two literatures: (1) Young (1975), (2) Daly (1991), (3) Girma (1992), (4) Thampapillai (1995), (5) Thampapillai and Uhlin (1996), (6) Thampapillai and Uhlin (1997), (7) Ahmed and Mallick (1997), (8) Heyes (2000), (9) Mallick, Sinden, and Thampapillai (2000), (10) Munasinghe (2002), (11) Lawn (2003a), (12) Lawn (2003b), (13) Lawn (2003c), (14) Daly and Farley (2004), (15) Sim (2006), (16) Morales’s (2007), (17) Thampapillai, Wu and Sunderaj (2007), (18) Emmanuel (2008), (19) Victor (2008), (20) Harris (2008/2009), (21) Custers (2010), and (22) Konar (2010).

Yet some undisclosed or unexplored lurking inconsistencies of HK persist, and hence, its “further new development” is exigent. In better words, despite the execution of “new developments” on HK by the foregoing twenty two literatures, this thesis emphasizes that “further new development” on HK is not only necessary, but also possible for realizing/restoring the context of sustainability and/or reducing/ruling out the context of unsustainability in order to contribute to macroeconomics of sustainability (MOS).

## **1.2. Keynesianisms**

But for the execution of further new development on HK, it is pertinent to proceed with the most relevant remark of Skidelsky (1992, p. 541):

“The *General Theory* is no one’s property”.

In Skidelsky’s (1992) remark, the *General Theory* (GT) has been substituted for Keynes’s (1936) “contextual” and “revolutionary” macroeconomic book *The General Theory of Employment, Interest and Money*. The GT is “contextual”, because it arose out of the context of reducing/ruling out the worldwide deplorable depression in the 1930s. The GT is also

“revolutionary”, because it is a denial and devoid of, and departure from the de-contextual macroeconomic literature introduced by the pre-Keynesian school(s) of macroeconomic thought.

The intrinsic implication of Skidelsky’s (1992) remark is that the GT has brought about a “reinterpretive/reconstructive revolution”. That is why, in 1992, the *Economic Journal* said of its former editor, “The Keynes industry....is now surely running a close second to the output of the Marx industry”, while the *Journal of Post Keynesian Economics* declared that “Each year seems to bring forth yet another ‘new interpretation’ of Keynes” (McInnes, 1994). Similarly, O’Donnell (1991) remarked that “The excessive proliferation of interpretations of Keynes’s (philosophical) thought is a matter of concern”. Moreover, Wolff (2009) argued that “Of course, different interpretations of Keynes (as of Marx) have always contested with one another”.

Thus, since its publication on 4 February 1936, there is no end of proliferation of “interpretation, reinterpretation and/or misinterpretation of the GT”, which can be substituted with, or reduced to the “reconstruction of the GT”. Hence, since its publication in 1936, the GT has acquired the “endless free play” of its “multitude of reconstructions”. The phenomenon of exponential growth of reconstruction of the GT over time may be sufficient to arrive at the following three similar propositions:

- (1) The GT has become the fable of the blind men touching the elephant.
- (2) The GT has proved to be a snake-like concept, whose twists and coils are difficult to pin down.
- (3) The GT can be likened to the skin of a living organism, which is metamorphic.

Keynes’s anti-fundamentalism attitude, which influenced, inspired or induced other economists to reconstruct the GT by their own desire, discretion or direction to adapt to the different contexts or the changing context, had been reflected in the remark of Paul A. Samuelson: “We don’t want unreconstructed Keynesians. We want people, who will carry the scientific analysis further” (Blaug, 1990). Most importantly, the frequency of reconstruction of the GT has assumed such a figure that Weintraub (1979) has designed/designated a chapter, entitled, *The 4,827<sup>th</sup> Reexamination of Keynes’s System!*

All the varied reconstructions of the GT are being termed as “Keynesianisms”, while all the reconstructors of the GT are being designated as “Keynesians”. Needless to note, Keynesianism is synonymous with Keynesonomics, Keynesiology, Keynesian macroeconomics and Keynesian macroeconomic model. Owing to its “revolutionary nature”, the GT has converted “Keynes” into “Keynesianism” as well as “Keynesian revolution”. “Keynesianism” is such an important “ism”, by which the macroeconomic schools of thought have been categorized into Pre-Keynesianism, Post-Keynesianism, Neo-Keynesianism, New-Keynesianism, etc.

Although it can be discovered that the 4,827<sup>th</sup> reconstruction of the GT was executed by Weintraub (1979), yet we must confront with much toil and trouble to assert who executed the *n*<sup>th</sup> (where  $n = 1, 2, 3, 4, 5, 6, \dots$ ) reconstruction of the GT. In order to tackle such a difficult problem, the English economist Alan Coddington (1941-1982 AD) suggested a classification of the “endless chain of reconstruction of the GT” into the following three broad variants (Coddington, 1976, 1983):

- (1) Hydraulic Keynesianism (HK), which consists of two Keynesian macroeconomic models: (i) Simple Keynesian Model (SKM) and (ii) More General Keynesian Model or IS-LM Keynesian Model (IS-LMKM), devised by Hicks (1937), Meade (1937), Samuelson (1939a, 1939b, 1946, 1947, 1948), Lerner (1944), Lange (1944), Modigliani (1944a, 1944b), Harrod (1937), Klein (1944, 1947), Hansen (1936a, 1936b, 1938, 1941, 1947, 1949, 1951, 1953), Smith (1956), and so forth.
- (2) Fundamentalist Keynesianism, developed by Robinson (1962a, 1962b), Shackle (1967, 1974), Davidson (1978, 1994), and so forth.
- (3) Reconstituted Reductionism or Disequilibrium Keynesianism, designed by Patinkin (1948, 1956), Clower (1965), Leijonhufvud (1968), Barro and Grossman (1971), Malinvaud (1977), and so forth.

Each of the three “Keynesianisms” includes many analogous/homologous Keynesian macroeconomic models. Noteworthy that Coddington (1976, 1983) was the originator of the foregoing categorization, but not the originator of any Keynesian macroeconomic model, which can be included in any one of the foregoing three Keynesianisms. Moreover, it needs reiteration that Coddington (1976, 1983) was neither the originator of the term “hydraulic”, nor the originator of “hydraulic macroeconomic model”. Hence, we can/should ask: Who is the first predecessor of hydraulic macroeconomic model?



### 1.3. First Predecessor of Hydraulic Macroeconomic Model

This question can be answered just after the next paragraph.

By analogy of hydraulic Keynesians, Alban William Housego (Bill) Phillips (1914-1975) drew the “little plumbing diagram” to help him to understand how the stocks and flows of a commodity interact in a market (Phillips, 1950). The little hydraulic diagram of Phillips (1950) is designed to work according to the hydraulics pictured, but is simultaneously subject to the rules of reasoning from the economic content enshrined in the arrangements of the parts: where demand and supply, and price and quantity can be changed in particular ordered ways. Moreover, with the collaboration of the monetary economist Walter Newlyn, such “little plumbing diagram” grew into a “large physical hydraulic machine of the economic system as whole” (Morgan & Boumans, 2004). The Newlyn-Phillips Machine is a big apparatus – “a real hydraulic model” – of which we can see only a “drawing in a two-dimensional diagram”. The physical model itself operates according to the language rules of hydraulics with the flow of water flowing around the machine controlled by physical valves. But the overall form and parts of the machine were designed to imitate the stocks and flows of money (red water) around an economy, and the behavioural functions of the economic relations are drawn into the small rectangular “slides”, which can be seen on the drawing. These in their turn control the opening and closing of the valves in the hydraulic system. Despite its complexity, and even without knowing what these economic relations are, we can see how the “rules of form” (hydraulics) and “content” (macroeconomics) are instantiated in the hydraulic machine (Morgan, 2009). More specifically, Phillips (1950) devised a “hydraulic system” with pipes and tanks, which was meant to put in concrete form the relations between macroeconomic stocks, flows and price level (Beaud & Dostaler, 2005).

In response to the question of the first predecessor of the hydraulic macroeconomic model, it is worthy to recall that: “No scientific discovery is named after its original discoverer” (S. M. Stigler, 1999). Stephen M. Stigler’s (1999) remark holds true for an American economist, Irving Fisher (1867-1947), who not only coined the term “hydraulic”, but also invented “hydraulic macroeconomic models”, which will be evident from the following six literatures:

(1) Dimand and Betancourt (2012) claim that Fisher (1892) not only imagined, but also actually built a “hydraulic mechanism” to simulate the determination of equilibrium prices and quantities - in effect, a “hydraulic computer” in the days before “electronic computers”.

(2) Brainard and Scarf (2005) took on the task of investigating how the “model of Fisher’s hydraulic computer” worked in *How to Compute Equilibrium Prices in 1891*. They reprinted the sketches of Fisher’s “hydraulic computer” from his dissertation of 1891. It apparently consists of a series of cisterns, rods, floats, bellows, tubes, levels, valves, levers, cams, etc. It represents three consumers and three commodities that they consume. “How to compute equilibrium prices in 1891” by W. C. Brainard and H. E. Scarf examines Fisher’s exposition of general equilibrium by the “hydraulic model” through MATLAB. Fisher articulated the limitations of static analysis and the necessity of dynamic analysis in the appendix of his *Mathematical Investigations in the Theory of Value and Prices* (1892)”.

(3) According to Morgan (2009), Irving Fisher (1892/1925), in his *Mathematical Investigations in the Theory of Value and Prices*, designed and constructed a “hydraulic macroeconomic model” to represent, explore, and so understand the workings of a “mini-economy”, one with only three commodities, three persons and three equations. He built his “hydraulic macroeconomic model” in the name of “hydraulic mini-economy model” to represent the ideas embedded in the *Elements of Pure Economics* (Walras, 1874/1954) of the French economist Marie Esprit Leon Walras (1834-1910 AD), and to figure out by exploring with his model the process, by which the latter’s mathematically postulated and proved general equilibrium might be arrived at. He accompanied this work with an outright defense of the three research objects: (i) mathematics, (ii) graphs and (iii) real machines that he designed and used for his economic analysis. Fisher’s thesis of 1891 was published in 1892 and republished in 1925, displaying photograph of the mechanism in the frontispiece labeled “model of mechanism”. The fact that he used mathematical ideas from “physical systems” demonstrates not only the closeness of mathematics and sciences, but also shows how treacherous relying on analogies as indicators of reasoning style can be.

(4) Morgan (1999) also points out that in choosing a “mechanical balance as a model” for the “equation of exchange” between money and commodities, Fisher (1911), in *The Purchasing Power of Money*, recognized the similarity between the “mechanical balance” and the “economic

subject matter” in his arithmetic “equation of exchange”. Here also, “hydraulic macroeconomic model” is congealed and concealed in Fisher’s (1911) text.

(5) Francis Ysidro Edgeworth (1845-1926) invited Fisher to apply a simplified version of his hydraulic macroeconomic model to *The Mechanics of Bimetallism* (1894) to the Economics Section of the British Association for the Advancement of Science and then publication in the *Economic Journal* (September, 1894), which Edgeworth edited (Dimand & Betancourt, 2012).

(6) More recently, in an article by Robert W. Dimand and Hichem Ben-El-Mechaiekh (2012), it has been clearly claimed that the hydraulic macroeconomic model is embedded in Fisher’s *Mathematical Investigations in the Theory of Value and Prices* (1892/1925).

Thus, Coddington (1976, 1983) may be assumed to borrow the term “hydraulic Keynesianism” from the “hydraulic macroeconomic model” of Fisher (1892/1925, 1911) or Phillips (1950).

Keynes’s appreciation, acceptance and approval of HK were primarily based on the fact that HK was able to capture the “full vision of the GT”. That was sufficient for Keynes (i) to publicly recognize the works of the “hydraulic interpreters of the GT” as a step in the right direction, and (ii) to approve the works of “hydraulic Keynesians” (Backhouse & Bateman, 2010).

#### **1.4. Objectives of Hydraulic Keynesianism**

The sole objective of HK is to explore and explicate the “causes, consequences and cures” of the “persistent economic instability” in the capitalist world “under the *ceteris paribus* assumption”, in which the two presumptions, such as, (i) the presumption of “sustained ecological stability”, and (ii) the presumption of “sustained non-economic sub-social stabilities”, are embedded. In better words, “under the *ceteris paribus* assumption”, in which the foregoing two presumptions are embedded, HK has attempted to solve only the “problem of persistent economic instability”, whose frightening indicators are poverty, inequality of wealth and income, unemployment, malnutrition, hunger, starvation, inflation, depression, stagflation, etc. of “mono capitalism” (*economic capitalism*), not “dual capitalism” (*coexistence of social capitalism and ecological capitalism*).

The “economic instability” is one of the multiple “sub-social instabilities”, which constitute “social instability”. The term “social” consists of various “sub-socials”, such as, cultural, economic, ethical, familial, gender, legal, marital, military, moral, philosophical, political, psychological, religious, ritual, scientific, sexual, spiritual, technological, terrorist, etc. Hence, “social instability” includes various “sub-social instabilities”, such as, economic instability, political instability, cultural instability, religious instability, ethical instability, moral instability, familial instability, gender instability, etc.

But the vitiating/violation of the validity of the foregoing “*ceteris paribus* assumption” started since the worldwide enthusiastic celebration of the *First Earth Day* on 22 April 1970. The *First Earth Day* has opened our eyes to new perspectives on old ideas/assumptions. Because it reminds us that over the last three centuries (*ranging from the eighteenth century to the twentieth century*), which can be designated as the “centuries of relentless revolutions” (*because no century before in history had offered so many varied revolutions to so many culturally different human societies in the globe in as short a time span as these three centuries did*), we have brought about a “series of revolutions” only to realize the “unprecedented economic growth” at the costs of “social instability” and “ecological instability”. The *First Earth Day* can also be viewed as a “warning signal” in the sense that it is a sign of our delayed realization or recognition about the “problem of emerging ecological instability”, by which the global human society is being threatened, given the “problem of persistent social instability”, which consists of various “sub-social instabilities” (Konar & Chakraborty, 2011).

Thus, since the 1970s, which is referred to as the *Decade of Environment*, our delayed realization/recognition is that the global human society is being threatened by the “coexistence of persistent social instability and emerging ecological instability”. This “dual instability” is designated as “ecologically social unsustainability”, or “ecologically unsustainable social instability”, which is renamed as simply “unsustainability”.

Hence, given the exogenously and spontaneously determined natural instability indicated by natural catastrophes, and natural stability indicated by the enduring equilibrium/homeostasis of various natural life support systems, “ecologically social sustainability (or unsustainability)”, or “ecologically sustainable (or unsustainable) social stability (or instability)” means simply “sustainability (or unsustainability)” [Konar & Chakraborty, 2011].

## **1.5. Lurking Inconsistencies of Hydraulic Keynesianism**

The “ecologically social unsustainability”, or “ecologically unsustainable social instability”, which is renamed as simply “unsustainability”, cannot be tackled by HK owing to the persistence of its “lurking inconsistencies”. Such lurking inconsistencies of HK to realize/restore sustainability and/or to reduce/rule out unsustainability in the capitalist world can be summarized in terms of the following five points:

- (1) The presupposition of the intrinsic embeddedness of economic capital, neither natural/ecological capital nor social capital or other sub-social capitals in it (Konar, 2010). This means that HK emphasizes the creation, control and/or conservation of economic capital ignoring the role of natural/ecological capital and social capital or other sub-social capitals (e.g. political capital, religious capital, cultural capital, moral capital, ethical capital, spiritual capital, etc.).
- (2) The persistence of a conventional national income (NI) accounting method, neither sustainable national income (SNI) accounting method, nor ecologically and socially adjusted NI accounting method in it.
- (3) The compositional stability/inertia of the conventional “representative equations” indicated by the “equilibrium equations” in it.
- (4) The aversion to incorporate the relevant macroecological variables (e.g. natural/ecological capital) and macrosocial or macrosocial variables (e.g. social and subsocial capitals) into the equilibrium equations in it.
- (5) Its inability to bring about neither “ecologically economic sustainability” (or “ecologically sustainable economic stability”), nor “ecologically social sustainability” (or “ecologically sustainable social stability”).

All the foregoing five factors can be reduced to the “de-ecologization” and “de-socialization” of HK.

## **1.6. Ends and Means of the Thesis**

Against the foregoing backdrop, the “end(s) and means” of this thesis, which is a crucial component of introduction, should be incorporated into it. Such incorporation is based on the

following “end(s)-oriented remarks” of Keynes (1936), Boland (1994), Bataille (1995) and Daly (2013):

The object of our analysis is, not to provide a machine, or method of blind manipulation, which will furnish an infallible answer, but to provide ourselves with an organized and orderly method of thinking out particular problems, and after we have reached a provisional conclusion by isolating the complicating factors one by one, we then go back on ourselves and allow, as well as we can, for the probable interactions of the factors among themselves. This is the nature of economic thinking (Keynes, 1936).

Every invention of an idea can be seen *post hoc* to solve a problem or answer a question (Boland, 1994).

The *object* of research cannot be distinguished from the *subject* at its boiling point (Bataille, 1995).

If purpose does not exist, then it is hard to imagine how we could experience the lure of value. To have a purpose means to serve an end, and value is imputed to whatever furthers attainment of that end. Alternatively, if there is objective value, then surely the attainment of value should become a purpose (Daly, 2013).

The “end of this thesis” has been directed to the reconstruction/remodeling of HK to realize/restore the context of sustainability and/or to reduce/rule out the context of unsustainability for contributing to MOS.

To achieve that “end”, the “major means” can be stated in terms of the following ten points:

- (1) Introduction of four types of essential (macro)economic activity.
- (2) Introduction of three principal macroeconomic goals.
- (3) Introduction of four spheres of macroeconomic activity.
- (4) Introduction of six sectors into national income accounting.
- (5) Introduction of three types of capital into national income accounting.
- (6) Compositional reconstruction of  $GDP = C + I + G + (X - M)$  by the decomposition of  $C$ ,  $I$  and  $G$ .
- (7) Reconstruction of National Income: From GDP to SNI (sustainable national income).
- (8) Incorporation of SNI into consumption or saving function.
- (9) Contextual reconstitution of the “representative equations” indicated by the “equilibrium equations” of the two constituent macroeconomic models of HK by (i) incorporating the relevant

macroeconomic, macroecological, macrosocial and/or macrosocial variables into such equilibrium equations and (ii) maintaining/keeping the consistency of the national income accounting method suggested by United Nations IEEA (1993) and SEEA (1993).

(10) Mathematical and diagrammatical representation of the reconstructed models of HK for sustainability.

Since the term “social” consists of various “sub-socials” (e.g. economic, political, cultural, religious, moral, ethical, spiritual, etc.), so the “framework of the thesis” can also be used/exploited to demonstrate how the “ecologically sub-social sustainability”, or “ecologically sustainable sub-social stability” can be achieved through the desired reconstruction of HK.

By analogy of Odum and Barrett (2006), it can be emphasized that sustainability can be realized/revived, or unsustainability can be reduced/ruled out through the gradual development of “dual capitalism” or “capitalist dualism”, which means the “coexistence of social capitalism and ecological capitalism”, as opposed to “mono capitalism” or “capitalist monism”, which implies “economic capitalism”.

The objective of “social capitalism” is to restore/realize “social sustainability” through the creation, control and/or conservation of “social capital”, while the objective of “ecological capitalism” is to restore/realize “ecological sustainability” through the creation, control and/or conservation of “natural/ecological capital” (Konar & Chakraborty, 2011).

There is hardly any “creation” or “construction”, which is free from “criticisms”. The book also is not de-critical or devoid of potential criticism(s). But the “mode/method of criticism” should be guided by Popper’s principle of sympathetic problem orientation (Boland, 1994). Such principle implies that the critic must indicate the researcher’s problem and solution, but only after making every effort to present the researcher’s views in the “most sympathetic light”. This means that the critic must make all unchallengeable improvements, which can be made before launching the criticism. One should not wish to distract the debate into irrelevant side issues. In effect, the criticism must be conducted in terms that the researcher can accept (Boland, 1994).

## 2. Review of Literature

History makes no sense without prehistory (Wilson, 2012).

Economic knowledge is historically determined...what we know today about the economic system is not something we discovered this morning, but is the sum of all our insights, discoveries and false starts in the past. Without Pigou, there would be no Keynes; without Keynes, no Friedman; without Friedman, no Lucas; without Lucas, no.....(Blaug, 1991).

In other words, without the history of economics, economic theories just drop from the sky; you have to take them on faith. The moment you wish to judge a theory, you have to ask how they came to be produced in the first place and that is a question that can only be answered by the history of ideas (Blaug, 1994).

The review of literature offers the intensive and extensive revisiting of those literatures, which have compatibility with the end(s) of the thesis. Such literatures can be divided into the two areas/parts: (2.1) Conceptual Clarification, (2.2) Reconstructions of HK for Sustainability by Previous Literatures for Contributing to MOS.

### 2.1. Conceptual Clarification

Various concepts/terms are embedded in the different sections and sub-sections of this book. Conceptual/terminological ambiguity makes this book naïve. The clarification of the crucial concepts/terms is needed for its sophistication, because the relevant concepts/terms are interrelated or interdependent. Their interrelationship/interdependence gives rise to the complementarity, consistency and/or coordination of the constituent components of the book.

#### 2.1.1. Sustainability

The *Substantive Signification of Sustainability* has been disclosed by Konar and Chakraborty (2011). By the principle of structuralism, we cannot conceptualize “sustainability” without considering its opposite polarity “anti-sustainability” or “unsustainability”. Sustainability is a synonym or a close/perfect substitute for stability, persistence, perpetuity, durability, endurance,



permanence, eternalness, intransience, constancy, continuity, indefinite existence or sustained survival. Sustainability is pointless without the suffix “of something”, say, “of *X*”. Thus, it is correct to substitute “sustainability of *X*” for simply “sustainability”. Sustainability is a “portmanteau word” or “telescope word”, which means a word formed by combining multiple words. Thus, sustainability of *X* implies “sustain plus ability”, which in turn implies “ability to sustain *X*”, which ultimately implies “ability to maintain and continue the survival of *X*”. Further, “sustainability of *X*” can also be translated into “*X* sustainability”, where *X* stands for an appropriate adjective. For example, sustainability of environment is mapped into environmental sustainability, sustainability of ecology is transformed into ecological sustainability, and sustainability of society is converted into social sustainability.

The concepts of sustainability and unsustainability acquired global recognition with the enthusiastic celebration of the *First Earth Day* on 22 April 1970 throughout the world. But the seeds of sustainability were sown in the various works of many scholars prior to the year 1970.

Hence, given the exogenously and spontaneously determined natural instability indicated by natural catastrophes, and natural stability indicated by the enduring equilibrium of various natural life support systems, “sustainability (or unsustainability)” means “ecologically social sustainability (or unsustainability)” or “ecologically sustainable (or unsustainable) social stability (or instability)”, where the concept “social” consists of multitude of “sub-socials”. In fact, under the *ceteris paribus* assumption, sustainability (or unsustainability) implies the coexistence of ecological stability (or instability) and social stability (or instability).

While the “indicators of ecological instability” can be encapsulated in the depletion, degradation and/or destruction of ecological/natural capital, the “indicators of social instability” can be reduced to the depletion, degradation and/or destruction of social capital, which consists of various sub-social capitals (e.g. economic capital, political capital, cultural capital, and moral capital).

Most importantly, there are people, who erroneously recommend for reducing sustainability to ecological sustainability. But social sustainability and ecological sustainability are interdependent, neither independent, nor dependent at the cost of other (Konar & Chakraborty, 2011).

The more we learn about current environmental trends, the more the unsustainability of our present course becomes clear to us (Foster, 2009). The emerging global environmental indications are so grave that the term sustainability may be treated as a “euphemism and euphuism for survival of human species” (Konar & Modak, 2010; Konar & Chakrabortty, 2011). Obviously, “unsustainability” should be regarded as the “crisis of human survival” (Gohn, 1980). In this context, it is worthy to recall *A Blueprint for Survival* (Ecologist Magazine, 1972) in *Only One Earth* (Ward & Dubos, 1972).

Sustainability is treated as an “enlightened self-interest”, as opposed to “destructive self-interest”, where “self-interest” is confined to “survival”, which refers to the perpetuation of life in the “tiny little islet of life amid the boundless ocean of lifelessness” (Rebrov, 1989) over the eons.

Further, sustainability can be likened to the global public goods, which have two properties: “non-rivalry” and “non-excludability”. Moreover, sustainability also implies “interspecies cosmopolitanism” (Konar & Chakrabortty, 2011).

Albert A. Bartlett (1997-1998) has devised the Seventeen Laws of Sustainability, with which he has sought to clarify the meaning of sustainability in terms of population and resource consumption. Moreover, Richard Heinberg (2011b) has disclosed the Five Axioms of Sustainability, as follows:

- (1) **First Axiom:** Any society that continues to use critical resources unsustainably will collapse. Exception: A society can avoid collapse by finding replacement resources. Limit to the Exception: In a finite world, the number of possible replacements is also finite.
- (2) **Second Axiom:** Population growth and/or growth in the rates of consumption of resources cannot be sustained.
- (3) **Third Axiom:** To be sustainable, the use of renewable resources must proceed at a rate that is less than or equal to the rate of natural replenishment.
- (4) **Fourth Axiom:** To be sustainable, the use of non-renewable resources must proceed at a rate that is declining, and the rate of decline must be greater than or equal to the rate of depletion.
- (5) **Fifth Axiom:** Sustainability requires that substances introduced into the environment from human activities be minimized and rendered harmless to biosphere functions.

## **2.1.2. Sustainable Development (SD)**

The World Commission on Environment and Development (WCED, 1987) has defined SD as follows:

Sustainable development involves more than growth. It requires a change in the content of growth to make it less material- and energy-intensive and more equitable in its impact. These changes are required in all countries as part of a package of measures to maintain the stock of ecological capital, to improve the distribution of income, and to reduce the degree of vulnerability to economic crises.

The precise meaning of the WCED's (1987) definition of SD is as follows:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

The WCED's (1987) concept is correct, but its important limitation is that it is anthropocentric in the sense that it only considers human species and it says nothing about nonhuman species. Thus, Boff (2012) has redefined SD as follows:

Sustainable development is every action destined to maintain the energy, information, and physical-chemical conditions that make all beings sustainable, especially the living Earth, the community of life and human life, seeking their continuity, and also to attend the needs of present and future generations in such a way that the natural capital is maintained and its capacity of regeneration, reproduction and eco-evolution is enriched.

According to Bartlett (2012), the WCED's (1987) definition of SD has a flaw. It focuses first on the needs of the present, which have nothing to do with sustainability, and secondarily, it mentions the needs of future generations, which are vital for sustainability. This sets the stage for intergenerational conflict, in which the present generation wins and future generations lose. Thus, Bartlett (2012) has redefined SD as follows:

Sustainable development is development that does not compromise the ability of future generations to meet their own needs.

The FAO's (1995) definition of sustainable development can be restated as follows:

Sustainable Development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development, which conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

From the WCED's (1987) definition of SD, it is possible to infer two different implications:

(1) That the stock of natural/ecological capital must be left intact for the next generations. In better words, the depletion of non-renewable resources must stop so that natural/ecological capital is not further depleted. In policy terms, this implies putting a stop to all activities, which exploit a non-renewable resources affecting the future generations.

(2) That the aggregate stock of manufactured capital and natural/ecological capital must not decline between one generation and the next generations. In better words, there can be trade-offs between manufactured capital and natural/ecological capital. The depletion of natural/ecological capital is justified so long as there is investment in a natural or manufactured alternative and the aggregate stock is retained. In policy terms, for example, this means that the oil stock can be depleted so long as it is replaced by investment in another capital, which allows future generations the same quality of life and choice as was supplied by oil to the present one. But this interpretation is also problematic, because there are some other capitals, which cannot be substituted for others (e.g. ozone layer, species, etc.). Nor can we be sure that future generations will accept or positively interpret our decisions about substitutes. How can we today know the needs of future generations? This highly normative definition raises some important questions. For example, needs are not given, but change constantly over time, and also vary cross-culturally. Further, development is not just a means to meet needs, but is a process, which entails the development of needs themselves. Therefore, how can "needs" be defined independently of "development", if it is often the process of economic growth/development initiated by the North, which creates and defines "needs"?

### **2.1.3. Weak Sustainability versus Strong Sustainability**

The generally accepted two versions of sustainability are weak sustainability and strong sustainability (Ayres, van den Bergh & Gowdy, 1998). They have been eloquently stated in Pearce, Markandya and Barbier (1989). Though the difference between them has created a hubbub of heated controversy (Solow, 1997; Stiglitz, 1997), yet there is a place for both of them. The difference between them is a matter of difference in the degree of substitutability between natural/ecological capital and manufactured capital. Either concept of sustainability implies some limits to economic growth. As planetary ecosystem has certain limits, there must also be limits on macroeconomic scale (the overall level of resource use and goods output). Hence, there is a need in the long term to reach a plateau, a steady state in terms of the consumption of material and energy resources. Some capitals must fall under the requirement of strong sustainability, others under the weak sustainability. Which of the two it is, will depend on the degree of substitutability between manufactured capital and natural/ecological capital. The depletion of fossil fuels (natural capital) is an example of weak sustainability. Provided other sources of energy (manufactured capital) can be developed instead, we are not obliged to leave our descendants an undiminished stock of petroleum. An extinct species, on the other hand, cannot, at the current state of scientific knowledge, be recovered, and must, therefore, be considered a loss in terms of strong sustainability.

#### **2.1.3.1. Weak Sustainability**

Weak sustainability shows that the substitutability of manufactured capital for natural/ecological capital is more or less unlimited. Unlimited substitutability and perfect substitutability are not the same. For example, in the case of Cobb-Douglas production function:  $X = AK^aN^b$ , manufactured capital  $K$  is an unlimited substitute for natural capital  $N$ , because however small a positive  $N$  is, there is always some  $K$ , which will produce a given level of output  $X$ . By contrast, in the case of linear production function:  $X = (aK + bN)$ , a unit of  $K$  is a perfect substitute for  $(a/b)$  units of  $N$ . In the case of weak sustainability, the next generation should inherit a stock of wealth, comprising manufactured capital and natural/ecological capital, no less than the stock inherited by the previous generation. The depletion of natural/ecological capital is justified as long as

manufactured capital can substitute for natural/ecological capital. Any loss of natural/ecological capital can/should be balanced by the creation of manufactured capital of at least equal value. Hence, it is acceptable to use or destroy natural/ecological capital provided that manufactured capital of equal value is substituted for what is lost. Weak sustainability can be criticized on the grounds that economic valuation does not reflect the full value of ecological/natural services, and therefore, encourages to ignore ecological limits. This can lead the process of economic growth or development on very dangerous roads. In the past, destructive ecological feedbacks have caused civilizations to collapse.

### **2.1.3.2. Strong Sustainability**

Strong sustainability shows that natural/ecological capital and manufactured capital are not substitutable and therefore, stock of natural/ecological capital must be maintained. In other words, the substitutability of manufactured capital for natural/ecological capital is absolutely ruled out. In the case of strong sustainability, the next generation should inherit a stock of natural/ecological capital no less than the stock inherited by the previous generation. Where there is danger of irreversibility, that is, damage that cannot be repaired, we should observe the precautionary principle. Such principle implies that we should not risk environmental damage, which can permanently harm our own society or future generations.

### **2.1.4. Contextual Macroeconomics**

By any criterion, economics is contextual or context-dependent. This means that the nature, role and principles of economics change with the change in context.

Although the reconstruction of economics started since the publication of Boulding's (1950) *A Reconstruction of Economics*, the first book on contextual economics is *Economics: Principles and Practices* (1979; Last edition, since the first edition is out of print) by Kelvin Lancaster, a Columbia University economist (Goodwin, Anaanyin, Ackerman & Weisskopf, 1997).

On the basis of the principles of the contextual economics, economics is being redefined as the study of the way people organize themselves or their efforts to sustain life and enhance its

quality (Goodwin, Nelson, Ackerman & Weisskopf, 2009; Goodwin, Nelson & Harris, 2009). Thus, economics studies how individuals engage in the following four essential economic activities and how their social coordination is achieved: (i) maintenance of resources (e.g. natural resources, manufactured resources, social resources, human resources, financial resources, etc.), (ii) production of goods and services, (iii) distribution of goods and services, and (iv) consumption of goods and services.

Hence, contextual economics is the result of an evolutionary process, in which economics practitioners have eliminated those ideas that failed and kept those that appear to explain reality well. In better words, contextual economics is the result of a sustained process of (re)construction of an interaction between ideas and events in the changing context.

The examples of contextual economics are cultural economics, ecological economics, environmental economics, family/household economics, institutional economics, military economics, political economics, religious economics, resource economics, social economics, social ecological economics, sustainability economics and “Sustainomics”, coined and clarified by Mohan Munasinghe (1992), the Chairman of Munasinghe Institute of Development (MIND), Sri Lanka.

As an important branch of economics, macroeconomics is not devoid of context or de-contextual. Because “the material is not homogeneous through time” (Keynes, 1938) and there are no unchanged structures or mechanisms for all times. That is why we have to make a new thinking, which is relevant to the changing or contemporary world. If macroeconomics is contextual, its objective is to cope with the changing context.

Needless to say, macroeconomics looks at the performance of the overall economy. But how the macroeconomics or macroeconomy and macroeconomic factors and their general conditions are examined varies in different schools of thought *ceteris paribus*.

Macroeconomics is also being contextualized to create the environmental macroeconomics, ecological macroeconomics, social macroeconomics, social ecological macroeconomics, sustainability macroeconomics, or macroeconomics of/for sustainability, etc.

The context of the 21<sup>st</sup> century macroeconomics is radically different from the context of the 19<sup>th</sup> and 20<sup>th</sup> century macroeconomics. The contextual difference creates a differentiation in the nature and role of macroeconomics.

Blanchard (2000) has divided the history of macroeconomics into three epochs: (i) *pre-1940 epoch*, (ii) *1940-1980 epoch*, and (iii) *post-1980 epoch*.

If macroeconomics for the former two epochs is designated as “old contextual macroeconomics”, then macroeconomics for the latter epoch should be denoted as “new contextual macroeconomics”. Evidence indicates that old contextual macroeconomics was confined to the exploration of the causes, consequences and cures of the problem of persistent economic instability through accelerating the economic growth in the capitalist world *ceteris paribus*. But economic instability is one of the multiple subsocial instabilities of social instability. The old contextual macroeconomics fails to tackle the problem of persistent social instability, non-economic social instability or remaining subsocial instabilities.

In addition, the worldwide celebration of the *First Earth Day* on 22 April 1970 reminds/warns us that the “old context” (*persistent social instability*) has been coupled with a “new context” (*emerging ecological instability*) in the capitalist world, given the exogenously and spontaneously determined natural instability and natural stability including solar stability. This “dual instability” (*dual context*), that is, the coexistence of the “persistent social instability” (*old context*) and the “emerging ecological instability” (*new context*) cannot be tackled by the “old contextual macroeconomics”. Hence, the need for a “new contextual macroeconomics” has become eventually inevitable. The substitution of a new contextual macroeconomics for an old contextual macroeconomics means contextualization of macroeconomics or contextual (re)construction of macroeconomics. Such contextualization is needed only when there is a substitution of a new context for an old context.

*Macroeconomics in Context* of Goodwin, Nelson and Harris (2009), is the result of contextualization of macroeconomics. In this book, they have reinterpreted economics, microeconomics and macroeconomics in the context of sustainability.

Thus, macroeconomics is not a set of principles, which is set in stone (Goodwin, Nelson & Harris, 2009). Rather, it has changed over time with the change in context. Contextual macroeconomics studies how the various macroeconomic principles fit into different contexts or changing context.

The contextual (re)construction of macroeconomics started since the 1970s. But such (re)construction needs adequate, apposite and/or appropriate context. The examples of contextualization of macroeconomics are as follows:



1. Fellner's (1976) *Towards a Reconstruction of Macroeconomics*
2. Sims's (1980) *Macroeconomics and Reality*
3. Gregory's (1988) *Recent Developments in Macroeconomics*
4. Fisher's (1988) *Recent Developments in Macroeconomics*
5. Phelps's (1990) *Recent Developments in Macroeconomics*
6. Lucas's (2000) *Some Macroeconomics for the 21<sup>st</sup> Century*
7. Harris and Goodwin's (2003) *New Thinking in Macroeconomics*
8. Goodwin's (2003) *Macroeconomics for the 21<sup>st</sup> Century*
9. Taylor's (2004) *Reconstructing Macroeconomics*
10. Aoki and Yoshikawa's (2006) *Reconstructing Macroeconomics*
11. Cohn's (2007) *Reintroducing Macroeconomics*
12. Goodwin, Nelson and Harris's (2009) *Macroeconomics in Context*
13. Harris and Goodwin's (2009) *Twenty-First Century Macroeconomics*
14. Sachs's (2009) *Rethinking Macroeconomics*.
15. Stiglitz's (2011) *Rethinking Macroeconomics: What Failed, and How to Repair It*.

In this connection, it is relevant to recall the title of a conference “Rethinking Macroeconomics”, which was held at the Pocantico Conference Centre of the Rockefeller Brothers Fund, on 20-23 June, 2002, and sponsored by Global Development and Environment Institute of Tufts University, Medford, USA.

### **2.1.5. Macroeconomics of Sustainability (MOS)**

A different kind of macroeconomics is going to be needed... The time is now ripe to develop a new macroeconomics for sustainability... There is no macroeconomics for sustainability... So there is an urgent need to develop the capabilities required to build a new macroeconomics for sustainability... A new macro economics for sustainability is not only essential, but possible (Jackson, 2009).

The implementation of ambitious programs for social investment and redirection of the macro economy towards sustainability will be essential for preserving economic systems in the twenty-first century (Harris, 2009).

When the “core concepts” of macroeconomics developed, the world contained four billion less people than it does today. The preanalytic vision, which informed the development of neoclassical thought, was that of a world, in which human activity was but a tiny fraction of global activity. Human use of resources and production of wastes was considered costless, because the regenerative and absorptive capacities of the earth appeared to have no limits. Today, evidence, to the contrary, arrives with regularity, to the point that the *Royal Society of London and the United States National Academy of Sciences, Population Growth, Resources Consumption, and Sustainable World* (1992) issued an unprecedented joint action statement-warning (Kysar, 2001):

The future of our planet is in the balance. Sustainable development can be achieved, but only if irreversible degradation of the environment can be halted in time. The next 30 years may be crucial. The continued dominance within economics of a view of nature as limitless demonstrates that macroeconomic theorists also may have committed Whitehead’s antirationalist fallacy: an arbitrary halt at a particular set of abstractions.

Yet surprisingly, little recognition has been given to the fact that macroeconomics rests on what is arguably now a discredited worldview. Among economists, increasing divergence between theory and reality is accounted for by increasing recognition of externalities, much like the Ptolemaic astronomers, who attempted to save their model of circular planetary motion through desperate addition of epicycles.

However, lest society is to risk growing beyond the biophysical limits of the earth (not to mention the point at which marginal costs of macroeconomic growth exceed marginal benefits), it seems appropriate to develop a “new macroeconomics”, which is grounded in scientifically plausible visions of the “relationship between macroeconomics and sustainability”. Such a new macroeconomics can be designated as “sustainability macroeconomics”, “macroeconomic for sustainability”, or “macroeconomics of sustainability” (MOS).

MOS is the eventual and inevitable responsiveness of a group of ecologically and socially conscious macroeconomists to the earlier intensive and extensive inducements provided by another group of environmentally conscious multidisciplinary and interdisciplinary

scholars/thinkers in the form of their writings about the causes, consequences and cures of the threat of global unsustainability. In better words, MOS can be seen as the collective, collaborative and independent effort of a group of ecologically and socially conscious practitioners of macroeconomics to respond to the threat of global unsustainability perceived/observed and documented/interpreted by the multidisciplinary and interdisciplinary scholars/thinkers in the form of their writings/articles in books and journals.

Such writings assumed unprecedented proliferation since the worldwide celebration of the *First Earth Day* on 22 April 1970. The *First Earth Day* can be treated as the “typical turning point” in the history of global human society. That is why all the sustainability-related writings can be divided into three different periods: (i) *pre-1970 sustainability writings*, (ii) *1970 sustainability writings*, and (iii) *post-1970 sustainability writings*. All these literatures can be treated as the roots, inputs or ingredients of a comprehensive MOS.

If macroeconomics is (re)constructed for realizing the context of sustainability, then macroeconomics can be designated as MOS. Unfortunately, up till now, no comprehensive text on MOS has been constructed/created. There are only several articles/texts, whose titles are like *Rethinking, Reconstructing, Reorienting, Reformulating or Rebuilding MOS*. These titles indicate that such texts are under (re)construction. Independently, but not simultaneously and collectively or collaboratively, many practitioners of macroeconomics are writing only the “pieces”, not the “whole” of MOS. Besides, such practitioners come from all over the world. Their specific concerns, interests, activities and cultures are diverse. There is hardly any coordination and consensus among them. Obviously, there are differences of thought and emphasis among them. Hence, their collected writings can constitute the “naïve whole” (*naïve MOS*), but not the “sophisticated whole” (*sophisticated MOS*). That is why in the *Prosperity without Growth*, Tim Jackson (2009) has rightly disclosed that “There is no macroeconomics for sustainability. So there is an urgent need for one. A new macroeconomics for sustainability is not only essential, but possible”.

However, the relevant examples of fractional and fragmented (re)constructions of macroeconomics for the realization/restoration of sustainability can be demonstrated by the following twenty one literatures:

1. Macroeconomics of Sustainability in Ikerd's (1997) *Toward an Economics of Sustainability*
2. Bretschger's (1998) *The Sustainability Paradigm: A Macroeconomic Perspective*
3. Macroeconomics of Sustainability in Robertson's (1999) *The New Economics of Sustainable Development*
4. Harris's (2001) *Macroeconomic Policy and Sustainability*
5. Kysar's (2001) *Sustainability, Distribution and Macroeconomic Analysis of Law*
6. Brandt 21 Forum's (2003) *The Macroeconomics of Sustainable Development*
7. Jespersen's (2004) *Macroeconomic Stability, Sustainable Development and Full Employment*
8. Harris and Goodwin's (2004) *New Thinking in Macroeconomics: Social, Institutional and Environmental Perspectives*
9. Courvisanos's (2005) *A Post Keynesian Innovation Policy for Sustainable Development*
10. Harris's (2007) *Reorienting Macroeconomic Theory towards Environmental Stability*
11. Goodwin, Nelson and Harris's (2007) *Macroeconomics and Ecological Sustainability*
12. Harris's (2008) *Ecological Macroeconomics: Consumption, Investment and Climate Change*
13. Macroeconomics for sustainability in Jackson's (2009) *Prosperity without Growth*
14. Custers's (2010) *The Task of Keynesianism Today: Green New Deals as Transition Towards a Zero Growth Economy*
15. Pollitt et al.'s (2010) *A Scoping Study on the Macroeconomic View of Sustainability*
16. Victor's (2010) *Macroeconomics for Sustainability*
17. Nadal's (2011) *Rethinking Macroeconomics for Sustainability*
18. van der Ploeg's (2011) *Macroeconomics of Sustainability Transitions*
19. Brown et al.'s (2013) *Macroecology Meets Macroeconomics: Resource Scarcity and Global Sustainability*
20. Antal & van den Bergh's (2014) *Macroeconomics, Financial Crisis and the Environment: Strategies for a Sustainable Transition*
21. Venkatesan's (2015) *Sustainability in the Curriculum and Teaching of Economics: Transforming Introductory Macroeconomics*

The construction of MOS is possible, if the preexisting or unreconstructed theoretical approaches, frameworks or models of macroeconomics can be reconstructed accordingly, or in other words, if the preexisting or unreconstructed theoretical approaches, frameworks or models of macroeconomics can be substituted with the new or reconstructed theoretical approaches, frameworks or models for sustainability. From neoclassical perspective, there is no need for a new macroeconomic framework/model for sustainability (Pollitt et al., 2010). But Victor (2008) claims that even in a rather conventional macroeconomic framework/model (e.g. hydraulic Keynesian macroeconomic model), a new MOS is not only meaningful, but also possible.

The construction of MOS is still being executed by many practitioners of environmental macroeconomics, ecological macroeconomics, social macroeconomics and social ecological macroeconomics to reduce/rule out the emerging threat of unsustainability and/or to restore/realize the state of sustainability of the “tiny little Titanic of global life amid the boundless ocean of lifelessness”.

Hence, the reconstruction of HK, coined and clarified by Coddington (1976, 1983), for restoring/realizing the context of sustainability, can be regarded as one of the complementary contributions to MOS.

Albert Einstein (1879–1955 AD) remarked that “problems cannot be solved at the same level of thinking that lead to their creation” (Ikerd, 1997). If so, problems arising from old contextual macroeconomic thinking cannot be solved using that thinking. A new contextual macroeconomics (e.g. MOS) cannot be derived from the contextual macroeconomics of the old belief system. A new belief system is inevitably needed for reconstructing MOS.

### **2.1.5.1. Need for a MOS**

The need for a MOS has been disclosed by Ikerd (1997) in his *Toward an Economics of Sustainability* by an analogy as follows:

We need a new (macro)economics of sustainability, because the old (macro)economics is fundamentally incapable of addressing the social and ecological issues of sustainability. The old (macro)economics is like an old house that has been fixed up over and over with new paint, new siding, new roofs, added rooms, and added stories; but still has the same support structure and

foundation. Now, the old beams are rotting and the foundation is crumbling. There is no way to fix it without tearing it down and starting over from the foundation up. This necessity should not be viewed as any discredit to those who have spent careers painting, roofing, and remodeling the old house. They have made due with what they had to work on – there seemed to be no logical alternative. We all hate to see the old building come down. But, nothing lasts forever. It simply is time to rebuild.

### **2.1.5.2. Crucial Characteristics of MOS**

The crucial characteristics of MOS have been described chronologically by the following ten authors:

(1) Indian economist Amlan Datta (1997) said:

There was a time when by the new (macro)economics was meant the Keynesian economics, which was notable as a response to the depression of the 1930s. The new (macro)economics that is struggling to grow today is something very different. It constitutes our response to a new set of problems, which was only dimly perceived earlier, but has steadily grown in urgency over the last quarter of this century. It attempts to put forward new ideas about how to organize the foundations of a sustainable (macro)economy at this juncture in history when there are clear signs that the global economy cannot move much further along the accustomed paths of industrial growth without ending up in total disaster. For the true welfare economist, the horizons of enquiry are shifting again in a new direction.... The study of wealth and welfare stands at a new crossroads.

(2) Ikerd (1997) argues that MOS must be multidimensional – with economic, ecological and social dimensions. It must deal with balance among, as well as attainment of, things economic, social, and ecological. Thus, MOS must be “holistic”, not just “aggregate”, in nature. It must promote the sustainability of communities, nations, and the world. We need a new MOS, because the old macroeconomics is fundamentally incapable of addressing the social and ecological issues of sustainability.

(3) According to Robertson (1999), MOS reflects the growing worldwide demand for new ways of economic life and thought that will conserve the earth and its resources, and empower people to meet their own needs and the needs of others. Robertson (1999) has pointed out the following six principles of MOS:

(a) Systematic empowerment of people (as opposed to making and keeping them dependent), as the basis for people-centered development.

- (b) Systematic conservation of resources and environment, as the basis for environmentally sustainable development.
- (c) Evolution from a wealth of nations model of economic life to a one-world model, and from today's inter-national economy to an ecologically sustainable, decentralizing, multi-level one-world economic system.
- (d) Restoration of political and ethical factors to a central place in economic life and thought.
- (e) Respect for qualitative values, not just quantitative values.
- (f) Respect for feminine values, not just masculine ones.

(4) Harris (2001) points out that there is as yet little work on reforming macroeconomic theory and policy to take account of sustainability. Since Herman Daly first called for an environmental macroeconomics a decade ago (Daly, 1991), there has been relatively little forward progress on this issue – certainly none that has penetrated the mainstream of macroeconomic theory, practice, and teaching. A sustainable perspective implies that radical and proactive government policies are required to achieve economic development that is both socially just and ecologically sound. The fundamental redirection required for sustainable development cannot be achieved without reorienting macroeconomic policy. There is an increasing recognition that the achievement of social goals is essential to environmental sustainability. Given the urgency of many macro-level and global environmental issues together with the clearly inadequate state of current macroeconomic theory, it appears that the time is ripe for a reassessment of macroeconomic theory and policy.

(5) Goodwin (2003) emphasizes that macroeconomic theory has not yet come to grips with major issues of the 21<sup>st</sup> century. These include environmental pressures, demographic changes, the size, structure, and power of MNCs, and growing economic inequality. Existing macroeconomic theory also does not deal adequately with normative issues, focuses excessively on market solutions, assumes that a single macroeconomic theory can apply to all situations, and ignores issues concerning the scale of economic activity and the speed of change. Macroeconomic theory has been left behind by some critical facts and trends that are emerging in the 21<sup>st</sup> century. One large set of discordant facts may be summarized as the limits of earth's carrying capacity in relation to both human demands for resources and anthropogenic emissions of destructive pollutants.

(6) Harris and Goodwin (2009) have examined the following seven crucial issues of MOS:

- (a) Understanding the challenge of global warming.
- (b) The new climate economics.
- (c) Economics and climate change: Resilience, equity, and sustainability.
- (d) The right to development in a climate-constrained world.
- (e) The economic fundamentals of global warming.
- (f) Macroeconomics and sustainable development: Applying “sustainomics” framework.
- (g) Ecological macroeconomics: Consumption, investment and climate change.

(7) According to Jackson (2009), there is an urgent need to develop a new ecologically literate macroeconomics capable of offering meaningful guidance for a lasting prosperity – a prosperity that for now at least will have to do without growth, and may eventually be able to replace it altogether. It will be essential in understanding how to build a different kind of macroeconomics, one in which stability is no longer predicated on increasing consumption growth, but emerges through strategic investment in jobs, social infrastructures, sustainable technologies and the maintenance and protection of ecosystem. A new macroeconomics for sustainability must abandon the presumption of growth in material consumption as the basis for economic stability. It will have to be ecologically and socially literate, ending the folly of separating economy from society and environment. MOS does not rely for its stability on relentless growth and expanding material throughput. Jackson (2009) has prescribed twelve steps to a sustainable economy as follows.

(A) Four Steps for Building a Sustainable Economy

(A<sub>1</sub>) Developing macroeconomic capability

(A<sub>2</sub>) Investing in public assets and infrastructures

(A<sub>3</sub>) Increasing financial and fiscal prudence

(A<sub>4</sub>) Reforming macroeconomic accounting

(B) Five Steps for Protecting Capabilities for Flourishing

(B<sub>1</sub>) Sharing the available work and improving the work-life balance

(B<sub>2</sub>) Tackling systemic inequality

(B<sub>3</sub>) Measuring capabilities and flourishing

(B<sub>4</sub>) Strengthening human and social capital



(B<sub>5</sub>) Reversing the culture of consumerism

(C) Three Steps for Responding Ecological Limits

(C<sub>1</sub>) Imposing clearly defined resource/emission caps

(C<sub>2</sub>) Implementing fiscal reform for sustainability

(C<sub>3</sub>) Promoting technology transfer and international ecosystem protection

(8) Sachs (2009) remarks that sustained and widespread future prosperity will require basic reforms in global macroeconomic governance and in macroeconomic science. Structural challenges like energy, climate change, higher education, public health and infrastructure are not treated as economic priorities in the conventional macroeconomics. A new strategy of economic governance – one that is structural and global – is now needed, and a new science of macroeconomics must supersede the stale debates of Keynesian and rational expectation theories. The new tools of macroeconomics are quite different from the existing tools. Macroeconomics needs an overhaul not only in concepts and tools, but in global cooperation as well. Global macroeconomics, as opposed to national macroeconomics, should be reconstituted around the global challenges, since solutions to the problems will do more to promote and sustain global growth than further fiddling with macroeconomic dials. Yet as important as these areas are to our current and future economic wellbeing, we have a surfeit of words and a dangerous deficit of real action. We will need, urgently, to strengthen global institutions so that they can provide reliable expert guidance, quantification, monitoring, and oversight of global cooperative actions. The data matter and we are flying blind. We will do well to start the new macroeconomics with three crucial and interconnected challenges: (a) climate and energy security, (b) food and nutrition security (including land use, water use and biodiversity), and (c) poverty reduction. The world's macroeconomic challenges are new, because we have hit generational roadblocks due to persistent poverty, escalating environmental threats, and deepening energy insecurity. Macroeconomic aggregates will not produce the next generation of automobiles, the safe worldwide use of nuclear power, the protection of rainforests, or global capture and disposal of carbon dioxide at cost-fired plants. The new macroeconomics must be structural – concerning itself with poverty, education, food, energy, and climate over CPI – if we are to find our way to sustainable recovery and development.

(9) Goodwin (2010) says that the critical role for macroeconomic theory is no longer simply to explain how the existing macroeconomic system works, but also to explore how the

macroeconomic system can be changed to become more adaptive and resilient in the face of the challenges of the 21<sup>st</sup> century, and how it can be more directly designed to support human wellbeing, in the present and the future. Simultaneous changes are needed, in both the actual macroeconomy and also in macroeconomic theory. In short, the major problems with mainstream macroeconomic theory begins with its assumption of final ends – most probably, maximizing GDP – that are not appropriate to a resource-constrained world. It views the macroeconomy as separate from its social and ecological contexts, understanding neither its dependence on these contexts nor the impacts of meta-externalities from the macroeconomic system upon them. It only counts things that go through the market, and it has a bias against the public sector and in favor of the status quo.

(10) Nadal's (2011) book *Rethinking Macroeconomics for Sustainability* reveals the linkages between monetary, financial and fiscal policies, and the environmental degradation, which threatens the planet's biosphere. Rebooting the world economic system is simply not enough to get us on the road to sustainability. If we do not bring macroeconomics to the discussion of sustainability, we will have failed in the endeavor to make this a better world. Nadal's (2011) book is an effort to bring together macroeconomics and the current debates on sustainability. The world will never reach sustainability, if we do not redefine macroeconomic theories, policies and practices. Nadal (2011) points out that it is a good time to seize the opportunity to go back to basics and redefine the object and the role of macroeconomics. It is time to rethink macroeconomics for sustainability.

## **2.2. Reconstructions of HK for Sustainability by Previous Literatures for Contributing to MOS**

The pursuit of knowledge is a cooperative endeavor, and will be more successful, if everyone is allowed to make a contribution. For each man has something personal to contribute toward the truth.

-----Aristotle (384-322 BC) [Richman, 2011]

A journey of a thousand miles begins with a single step. This is an old proverb. Initiatives to integrate the sustainability with macroeconomic theory and policy are a step in the right direction

to develop a MOS. The objective of the reconstruction of HK to realize the context of sustainability is to lay the foundation for that *first step*.

Earlier, it has been stated that the two constituent Keynesian macroeconomic models of HK are (i) *Simple Keynesian Model* and (ii) *IS-LM Keynesian Model*. Hence, reconstruction of HK for sustainability means the reconstruction of both the foregoing two models of HK for realizing/restoring sustainability to contribute to MOS.

Chronologically, the following twenty two literatures demonstrate how HK can be reconstructed for realizing/restoring “different dimensions” of sustainability:

(1) Young (1975) argues that in addition to describing short-run functional and causal relationships between the main economic aggregates in a capitalist or mixed economy, the hydraulic Keynesian model can also be reconstructed in “ecological terms”. This follows from the fact that psychosocial, normative, and subjective factors are both explicitly and implicitly included in the hydraulic Keynesian system. This system can, therefore, be described in terms broader than purely economic ones, and thus the word ecosystem can be utilized in this regard, as it seems to cover both the economic and ecological factors involved.

(2) Daly (1991) pleads for an environmental macroeconomics. The response within the school of ecological economics has been limited to the use of the hydraulic Keynesian model (IS-LM Keynesian model), because the IS-LM Keynesian model is the “workhorse model” in macroeconomics (Daly & Farley, 2004; Lawn, 2003b). It is more accurate to say that the IS-LM Keynesian model is the Trojan horse, from which the effort to distort and recover Keynesian theory has been launched by the establishment (Nadal, 2011).

(3) According to Girma (1992), macroeconomic and program policymakers are presently not well equipped with analytical methods for examining the environmental effects of their recommendations and actions. Girma’s (1992) article proposes a framework for examining macropolicy effects on incentives and constraints in the environmental sector and approach for adapting policy cost-benefit analysis to incorporate sustainability concerns. A simple Keynesian model is constructed, and used to show how the environment may be incorporated as a sector of the macroeconomy. Aggregate demand policy, sectoral policy and distributional issues are examined within the context of this simple Keynesian model. In short, Girma’s (1992) article

starts from a simple Keynesian model and adds an environment sector to examine key macroeconomic policies and their impacts on the environment.

(4) Thampapillai (1995) was the first author to try to assimilate the environment into a macroeconomic model by defining an environmental cost function and projecting it on to a conventional IS-LM Keynesian model. The model is used to identify how macroeconomic policies can be used to alter the IS-LM equilibrium in order to attain a position, which maintains the assimilative capacity of the environment. The issue is how macroeconomic policies can be used to attain a position of environmental equilibrium. In terms of modified IS-LM Keynesian model, Thampapillai (1995) suggests that the restrictive or tighter fiscal and monetary policies can reduce the level of macroeconomic activity, and such reduction of the volume of macroeconomic activity can return the economy to the level of environmental sustainability.

(5) The article of Thampapillai and Uhlin (1996) discloses that the depreciation of environmental capital is internalized within a simple Keynesian model to permit the determination of sustainable national income (SNI). This article includes the simulation of SNI paths and the evaluation of wages and technology/management policies for achieving convergence between full employment and SNI. The scope for further conceptual development is demonstrated by the illustration of aggregate supply in the context of environmental depreciation.

(6) Building on the basic tenet of environmental accounting, a simple Keynesian model has been adapted by Thampapillai and Uhlin (1997) for the determination of SNI. This adaptation involves the formulation of linear (See Figure 2, Thampapillai and Uhlin, 1997) as well as nonlinear (See Figure 3, Thampapillai and Uhlin, 1997) frameworks of national income determination. These frameworks are empirically demonstrated for the US economy by integrating standard macroeconomic data with macro-environmental data. The analysis includes the derivation of SNI paths and the evaluation of wages and technology/management policies for jointly achieving full employment and SNI. The results indicate efficiency improvements in the utilization of environmental capital and possible converges between the SNI path and actual NI path.

(7) The article of Ahmed and Mallick (1997) has incorporated environment into a simple Keynesian model for estimation of SNI of Pakistan and Bangladesh. It is now widely accepted that the indicators of NI accounts do not correctly portray the state of the economy. GDP is the widely used measure of economic activity, and is generally used in formulating demand

management and stabilization policies. A major shortcoming of relying solely on GDP is that it ignores the effects of environmental degradation and depletion of natural resources. Where environment is concerned, there is no such thing as a free lunch and the burden of the excessive use will have to be borne by the coming generations. In environmental economics, the environment is regarded as capital, which is durable and provides services overtime. If managed properly, it can provide services indefinitely. As manufactured capital depreciates overtime, the environment also deteriorates if not maintained. Thus, the allowance for the depreciation of environmental capital has to be deducted from a country's NI to ensure its proper maintenance, that is, to offset the wear and tear of natural endowments. This allowance is called environmental capital depreciation and is deducted from the GNP to achieve the SNI.

(8) Heyes's (2000) article has used a modified IS-LM Keynesian model to examine how monetary and fiscal policies affect the environment. The method of Heyes (2000) differs from that of Thampapillai (1995), because Heyes introduces the environmental restriction directly as an environmental equilibrium curve, denoted by EE. Each point of this EE curve corresponds to a situation, in which the wear-and-tear effect on the environment is being restored. In the EE curve, the rate, at which the economy is using the natural resource base or the environment, is equal to its resilience. The EE curve shows that all interest-output combinations are such that the rate at which the economy is using environmental services is exactly equal to the natural environment's ability to supply them. In a nutshell, the EE curve is introduced into the IS-LM Keynesian Model to show how monetary and fiscal policies can return the economy to a position of environmental equilibrium. Traditional fiscal and monetary policies can set the economy on a scale, which is compatible with environmental equilibrium.

(9) The article of Mallick, Sinden and Thampapillai (2000) shows that the environment is an asset that provides essential services. Like any other asset, its services will diminish as it depreciates. The environmentally SNI of a nation depends on a sustained flow of these services, and can be estimated by including the environment in a macroeconomic framework, with a goal to achieve both full employment and sustainability. The relationship of NI to employment is estimated at full employment, actual employment and the employment level that is necessary to SNI, for the Australian economy. There proved to be a widening gap between actual NI and environmentally SNI, and between actual NI and full employment NI. Wage reduction and improvement of technology are analyzed as possible ways to meet the goal of an

environmentally SNI. In the analysis of the Australian economy, this article suggests that reconciliation between the goals of sustainability and employment may be achieved by a real wage reduction of approximately 8-10%. This analysis has been structured within the framework of a simple Keynesian model of NI determination and a Cobb-Douglas production function. In this article, the 8-10% wage reduction has been estimated by recourse to a Cobb-Douglas production function for full employment. This wage reduction amounts to the same magnitude as the environmental capital depreciation allowance, which can be subtracted from NNP in the simple Keynesian model of NI determination in order to achieve sustainability.

(10) Munasinghe (2002) traces the relation between macroeconomics and the environment from historical perspective. Then he discusses how environmental considerations can be incorporated into more conventional Keynesian macroeconomic models used in policymaking, ranging from extensions of the IS-LM Keynesian model used in analyses of comparative statics, to sophisticated computable general equilibrium models (CGEMs), which include environmental variables. Longer run environmental macroeconomic models for both closed and open economies are built around supply side issues like capital accumulation, natural resource depletion, long run labour supply, discount rate and the rate of technological progress. Finally, he reintroduces the IS-LM-EE Keynesian model of Heyes (2000) briefly in terms of IS-LM-EE diagram and its mathematical explanation.

(11) Lawn (2003a) has given an introduction to Heyes's (2000) IS-LM-EE Keynesian model in order to establish an environmental macroeconomics.

(12) Lawn (2003b) has provided an appraisal of Heyes's (2000) IS-LM-EE Keynesian model for the further development of environmental macroeconomics.

(13) Lawn (2003c) has extended the IS-LM Keynesian model to include an environmental equilibrium curve, which is similar to Heyes's (2000) EE curve. Lawn (2003c) has demonstrated that a decade has now passed since Daly made a plea for an environmental macroeconomics. Despite an expanding literature on green NI accounting and the efforts of ecological economists to measure the sustainable net benefits of a growing macroeconomy, it is only recently that Daly's plea has been adequately answered. This has been achieved with the incorporation by Heyes of an environmental equilibrium curve (EE) into the familiar IS-LM Keynesian model. However, the IS-LM-EE Keynesian model proposed by Heyes is incomplete. By extending

Heyes's model to include the role of technological progress and the sustainable net benefits of economic activity, this article shows that conclusions regarding the desirability of expansionary fiscal and monetary policies alter quite radically. Moreover, it sends out a clear message that environmental concerns should be incorporated into macroeconomic models. They should not be solely confined to microeconomics.

(14) The article of Daly and Farley (2004) has adopted a different approach to the use of an IS-LM Keynesian model. First, it assumes that it is possible to calculate the throughput-intensity per unit of output. Second, it also assumes that it is possible to estimate the maximum ecologically sustainable level of output. This can then be imposed as an external physical constraint. The new physical restriction is introduced into the model through a vertical line, which is called ecological capacity line and is denoted by EC. Each point on the vertical EC line shows a biophysical equilibrium. Given the technology used in the economy, the EC line indicates the balance between usage and extraction rates, and the capacity of the environment to replace used materials and restore the health of ecosystem. The points on the EC line are ignored by the actors, whose behavior is captured in the IS-LM curves.

(15) Sim (2006) revisits Heyes's (2000) attempt to incorporate an environmental constraint into the IS-LM Keynesian model. Sim's (2006) article extends the IS-LM-EE Keynesian model of Heyes (2000). In Heyes's (2000) model, exogenous fiscal or monetary shocks are needed so that the intersection of all the three curves: IS curve, LM curve and EE curve, is reached. Such independent adjustments are circumvented in Sim's (2006) article, which argues that a naturally adjusting process exists and formalizes the mechanism for the IS-LM-EE Keynesian model. Sim's (2006) model arises out of the requirement of overcoming the inadequacies of Heyes's (2000) model. The main inadequacy of Heyes's (2000) model is that it fails to answer the question raised by Sim (2006): Is there a natural adjustment mechanism in the environmental Keynesian framework? Sim (2006) claims that Heyes (2000) cannot suggest so. While the simplicity and elegance of Heyes's model deserves merit, nevertheless one difficulty is existent in his model. In Heyes's model, convergence to the macro-environmental equilibrium is not automatically guaranteed, but is achieved by exogenous adjustment of IS or LM curve. In this respect, Heyes's model imposes a strong assumption that policy maker has perfect knowledge of what the environmental constraint is, and the precise amount of monetary or fiscal policy stimulus to attain an environmentally consistent market equilibrium. Sim's (2006) model offers

an adjustment process for the IS-LM-EE Keynesian model of Heyes based on insights from the question: Will a level of economic activity, which is excessively polluting, be sustainable in the long run? Recent works suggest that the answer is negative. Sim's (2006) article suggests that in the absence of institutional arrangements, the level of economic activity must eventually conform to that accommodable by the environment. Through the IS-LM-EE Keynesian model, one important lesson emerges: overlooking the environment, when developing an economy, is a strategy programmed for serious breakdowns. Eventually, drastic but costly control measures have to be initiated, heavily polluting manufacturing and power plants may have to be retired, and lifestyles could change. Sustainable economic growth must also be accompanied by progressive upgrading of regulatory standards. The objective of Sim's (2006) article is to offer a simple way to improve the workability of the IS-LM-EE Keynesian model so that further extensions can be conducted from this point onwards.

(16) In Morales's (2007) article, a simple framework extending the IS-LM-EE Keynesian model is presented to address the perceived problem of having to balance the twin macro goals of economic growth and environmental sustainability. This article shows that unless environmental policy is optimal, the policy maker's decision will lead to unsustainable growth. On the contrary, if environmental policy is optimal, there is a: (i) finite period of sustainable growth initially, and (ii) gradual adjustment to a stationary sustainable output level due to thermodynamic constraints. Social preferences, however, play a crucial role in terms of characterizing the long-run adjustment process. The aim of Morales's (2007) article is to contribute further to Heyes's (2000) original proposal – the greening of textbook macro theory in terms of IS-LM-EE Keynesian model. Morales's (2007) article has been influenced by Daly's suggestion that macroeconomic theory should promote the basic goals of human development and sustainability.

(17) In terms of simple Keynesian model, Thampapillai, Wu and Sunderaj (2007), in their joint article, demonstrate that China has been heralded as the fast growing economy in the world. This growth has been achieved significantly at the expense of its environment. Conventional measures of economic performance (e.g. GDP) do not take into account environmental damages, and thus may be biased towards an unsustainable development path. This article compares China's economic performance as measured by GDP against a measure of sustainable GDP, estimated by adjusting GDP for the depreciation of air, soil, and water resources. The results of this article indicate that China's performance may not be as remarkable as commonly perceived, and that its



quest for sustainable development may be challenged by political and social considerations. The challenge includes the resolution of conflict between the goals of employment and sustainability. With the help of several equations and the income-expenditure diagram (See Figure 3, Thampapillai, Wu and Sunderaj, 2007) of simple Keynesian model, this article illustrates the potential conflicts between sustainability and the pursuit of full employment. This article also points out formidable challenges in searching for sustainable development path for the Chinese economy. The sustainability-employment conflict shows that the quest for sustainable development could severely undermine the government's ability to maintain social and political stability through labour participation. While the concept of sustainable development has gained a wide acceptance among the decision-makers in China, its implementation involves difficult trade-offs among the various objectives.

(18) Emmanuel (2008) has transformed the IS-LM Keynesian model into the IS-LM-BP-BE Keynesian model to incorporate the problem of pollution. This reconstruction of the IS-LM Keynesian model has shown the ecological and economic effects of different monetary and fiscal policies depending on the type of small open economy considered (with or without different kind of pollution control activities). The introduction of pollution in the form of stock in a dynamic IS-LM Keynesian model, has allowed us to analyze the environmental consequences of macroeconomic policies. According to this model, an environmental public expenditure, even if it leads to increased pollution, is preferable to a usual public expenditure, because it causes relatively fewer emissions of pollution than the latter, for an identical increase in national income. The environmental effect of an expansionary monetary policy depends on the type of economy involved in. In the unusual case, where the bulk of investment activities is dedicated to clean up, any change in money supply leads to a variation in the opposite sense in the level of pollution, for the reason that a lower interest rate stimulates investment in pollution control that compensates the much more adverse effects of investment in usual sector. In the normal case, where the private sector pollution is smaller than the usual private sector, any monetary policy induced by the decline of interest rates, encourages more the usual investment (with environmental standards unchanged), and thereby increases pollution and the income levels. Hence, one of the major lessons of this model is that what is important is the expectation in the sector of the pollution control and the size of this sector relatively to the rest of the economy. Also, a government anxious to make a sustainable economic growth should give priority to try to

drive the expectations of these pollution control firms through environmental standards increasingly severe as long as the economy did not have a private sector of pollution control at least as important in its economic size as the usual private sector. In the meantime, environmental public policies should be preferred, from an environmental point of view, to any monetary and budgetary policy, provided that public environmental measures are concrete and truly effective remediation. Thus, our findings reinforce the arguments of post-Keynesians, who recognized the importance of informational constraints in a state of uncertainty, and preferred maintaining standards seeking optimality. Moreover, if one takes as relevant the criterion proposed by Daly of carrying capacity, i.e., the optimal scale of the economy compared to the ecosystem behind it, it can be concluded that the model, except in unusual circumstances, shows that any monetary or budgetary policy increases the pollution level and therefore drives the economy a little closer to the sustainable limit. If the economy is in an unusual case, one moves more and more from this limit, and then there is sustainable development in its fullest sense.

(19) On the basis of simple Keynesian model, Victor (2008) has invented a notion of LowGrow, which is an interactive computerized model of the Canadian economy. This LowGrow model has suggested how both ecological sustainability and social sustainability can be achieved.

(20) Harris (2008/2009) has tried to solve the following three dilemmas by extending the simple Keynesian model, in which three modified equilibrium equations are embedded: (i) The balancing of consumption and investment while maintaining high employment as well as limits on material consumption, (ii) The provision of adequate social and health expenditures, including the added expenditures necessary for a graying population with greater longevity, and (iii) The sufficient investment in the maintenance of critical natural capital systems including ecosystems and atmosphere.

(21) The remark of Custers (2010) is much relevant to realize the need for reconstructing the “ecological Keynesianism”. His argument can be summarized as follows. The world economy today is facing the juncture of two simultaneous crises: (i) The deepest recession since the end of World War Two, and (ii) An unprecedented world ecological crisis. Does Keynesianism offer viable ideas to face this combined crisis, alternative to the neoliberal policymaking, which has prevailed during the last thirty years? Historically, if viewed from a longer-term perspective, the form of Keynesianism, which has predominated is “military Keynesianism”, defined as macroeconomic policymaking by capitalist governments aimed at stimulating aggregate demand

for goods. Thus, deficit spending was already applied by the British government, when it competed with other European states to gain world hegemony in the late 17th and the 18th century. Again, whereas for a limited period of time after World War Two, a “civilian type of Keynesianism” has coexisted with “military Keynesianism”, especially in Western Europe, the “military form of Keynesianism” has clearly prevailed in the era of globalization, especially in the US. Keynesianism offers possibilities for a shift from current policymaking, but only if its mode of application is radically different from its historical modes. An “ecological Keynesianism” needs to fulfill both a social criterion - promotion of employment - and an ecological standard - countering capitalism’s inherent tendency to destroy its natural surroundings. Three examples of an “ecological Keynesianism” initially come to mind: (i) The state’s use of transfer and investment measures so as to accelerate the shift from reliance on fossil fuels towards reliance on renewable energy, (ii) State intervention to discourage incineration of waste, and to enhance reliance on recycling, and (iii) Conversion of military production facilities into units, which produce for the sustenance of life on earth. While an “ecological Keynesianism” does offer ample possibilities to address today’s combined crisis, the given policymaking needs to be understood as transitional. A solution to the world’s ecological crisis is only possible via the transition towards a stationary state - a zero growth economy at the world level, which protects the interests of the global South.

(22) Konar (2010) argues that *Simple Keynesian Model* and *Hicks-Hansen IS-LM Keynesian Model* of Coddington’s HK are devoted to explore the causes, consequences and cures of the “persistent problem of economic instability” in the capitalist world. But recently the global environmental indications are that the “persistent economic instability” is being coupled with the “emerging threat of ecological instability” in the world capitalist system. This dual instability – the coexistence of persistent economic instability and the emerging ecological instability – constitutes the “ecologically unsustainable economic instability” or “ecologically economic unsustainability”, which cannot be tackled by conventional HK due its ingrained inadequacies. This article shows how the foregoing two models of HK can be “ecologized” to restore “ecologically economic sustainability” through the compositional modifications of the conventional equilibrium conditions for income determination by incorporating the macroecological variables into these equilibrium conditions, and also through the introduction of new policy measures and applications. This article suggests that conventional HK shows upward

or downward bias with respect to ecological HK in the sense that the values of most of the conventional macroeconomic variables (that is, surface values) are significantly different from that of ecologically adjusted macroeconomic variables (that is, true or real values).

### **2.2.1. A Critical Conclusion from Previous Literatures on the Reconstructions of HK for Sustainability**

Serious criticisms and serious replies are both essential parts of science (Daly, 1997).

The twenty two previous literatures on the reconstructions of HK for realizing the varied versions of sustainability can be classified into two groups. While the first group has attempted to reconstruct the *Simple Keynesian Model*, the second group is devoted to reconstruct the *IS-LM Keynesian Model*.

The first group includes Young (1975), Girma (1992), Thampapillai and Uhlin (1996), Thampapillai and Uhlin (1997), Ahmed and Mallick (1997), Mallick, Sinden and Thampapillai (2002), Thampapillai, Wu and Sunderaj (2007), Victor (2008), Harris (2008/2009), Custers (2010) and Konar (2010), while the second group contains Daly (1991), Thampapillai (1995), Heyes (2000), Munasinghe (2002), Lawn (2003a, 2003b, 2003c), Daly and Farly (2004), Sim (2006), Morales (2007), Emmanuel (2008) and Konar (2010).

### **2.2.2. Common Features of Previous Literatures**

The common features of the twenty two previous literatures on the reconstructions of HK for realizing the different versions of sustainability can be summarized as follows:

- (1) The previous literatures are based on hydraulic Keynesian methodology, framework, setup, model or paradigm.
- (2) They have devised different models, in which different tools of analysis are embedded.
- (3) While some models have introduced the different new variables, other some models have introduced the different new equations, functions or curves.

(4) Some models have been designed to tackle the problem of environmental or ecological sustainability, while few models have considered social sustainability, ecologically social sustainability or ecologically sustainable social stability.

### **2.2.3. Distinctive Features of the Reconstructed HK for Sustainability**

The distinctive features of the reconstructed HK for sustainability in the present thesis can be summarized in terms of the following two points:

(1) Reconstructed HK for sustainability consists of different submodels. Each sub-model is characterized by its “representative equations”, which are indicated by the “equilibrium equations” of the commodity market and/or money market. The nature of the equilibrium equations is determined by the nature of the (i) economy (e.g. two-sector closed economy, three-sector closed economy, four-sector open economy) and (ii) new variables (e.g. economic, ecological, social, sub-social) incorporated into the equilibrium equations.

(2) Though the nature and composition of equilibrium equations in each submodel has been transformed through the incorporation of the new variables, yet no new equations, functions or curves have been introduced. Because adequate or appropriate reconstitutions of the equilibrium equations rule out the necessity of introducing the new equations, functions or curves.

### **2.2.4. Two Critical Questions**

The critics can raise the following two crucial questions:

- (1) What are the missing points or demerits of the previous literatures?
- (2) What is the novelty, newness, originality or merit of the present thesis?

### **2.2.5. Response to Two Critical Questions**

The response to the foregoing two critical questions is based on the most relevant remarks of the following three authors:

(1) According to the American Nobel laureate (1982) economist George J. Stigler, originality has the temporal priority in the statement of an idea. Originators usually discover their leading ideas

rather than excavate them from the literature. This is an interesting problem, but it makes no difference whether the new ideas come from current originality or past originality. Originality should be measured against the knowledge of one's contemporaries. If one opens our eyes to new ideas, new perspectives on old ideas, or new errors/inconsistencies, she/he is an originator. Originality means difference, not improvement, and one may invent new errors as well as new truths (Stigler, 1955).

(2) Lawrence Boland (1994) argues that those, who actively engage in refuting one theory, are doing so only because they have an alternative theory in mind. It is not enough to indicate that the researcher's idea is or was new, but one may want to show that it is a solution to some problem. When examining the contribution of an economic thinker, problem orientation always involves presuming that the thinker was implicitly or explicitly trying to solve a problem: achieving his/her aims by overcoming or dealing with all relevant obstacles. But problem orientation is always retrospective. Sometimes, the situational analysis is substituted for problem orientation (Boland, 1994).

(3) The French Nobel laureate (1988) economist Maurice Allais argues that the successful scholar is always the one, who adds some marginal improvement to the dominant theories to which everyone is accustomed. If, however, a new theory falls outside established paths, it is certain to face general opposition whatever its justification. For all these reasons, it is essential to subject established truths (which cannot be questioned without confronting the active ostracism of the establishment) constantly to a critical analysis without indulgence. All genuine scientific progress comes up against the tyranny of the dominant ideas generated by the establishment. The true scholar undoubtedly seeks truth for its own sake, but he/she cannot be insensitive to the recognition of the value of his/her work. Whatever they may have said, the most eminent scholars have never remained completely indifferent to the opinions of others (Allais, 1997).

By comparison of the present thesis with the previous literatures, it can be emphasized that the introduction of the new equations, functions or curves by some of the previous literatures indicates not only their "superfluity", but also the "lack of methodological mechanism" about the transformations of the equilibrium equations. Some literatures have used ecological/environmental equilibrium curves to indicate ecological/environmental sustainability. Surprisingly, none has thought to introduce "similar curves" (e.g. social equilibrium curves or subsocial equilibrium curves) in his/her model in order to realize social sustainability or multiple

variants of subsocial sustainability. This implies that such literatures have concentrated only on ecological or environmental sustainability, not on social sustainability, ecologically social sustainability or ecologically sustainable social stability. In better words, social sustainability, ecologically social sustainability or ecologically sustainable social stability has been (deliberately or decidedly?) “denied” by the previous authors. Hence, it is a matter of “denialism”, coined by John Bellamy Foster (2011), who said, “Our worst enemy is denialism”. Because the previous literatures have “denied the real truth about sustainability”: social sustainability and ecological sustainability are interdependent, neither independent, nor dependent at the cost of other (Konar & Chakraborty, 2011). Moreover, social sustainability includes sustainability of multiple subsocials: economic sustainability, political sustainability, cultural sustainability, ethical sustainability, moral sustainability, spiritual sustainability, familial sustainability, psychological sustainability, religious sustainability, etc.

On the contrary, the reconstructed HK of the present thesis can ensure the following three variants of sustainability: (i) Ecological Sustainability, (ii) Social Sustainability and (iii) Ecologically Social Sustainability or Ecologically Sustainable Social Stability without the usage of new equations, functions or curves, but by the “rational reconstitutions” of the “conventional equilibrium equations” of HK. Hence, the present thesis can be treated as a “protest against such denialism”.

The major missing point of all the previous literatures is their inability/inadequacy to transform the “conventional equilibrium equations” into “sustainable equilibrium equations” by:

- (i) Incorporating the relevant macroeconomic, macroecological, macrosocial and/or macrosocial variables into them.
- (ii) Maintaining the consistency of the national income accounting method suggested by United Nations IEEA (1993) and SEEA (1993).
- (iii) Rationally reconsidering or reconstructing the definitional equations of sustainable national income (SNI).
- (iv) Incorporating the SNI into the consumption or saving function.

### **3. Simple Keynesian Model: An Anatomical Sketch**

Economics is a science of thinking in terms of models joined to the art of choosing models, which are relevant to the contemporary world. It is compelled to be this, because, unlike the typical natural science, the material to which it is applied is, in too many respects, not homogeneous through time... Progress in economics consists almost entirely in a progressive improvement in the choice of model (Keynes, 1938).

Simple Keynesian Model (SKM) is also known as *Keynesian Cross Diagram*. It was developed by Meade (1937), Samuelson (1948, 1965/1948), Hansen (1953), et al. The appraisal and reappraisal of SKM was executed by Fusfeld (1985), Patinkin (1989), Davidson (1989), et al. The sole objective of SKM is to explore the causes, consequences and cures of the “secular economic stagnation” in the capitalist world. This model suggests that deficiency of effective demand or excessive saving over investment is the only cause of secular economic stagnation in the capitalist world. As policy prescription, the SKM offers the solution that the increase in effective demand or the excessive investment over saving can cure such stagnation. If the effective demand is not increased by the increase in private consumption and/or investment, government should adopt adequate fiscal policy to stimulate effective demand by the “socialization of investment” (Keynes, 1936) to reduce or rule out such stagnation. Noteworthy that the equilibrium income of SKM does not necessarily indicate a full employment level of equilibrium income, rather it generates involuntary unemployment equilibrium income as opposed to Classical full employment level of equilibrium income. As Keynes (1936) said, “The outstanding faults of the economic society, in which we live, are its failure to provide for full employment and its arbitrary and inequitable distribution of wealth and incomes”. This occurs because “there has been a chronic tendency throughout human history for the propensity to save to be stronger than the inducement to invest. The weakness of the inducement to invest has been all times the key to the economic problem” (Keynes, 1936).

The salient features of the SKM can be summarized in terms of the points indicated by (3.1 – 3.6).

#### **3.1. Classification of Simple Keynesian Model (SKM)**



SKM can be classified into the three categories depending upon the nature of the economy as follows. Such classification will also be evident from Table 3.1.

(1) SKM for Two-Sector Closed Economy consisting of household sector and firm/business sector.

(2) SKM for Three-Sector Closed Economy consisting of household sector, firm/business sector and government sector.

(3) SKM for Four-Sector Open Economy consisting of household sector, firm/business sector, government sector and foreign sector.

### 3.2. Approaches to SKM

SKM has two approaches: (i) Income-Expenditure Approach and (ii) Saving-Investment Approach. Each approach is basically characterized by the nature of its “equilibrium equations” as shown in Table 3.1.

**Table 3.1: Equilibrium Equations of SKM**

Nature of Economy	Saving-Investment Approach	Income-Expenditure Approach
Two-Sector Closed Economy	$S(Y) = I$ (3.1a)	$Y = C(Y) + I$ (3.1b)
Three-Sector Closed Economy	$S(Y_d) + T = I + G$ (3.2a)	$Y = C(Y_d) + I + G$ (3.2b)
Four-Sector Open Economy	$S(Y_d) + T + M = I + G + X$ (3.3a)	$Y = C(Y_d) + I + G + (X - M)$ (3.3b)

The notions of the notations/variables used in Table 3.1 are as follows:

$C$  ≡ Consumption expenditure by household sector

$G$  ≡ Government expenditure (consumption-oriented)

$I$  ≡ Private investment expenditure in manufactured capital

$M$  ≡ Import by foreign sector

$S$   $\equiv$  Saving by household sector

$T$   $\equiv$  Net tax = (Tax – Transfer payment) collected by government sector

$X$   $\equiv$  Export by foreign sector

$Y$   $\equiv$  Net domestic product ( $NDP$ ) = ( $GDP - D^m$ ) = National income ( $NI$ ), where  $GDP$   $\equiv$  Gross domestic product, and  $D^m$   $\equiv$  Depreciation, depletion or degradation of manufactured capital

$Y_d$   $\equiv$  Disposable  $NI = (Y - T)$

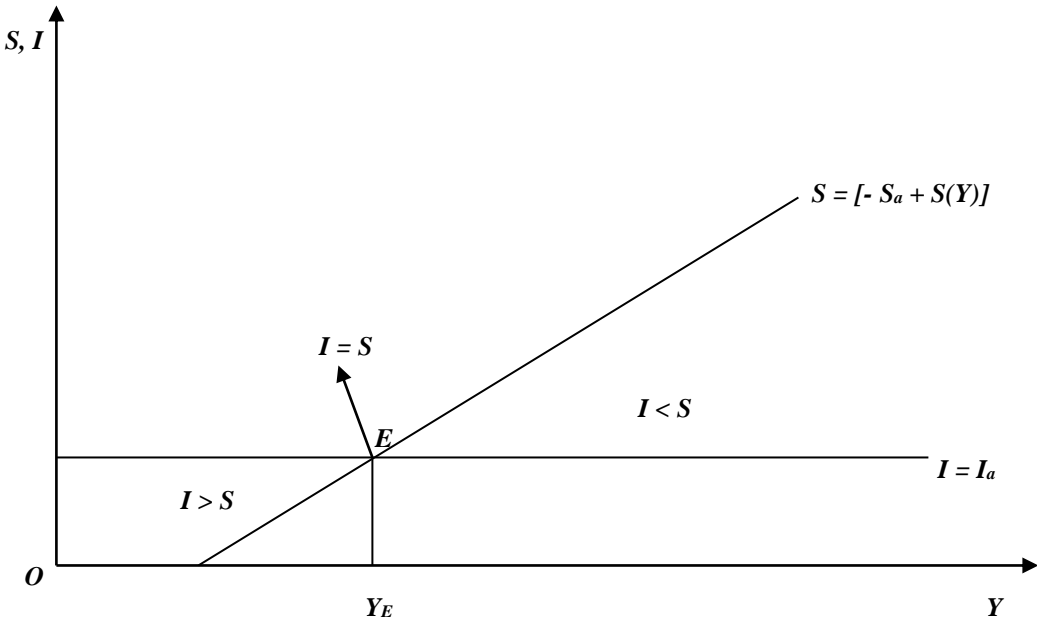
### **3.3. Composition of Equilibrium Equations in SKM**

The composition of equilibrium equations of the *income-expenditure approach* and the *saving-investment approach* in the SKM depends on the nature of the economy as shown in Table 3.1 (Konar, 2010).

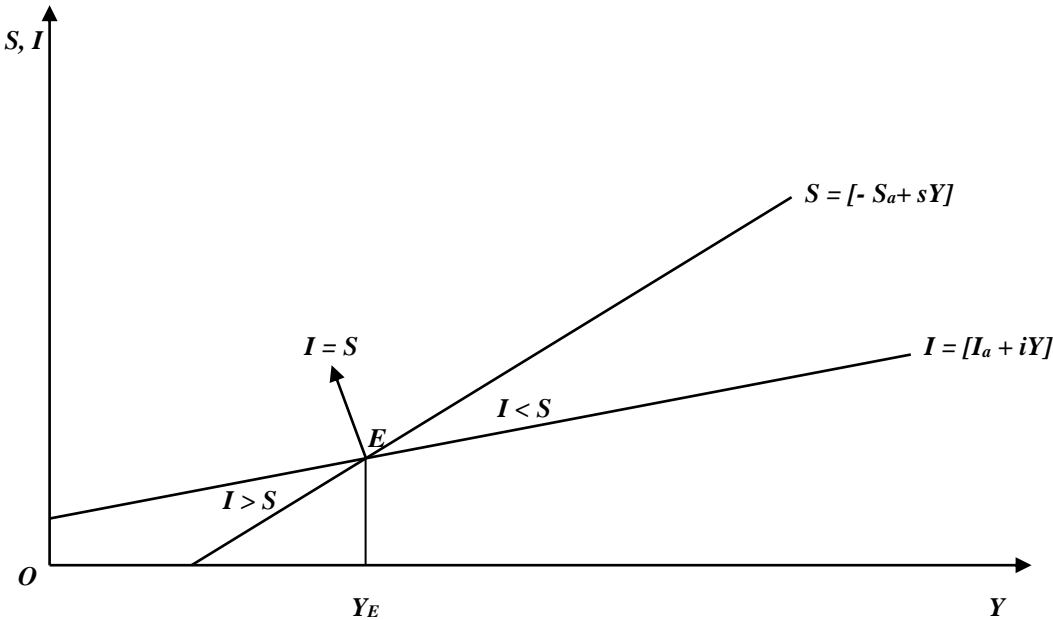
### **3.4. Determination of Equilibrium in SKM for Two-Sector Closed Economy by Saving-Investment Approach with Autonomous Investment ( $I = I_a$ )**

The determination of equilibrium income in SKM for two-sector closed economy by saving-investment approach with autonomous investment can be represented in terms of Figure 3.1. To do this, let us reconsider the equation (3.1a) in Table 3.1. The explicit form of such equation can be given by equation (3.4).

**Figure 3.1: Equilibrium in SKM for Two-Sector Closed Economy by Saving-Investment Approach with Autonomous Investment**



**Figure 3.2: Equilibrium in SKM for Two-Sector Closed Economy by Saving-Investment Approach with Induced Investment**



$$[- S_a + sY] = I_a \quad (3.4)$$

where  $S_a \equiv$  autonomous saving,  $I_a \equiv$  autonomous investment,  $s \equiv S'(Y) = MPS$

Rearranging equation (3.4), we get equilibrium  $NI (Y_E)$  by equation (3.5).

$$Y_E = (I_a + S_a)/s \quad (3.5)$$

The equilibrium  $NI$  denoted by  $Y_E$  in Figure 3.1 is statically stable, because the condition for static stability of equilibrium income requires that the slope of the *excess investment (EI) curve* will be negative, which implies that  $MPS > 0$ . This is evident from equation (3.6).

$$dEI/dY = d[I_a + S_a - sY]/dY < 0, \text{ or } s = S'(Y) = MPS > 0 \quad (3.6)$$

Thus, the point of intersection between  $S = [- S_a + sY]$  curve and  $I = I_a$  curve in Figure 3.1 indicates the existence, uniqueness and static stability of  $Y_E$ .

### **3.5. Determination of Equilibrium in SKM for Two-Sector Closed Economy by Saving-Investment Approach with Induced Investment [ $I = I_a + I(Y)$ ]**

The determination of equilibrium income in SKM for two-sector closed economy by saving-investment approach with induced investment can be represented in terms of Figure 3.2. To do this, let us reconsider the equation (3.1a) in Table 3.1. The explicit form of such equation can be given by equation (3.7).

$$[- S_a + sY] = [I_a + iY] \quad (3.7)$$

where  $S_a \equiv$  autonomous saving,  $I_a \equiv$  autonomous investment,  $s \equiv S'(Y) = MPS$ ,

$$i \equiv I'(Y) = MPI$$

Rearranging equation (3.7), we get equilibrium income ( $Y_E$ ) by equation (3.8).

$$Y_E = (I_a + S_a)/(s - i) \quad (3.8)$$

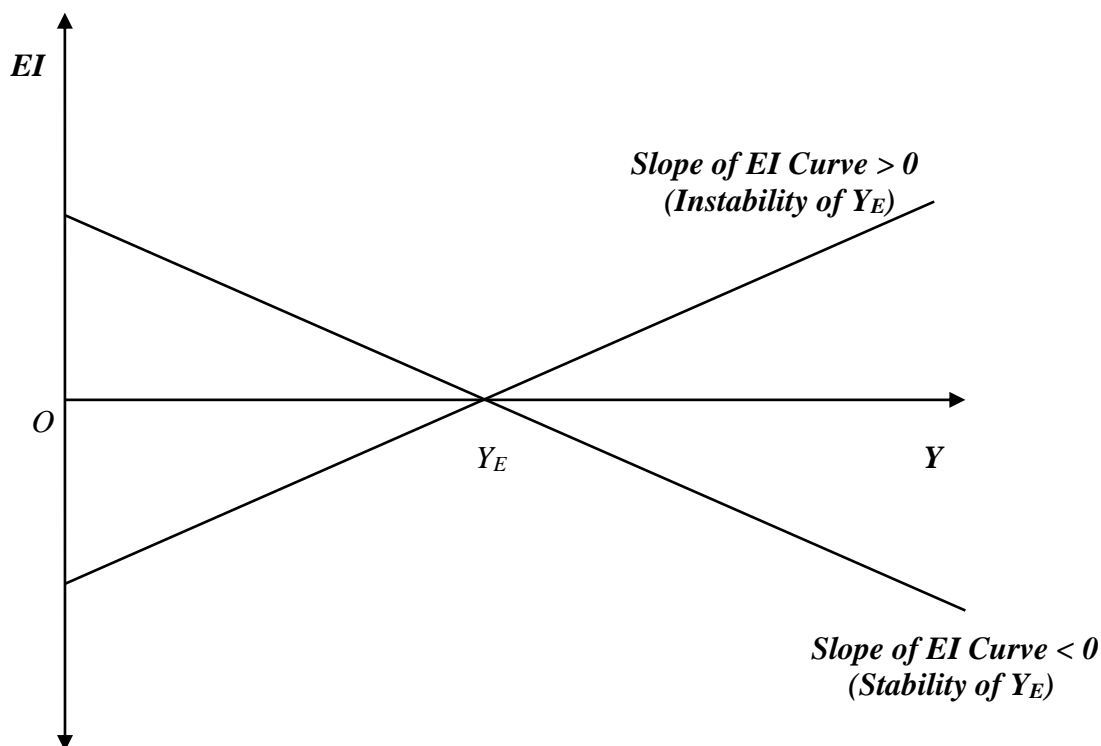
The equilibrium income denoted by  $Y_E$  in Figure 3.2 is statically stable, because the condition for static stability of equilibrium income requires that the slope of the *excess investment* (EI) curve will be negative, which implies that  $MPS > MPI$ , or  $s > i$ . This is evident from equation (3.9).

$$dEI/dY = d[I_a + iY + S_a - sY]/dY < 0, \text{ or } s = S'(Y) > i = I'(Y) \quad (3.9)$$

Thus, the point of intersection between  $S = [-S_a + sY]$  curve and  $I = [I_a + iY]$  curve in Figure 3.2 indicates the existence, uniqueness and static stability of  $Y_E$ .

The condition for static stability or instability of  $Y_E$  depends on the slope of the *excess investment* (EI) curve. If the EI curve is negatively (or positively) sloping,  $Y_E$  will be statically stable (or unstable), as shown in Figure 3.3.

**Figure 3.3: Static Stability of Equilibrium in SKM**



## 4. IS-LM Keynesian Model: A Compositional Outline

The backbone of hydraulic Keynesianism is the IS-LM framework (Snowdon & Vane, 2005).

The IS-LM model emerged as the starting point for the development of “hydraulic Keynesianism” (Coddington, 1976), a very fertile research programme (Gerrard, 1995).

While  $I$  stands for investment,  $S$  stands for saving. Hence, the curve or the locus of various combinations of  $Y$  and  $r$ , which shows the equality between  $I$  and  $S$  ( $I = S$ ), is called IS curve. Further,  $L$  stands for liquidity preference or demand for money, while  $M$  stands for supply of money. Hence, the curve or the locus of various combinations of  $Y$  and  $r$ , which shows the equality between  $L$  and  $M$  ( $L = M$ ), is called LM curve. While  $I = S$  indicates the product or commodity market equilibrium, the  $L = M$  shows the money market equilibrium.

### 4.1. Classification of IS-LM Keynesian Model

The IS-LM Keynesian Model is dichotomized into (i) Simple IS-LM Keynesian Model and (ii) Generalized IS-LM Keynesian Model. Such dichotomization is determined by whether the IS curve is simple or generalized. But the LM curve is devoid of any division/dichotomization and it is also independent of the nature of the economy (Konar, 2010). Thus, while IS curve is of two types: (i) Simple IS Curve (SISC) and (ii) Generalized IS Curve (GISC), the LM curve is *unique*.

### 4.2. Equations of Simple IS Curve (SISC)

The composition of equations of SISC is determined by the nature of the economy as shown in Table 4.1.

### 4.3. Equations of Generalized IS Curve (GISC)

The composition of equations of the GISC is also determined by the nature of the economy as shown in Table 4.2.

**Table 4.1: Composition of Equations of SISC**

Nature of the Economy	Equations of SISC
Two-Sector Closed Economy	$S(Y) = I(r)$ (4.1)
Three-Sector Closed Economy	$S(Y_d) + T = I(r) + G$ (4.2)
Four-Sector Open Economy	$S(Y_d) + T + M = I(r) + G + X$ (4.3)

**Table 4.2: Composition of Equations of GISC**

Nature of the Economy	Equations of GISC
Two-Sector Closed Economy	$S(Y, r) = I(Y, r)$ (4.4)
Three-Sector Closed Economy	$S(Y_d, r) + T = I(Y, r) + G$ (4.5)
Four-Sector Open Economy	$S(Y_d, r) + T + M = I(Y, r) + G + X$ (4.6)

The notions of the notations used in Table 4.1 and Table 4.2 are as follows:

$G$   $\equiv$  Government expenditure

$I$   $\equiv$  Private investment expenditure in manufactured capital

$M$   $\equiv$  Import

$r$   $\equiv$  Rate of interest

$S$   $\equiv$  Saving

$T$   $\equiv$  Net tax = (Tax – Transfer payment)

$X$   $\equiv$  Export

$Y$   $\equiv$  Net domestic product ( $NDP$ ) = ( $GDP - D^m$ ) = National income ( $NI$ ), where  $GDP$   $\equiv$  Gross domestic product,  $D^m$   $\equiv$  Depreciation of manufactured capital

$Y_d$   $\equiv$  Disposable  $NI = (Y - T)$

#### **4.4. Equation of LM Curve**

The equation of LM curve is given by equation (4.7).

$$M_a^* = [L_1(Y, P^*) + L_2(r)] = L(Y, r, P_a^*) \quad (4.7)$$

Where  $L_1 \equiv$  Active demand for money = [Transaction demand for money ( $L_T$ ) + Precautionary demand for money ( $L_P$ )],  $L_2 \equiv$  Speculative demand for money,  $M_a^* \equiv$  Autonomous money supply,  $P_a^* \equiv$  Autonomous price level,  $L \equiv$  Demand for money  $\equiv$  Liquidity preference,  $Y \equiv NI$ ,  $r \equiv$  Rate of interest

#### 4.5. Slope of SISC

The equation of the SISC indicated by equation (4.1) in Table 4.1 can be rewritten as equation (4.8).

$$S(Y) = I(r) \quad (4.8)$$

By total differentiation of equation (4.8) with respect to  $Y$ , we get equation (4.9).

$$[dr/dY]_{SISC} = S'(Y)/I'(r) \quad (4.9)$$

= Slope of SISC

The SISC assumes four slopes depending upon the signs of  $S'(Y)$  and  $I'(r)$  as follows:

- a) If  $S'(Y) = 0$  irrespective of  $I'(r)$ , the SISC is zero sloping.
- b) If  $I'(r) = \infty$  irrespective of  $S'(Y)$ , the SISC is zero sloping.
- c) If  $I'(r) = 0$  irrespective of  $S'(Y) > 0$ , the SISC is infinitely sloping.
- d) If  $S'(Y) = \infty$  irrespective of  $I'(r)$ , the SISC is infinitely sloping.
- e) If  $S'(Y) > 0$  and  $I'(r) < 0$ , the SISC is negatively sloping.



- f) If  $S'(Y) < 0$  and  $I'(r) > 0$ , the SISC is negatively sloping.
- g) If  $S'(Y) > 0$  and  $I'(r) > 0$ , the SISC is positively sloping.
- h) If  $S'(Y) < 0$  and  $I'(r) < 0$ , the SISC is positively sloping.

The foregoing four slopes of SISC have been shown in Figure 4.1.

#### 4.6. Slope of GISC

The equation of the GISC given by equation (4.4) in Table 4.2 can be rewritten as equation (4.10).

$$S(Y, r) = I(Y, r) \tag{4.10}$$

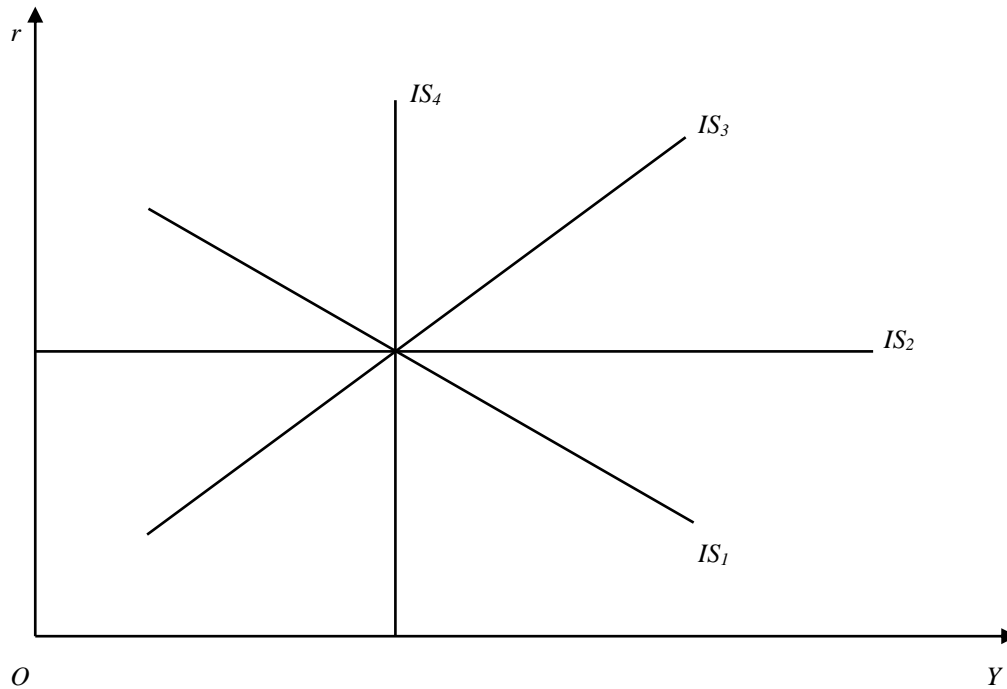
By total differentiation of equation (4.10) with respect to  $Y$ , we get equation (4.11).

$$[dr/dY]_{GISC} = [I_Y - S_Y]/[S_r - I_r] \tag{4.11}$$

= Slope of GISC

Like SISC, the GISC also assumes four slopes depending upon the signs of  $S_Y$ ,  $I_Y$ ,  $S_r$ , and  $I_r$ . The four slopes of SISC and GISC have been shown by  $IS_i$  ( $i = 1, 2, 3, 4$ ) in Figure 4.1.

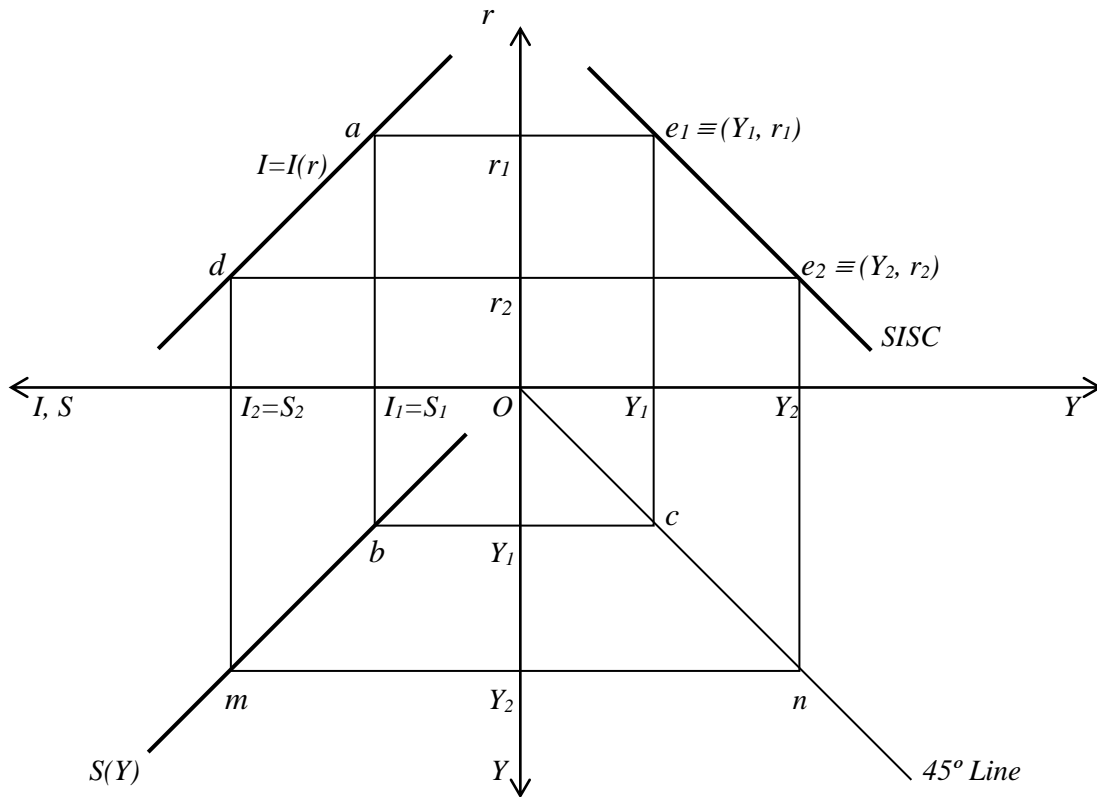
**Figure 4.1: Four Slopes of IS Curve**



#### **4.7. Diagrammatic Derivation of SISC**

There are two circuits: (i)  $abce_1$  and (ii)  $dmne_2$  in Figure 4.2. The first circuit starts with  $r_1$  rate of interest and ends with  $Y_1$  income and thereby produces the coordinate  $(Y_1, r_1)$  keeping the commodity market in equilibrium ( $S = I$ ). Similarly, the second circuit starts with  $r_2$  rate of interest and ends with  $Y_2$  income and thereby produces the coordinate  $(Y_2, r_2)$  keeping the commodity market in equilibrium ( $S = I$ ). The line, which connects the two coordinates:  $(Y_1, r_1)$  and  $(Y_2, r_2)$ , is the resulting SISC.

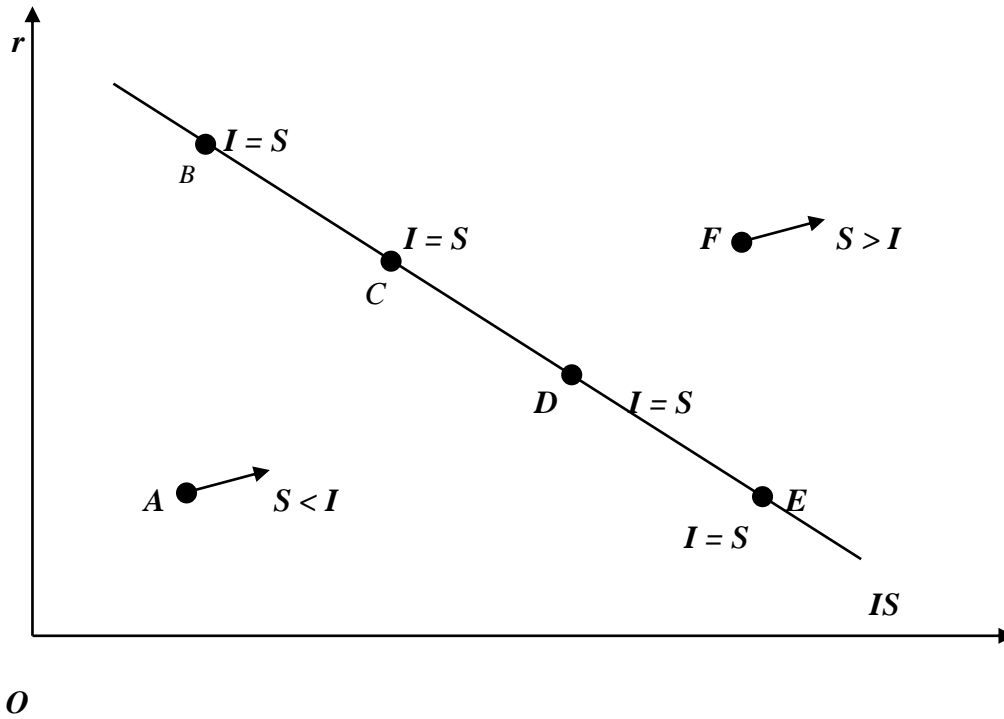
**Figure 4.2: Diagrammatic Derivation of SISC**



#### 4.8. Points “Of” IS Curve and Points “Off” IS Curve

Points of the IS curve means the points on the IS curve, which shows  $I = S$  (commodity market equilibrium). But points off the IS curve means the points, which lie to the right and left of the IS curve. Any point, which lies to the right (or left) of the IS curve represents an excess supply of commodity (or excess demand for commodity) in the commodity market. The excess supply of commodity [ $Y > (C + I)$ ] and the excess demand for commodity [ $Y < (C + I)$ ] can be translated into  $S > I$  and  $S < I$  respectively, both of which indicate disequilibrium in the commodity market. In Figure 4.3, while the point  $A$  indicates  $S < I$ , the point  $F$  indicates  $S > I$ .

**Figure 4.3: Points “of” and “Off” IS Curve**



#### 4.9. Slope/Shape of LM Curve

The LM curve is devoid any dichotomization/division (e.g. *Simple LM Curve* and *Generalized LM Curve*). The equation of the LM curve given by equation (4.7) can be rewritten as equation (4.12).

$$M_a^* = [L_1(Y, P^*) + L_2(r)] = L(Y, r, P_a^*) \quad (4.12)$$

By differentiation of equation (4.12) with respect to  $Y$ , we get equation (4.13).

$$[dr/dY]_{LM} = -L_Y/L_r \quad (4.13)$$

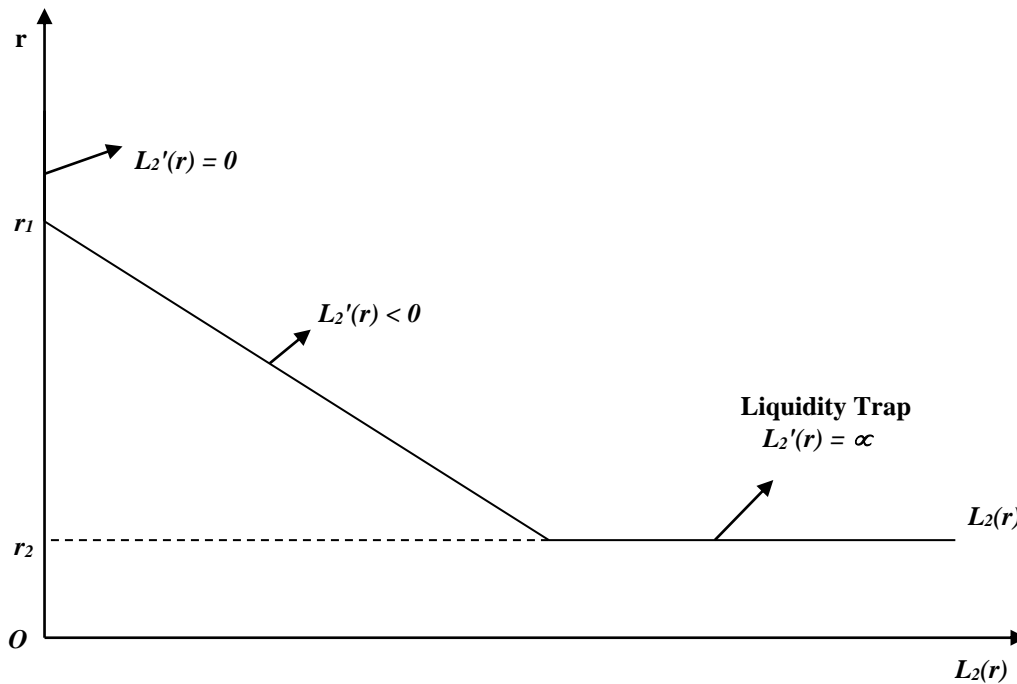
= Slope of LM Curve

The slope/shape of LM curve is determined by the slope/shape of  $L_2(r)$  curve [i.e. on the sign/value of  $L_r$ ] on the assumption that  $L_Y > 0$ . The slope/shape of  $L_2(r)$  curve has been shown in Figure 4.4, while the slope/shape of LM curve has been shown in Figure 4.5.

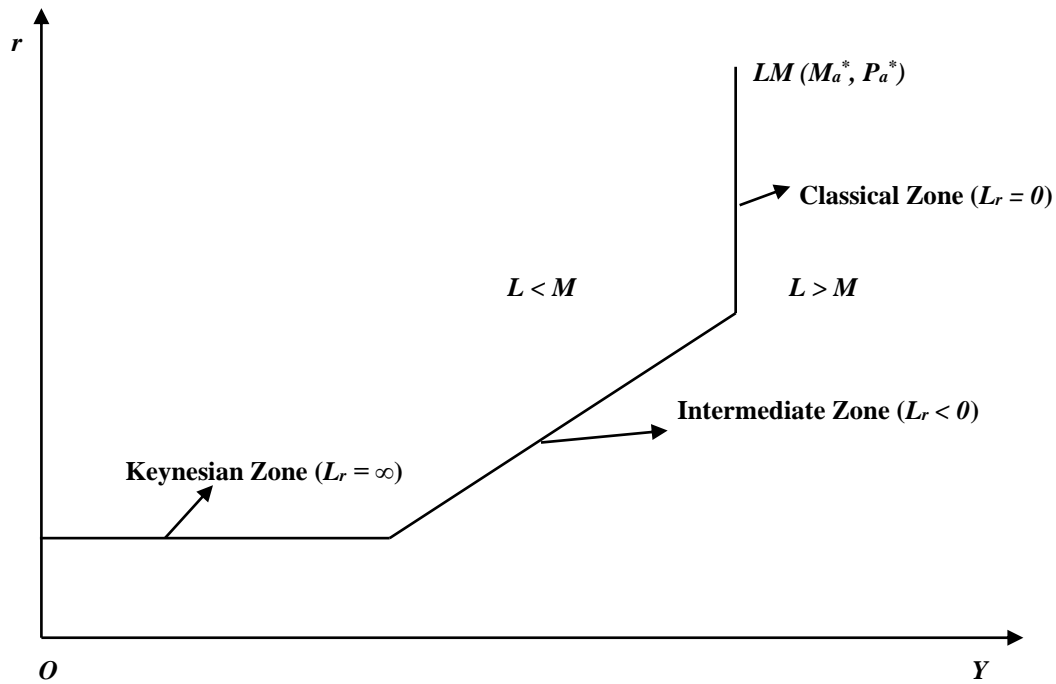
From equation (4.13), it is amply clear that when  $L_2(r)$  curve is vertical, LM curve follows suit, when  $L_2(r)$  curve is horizontal, LM curve follows suit and when  $L_2(r)$  curve is negatively sloping, LM curve does not follow suit, that is, LM curve is positively sloping.

In fine, LM curve is the “mirror image” of  $L_2(r)$  curve in the sense that if a “mirror” is kept vertically to the right of  $L_2(r)$  curve in Figure 4.4, then its “reflection” will be LM curve in Figure 4.5.

**Figure 4.4: Slope/Shape of  $L_2(r)$  Curve**



**Figure 4.5: Slope/Shape of LM Curve**



#### 4.10. Points “Of” and “Off” LM Curve

The kinked shaped LM curve has been shown by  $LM (M_a^*, P_a^*)$  in Figure 4.5. Any point, which lies to the right (or left) of LM curve, represents an excess demand for money (or excess supply of money) in the money market. Both the excess demand for money ( $L > M$ ) and the excess supply of money ( $L < M$ ) in the money market imply the disequilibrium in the money market. If the equilibrium in the money market is to be obtained, then it is only possible along LM curve, because LM curve is the locus of various combinations of  $Y$  and  $r$  along which the equality:  $L = M$  (the equilibrium condition of the money market) is maintained. Thus,  $L > M$  is possible to the right of LM curve, while  $L < M$  is possible to the left of LM curve (Figure 4.5).

### 4.11. Equilibrium in IS-LM Keynesian Model

If both IS curve and LM curve are brought together in a diagram (Figure 4.6), the point of intersection between them determines the equilibrium of both the commodity market and the money market simultaneously. Such equilibrium point is denoted by  $E$  in Figure 4.6, which shows that the point of intersection between  $IS$  and  $LM$  ( $M_a^*$ ,  $P_a^*$ ) determines the equilibrium income ( $Y_E$ ) and equilibrium rate of interest ( $r_E$ ) simultaneously. This is the “existence” of equilibrium in IS-LM Keynesian model.

### 4.12. Stability of Equilibrium in IS-LM Keynesian Model

The “stability” of equilibrium in IS-LM Keynesian model can be demonstrated in the following way:

In Figure 4.6, IS curve and LM curve intersect to create four zones indicated by Zone I, Zone II, Zone III and Zone IV.

**The following results can be obtained from the four zones:**

In Zone I,  $I < S$  and  $L < M$ , which lead to fall in both  $Y$  and  $r$ .

In Zone II,  $I > S$  and  $L < M$ , which lead to rise in  $Y$  and fall in  $r$ .

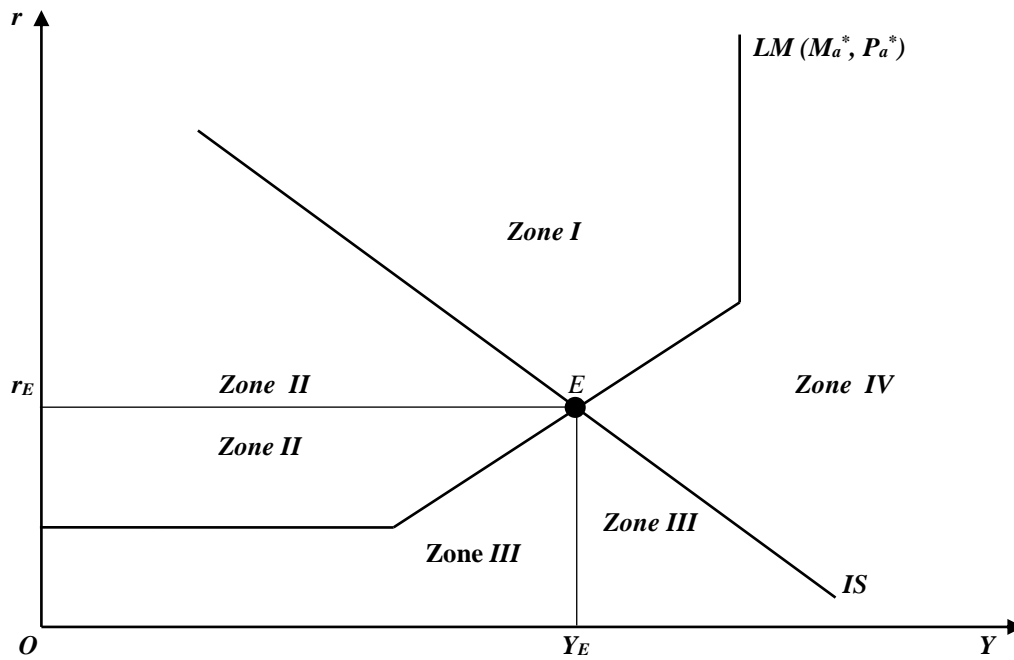
In Zone III,  $I > S$  and  $L > M$ , which lead to rise in both  $Y$  and  $r$ .

In Zone IV,  $I < S$  and  $L > M$ , which lead to fall in  $Y$  and rise in  $r$ .

The stability condition of equilibrium in IS-LM Keynesian model requires that any departure from equilibrium, or deviation of equilibrium, leads market forces to function in such a way that the resulting change in  $Y$  and  $r$  restores the equilibrium point  $E$  through a counter clock-wise

(circular, rectangular or similar) movement. Noteworthy that the market forces will continue to function to change the  $Y$  and  $r$  until the equilibrium point  $E$  is reached through a counter clock-wise movement (Figure 4.6).

**Figure 4.6: Equilibrium in IS-LM Keynesian Model**





## 5. Means of Reconstruction of HK for Sustainability

The recent events have brought Keynes back to life. The income-expenditure model that is conventionally taken to be the core of Keynesian theory was thus the bit of Keynes most suitable for the policy maker. The theory of income or employment multiplier showed much extra demand needed to be pumped into a depressed economy to bring it back to full employment. We do not need a new Keynes. We do need the old Keynes, suitably updated. He will not be our sole guide to the economic future, but he remains an indispensable guide (Skidelsky, 2011).

The means of reconstruction of HK, which consists of (i) *Simple Keynesian Model* and (ii) *IS-LM Keynesian Model*, for realizing/restoring sustainability, can be described in terms of the following nine points indicated by (5.1. – 5.9).

### 5.1. Introduction of Four Types of Essential Economic Activity

In opposition to the preexisting contextual notion, economics, in the present context of sustainability, has been redefined as the study of the way people organize themselves or organize their efforts to sustain life and enhance its quality (Goodwin, Nelson & Harris, 2009; Goodwin, Nelson, Ackerman & Weisskopf, 2009). Hence, economics studies how individuals engage in the following four economic activities and how their social coordination is achieved:

(1) Maintenance of Resources, such as, natural resources, manufactured resources, human resources and social resources. Maintenance of resources means tending to, preserving, or improving the stocks of resources, which form the basis for the preservation and quality of life. In other words, maintenance of resources is the management of various capital (e.g. natural capital, manufactured capital, human capital, social capital) stocks so that their productivity is sustained.

(2) Production of Goods and Services. Production is the conversion of some of these resources into usable products.

(3) Distribution of Goods and Services. Distribution refers to the sharing of products and resources among people.

(4) Consumption of Goods and Services. Consumption indicates their final use.

## **5.2. Introduction of Three Principal Macroeconomic Goals**

Conventionally, macroeconomic goals are confined to (i) internal stability, which means economic growth with price stability, equitable distribution and full employment, and (ii) external stability, which implies equilibrium in balance of payment. In the present context of sustainability, the following three principal macroeconomic goals are substituted for the foregoing two conventional macroeconomic goals:

- (1) Improvement of people's living standards so that their lives can be long, healthy, enjoyable, and offer them the opportunity to accomplish the things they believe give their lives meaning.
- (2) Achievement of sufficient economic stability to enable individuals and families to enjoy economic security and to be able to make reasonable predictions about their future.
- (3) Achievement of sustainability, which consists of "ecological sustainability" and "social sustainability", given the exogenously and spontaneously determined natural stability and natural instability.

## **5.3. Introduction of Four Spheres of Macroeconomic Activity**

- (1) Core Sphere, which consists of households, families and communities. They organize resource-management, production, distribution, and consumption of goods and services.
- (2) Public-Purpose Sphere, which consists of governments and their agencies, as well as nonprofit organizations, such as, charities and professional associations, and international institutions, such as, the World Bank and the United Nations established for some public purpose beyond individual or family self-interest, and not operating with the goal of making a profit. The economic functions of this sphere can be divided into: (i) regulation, where rules or standards are set for the actions of other economic entities, and (ii) direct provision, where public-purpose organization itself takes on economic activities.
- (3) Business Sphere, which consists of firms producing goods and services for profitable sale. Whereas the core sphere responds to direct needs, and the public-purpose sphere responds to its constituents, business firms are responsive to demands for goods and services, as expressed through markets by people, who can afford to buy the products produced by the firms.

(4) Informal Sphere, which consists of small enterprises operating outside of government oversight and regulation. In less developed countries, most people are employed/engaged in small-scale agriculture, trade, and services, which often go unaccounted. Most informal activities are often ignored in government complied accounts.

#### **5.4. Introduction of Six Sectors into National Income Accounting**

In conventional national income accounting, only four sectors such as (i) household sector, (ii) business/firm sector, (iii) government sector, and (iv) foreign sector are considered. But presently, the following five sectors are incorporated into national income accounting:

(1) Personal Sector, which consists of households and nonprofit institutions serving households.

(2) Business Sector, which consists of all entities concerned with producing goods and services for profitable sale.

(3) Government Sector, which consists of central, state and local government entities.

(4) Foreign Sector, which consists of entities located outside the borders of national countries.

(5) Natural Sector, which provides diverse natural resources for consumption and production of goods and services by the regenerative and absorptive capacities of *Only One Earth* (Ward & Dubos, 1972).

(6) Social Sector, which creates, conserves and/or control social capital for ensuring social cohesion, cooperation, coordination, solidarity, stability, trust, transparency and accountability.

#### **5.5. Introduction of Three Types of Capital into National Income Accounting**

In conventional national income accounting, only one type of capital, such as manufactured capital, is used. But the context of sustainability requires at least the following three types of capital:

(1) Natural Capital, which refers to physical assets provided by nature, such as, land that is suitable for agriculture or other human uses, fresh water sources, and stocks of mineral and crude oil, which are still in the ground.

(2) Manufactured Capital, which refers to physical assets that are generated by applying human productive activities to natural capital.

(3) Social Capital, which consists of various sub-social capitals (e.g. cultural capital, political capital, moral capital, ethical capital, religious capital, etc). Social capital refers to the institutions, relationships, and norms, which shape the quality and quantity of a society's social interactions. Social cohesion is critical for societies to prosper economically and for development to be sustainable. Social capital is not just the sum of the institutions, which underpin a society. It is the glue that holds them together. Social capital, when enhanced in a positive manner, can improve project effectiveness and sustainability by building the community's capacity to work together to address their common needs, fostering greater inclusion and cohesion, and increasing transparency and accountability.

### **5.6. Compositional Reconstruction of $GDP = [C + I + G + (X - M)]$ by Decomposition of $C, I$ and $G$**

In conventional national income accounting, the notations  $C$ ,  $I$  and  $G$  imply the following notions:

$C \equiv$  Consumption expenditure by household sector

$I \equiv$  Investment expenditure by private sector firms

$G \equiv$  Government expenditure on goods and services (consumption-oriented)

But in the context of sustainability, the decomposition/division of the foregoing three notations:  $C$ ,  $I$  and  $G$  has become inevitable as follows:

$$C = [(consumption\ of\ households) + (consumption\ of\ non-profit\ institutions\ serving\ households)]$$

$$= [(consumption\ of\ non-durable\ goods\ and\ energy-intensive\ services) + (consumption\ of\ human\ capital-intensive\ services) + (household\ investment\ in\ consumer\ durables)]$$

$$I = [(private\ investment\ in\ manufactured\ capital) + (private\ investment\ in\ natural\ capital) + (private\ investment\ in\ social\ capital) + (private\ investment\ in\ human\ capital)]$$

$$G = [(government\ consumption) + (government\ investment)]$$

$$= [ \{ (government\ consumption\ of\ non-durable\ goods\ and\ energy-intensive\ services) + (Government\ consumption\ of\ human\ capital-intensive\ services) \} + \{ (government\ investment\ in\ manufactured\ capital) + (government\ investment\ in\ natural\ capital) + (government\ investment\ in\ social\ capital) + (government\ investment\ in\ human\ capital) \} ]$$

## 5.7. Reconstruction of National Income: From GDP to Sustainable National Income (SNI)

In 1937, the first set of national accounts was presented to the Congress of USA by the economist Simon Kuznets, who was commissioned to develop national accounts by the Department of Commerce of USA. Mere environmental consciousness and activities cannot resolve the emerging problem of unsustainability. What is urgently needed is an objective, scientific and standardized checking system, which is called “environmental accounting system” (IEEA, 1993; SEEA, 1993). Environmental accounting is treated as synonymous with green accounting and resource accounting. The transition of national income from GDP to SNI can be briefly sketched by the following three points indicated by (5.7.1 – 5.7.3).

### 5.7.1. Conventional Method of National Income Accounting

In 1948, the *System of National Accounts* (SNA) originated in the United Nations (UN) *Measurement of National Income and the Construction of Social Accounts*, and has been developing as a standard system of national accounting. According to the conventional national income accounting method of SNA,

$$NDP = [GDP - D^m] = C + I + G + (X - M) \quad (5.1)$$

where **GDP** ≡ Gross Domestic Product, **NDP** ≡ Net Domestic Product, **D<sup>m</sup>** ≡ Depreciation, degradation, depletion or destruction of manufactured capital.

### 5.7.2. Construction of Environmentally Adjusted NDP

Ahmad, Serafy and Lutz's (1989) edited book, entitled, *Environmental Accounting for Sustainable Development*, is the outcome of the joint workshops organized by the *United Nations Environment Programme* (UNEP) and the *World Bank* to examine the feasibility of physical and monetary accounting in the area of natural resources and the environment and to develop alternative macro-indicators of environmentally adjusted and sustainable income and product. A consensus emerged in the workshops that enough progress had been achieved to develop the links between environmental accounting and the SNA. However, according to the *United Nations System of Integrated Environmental and Economic Accounting* (SEEA, 1993) and *Integrated Environmental and Economic Accounting* (IEEA, 1993), a measure called "Environmentally Adjusted NDP" (EANDP) had been developed as follows:

$$NDP = C + I + G + (X - M) \quad (5.2)$$

$$EANDP = [GDP - (D^m + D^n)] \quad (5.3)$$

$$EANDP = C + (P + N - D^n) + G + (X - M) \quad (5.4)$$

where  $P \equiv$  Net capital accumulation in produced (or manufactured) assets,  $N \equiv$  Net capital accumulation in non-produced (or non-manufactured) assets,  $D^n \equiv$  Depreciation, degradation, depletion or destruction of natural/ecological assets

### 5.7.3. Construction of Sustainable National Income (SNI)

Empirical attempts to estimate modified national income accounts predate the interests of environmental economists in green NNP (Eisner, 1988). In 1989, the first set of national income accounts to incorporate environmental depreciation was produced for Indonesia by scholars at the *World Resources Institute* in Washington, DC. Since the *World Resources Institute Study* (1989), several dozen studies of modified national income have been published and reviewed by Hamilton and Lutz (1996). The theoretical foundations for modifying the national income

accounts have been subsequently set out by Hartwick (1990) and M'aler (1991). Further, Hueting, Bosch and de Boer (1991) developed the *Methodology for the Calculation of Sustainable National Income*. An extensive guide to new national income accounting theory has been offered by Hartwick (2000).

The concept of sustainable development suggests that a development path is sustainable, if and only if the stock of overall capital remains constant or rises over time. There are various types of capital. But for our present purpose, only the following three forms of capital will be considered: (i) Manufactured Capital, (ii) Natural/Ecological Capital, and (iii) Social Capital. Noteworthy that social capital includes various forms of sub-social capital (e.g. political capital, economic capital, cultural capital, moral capital, spiritual capital, religious capital, etc.).

To be on a sustainable development path, then, a nation must be living within its means, which, in this context, means non-decreasing of its overall capital stock. The proper measure of national income corresponding to this idea of SD is widely accepted to be the amount that can be consumed without running the stock of capital down. An indicator of SD, then, is a measure of SNI, defined here, as the level of national income, which can be secured without decreasing the overall level of capital stock.

As the creation, control and conservation of manufactured capital create no problem, so depending upon the nature or classification of capital, SNI can be categorized into:

- (i) Ecologically Sustainable National Income (ESNI)
- (ii) Socially Sustainable National Income (SSNI)
- (iii) Ecologically and Socially Sustainable National Income (ESSNI)

Following Hueting, Bosch and de Boer (1991), Lutz (1993), *United Nations Handbook of National Accounting* (1993), *United Nations IEEA* (1993) and *United Nations SEEA* (1993), the definitional equations of the foregoing three types of SNI can be stated in terms of equations (5.5) - (5.7) on the assumption that government sector is non-existent:

$$ESNI = [NDP - D^n] \tag{5.5}$$

$$SSNI = [NDP - D^s] \tag{5.6}$$

$$ESSNI = [NDP - (D^n + D^s)] \tag{5.7}$$

where  $D^s \equiv$  Depreciation of Social Capital and  $D^n \equiv$  Depreciation of natural or ecological capital

But in the presence of government sector, the definitional equations of the foregoing three types of SNI can be modified in terms of equations (5.8) - (5.10).

$$ESNI = [Y_d - D^n] \quad (5.8)$$

$$SSNI = [Y_d - D^s] \quad (5.9)$$

$$ESSNI = [Y_d - (D^n + D^s)] \quad (5.10)$$

where  $Y_d \equiv$  Disposable **NI** = [ $NDP$  – Net Tax] = [ $NDP$  – (Tax – Transfer Payments)]

Noteworthy that  $GDP$  and  $NDP$  can be substituted with  $GNP$  and  $NNP$  respectively. Further, in the absence of government sector, the definitional equations of  $ESNI$ ,  $SSNI$  and  $ESSNI$  can be modified through the incorporation of the following three elements: (i) Restorative Expenditure ( $E^r$ ), (ii) Defensive or Aversive Expenditure ( $E^a$ ) and (iii) Overstatement due to Non-optimal Use of Natural Resources ( $O^n$ ) in terms of equations (5.11) - (5.13).

$$ESNI = [NDP - (D^n + E^r + E^a + O^n)] \quad (5.11)$$

$$SSNI = [NDP - (D^s + E^r + E^a + O^n)] \quad (5.12)$$

$$ESSNI = [NDP - (D^n + D^s + E^r + E^a + O^n)] \quad (5.13)$$

But in the presence of government sector, the definitional equations of the foregoing three types of SNI can be modified in terms of equations (5.14) - (5.16).

$$ESNI = [Y_d - (D^n + E^r + E^a + O^n)] \quad (5.14)$$



$$SSNI = [Y_d - (D^s + E^r + E^a + O^n)] \quad (5.15)$$

$$ESSNI = [Y_d - (D^n + D^s + E^r + E^a + O^n)] \quad (5.16)$$

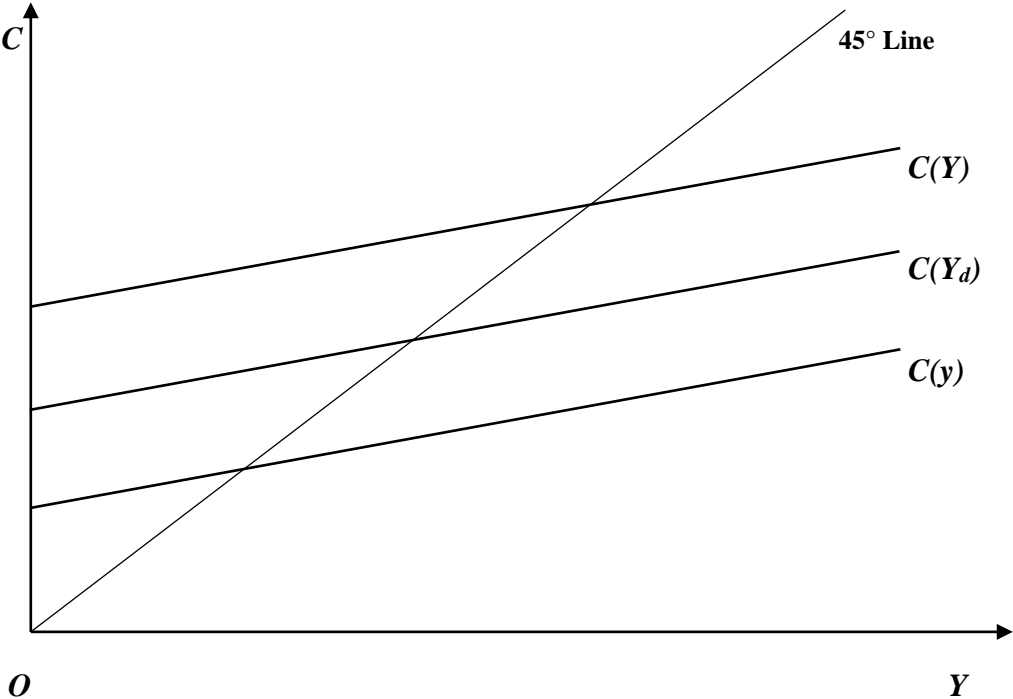
## 5.8. Incorporation of SNI into Consumption or Saving Function

By any criterion, consumption plans of the people are determined by their net income and not by their earned income. At the micro level, net income of an individual means total income earned minus total deductions. But conventionally, at the macro level, net income implies NDP or  $Y_d$ . But in the context of sustainability, net income, at the macro level, implies SNI, not NDP or  $Y_d$ . Hence, while conventional macro consumption function can be written as (i)  $C = C(Y)$  such that  $C'(Y) = MPC > 0$ , where  $Y \equiv NDP$ , and (ii)  $C = C(Y_d)$  such that  $C'(Y_d) = MPC > 0$ , the sustainable macro consumption function can be represented by  $C = C(y)$  such that  $C'(y) = MPC > 0$ , where  $y \equiv SNI$ . By definition,  $S = [Y - C]$ . So the sustainable macro saving function can be represented by  $S = S(y)$  such that  $S'(y) = MPS > 0$ , where  $y \equiv SNI$ . The clear-cut distinction between the conventional consumption or saving function and the sustainable consumption or saving function is inevitable, because the latter will be incorporated into the next sub-section (5.9). The distinction between the conventional consumption or saving function and the sustainable consumption or saving function will be amply clear from Figure 5.1. and Figure 5.2.

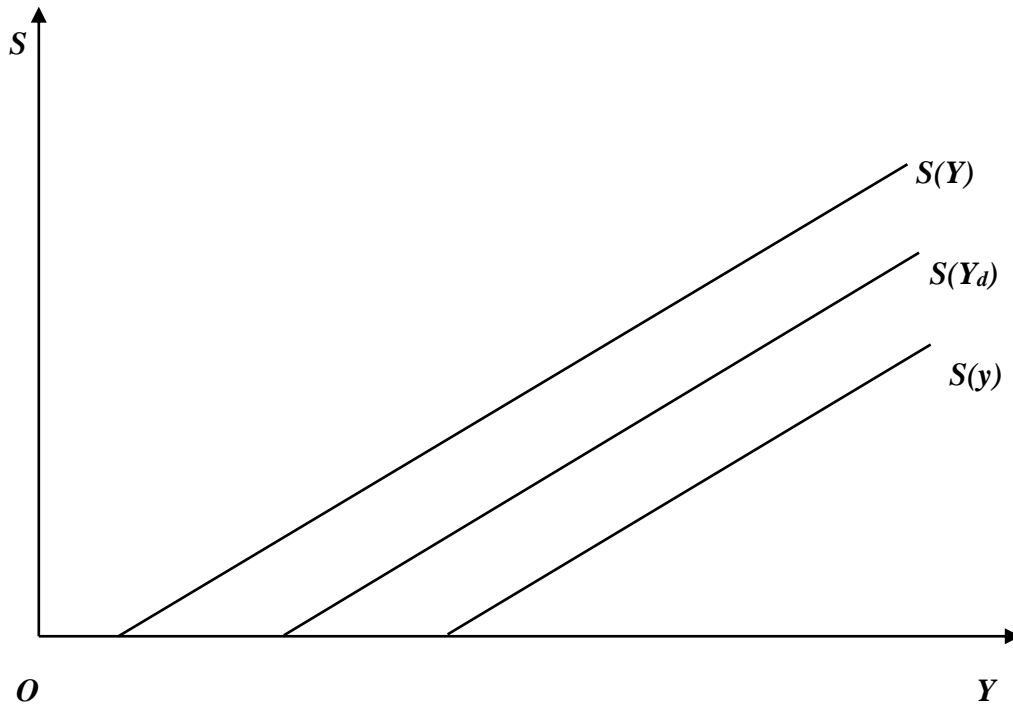
In Figure 5.1, three consumption functions are existent, such as,  $C(Y)$ ,  $C(Y_d)$  and  $C(y)$ . The  $C = C(Y)$  function is called conventional consumption function when government sector is non-existent. The  $C = C(Y_d) = C(Y - T)$  function is also called conventional consumption function when government sector is existent. But  $C = C(Y - T - D) = C(Y_d - D) = C(y)$  function is called sustainable consumption function when government sector, natural sector and social sector are existent, where  $D = (D^n + D^s)$ . Similarly, in Figure 5.2, the  $S = S(Y)$  function is called conventional saving function when government sector is non-existent. The  $S = S(Y - T) = S(Y_d)$  function is also called conventional saving function when government sector is existent. But  $S = S(Y - T - D) = S(Y_d - D) = S(y)$  function is called sustainable saving function when government sector, natural sector and social sector are existent. Thus, as  $Y$  is substituted successively with  $Y_d$  and  $y$  in the  $C(\dots)$  and  $S(\dots)$  functions, these functions shift successively in the downward direction. This means that with such substitution, both  $C$  and  $S$  fall consecutively. In

consequence, sustainable consumption and saving will be lower than conventional consumption and saving.

**Figure 5.1: Conventional vis-à-vis Sustainable Consumption Function**



**Figure 5.2: Conventional vis-à-vis Sustainable Saving Function**



**5.9. Contextual Reconstruction of Equilibrium Equations of Two Models of HK by (i) Incorporating Relevant Macroeconomic, Macroecological, Macrosocial and/or Macrosub-Social Variables into Equilibrium Equations and (ii) Maintaining the Consistency of the NI Accounting Method Suggested by IEEA (1993) and SEEA (1993) of UN**

To satisfy the end of the thesis, context has been divided into three categories: (i) ecological context, (ii) social context and (iii) ecological context coupled with social context.

But social context includes various sub-social contexts, such as, economic context, political context, cultural context, philosophical context, religious context, moral context, ethical context, spiritual context, familial context, gender context, etc.

Economics is a science of thinking in terms of ‘models’ joined to the art of choosing models, which are relevant to the contemporary world (Keynes, 1938).

The reconstruction of a model may be complete or partial. Complete reconstruction of a model means the perfect substitution of a new model for an old one. But the partial reconstruction of a model implies that some elements of the old model still constitute a part of the new model. The partial reconstruction of a model “should not be a matter of tearing up roots, but of slowly training a plant to grow in a different direction” (Keynes, 1933).

This thesis is a partial reconstruction of the two constituent models (*Simple Keynesian Model* and *IS-LM Keynesian Model*) of HK with respect to the three contexts: (i) ecological context, (ii) social context, and (iii) both ecological and social context for making a contribution to MOS.

Model is characterized by its representative equations. The reconstruction of a model means the reconstruction of its “representative equations”. The representative equations of *Simple Keynesian Model* and *IS-LM Keynesian Model* are indicated by their respective “equilibrium equations”.

Hence, the reconstruction of HK for sustainability implies the reconstruction of the equilibrium equations of the foregoing two models for sustainability.

The reconstruction of the equilibrium equations of each Keynesian model requires the “rational reconstitution” of the composition of the “equilibrium equations” through the incorporation of contextually relevant macroeconomic, macroecological, macrosocial and/or macrosub-social variables into those equilibrium equations and by maintaining the consistency of the national income accounting method suggested by United Nations IEEA (1993) and SEEA (1993).

If it is true that philosophers have only interpreted the world differently, whereas what matters is to change it, then it is also true that moral philosophers have only interpreted nature in different ways, whereas what matters is to sustain it.

From a phenomenological perspective, the sustainability crisis consists in the fact that human beings consume nature without being aware of the fact that they constitute it.

-----George Heffernan (2010)

## 6. Reconstruction of Simple Keynesian Models for Sustainability

The necessary means of reconstruction of the two constituent models of HK for sustainability have been indicated by section 5.9 in chapter 5. The reconstruction of SKM means the reconstruction of its “representative equations”, which are shown by its “equilibrium equations”. They have been shown in Table 3.1. These equilibrium equations can be reconstructed into the equilibrium equations of the following three new sets of models.

(1) Set of Ecologically Sustainable Simple Keynesian Models (Table 6.1)

(2) Set of Socially Sustainable Simple Keynesian Models (Table 6.2)

(3) Set of Ecologically and Socially Sustainable Simple Keynesian Models (Table 6.3)

**Table 6.1: Equilibrium Equations of Ecologically Sustainable Simple Keynesian Models**

Nature of Economy	Saving-Investment Approach	Income-Expenditure Approach
Two-Sector Closed Economy	$S(y^{es}) + D^n = I^m + I^n$ (6.1a)	$Y = C(y^{es}) + I^m + I^n$ (6.1b)
Three-Sector Closed Economy	$S(y^{es}) + D^n + T = I^m + I^n + G$ (6.2a)	$Y = C(y^{es}) + I^m + I^n + G$ (6.2b)
Four-Sector Open Economy	$S(y^{es}) + D^n + T + M = I^m + I^n + G + X$ (6.3a)	$Y = C(y^{es}) + I^m + I^n + G + (X-M)$ (6.3b)

**Table 6.2: Equilibrium Equations of Socially Sustainable Simple Keynesian Models**

Nature of Economy	Saving-Investment Approach	Income-Expenditure Approach
Two-Sector Closed Economy	$S(y^{ss}) + D^s = I^m + I^s$ (6.4a)	$Y = C(y^{ss}) + I^m + I^s$ (6.4b)
Three-Sector Closed Economy	$S(y^{ss}) + D^s + T = I^m + I^s + G$ (6.5a)	$Y = C(y^{ss}) + I^m + I^s + G$ (6.5b)
Four-Sector Open Economy	$S(y^{ss}) + D^s + T + M = I^m + I^s + G + X$ (6.6a)	$Y = C(y^{ss}) + I^m + I^s + G + (X - M)$ (6.6b)

**Table 6.3: Equilibrium Equations of Ecologically and Socially Sustainable Simple Keynesian Models**

Nature of Economy	Saving-Investment Approach	Income-Expenditure Approach
Two-Sector Closed Economy	$S(y^{ess}) + D^n + D^s = I^m + I^n + I^s$ (6.7a)	$Y = C(y^{ess}) + I^m + I^n + I^s$ (6.7b)
Three-Sector Closed Economy	$S(y^{ess}) + D^n + D^s + T = I^m + I^n + I^s + G$ (6.8a)	$Y = C(y^{ess}) + I^m + I^n + I^s + G$ (6.8b)
Four-Sector Open Economy	$S(y^{ess}) + D^n + D^s + T + M = I^m + I^n + I^s + G + X$ (6.9a)	$Y = C(y^{ess}) + I^m + I^n + I^s + G + (X - M)$ (6.9b)

The notions of the notations used in Table 6.1, Table 6.2 and Table 6.3 are as follows:

$C(y^{es}) \equiv$  Ecologically sustainable consumption function

$C(y^{ss}) \equiv$  Socially sustainable consumption function

$C(y^{ess}) \equiv$  Ecologically and socially sustainable consumption function

$D^m \equiv$  Depreciation, depletion or degradation of manufactured capital

$D^n \equiv$  Depreciation, depletion or degradation of natural/ecological capital

$D^s \equiv$  Depreciation, depletion or degradation of social capital

$G$   $\equiv$  Government expenditure

$$G = [G_C + G_I] = [G_C + (G_I^n + G_I^m)]$$

$G_C$   $\equiv$  Government consumption expenditure

$G_I$   $\equiv$  Government investment expenditure

$G_I^n$   $\equiv$  Government investment in natural capital

$G_I^m$   $\equiv$  Government investment in manufactured capital

$GDP$   $\equiv$  Gross domestic product

$I^m$   $\equiv$  Private investment in manufactured capital

$I^n$   $\equiv$  Private investment in natural capital

$I^s$   $\equiv$  Private investment in social capital

$M$   $\equiv$  Import

$NDP$   $\equiv$  Net domestic product

$NI$   $\equiv$  National income

$S(y^{es})$   $\equiv$  Ecologically sustainable saving function

$S(y^{ss})$   $\equiv$  Socially sustainable saving function

$S(y^{ess})$   $\equiv$  Ecologically and socially sustainable saving function

$T$   $\equiv$  Net tax = (Tax – Transfer payments)

$X$   $\equiv$  Export

$$Y \equiv NI = NDP = (GDP - D^m)$$

$$Y_d \equiv \text{Disposable } NI = (Y - T)$$

$y^{es}$   $\equiv$  Ecologically sustainable  $NI = (Y - D^n)$ [when government sector is non-existent] =  $(Y_d - D^n)$ [ when government sector is existent]

$y^{ss}$   $\equiv$  Socially sustainable  $NI = (Y - D^s)$ [when government sector is non-existent] =  $(Y_d - D^s)$ [ when government sector is existent]

$y^{ess}$   $\equiv$  Ecologically and socially sustainable  $NI = [Y - (D^n + D^s)]$ [when government sector is non-existent] =  $[Y_d - (D^n + D^s)]$ [ when government sector is existent]

The foregoing nine different equilibrium equations given by equations (6.1a) – (6.9a) or (6.1b) – (6.9b) embedded in the three tables (Table 6.1, Table 6.2, and Table 6.3) imply nine different variants of sustainable SKM. But deliberately bypassing other eight equilibrium equations, only one equilibrium equation indicated by (6.7a) or (6.7b) in Table 6.3 will be considered in order to

determine the equilibrium of ecologically and socially sustainable SKM for two-sector closed economy.

### 6.1. Determination of Equilibrium in Sustainable Simple Keynesian Model for Two-Sector Closed Economy

If the methodology for the mathematical and diagrammatical representation of the determination of equilibrium can be disclosed in terms of any one model of the foregoing three sets of sustainable SKMs, then such methodology can easily be applied to the remaining sustainable SKMs.

In order to realize the “ecologically social sustainability” or “ecologically sustainable social stability”, the Ecologically and Socially Sustainable Simple Keynesian Model for Two-Sector Closed Economy, which has been indicated by equation (6.7a) or (6.7b), will be extracted from Table 6.3.

The *Saving-Investment Approach* is preferred to the *Income-Expenditure Approach* that is why only the equation (6.7a) will be taken from Table 6.3. The sustainable equilibrium equation (6.7a) can be rewritten as equation (6.10).

$$[S(y^{ess}) + (D^n + D^s)] = [I^m + (I^n + I^f)] \quad (6.10)$$

Equation (6.10) can be transformed into its “reduced form” given by equation (6.11) on the basis of the assumptions that (i)  $y = y^{ess}$ , (ii)  $D = (D^n + D^s)$ , (iii)  $P = I^m$  and (iv)  $N = (I^n + I^f)$ .

$$S(y) + D = P + N \quad (6.11)$$

The sustainable equilibrium equation (6.11) may assume “more explicit forms” indicated by equations (6.12) – (6.19) depending upon whether the variables  $D$ ,  $P$  and  $N$  are autonomous or induced, because  $S = [S_a + S(y)]$  function is always induced.

$$[S_a + S(y)] + D_a = P_a + N_a \quad (6.12)$$



$$[S_a + S(y)] + D_a = [P_a + P(Y)] + N_a \quad (6.13)$$

$$[S_a + S(y)] + D_a = P_a + [N_a + N(Y)] \quad (6.14)$$

$$[S_a + S(y)] + D_a = [P_a + P(Y)] + [N_a + N(Y)] \quad (6.15)$$

$$[S_a + S(y)] + [D_a + D(Y)] = P_a + N_a \quad (6.16)$$

$$[S_a + S(y)] + [D_a + D(Y)] = [P_a + P(Y)] + N_a \quad (6.17)$$

$$[S_a + S(y)] + [D_a + D(Y)] = P_a + [N_a + N(Y)] \quad (6.18)$$

$$[S_a + S(y)] + [D_a + D(Y)] = [P_a + P(Y)] + [N_a + N(Y)] \quad (6.19)$$

where  $a \equiv$  autonomous part and  $i(j) \equiv$  induced part of the  $i$  function given by  $i = i_a + i(j)$ .

Now, we will proceed with only equation (6.12) deliberately bypassing other equations (6.13) – (6.19). By substitution of the “most explicit form” of  $S(y)$  function:  $[- S_a + sy]$  for the “more explicit form” of  $S(y)$  function:  $[- S_a + S(y)]$  in equation (6.12), we get equation (6.20).

$$[- S_a + sy] + D_a = P_a + N_a \text{ or, } [- S_a + s(Y - D_a)] + D_a = P_a + N_a \quad (6.20)$$

Rearranging equation (6.20), we get the ecologically and socially sustainable equilibrium NI ( $Y_{ess}$ ) by equation (6.21).

$$Y_{ess} = (P_a + S_a)/s + N_a/s - D_a(1-s)/s \quad (6.21)$$

In equation (6.21), if we put  $P = P_a = I_a = I$  and  $N = N_a = 0$ , then  $Y_{ess}$  can be given by equation (6.22).

$$Y_{ess} = [(I_a + S_a)/s] - [D_a(1-s)/s] \quad (6.22)$$

Further, in equation (6.22), if we put  $D = D_a = 0$ , we get the conventional equilibrium NI ( $Y_c$ ) by equation (6.23).

$$Y_c = [(I_a + S_a)/s] \quad (6.23)$$

Comparing equation (6.22) and equation (6.23), we get the inequality (6.24).

$$Y_{ess} < Y_c \quad (6.24)$$

as  $[D_a(I - s)/s] > 0$  due to the assumption that  $0 < s < I$  and  $D_a > 0$ .

The results of the three equations given by (6.22), (6.23) and (6.24) have been shown in Figure 6.1.

But if  $N = N_a > 0$ , then the three possibilities may occur:

(i)  $Y_{ess} < Y_c$

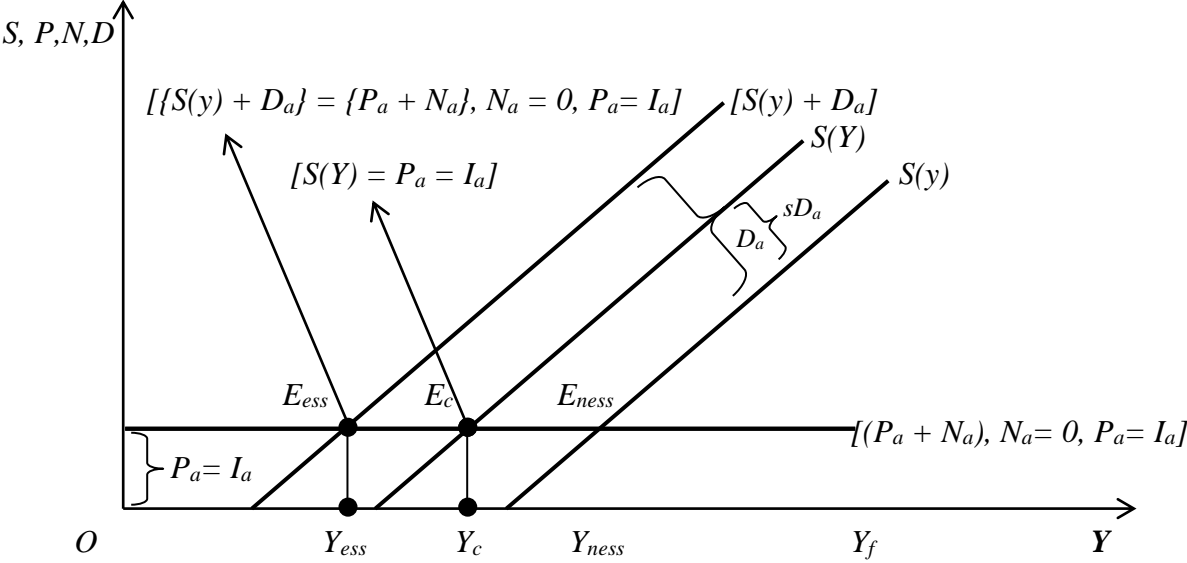
(ii)  $Y_{ess} = Y_c$

(iii)  $Y_{ess} > Y_c$

These three possibilities depend on the amount of  $N = N_a$ . The greater the amount of  $N = N_a$ , the greater is the possibility of  $Y_{ess}$  (i) to approach to  $Y_c$ , or (ii) to exceed  $Y_c$ . Such phenomena have been shown in Figure 6.1.

The same or similar result can be obtained from the remaining equations given by (6.13) – (6.19) and the remaining equations in Table 6.1, Table 6.2 and Table 6.3.

**Figure 6.1: Determination of Equilibrium in Sustainable Simple Keynesian Model**



## 7. Reconstruction of Simple IS-LM Keynesian Models for Sustainability

The conventional simple IS-LM Keynesian model for the two-sector closed economy can be represented in terms of two equations (7.1) and (7.2).

$$S(Y) = I(r) \Rightarrow \text{Conventional Simple IS Curve } (IS_c) \quad (7.1)$$

$$M_a^* = L(Y, r, P_a^*), \Rightarrow \text{LM Curve } (LM), \quad (7.2)$$

The conventional generalized IS-LM Keynesian model has been deliberately bypassed in order to avoid complication.

### 7.1. Construction of Sustainable Simple IS Curves

The equations of conventional simple IS curves displayed in Table 4.1 can be reconstructed into the equations of the three new sets of sustainable simple IS curves as follows:

(1) Set of Ecologically Sustainable Simple IS Curves (Table 7.1).

(2) Set of Socially Sustainable Simple IS Curves (Table 7.2).

(3) Set of Ecologically and Socially Sustainable Simple IS Curves (Table 7.3).

The reconstructions of the conventional simple IS curves have been executed through the incorporation of newly relevant macroeconomic, macroecological, macrosocial and/or macrosub-social variables into the equations of conventional simple IS curves shown in Table 4.1.

**Table 7.1: Equations of Ecologically Sustainable Simple IS Curves**

Nature of the Economy	Equations of Ecologically Sustainable Simple IS Curve
Two-Sector Closed Economy	$S(y^{es}) + D^n = I^m(r) + I^n$ (7.3)
Three-Sector Closed Economy	$S(y^{es}) + D^n + T = I^m(r) + I^n + G$ (7.4)
Four-Sector Open Economy	$S(y^{es}) + D^n + T + M = I^m(r) + I^n + G + X$ (7.5)

**Table 7.2: Equations of Socially Sustainable Simple IS Curves**

Nature of the Economy	Equations of Socially Sustainable Simple IS Curve
Two-Sector Closed Economy	$S(y^{ss}) + D^s = I^m(r) + I^s$ (7.6)
Three-Sector Closed Economy	$S(y^{ss}) + D^s + T = I^m(r) + I^s + G$ (7.7)
Four-Sector Open Economy	$S(y^{ss}) + D^s + T + M = I^m(r) + I^s + G + X$ (7.8)

**Table 7.3: Equations of Ecologically and Socially Sustainable Simple IS Curves**

Nature of the Economy	Equations of Ecologically and Socially Sustainable Simple IS Curve
Two-Sector Closed Economy	$S(y^{ess}) + D^n + D^s = I^m(r) + I^n + I^s$ (7.9)
Three-Sector Closed Economy	$S(y^{ess}) + D^n + D^s + T = I^m(r) + I^n + I^s + G$ (7.10)
Four-Sector Open Economy	$S(y^{ess}) + D^n + D^s + T + M = I^m(r) + I^n + I^s + G + X$ (7.11)

The notions of the notations/variables used in Table 7.1, Table 7.2 and Table 7.3 are as follows:

$D^m$  ≡ Depreciation, depletion or degradation of manufactured capital,

$D^n$  ≡ Depreciation, depletion or degradation of natural capital

$D^s$  ≡ Depreciation, depletion or degradation of social capital

$G$  ≡ Government expenditure

$G = [G_C + G_I] = [G_C + (G_I^m + G_I^n + G_I^s)]$

$G_C$  ≡ Government consumption expenditure

$G_I$  ≡ Government investment expenditure

$G_I^m$  ≡ Government investment in manufactured capital

$G_I^n$  ≡ Government investment in natural capital

$G_I^s$  ≡ Government investment in social capital

$GDP$  ≡ Gross domestic product

$I^m$  ≡ Private investment in manufactured capital

$I^n$  ≡ Private investment in natural capital

$I^s$  ≡ Private investment in social capital

$M$  ≡ Import

$NDP$  ≡ Net domestic product

$NI$  ≡ National income

$r$  ≡ Rate of interest

$S(y^{es})$  ≡ Ecologically sustainable saving function

$S(y^{ss})$  ≡ Socially sustainable saving function

$S(y^{ess})$  ≡ Ecologically and socially sustainable saving function

$T$  ≡ Net tax = (Tax – Transfer payments)

$X$  ≡ Export

$Y$  ≡  $NI = NDP = (GDP - D^m)$

$Y_d$  ≡ Disposable  $NI = (Y - T)$

$y^{es}$  ≡ Ecologically sustainable  $NI = (Y - D^n)$ [when government sector is non-existent] =  $(Y_d - D^n)$ [ when government sector is existent]

$y^{ss}$  ≡ Socially sustainable  $NI = (Y - D^s)$ [when government sector is non-existent] =  $(Y_d - D^s)$ [ when government sector is existent]

$y^{ess} \equiv$  Ecologically and socially sustainable  $NI = [Y - (D^n + D^s)]$ [when government sector is non-existent] =  $[Y_d - (D^n + D^s)]$ [ when government sector is existent]

## 7.2. Diagrammatic Derivation of Sustainable vis-à-vis Conventional Simple IS Curve

The equations of Ecologically and Socially Sustainable Simple IS Curve for different economies have been displayed by the equations (7.9), (7.10) and (7.11) in Table 7.3. But for the sake of simplicity, only the equation of Ecologically and Socially Sustainable Simple IS Curve for the Two-Sector Closed Economy will be considered. That is why equation (7.9) will be extracted from Table 7.3. The equation (7.9) can be rewritten as an equation (7.12).

$$S(y^{ess}) + [D^n + D^s] = I^m(r) + [I^n + I^s] \quad (7.12)$$

On the basis of the following Simplifying Assumptions, equation (7.12) can be transformed into the equation (7.13).

$$S(y) + D_a = I(r) \quad (7.13)$$

$\Rightarrow$  Ecologically and Socially Sustainable Simple IS Curve ( $IS_{ess}$ )

### Simplifying Assumptions

- (1)  $S(Y)$  is the conventional saving function.
- (2)  $I(r)$  is the conventional investment function.
- (3)  $y$  is substituted for  $y^{ess}$ , that is,  $y = y^{ess} = [Y - (D^n + D^s)]$ .
- (4)  $S(y)$  is the ecologically and socially sustainable saving function.
- (5)  $D$  consists of  $D^n$  and  $D^s$ , that is,  $D = (D^n + D^s)$ .
- (6)  $P$  function is substituted for  $I^m$  function and  $N$  function is substituted for  $(I^n + I^s)$ , that is,  $P = I^m$  and  $N = (I^n + I^s)$ .





### 7.3. Simple IS Curve: Conventional Vs. Sustainable: A Mathematical Analysis

The **slope** of the conventional simple IS curve ( $IS_c$ ) denoted by:  $[S(Y) = I(r)]$

$$= (dr/dY)_c = S'(Y)/I'(r) < 0, \quad (7.14)$$

since  $S'(Y) > 0$ ,  $I'(r) < 0$ , where  $c \equiv \text{conventional}$

The **slope** of the ecologically and socially sustainable simple IS curve ( $IS_{ess}$ ) denoted by:  $S(y) + D_a = I(r)$  (under the foregoing simplifying assumptions)

$$= (dr/dY)_{ess} = S'(y)/I'(r) < 0, \quad (7.15)$$

since  $S'(y) > 0$ ,  $I'(r) < 0$ , where  $ess \equiv \text{ecologically and socially sustainable}$

By definition,  $y = (Y - D_a)$ . So by its differentiation with respect to  $Y$ , we get:

$$dy/dY = 1, \text{ or } dy = dY \quad (7.16)$$

Further, by total differentiation of  $S(y) = S(Y - D_a)$ , we get:

$$S'(y)dy = S'(Y)dY \quad (7.17)$$

From equations (7.16) and (7.17), we get:

$$S'(y) = S'(Y) \quad (7.18)$$

Thus from equations (7.14) – (7.18), what we get is:

$$(dr/dY)_{ess} = [S'(y)/I'(r)] = [S'(Y)/I'(r)] = (dr/dY)_c \quad (7.19)$$

Equation (7.19) indicates that no difference exists between the slope of  $IS_c$  and the slope of  $IS_{ess}$ .

Despite the validity of the equation (7.19), the following inequality (7.20) holds.

$$|E_{rY}|_{ess} < |E_{rY}|_c \quad (7.20)$$

where  $|E_{rY}|$

$$= |(dr/r)/(dY/Y)|$$

$$= |(dr/dY)/(r/Y)$$

≡ Absolute elasticity of  $r$  with respect to  $Y$  at a given  $r$  on the  $IS$  curve,

$|E_{rY}|_{ess}$  ≡ Absolute elasticity of  $r$  with respect to  $Y$  at a given  $r$  on the  $IS_{ess}$  curve

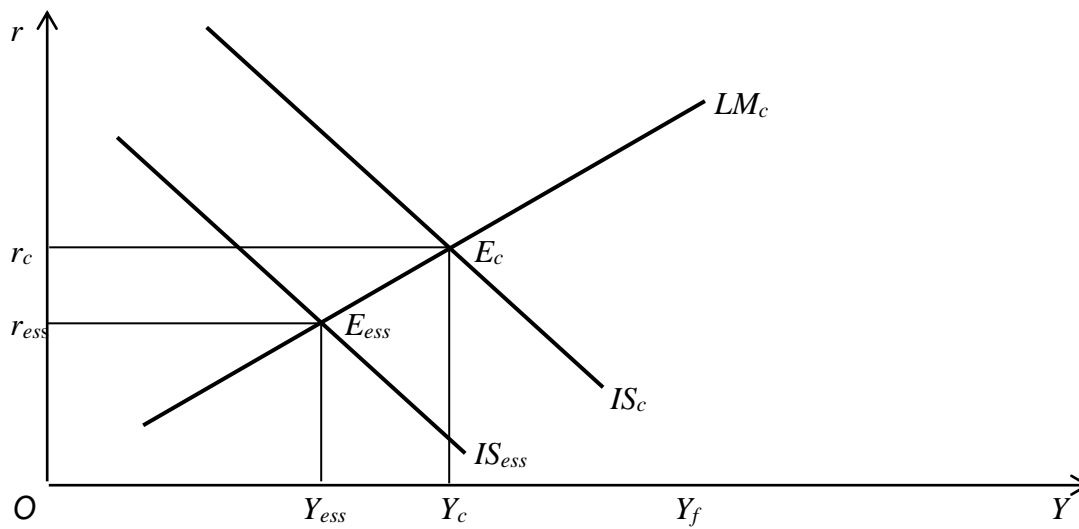
$|E_{rY}|_c$  ≡ Absolute elasticity of  $r$  with respect to  $Y$  at a given  $r$  on the  $IS_c$  curve

The inequality denoted by (7.20) implies that the  $IS_{ess}$  curve must lie below the  $IS_c$  curve.

#### 7.4. Equilibrium in IS-LM Keynesian Model: Conventional Vs. Sustainable

If both  $IS_c$  and  $IS_{ess}$  are brought together with the  $LM_c$  in Figure 7.2, it is amply clear that  $Y_{ess} < Y_c$  and  $r_{ess} < r_c$ , which occur because the  $IS_{ess}$  lies below the  $IS_c$ .

**Figure 7.2: Equilibrium: Conventional Vs. Sustainable in IS-LM Keynesian Model**



## 8. Reconstructed HK for Sustainability: Results and Roles

All theory depends on assumptions, which are not quite true. That is what makes it theory. The art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive. A crucial assumption is one, on which the conclusions do depend sensitively, and it is important that crucial assumptions be reasonably realistic. When the results of a theory seem to flow specifically from a special crucial assumption, then if the assumption is dubious, the results are suspect (Solow, 1956).

### 8.1. Results of Reconstructed HK

The results, realized/derived from the reconstructed hydraulic Keynesianism for sustainability, can be discussed in terms of the points indicated by (8.1.1) – (8.1.5).

#### 8.1.1. Conventional Vs. Sustainable Equilibrium NI

From Figure 6.1 and Figure 7.2, it is evident that *ecologically and socially sustainable equilibrium NI* ( $Y_{ess}$ ) is less than the *conventional equilibrium NI* ( $Y_c$ ), that is, symbolically,  $Y_{ess} < Y_c$ . While the *proximate determinant* of the inequality:  $Y_{ess} < Y_c$  is  $S(y)$ , the *remote one* is  $D$ . The paradoxical inequality:  $Y_{ess} < Y_c$  implies that  $Y_c$  shows upward bias. That is why  $Y_c$  is treated as *superficial equilibrium NI*, while  $Y_{ess}$  as *real or true equilibrium NI*. Further, both  $Y_{ess}$  and  $Y_c$  cannot guarantee that they are equal to the full employment equilibrium NI ( $Y_f$ ). Rather there is every possibility that  $Y_{ess} < Y_c < Y_f$ . Given that  $P = P_a = I = I_a$  and  $N = N_a = 0$ , only the difference between the  $S(Y)$  and the  $S(y)$  functions caused by  $D$  can generate the inequality:  $Y_{ess} < Y_c$  provided that the slope of the  $S(Y)$  or  $S(y)$  function is greater than that of  $P$  and  $N$  functions. If  $P = [P_a + P(Y)]$  and  $N = [N_a + N(Y)]$  are respectively substituted for  $P = P_a = I = I_a$  and  $N = N_a = 0$ , then also the inequality:  $Y_{ess} < Y_c$  holds.

#### 8.1.2. Dual Stagnation

If the macro production function is denoted by  $Y = F(L)$  such that  $F'(L) > 0$  and  $F''(L) < 0$ , the *income inequality*:  $Y_{ess} < Y_c < Y_f$  can be translated into the *employment inequality*:  $L_{ess} < L_c < L_f$ , which means that [true involuntary unemployment ( $L_f - L_{ess}$ )] = [{conventional involuntary unemployment ( $L_f - L_c$ )}] + {latent involuntary unemployment ( $L_c - L_{ess}$ )}. The gap: ( $Y_c - Y_{ess}$ ) or ( $L_c - L_{ess}$ ) measures the *ecological and social cost* inflicted to, or borne by the capitalist world, or alternatively, this gap measures the *cost of capitalism's self-defeatism*. Thus, the gap: ( $Y_f - Y_{ess}$ ) or ( $L_f - L_{ess}$ ) shows how the *secular social stagnation* measured by the gap: ( $Y_f - Y_c$ ) or ( $L_f - L_c$ ) is coupled with the *secular ecological stagnation* measured by the gap: ( $Y_c - Y_{ess}$ ) or ( $L_c - L_{ess}$ ) in the capitalist world. The coupling of the *secular social stagnation* with the *secular ecological stagnation* gives rise to *dual stagnation*. Such dual stagnation can be reduced or ruled out by the development of *dual capitalism* (social capitalism coupled with ecological capitalism) gradually over a period of time. Theoretically, this *dual stagnation* can be reduced or ruled out if a *new ecologically and socially sustainable equilibrium condition*: [ $S(y) = I_a = P_a$ ] can be substituted for the *conventional one*: [ $S(Y) = I_a = P_a$ ] in Figure 6.1, in which not only is  $Y_{ess}$  greater than  $Y_c$ , but also  $Y_{ess}$  approximates to  $Y_f$ . In Figure 6.1, this *new ecologically and socially sustainable equilibrium condition* is denoted by  $E_{ness}$ .

### 8.1.3. Policy Prescription via Multiplier Method

The relevance of Keynesian multiplier process after sixty years has been disclosed by Dalziel (1996). Gnos and Rochon (2009) have pointed out that the multiplier is a central concept in Keynesian and Post-Keynesian economics. It is largely what justifies activist full-employment fiscal policy. Nallari and Mba (2010) emphasize the importance of multipliers in a globalized world. Syed, Tahir and Sahibzada (2011) have measured the impact of Keynesian four sector open economy multiplier model in the context of Pakistan's economy and suggested to the government how the size of multiplier could be increased.

In the *conventional equilibrium equation of SKM for two-sector closed economy*:  $S(Y) = I$ , if  $S(Y) > I$ , which is the "chronic tendency throughout human history", then according to Keynes (1936), "economic instability" (which is one of the multiple sub-social instabilities) emerges. But

in the *equilibrium equation of ecologically and socially sustainable SKM for two-sector closed economy*:  $[S(y) + D = P + N]$ , if  $[S(y) + D] > [P + N]$ , then the coexistence of “social instability” and “ecological instability” leads to the emergence of “ecologically unsustainable social instability” or “ecologically social unsustainability”, which is renamed as simply “unsustainability”.

Hence, the task of the policy scientists is to adopt such measures so that  $[P + N]$  can be raised and/or  $[S(y) + D]$  can be reduced to fill the gap between  $[S(y) + D]$  and  $[P + N]$  in order to realize/restore “ecologically social sustainability” or “ecologically sustainable social stability”, which is renamed as simply “sustainability”.

For the operationalization of this stabilization policy, the adequate measures are the manipulation of different Keynesian multipliers, which can be categorized into *conventional multipliers* and *sustainable multipliers*.  $dY/dX \equiv$  conventional X-multiplier and  $dy/dX \equiv$  sustainable X-multiplier.

Further, both conventional multipliers and sustainable multipliers can also be classified into *dyadic multipliers*, *triadic multipliers*, *quadratic multipliers*, etc.

If any two parameters of the equilibrium equation, which have the opposite or conflicting effects on equilibrium  $NI$  (conventional or sustainable), are changed at equal or unequal rate and in the same direction, then their combined effect on equilibrium  $NI$  is designated as *dyadic multiplier*. Analogously, if three or four parameters of the equilibrium equation, which have conflicting effects on equilibrium  $NI$  (conventional or sustainable), are changed in the same direction, their combined effect on equilibrium  $NI$  is called *triadic multiplier* or *quadratic multiplier*.

The significance of the foregoing Keynesian multipliers is that they suggest the policy scientists how to realize/restore “ecologically social sustainability” or “ecologically sustainable social stability” through the manipulation or adjustment of different parameters of the equilibrium equations simultaneously.

### **8.1.3.1. Examples of Conventional and Sustainable Multipliers in Sustainable SKM for Two-Sector Closed Economy**

From equation (6.12), we get the different conventional and sustainable multipliers, which have been encapsulated in equations (8.1) - (8.3).

$$dY/dD_a = (S' - 1)/S' < 0 \quad (8.1)$$

$$dy/dD_a = dY/dS_a = dy/dS_a = -1/S' < 0 \quad (8.2)$$

$$dY/dP_a = dy/dP_a = dY/dN_a = dy/dN_a = 1/S' > 0 \quad (8.3)$$

where  $0 < S' < 1$ .

(2) From equation (6.13), we get the different conventional and sustainable multipliers, which have been encapsulated in equations (8.4) - (8.7).

$$dY/dD_a = (S' - 1)/(S' - P') < 0 \quad (8.4)$$

$$dy/dD_a = (P' - 1)/(S' - P') < 0 \quad (8.5)$$

$$dY/dP_a = dy/dP_a = dY/dN_a = dy/dN_a = 1/(S' - P') > 0 \quad (8.6)$$

$$dY/dS_a = dy/dS_a = -1/(S' - P') < 0 \quad (8.7)$$

where  $1 > S' > P'$ .

(3) From equation (6.19), we get the different conventional and sustainable multipliers, which have been encapsulated in equations (8.8) - (8.13).

$$dY/dD_a = (S' - 1)/Z < 0 \quad (8.8)$$

$$dy/dD_a = [(P' + N') - 1]/Z < 0 \quad (8.9)$$

$$dY/dP_a = dY/dN_a = 1/Z > 0 \quad (8.10)$$

$$dy/dP_a = dy/dN_a = (1 - D')/Z > 0 \quad (8.11)$$

$$dY/dS_a = -1/Z < 0 \quad (8.12)$$

$$dy/dS_a = -(1 - D')/Z < 0 \quad (8.13)$$

where  $Z = [S' + D'(1 - S') - (P' + N')] > 0$ , as  
 $S' < 1$ ,  $D' < 1$  and  $[S' + D'(1 - S')] > (P' + N')$ .

### 8.1.3.2. Examples of Conventional and Sustainable Multipliers in Sustainable Simple IS-LM Keynesian Model for Two-Sector Closed Economy

The equations of sustainable simple IS-LM Keynesian model for two-sector closed economy can be written as equations (8.14) and (8.15).

$$[S_a + S(y)] + D_a = [P_a + P(r)] + N_a \Rightarrow IS_s \quad (8.14)$$

$$M_a^* = L(Y, r) \Rightarrow LM \quad (8.15)$$

where  $IS_s \equiv$  Sustainable simple IS curve and  $0 < S'(y) < 1$ ,  $P'(r) < 0$ ,  $L'(Y) > 0$ ,  $L'(r) < 0$ .

From equations (8.14) and (8.15), we get the different conventional and sustainable multipliers, which have been represented by equations (8.16) - (8.19).

$$dY/dD_a = L'(r) [S'(y) - 1]/\Delta < 0 \quad (8.16)$$

$$dy/dD_a = -[L'(r) + P'(r) L'(Y)]/\Delta < 0 \quad (8.17)$$

$$dY/dN_a = dy/dN_a = dY/dP_a = dy/dP_a = L'(r)/\Delta > 0 \quad (8.18)$$

$$dY/dS_a = dy/dS_a = -L'(r)/\Delta < 0 \quad (8.19)$$

where the determinant  $\Delta = [S'(y)L'(r) + P'(r)L'(Y)] < 0$ .

### 8.1.3.3. Examples of Conventional and Sustainable Dyadic, Triadic and Quadratic Multipliers in Sustainable HK for Two-Sector Closed Economy



(1) From equation (6.12), we can get one *conventional dyadic multiplier* given by equation (8.20) and one *sustainable dyadic multiplier* given by equation (8.21).

$$(dY/dD_a + dY/dP_a) = 1 \quad (8.20)$$

$$(dy/dD_a + dy/dP_a) = 0 \quad (8.21)$$

(2) From equations (8.14) and (8.15), we can get the *conventional triadic* and *quadratic multipliers* given by equations (8.22) and (8.23) respectively and the *sustainable quadratic multiplier* given by equation (8.24).

$$(dY/dD_a + dY/dS_a + dY/dP_a) = [L'(r)\{S'(y) - 1\}/\Delta] < 0 \quad (8.22)$$

where the determinant  $\Delta = [S'(y)L'(r) + P'(r)L'(Y)] < 0$

$$\begin{aligned} &(dY/dD_a + dY/dS_a + dY/dP_a + dY/dN_a) \\ &= 1/[1 + \{P'(r)L'(Y)\}/\{S'(y)L'(r)\}] > 0 \end{aligned} \quad (8.23)$$

$$(dy/dD_a + dy/dS_a + dy/dP_a + dy/dN_a) = -1/[\{S'(y)L'(r)\}/\{P'(r)L'(Y)\} + 1] < 0 \quad (8.24)$$

#### 8.1.4. Growth: Conventional Vs. Sustainable

The growth, we are talking about, is the expansion of the overall size of the economy ... and of the quantities of energy and material goods flowing through it (Heinberg, 2011a).

$$\text{By definition, } y = (Y - D). \quad (8.25)$$

By differentiation of equation (8.25) with respect to  $t$ , we get equation (8.26).

$$dy/dt = [dY/dt - dD/dt] \quad (8.26)$$

If it is assumed that  $dD/dt = 0$  in equation (8.26), we get equation (8.27).

$$[(dY/dt)/Y] = [(dy/dt)/Y] < [(dy/dt)/y] \quad (8.27)$$

Equation (8.27) implies that the *rate of change in sustainable equilibrium NI (y)* exceeds that of *conventional equilibrium NI (Y)*. But if it is assumed that  $D = uY$  in equation (8.25), where  $u > 0$ , and then by its differentiation with respect to  $t$ , we get equation (8.28).

$$[(dY/dt)/Y] = [(dy/dt)/y] = [(dD/dt)/D] \quad (8.28)$$

Equation (8.28) implies that  $Y$ ,  $y$  and  $D$  change at the same rate. This is the *condition of steady state rate of growth*.

### **8.1.5. Reconstruction of Degrowth by the “Inequation of Sustainability”**

Economic growth, as we have known it, is over and done with. The economic crisis that began in 2007-2008..... marks a permanent fundamental break from past decades – a period during which most economists adopted the unrealistic view that perpetual economic growth is necessary and also possible to achieve. There are now fundamental barriers to ongoing economic expansion, and the world is colliding with those barriers (Heinberg, 2011a).

Degrowth simply means negative growth. It is different from zero growth, which means stationary state of John Stuart Mill (1846). The stationary state is a non-growing, non-declining, and it is synonymous with the “steady-state” of Herman Daly (1973) in ecological economics. Steady-state refers to the condition of an economy with a constant level of consumption of material and energy resources over time. According to Alejandro Nadal (2010, 2011), degrowth refers to a reduction of production and consumption in physical terms through downscaling and not through efficiency improvements. Degrowth is a smooth, voluntary and equitable downscaling of production and consumption, which ensures “social sustainability” and “ecological sustainability” locally as well as globally on the short and long term. Thus, degrowth

is not limited to a technological dimension. Growth is not a cultural phenomenon or a feature of a maniac mentality. It is the direct consequence of how capitalist economies operate. It is not possible to have capitalism without growth. In the words of Richard Smith, “We either save capitalism, or save ourselves, we cannot do both” (Nadal, 2010, 2011).

Following Joachim H. Spangenberg (2008), the concept of degrowth can be reconstructed on the basis of the following seven notations and their notions:

(1)  $Y \equiv$  Size of the economy  $\equiv GDP$

(2)  $dY \equiv$  Change or growth of  $Y$

(3)  $L \equiv$  Number of employed persons

(4)  $L/Y \equiv$  Labor-intensity of the economy

(5)  $Y/L \equiv$  Per capita productivity

(6)  $y = (Y - D) \equiv$  SNI and hence,  $Y = (y + D)$

(7)  $D = (D^u + D^s)$

The number of jobs can only increase, if the economy grows faster (or declines slower) than the production per capita. In consequence, more workers are needed to do the job. Symbolically, this condition can be written by the inequality given by (8.29).

$$d(Y/L) < dY \leftrightarrow dL > 0 \Rightarrow \text{Conventional First Inequality} \quad (8.29)$$

The *Conventional First Inequality* can alternatively be written as (8.30).

$$d(y + D)/L < d(y + D) \Rightarrow \text{Reconstructed First Inequality} \quad (8.30)$$

Now let us consider the following three new notations and their notions:

(8)  $R \equiv$  Use or consumption of resource

(9)  $R/Y \equiv$  Resource intensity

(10)  $Y/R \equiv$  Resource productivity of the economy

If  $(Y/R)$  grows faster or declines slower than the  $Y$ , the total consumption of resources decreases. Symbolically, this condition can be written by the inequality given by (8.31), which can be converted into an alternative inequality given by (8.32).

$$d(Y/R) > dY \leftrightarrow dR < 0 \Rightarrow \text{Conventional Second Inequality} \quad (8.31)$$

$$d(y + D)/R > d(y + D) \Rightarrow \text{Reconstructed Second Inequality} \quad (8.32)$$

Combining the two sets of inequalities given by [(8.29), (8.31)] and [(8.30), (8.32)], we get the resulting set of inequalities given by [(8.33), (8.34)], which includes Conventional Inequation of Sustainability (Spangenberg, Omann & Hinterberger, 2002) and Reconstructed Inequation of Sustainability. Either of the Inequations of Sustainability is a minimum condition for a potentially sustainable pattern of economic growth. Noteworthy that jobs, growth, and the environment are reconciled, if either of the Inequations of Sustainability given by (8.33) and (8.34) is valid:

$$d(Y/L) < dY < d(Y/R) \leftrightarrow dR < 0 < dL \Rightarrow \text{Conventional Inequation of Sustainability} \quad (8.33)$$

$$d(y + D)/L < d(y + D) < d(y + D)/R \Rightarrow \text{Reconstructed Inequation of Sustainability} \quad (8.34)$$

If either of the foregoing two *Inequations of Sustainability* is fulfilled, growth may be sustainable. If it is not, growth is definitely unsustainable. Either of the *Inequations of Sustainability* clearly indicates that “social sustainability” defines a necessary minimum of “economic growth”, while “ecological sustainability” defines an upper “threshold”. Thus,

sustainable development has to be based on a balanced approach between social demands and ecological limits. According to Peter Custers (2010), “The survival of humans and of other species living on planet earth, in my view, can only be guaranteed via a timely transition towards a ‘stationary state’, a world economy without growth”. That is why John Bellamy Foster wrote an article, entitled, *Degrow or Die?* which was published in December-January 2011 issue of the UK Journal *Red Pepper*.

Against the earlier degrowth discussion, it can be emphasized that the “dictum/doctrine of degrowth” should be imposed only on the North, while the South should be allowed to “gain from growth” so that “global growth-equity” can be maintained.

Victor (2010) has classified degrowth into: *Green Degrowth* and *Black Degrowth* on the basis of the (i) trend in GDP and (ii) trend in GHG emissions as follows. Green degrowth indicates the decline in both GDP and GHG emissions, while black degrowth implies decline in GDP, but increase in GHG emissions-intensity is so fast that total emissions rise.

In *The Meaning of Sustainability*, Albert Bartlett (2012) has differentiated between the *Dumb Growth* and the *Smart Growth* as well as their eventual consequences in terms of the following lines:

Dumb growth destroys the environment.  
Smart growth destroys the environment.  
The difference is that smart growth  
destroys the environment with good taste.  
So it's like buying a ticket on the TITANIC.  
If you're smart, you go first class.  
If you're dumb, you go steerage.  
Either way the result is the same.

## 8.2. Roles of Reconstructed HK

The newly introduced variables and/or functions in the reconstructed HK for sustainability can be incorporated into different conventional macroeconomic models/theories for realizing the different roles of the reconstructed HK for sustainability. The following examples may be relevant.

### 8.2.1. Construction of Harrod-Domar Model of Sustainable Growth

The conventional Harrod (1939, 1948)–Domar (1957) growth model can be transformed into the sustainable Harrod - Domar growth model in the following way. The conventional Harrod – Domar growth model is based on the three equations given by (8.35) - (8.37).

$$S = S(Y) = sY, \quad (8.35)$$

where  $s \equiv MPS = APS$

$$I = [v dY/dt], \quad (8.36)$$

where  $v \equiv$  Capital-output ratio  $= (K/Y)$

$$S(Y) = I, \quad (8.37)$$

$\Rightarrow$  Conventional equilibrium equation of the commodity market

Combining equations (8.35) - (8.37), we get equation (8.38):

$$[(dY/dt)/Y]_c = g_c = [s/v] \quad (8.38)$$

$=$  Rate of change in conventional equilibrium NI, where  $c \equiv$  conventional

The conventional Harrod - Domar growth model can be transformed into a sustainable Harrod - Domar growth model on the basis of the five equations indicated by (8.39) - (8.43).

$$S = S(y) = sy = s(Y - D), \quad (8.39)$$

$\Rightarrow$  Sustainable saving function, where  $s \equiv MPS = APS$

$$D = uY, \quad (8.40)$$

where  $u = (D/Y)$

$$P = [pdY/dt], \quad (8.41)$$

where  $p = (P/Y)$

$$N = [ndY/dt], \quad (8.42)$$

where  $u > 0, p > 0, n = (N/Y) > 0$

$$[S(y) + D = P + N] \quad (8.43)$$

$\Rightarrow$  Sustainable equilibrium equation of SKM for two-sector closed economy

Combining equations (8.39) - (8.43), we get equation (8.44).

$$[(dY/dt)/Y]_{ess} = g_{ess} = [s - sD + u]/[p + n] \quad (8.44)$$

= Rate of change in sustainable equilibrium NI.

If  $D = 0 = n$  and  $p = v$  in equation (8.44), we get equation (8.45).

$$g_{ess} = [(s/v) + (u/v)], \quad (8.45)$$

which means  $g_{ess} > g_c$

If  $u = 0$  in equation (8.45), we get equation (8.46).

$$g_{ess} = g_c = (s/v). \quad (8.46)$$

### 8.2.2. Construction of Solow's Model of Sustainable Growth

In conventional Solow's (1956) model of growth, the *condition of steady state rate of change in conventional equilibrium NI* ( $Y_c$ ) is given by equation (8.47):

$$[sf(k) - qk] = 0, \quad (8.47)$$

where  $s = [S(Y)/Y]$ ,  $f(k) = Y/L = AP_L$ ,  $q = [(dL/dt)/L]$  and  $k = K/L$

But if conventional saving function:  $S = S(Y)$  is substituted with sustainable saving function:  $S = S(y) = sy = s(Y - D)$ , the *condition of steady state rate of change in ecologically and socially sustainable equilibrium NI* ( $Y_{ess}$ ) is given by equation (8.48).

$$[sf(k) - qk] - sD/L = 0 \text{ or, } [sf(k)w - qk] = 0, \quad (8.48)$$

where  $w = (1 - u)$  and  $u = D/Y > 0$ .

Comparing equations (8.47) and (8.48), we get the inequality indicated by (8.49).

$$k_c > k_{ess} \quad (8.49)$$

The inequality indicated by (8.49) means that the *conventional steady state equilibrium k* ( $k_c$ ) is greater than the *ecologically and socially sustainable steady state equilibrium k* ( $k_{ess}$ ), which involves upward bias. But if  $D = 0$  in equation (8.48), we get equation (8.50).



$$k_c = k_{ess} \quad (8.50)$$

Further, in Solow's growth model, the *ecologically and socially sustainable golden rule*  $s$  is less than the *conventional golden rule*  $s$ , because the *condition of the conventional golden rule*  $s$  is given by equation (8.47), while the *condition of the ecologically and socially sustainable golden rule*  $s$  is given by equation (8.48). Noteworthy that "golden rule  $s$ " is defined as that "steady state equilibrium  $s$ " (say,  $s^*$ ), at which per capita consumption ( $C/L$ ) is maximized, which is possible if  $s^*f(k)$  curve, which is concave to the horizontal axis, intersects the  $qk$  line, which is a positively sloping straight line through the origin.

### 8.2.3. Construction of Swan's Model of Sustainable Growth

The Swan's (1956) conventional model of growth is based on the four equations given by (8.51) - (8.54).

$$Y = K^a L^b \quad (8.51)$$

$\Rightarrow$  Macro production function, where  $(a+b) = 1 \Rightarrow CRS$

$$S = sY \quad (8.52)$$

$\Rightarrow$  Macro conventional saving function, where  $s \equiv APS = MPS$

$$L = L_0 e^{nt} \quad (8.53)$$

$\Rightarrow$  Macro labour supply function

$$dK/dt = I = S \quad (8.54)$$

$\Rightarrow$  Equilibrium equation of the commodity market for two sector closed economy.

From equations (8.52) and (8.54), we get equation (8.55).

$$[(dK/dt)/K] = s(Y/K), \quad (8.55)$$

which is called *rate of change in capital (K)*. It is a positively sloping straight line through the origin in a diagram where  $(Y/K)$  is measured along the horizontal axis. By differentiation of equation (8.51) with respect to  $t$ , we get equation (8.56).

$$[(dY/dt)/Y] = [a (dK/dt)/K] + [b (dL/dt)/L], \quad (8.56)$$

which is called the *rate of change in NI (Y)*.

By differentiation of equation (8.53) with respect to  $t$ , we get equation (8.57).

$$[(dL/dt)/L] = n, \quad (8.57)$$

which is parallel to the horizontal axis, along which  $(Y/K)$  is measured. It is called the *rate of change in labour (L)*. Combining equations (8.55) - (8.57), we get equation (8.58).

$$[(dY/dt)/Y] = [as(Y/K) + bn], \quad (8.58)$$

which is a positively sloping straight line with a positive vertical intercept amounting to  $bn$ . This line is flatter than the  $[(dK/dt)/K] = s(Y/K)$  line indicated by equation (8.55).

In conventional Swan's model of growth, the *conventional steady state equilibrium* is achieved at that  $(Y/K)$ , say  $(Y/K^c)$ , where the three functions indicated by equations (8.55), (8.57) and (8.58) intersect simultaneously. At the *conventional steady state equilibrium (Y/K)*, we get equation (8.59).

$$[(dY/dt)/Y] = [(dK/dt)/K] = [(dL/dt)/L] = n, \quad (8.59)$$

since  $(a + b) = 1$ . This conventional steady state equilibrium is also stable.

Swan's conventional model of growth can be transformed into the sustainable model of growth by the substitution of "sustainable saving function" for "conventional saving function" *ceteris paribus*. While the *conventional saving function* is given by equation (8.52), the *sustainable saving function* is indicated by equation (8.60).

$$S = sy = s(Y - D) \quad (8.60)$$

From equations (8.54) and (8.60), we get equation (8.61).

$$[(DK/dt)/K] = [sY/K - sD/K], \quad (8.61)$$

which means that sustainable  $[(DK/dt)/K]$  function lies below the conventional  $[(DK/dt)/K]$  function indicated by equation (8.55), since  $0 < s < 1$  and  $(D/K) > 0$ . Combining equations (8.56), (8.57) and (8.61), we get equation (8.62).

$$[(dY/dt)/Y] = [as(Y/K) + bn - as(D/K)], \quad (8.62)$$

which means that the sustainable  $[(dY/dt)/Y]$  function lies below the conventional  $[(dY/dt)/Y]$  function indicated by equation (8.58), since  $0 < s < 1$ ,  $0 < a < 1$  and  $(D/K) > 0$ . At *steady state equilibrium*, we get equation (8.63).

$$[(DK/dt)/K] = [s(Y/K) - s(D/K)] = [(dL/dt)/L] = n \quad (8.63)$$

Hence, from equations (8.62) and (8.63), we get equation (8.64).

$$\begin{aligned} [(dY/dt)/Y] &= [as(Y/K) + bn - as(D/K)] \\ &= a[s(Y/K) - s(D/K)] + bn \\ &= (an + bn) = n(a + b) = n, \end{aligned} \quad (8.64)$$

since  $(a + b) = 1$ .

The *sustainable steady state equilibrium* is achieved at that  $(Y/K)$ , say  $(Y/K^s)$ , where the three functions indicated by equations (8.57), (8.61) and (8.62) intersect simultaneously. Hence, the *sustainable steady state equilibrium*  $(Y/K)$  must be greater than the *conventional steady state equilibrium*  $(Y/K)$ , which is shown by the inequality (8.65).

$$(Y/K^s) > (Y/K^c) \quad (8.65)$$

Since  $y = (Y - D)$ , so  $Y = (y + D)$ . In consequence,  $(Y/K) = [(y/K) + (D/K)]$ . Thus, we get the inequality indicated by (8.66) as  $(D/K) > 0$

$$(y/K) < (Y/K) \quad (8.66)$$

The inequality given by (8.66) implies that *sustainable NI produced by one unit of capital is less than the conventional NI produced by one unit of capital*.

#### **8.2.4. Construction of Global Hydraulic Keynesianism by Analogy of Kohler (1999)**

The unreconstructed HK is confined to “nation states”. That is why it may be renamed as “unreconstructed national HK”. But “contextually reconstructed HK” can be applied to the “global level” also to give rise to “Contextually Reconstructed Global HK” by analogy of Kohler’s (1999) *Global Keynesianism*.

#### **8.2.5. Reconstruction of Simple Keynesian Model for Sustainability by Analogy of Harris (2008/2009, 2013)**

By analogy of Harris (2008/2009, 2013), *Simple Keynesian Model* of HK can be remodeled to realize “some dimensions of sustainability” through the decomposition of conventional

macroeconomic variables:  $C$ ,  $I$ ,  $G$ , etc., and thereby transforming the “conventional equilibrium equations” of Simple Keynesian Model. Harris’s (2013) reconstructed Simple Keynesian Model explores the possibilities for “Green Keynesianism” in theory and practice, and suggests that “Green Keynesianism” offers a solution to both “economic stagnation” and “global environmental threats”.

### **8.2.6. Securing Sub-Social Sustainability**

HK can also be used to realize various variants of “sub-social sustainability”. To do this, the only precondition is the “rational reconstitutions” of “conventional equilibrium equations” of HK by the incorporation of relevant macrosocial variables into such equilibrium equations and by maintaining/keeping the consistency of the national income accounting method suggested by IEEA (1993) and SEEA (1993) of UN.

Living within our planet’s natural boundaries is essential, but taking into consideration social boundaries, such as, access to fresh water, education, health care, and other basic needs is as important. Between the social foundation of human rights and the environmental ceiling of planetary boundaries lies a space that is both environmentally safe and socially just, and we must work to move in to that space.

----World Watch Institute’s *State of the World 2013*  
(<http://www.worldwatch.org>)

## 9. Concluding Comments

Conclusion is claimed to be true, whenever all of the assumptions are true. In other words, the conclusion is true, whenever one accepts the assumptions as true. In one sense, it can be claimed that the conjunction of the assumptions forms a justification of truth of the conclusive statement. But the justification is conditional on the actual truth of the assumptions. Thus such a justification is always open to question. If one accepts all the assumptions as true, then one cannot at the same time accept statements, which contradict any valid conclusion based on those assumptions (Boland, 1994).

“When states of knowledge are of the essence, it is best to acknowledge the reality by clearly and consistently theorizing about the consequences of partial ignorance” (Fitzgibbons, 2000).

A famous Bengali writer, Lila Majumdar, said, “An animal can be lifted from the forest, but the forest cannot be lifted from the mind of that animal”. By analogy, it can be stated that an economics practitioner can be lifted from HK, but HK cannot be lifted from the mind of that economics practitioner. Even if HK is radically rejected, “X Keynesianism” will be substituted for HK.

There is no end of proliferation of criticism against HK about its adequacy for tackling the economic and non-economic problems. This means that HK is inadequate to tackle the problems of economic and extra-economic instabilities. The answer to such an allegation is that *HK is not inadequate, rather it is used or applied inadequately.*

HK can be likened to language, which, in turn, can be likened to dress. Variation of dress is needed to suit the occasion. For example, one does not appear at a friend’s silver wedding anniversary in gardening clothes, nor does one punting on the river in a dinner-jacket. As variation of dress becomes necessary to suit the occasion, similarly variation in the “composition of equilibrium equations” of the constituent models of HK becomes inevitable to suit the context. That is why the significance of the nomenclature of the title of this thesis is justified.

Mesarovic (1982) emphasizes that the objective of the models of sustainability should be to “separate the realm of possible paths into the future from the realm of impossible ones”. According to Costanza, et al. (1993), “models are analogous to maps...they have many possible purposes and uses, and no one map or model is right for the entire range of uses”. Against the

remark of Costanza, et al. (1993), it is worthy to recall what Strawson (1959) said: “*We do not use a different scheme, a different framework, on each occasion. It is the essence of the matter that we use the same framework on different occasions*”. Thus, following Strawson (1959), it can be argued that through the incorporation of the relevant macro variables (e.g. macroeconomic, macroecological, macrosocial or macrosub-social variables) into the “equilibrium equations” of HK, it can easily be reconstructed to fit the contemporary context.

However, it can be admitted that the contextually reconstructed HK is not free from limitations. The most important limitation of it is that up till now, no adequate, appropriate or apposite method or measure has been discovered to execute the valuation of the new macro variables (e.g. natural capital, social capital, various sub-social capitals, human capital, etc.), which have been incorporated into the “equilibrium equations” of hydraulic Keynesian models.

Thinking about a sustainable world is pointless, unless an adequate, appropriate or apposite “way” can be discovered to get there. The nature of sustainable world can be imagined easily, but whether and how human population can continue to survive indefinitely on this “tiny little islet of life amid the boundless ocean of lifelessness” (Rebrov, 1989) without threatening the survival of all other biological populations, may not be so easy. The reasons lie in the remarks of the following three authors:

- (1) Baba Dioum stated that “In the end, we conserve only what we love. We will love only what we understand. We will understand only what we are taught” (Cunningham & Cunningham, 2009).
- (2) Mollie Beatty pointed out that “What a country chooses to save is what a country chooses to say about itself” (Cunningham & Cunningham, 2009).
- (3) Lynn Lands asserted that “We are living in a false economy, where the price of goods and services does not include the cost of waste and pollution” (Cunningham & Cunningham, 2009).

That is why Wangari Meathai, the Nobel laureate in Peace in 2004, argued: “Today we are faced with a challenge that calls for a shift in our thinking, so that humanity stops threatening its life-support system” (Cunningham & Cunningham, 2009). But historical evidence reveals that neither ecological system nor social system can continue forever.

Can life possibly be sustained on forever? Given our limited knowledge, we cannot conceive of being able to sustain life on earth without a continuing inflow of “solar energy”. Thus, solar-

based systems of production represent the current limit to our thinking with respect to means of ensuring sustainability. Perhaps the “post-solar phase” will be spiritual, rather than physical in nature. If this is so, this may explain why spirituality is coming into discussions of “physical sustainability” to prepare humanity for “post-solar sustainability” (Ikerd, 1997).

Sustainability is neither a macroeconomic issue, nor a nature-conservation issue. Rather sustainability synchronizes and harmonizes social process and ecological process. An adequate model of sustainability cannot be built on the existing understanding of society and nature. Humans have also created what can be described as “second nature”, that is, the human-made material world, which by size and importance, has become comparable to the global natural world. It not only acts as a buffer between humans and nature, but has also become the main objective of human development. Following its own developmental logic and laws, this “second nature” ironically is now threatening the planet’s nature.

In an article *Economic Strategies for Sustainability*, what Wayne Hayes (2005) speaks of sustainability is as follows:

Sustainability must not be confounded with parochialism, isolationism, or xenophobia. Sustainability demands a cosmopolitan outlook, negotiating and integrating levels of social organization ranging from the local through the regional and the national into the global order of things. Sustainability, like ecology, thrives on diversity. Indeed, sustainability presents a daunting conceptual challenge that must be worked out in practice, not given to pre-ordained or ideologically driven preconceptions. The practice of sustainability presumes an illuminating public discourse built on a vibrant civic culture, from your neighborhood to the global village we all share. The level of human development evoked by sustainability poses an imposing challenge of societal evolution that can only be conceived in intergenerational context although we don’t know how much time we have available until catastrophe ([profwork.org/eee/ess](http://profwork.org/eee/ess)).

The heuristic, theoretical and practical value of this thesis can be described in terms of the following two remarks:

(1) “You don’t see those, who stand in the dark”.

---Bertolt Brecht and Kurt Julian Weil (1928) in *The Three Penny Opera*

(2) “But those, in the dark, could use some effective help from the presently living intelligentsia”.

---Gernot Kohler (1999) in *Global Keynesianism and Beyond*



Borrowing the relevant words from Keynes's (1933) remark, as stated below, it is worthy to admit that the completeness of this thesis has been executed "not by tearing up roots, but by slowly training a plant like HK to grow in a different direction".

It should not be a matter of tearing up roots, but of slowly training a plant to grow in a different direction (Keynes, 1933).

Foster (2011) points out that "All of us here today along with countless others around the world are currently engaged in the collective struggle to save the planet as a place of habitation for humanity and innumerable other species".

But, on 16 April 2013, *World Watch Institute* launched the latest edition of its Annual Flagship Report *State of the World 2013*, in which fifty coauthors (Adamson, et al., 2013) devised and devoted their articles to answer the critical question:

Is Sustainability Still Possible?

## 10. References

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# NATURE AND ROLE OF SUBSTITUTION IN MICROECONOMICS



ARUP KANTI KONAR

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Publication

# Nature and Role of Substitution in Microeconomics

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Arup Kanti Konar

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# CHAPTER 1

## 1.1. Origin and Meaning of Substitution

The concept of "substitution" was introduced by the Greek scientist Archimedes (287-212 BC) of Syracuse in his *On the Sphere and Cylinder*. It is a work published by Archimedes in two volumes in 225 BC. Archimedes wrote: "Further of unequal lines, unequal surfaces, and unequal solids, the greater exceeds the less by such a magnitude as, when added to itself, can be made to exceed any assigned magnitude among those, which are comparable with [it and with] one another" (Heath, 1897, p.4). The signification of substitution can be understood from the "law of substitution of similars" and the "axiom of substitution". The "law of substitution of similars" was applied in his economic theory as the "law of indifference" by Wicksteed (Robertson, 1951, p. 243). But the "axiom of substitution" can be defined from the economist's intuitive point of view - "Given a particular quantity of some commodity of which a person is desirous, it is always possible to find some quantity of other commodities sufficiently great to compensate him for loss of part of his consumption of the given commodity" (Chipman, 1960, p. 194). Stigler (1966, pp.25-26) emphasizes that "there is no simple 'technical' measure of substitution: not only is it difficult to compare heterogeneous things (is radio a better substitute for television than for a theatre or a newspaper?), but substitutability varies with circumstances (a tractor is a substitute for a horse to a farmer, less so to a riding academy)".

The process of substitution can be likened to the (i) operation of a scissor, (ii) process of exchange and (iii) process of chemical reaction. In the first case, both the blades of a scissor function simultaneously in any operation. In the second case, both the sale and purchase of any commodity are subject to synchronization. And in the third case, both



the oxidation and reduction occur simultaneously during the process of a chemical reaction. Thus substitution is process/phenomenon, in which both the inclusion/addition of something and the exclusion/subtraction of another thing occur simultaneously.

Substitution between any two variables  $L$  and  $K$  is of two types: (i) substitution of  $L$  for  $K$ , which can be symbolized by  $S_{LK}$  and (ii) substitution of  $K$  for  $L$ , which can be denoted by  $S_{KL}$ . In the case of  $S_{LK}$ ,  $L$  is injected, included or added, while  $K$  is ejected, excluded or ousted simultaneously. But in the case of  $S_{KL}$ ,  $K$  is injected, included or added, while  $L$  is ejected, excluded or ousted simultaneously.

The concept of "substitution" is associated with the concept of "iso-Z-function" (IZF) denoted by  $Z=Z(L, K)$ , where  $Z$  is a parameter and  $L$  and  $K$  are two variables. Along a given IZF,  $S_{LK}$  or  $S_{KL}$  is possible, if and only if the algebraic slope of the IZF is negative (i.e.  $dK/dL < 0$ ) irrespective of the curvature of the IZF (i.e.  $d^2K/dL^2 \lessgtr 0$ ), provided that  $d^2K/dL^2 \neq \infty$ . Along a given IZF, which is negatively sloping,  $S_{LK}$  implies that an increase in  $L$  must be accompanied by a decrease in  $K$  in order to maintain the "isoness" of the IZF,  $Z=Z(L, K)$ . Further,  $S_{LK}$  refers to the synchronization of an increase in  $K$  and a decrease in  $L$  for keeping intact the parametric value of  $Z$  along a given IZF.

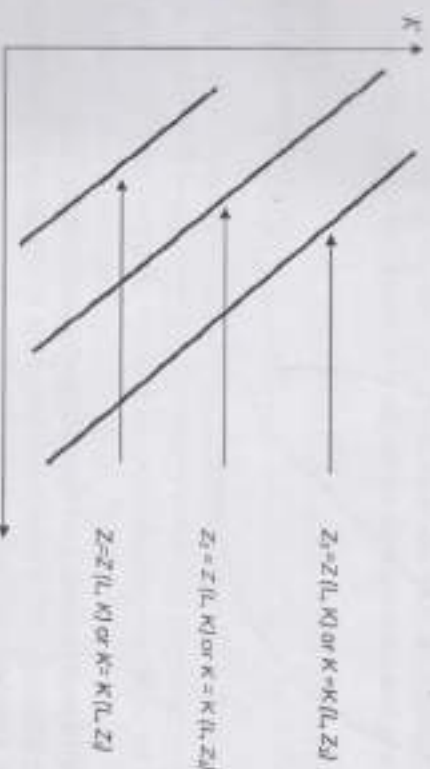
## 1.2. Origin and Meaning of Iso-Z-Function

The concept of "iso-z-function" (IZF) was introduced into economics in the name of "isoperimetric problem" by the Italian mathematician Paolo Frisi (1728-1784 AD), the editor of the book *Meditazioni sulla economia politica* (1772), written by Pietro Verri (1728-1797 AD) (Robertson, 1949).

Though IZF is a multivariate function, yet the present analysis will be confined only to bi-variate IZF, which can be represented by  $Z=Z(L, K)$ , where  $Z$  is a parameter, but  $L$  and  $K$  are two variables. The nomenclature of IZF is determined by the name of the parameter  $Z$ . For example, if  $Z$  successively stands for utility, output, cost, revenue and profit, we get isoutility function, isocost function, isorevenue function and isoprofit function respectively.

The IZF,  $Z=Z(L, K)$  is defined as the locus of various combinations of  $L$  and  $K$ , which shows the "isoness" of the parametric value of  $Z$ . The IZF for  $Z=Z_0$ , denoted by  $Z_0=Z(L, K)$  can be rewritten as  $K=K(L, Z_0)$ . For different parametric values of  $Z$ , say,  $Z_1, Z_2, Z_3, \dots, Z_n$ , the "iso-z-map" (IZM) can be shown in terms of Figure 1.

Figure 1: Linear Iso-Z-Map

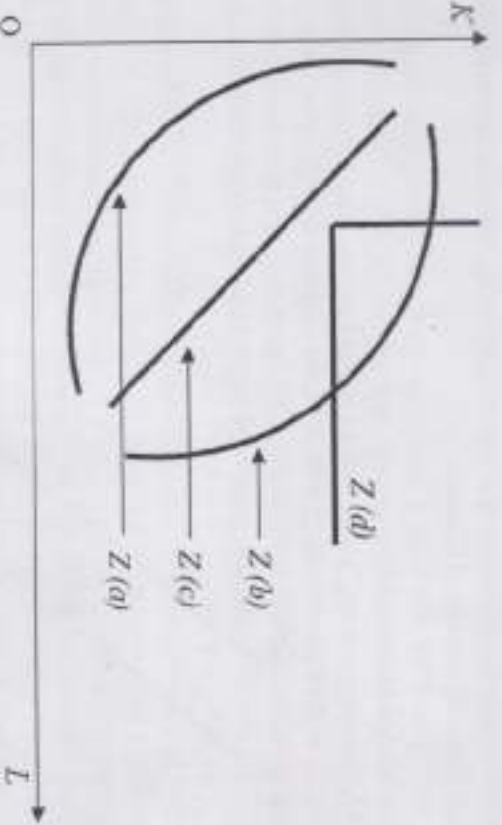


Further, the IZF assumes different shapes depending upon the sign of  $dK/dL$  and  $d^2K/dL^2$ , as follows:

- (a)  $dK/dL < 0$  and  $d^2K/dL^2 > 0 \Rightarrow$  convexity of IZF.
- (b)  $dK/dL < 0$  and  $d^2K/dL^2 < 0 \Rightarrow$  concavity of IZF.
- (c)  $dK/dL < 0$  and  $d^2K/dL^2 = 0 \Rightarrow$  negatively sloping linearity of IZF.
- (d)  $dK/dL < 0$  and  $d^2K/dL^2 = \infty \Rightarrow$  L-shaped IZF.

These four IZF<sub>s</sub> are shown in Figure 2.

Figure 2: Iso-Z Functions of Different Curvatures



### 1.3. Origin and Meaning of Elasticity of Substitution (ES)

The word "elasticity" is alien to economics. It has been imported from physics. Conflicting views about the introduction of "elasticity" into economics persist.

The generally acceptable impression is that elasticity was introduced into economics in terms of Marshall's elasticity of demand. According to Stigler (1955), "Marshall was the first man to write about elasticity of demand =  $-(dq/dp, p/q)$ ". Allen (1938/1979, p. 251) points out that "No established notation for elasticity is in current use".

If Marshall's "price elasticity of demand" is denoted by  $E_{dp}$  (sign ignored) for the demand function  $P=P(D)$  such that  $P'(D) < 0$ , then we get:

$$E_{dp} = (dD/D)/(dP/P)$$

$$= (dD/dP)/(D/P)$$

$$= (\text{marginal demand})/(\text{average demand})$$

$$= (P/D)/(dP/dD)$$

$$= (\text{average demand price})/(\text{marginal demand price})$$

In the early 1930s, Hicks (1932) and Robinson (1933), all about simultaneously and independently of one another and of their forerunners, struck out what came to be known as ES. Though they worked independently, they arrived at an identical result in the sense that by a curious coincidence Hicks's ES (HES) was exactly the same as Robinson's ES (RES).

If the isoquant  $(Q)$  for  $Z_0$  level of output is denoted by  $Z_0 = Z(L, K)$  or  $K=K(L, Z_0)$ , where  $L$  and  $K$  are two inputs and  $Z$  a parameter stands for the level of output produced by the firm, then HES and RES can be denoted by the common notation, which can be defined as follows:

$\sigma =$  (rate of change in input-ratio) / (rate of change in marginal physical product-ratio of inputs).

ES ( $\sigma$ ) is of two types: (i)  $\sigma_{LK}$  and (ii)  $\sigma_{LM}$ , where  $\sigma_{LK} =$  ES of  $L$  for  $K$  and  $\sigma_{LM} =$  ES of  $K$  for  $L$ . If  $k = (K/L)$ ,  $l = (L/K)$ ,  $m = (MP_L/MP_K)$ ,  $n = (MP_K/MP_L) = (Z_L/Z_K)$ ,  $n = (MP_L/MP_K) = (Z_L/Z_K)$ ,  $m = (MP_K/MP_L) = (Z_K/Z_L)$ ,  $n =$  marginal physical product of  $L$  and  $MP_K =$  marginal physical product of  $K$ , then

- (i)  $\sigma_{LK}$  (along a given  $(Q)$ )
  - $= (dk/k)/(dm/m)$
  - $= (dk/dm)/(k/m)$
  - $= (\text{marginal } k)/(\text{average } k)$
  - $= (m/k)/(dm/dk)$
  - $= (\text{average } m)/(\text{marginal } m)$
- (ii)  $\sigma_{LM}$  (along a given  $(Q)$ )
  - $= (dl/l)/(dn/n)$
  - $= (\text{marginal } l)/(\text{average } l)$
  - $= (n/l)/(dn/dl)$
  - $= (\text{average } n)/(\text{marginal } n)$

### 1.4. Origin and Meaning of Substitution Curve (SC)

The concept of SC was introduced by Lerner (1933). By analogy of Marshall's demand curve, denoted by  $P = P(D)$  such that  $P'(D) < 0$  or its inverse  $D = D(P)$  such that  $D'(P) < 0$ , Lerner devised the SC from a given  $(Q)$ . As Marshall's demand curve (MDC) shows the functional relationship between the price  $(P)$  and demand  $(D)$ , similarly the SC

shows that between  $m$  ( $= MP/M_P$ ) or  $n$  ( $= MP/M_P$ ) and  $k$  ( $= K/L$ ) or  $l$  ( $= L/K$ ) given the  $IQ$ . Further, as MDC can symbolically be represented by  $P = P(D)$  or its inverse  $D = D(P)$ , similarly SC can be given by  $m = m(l)$  or its inverse  $l = l(m)$  given the  $IQ$ . The SC is the mapping of  $IQ$  from the input-space ( $L$ - $K$ -space) into the relative input–relative marginal physical product-space ( $m$ -space). According to Lerner (1933),  $m$  is the substitutability of  $L$  for  $K$ , while  $n$  is the substitutability of  $K$  for  $L$  along the same  $IQ$ . Following Lerner (1933), the relationship among the  $IQ$ , SC, and ES can be shown in terms of Figures 3 and Figure 4.

Figure 3: Isoquants of Varied Degrees of Curvature

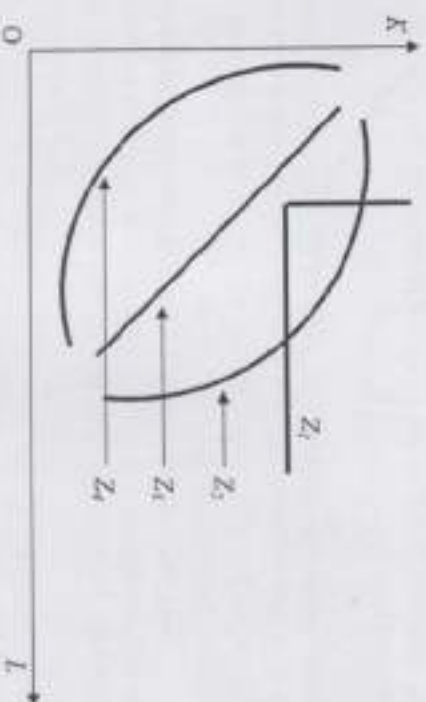
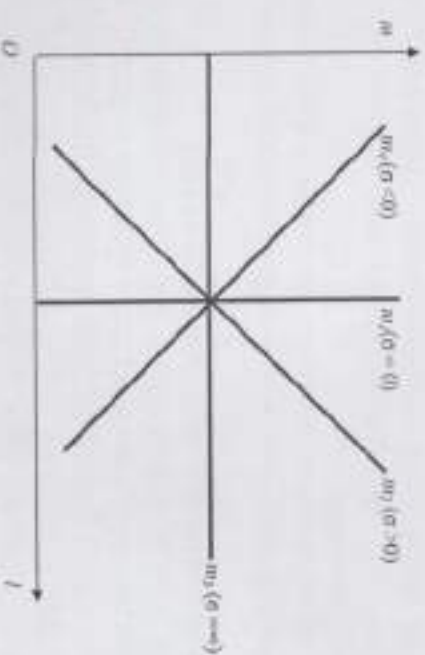


Figure 4: Lerner's SCs of Varied ESS (a)



The SC denoted by  $m$ , in Figure 4 is the mapping of  $IQ$  denoted by  $Z$ , in the Figure 3 from  $L$ - $K$ -space into  $m$ -space. Lerner (1933) points out that ES is inversely related to the curvature of the  $IQ$  ( $= d^2K/dL^2$ ), which is reflected in the shape and curvature of SC [i.e.  $m'(l)$  and  $m''(l)$ ]. He remarks that ES could be read off in the same way that the elasticity of demand is read off a demand curve and the elasticity of such a curve (SC) will give us the ES. The analogy between SC and MDC can be encapsulated in Table 1. Needles to say, various types of SC or "similar curves" were developed later on by the economists like Kahn (1933), Sweezy (1933), Kennedy (1962), Matyas (1980), et al. But no vital difference is found among Lerner's (1933) SC, Kennedy's (1962) SC and Matyas's (1980) "capital intensity function".

Table 1: Similarity between Marshall's Demand Curve and Lerner's SC

Marshallian Demand Curve (MDC)	Lerner's SC
$P =$ (demand) price	$m = MP/M_P =$ substitutability of $L$ for $K$ .
$D =$ quantity demanded	$l = L/K =$ substitution or substitutability.
$P = P(D) \Rightarrow$ Marshall's demand function	$m = m(l) \Rightarrow$ Lerner's substitution function.
$dP/dD =$ slope of MDC	$dm/dl =$ slope of SC.
$E_m$ (sign ignored) $= (dD/dP) / (D/P)$ $=$ marginal demand / average demand $= (P/D) / (dP/dD) =$ average (demand) price / marginal (demand) price	$E_m$ (sign ignored) $= (dl/dm) / (l/m) =$ marginal substitution / average substitution $= (m/l) / (dm/dl) =$ (average substitutability of $L$ for $K$ ) / (marginal substitutability of $L$ for $K$ ) $=$ HES = RES = 0.
$E_l =$ elasticity of $l$ with respect to $l$ for the function $l = l(j)$	

### 1.5. Origin and Meaning of Marginal Rate of Substitution (MRS)

Conventionally, it is received that the term MRS was used chronologically by Hicks and Allen (1934), Allen (1938/1979) and Hicks (1939). Such established notion is incorrect, because the concept of MRS was conceived or concealed in both HES (1932) and RES (1933).

where  $MRS$  was treated as the "marginal physical product-ratio of inputs", that is,  $MP_x/MP_y$  ( $=m$ ) or  $MP_x/MP_z$  ( $=n$ ).

In modern terminology,  $MRS$  is the absolute slope of the IZF such as  $IQ$ , indifference curve or the similar curves. Like  $ES$ ,  $MRS$  is also of two types: (i)  $MRS_{xy}$  and (ii)  $MRS_{xz}$ . While  $MRS_{xy}$  is read as  $MRS$  of  $L$  for  $K$ ,  $MRS_{xz}$  is read as  $MRS$  of  $K$  for  $L$ .

So  $MRS_{xz} = |dk/dl| = MP_x/MP_z = Z_x/Z_z = m$  and  $MRS_{xy} = |dl/dk| = MP_y/MP_x = Z_y/Z_x = n$ , where the  $IQ$  is given by  $Z_x = Z(L, K)$  or  $K = K(L, Z_x)$  and in the diagram of  $IQ$  map,  $L$  and  $K$  are measured along the horizontal and vertical axes respectively.

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# CHAPTER 2

## 2.1 Surrogate "Substitution Curve" of Lerner (1933)

Lerner (1933) was the originator of the substitution curve. Sweezy (1933) arrives independently at a similar curve obtained by a different process for the special case when the factors are labour and time. Later on, Kennedy (1962) also used the substitution curve as a tool of his analysis. But Matyas's (1985) capital-intensity function is the reshaped version of Lerner's (1933) substitution curve. Analogously, it can be admitted that the present concept of surrogate substitution curve is also the reshaped version of Lerner's (1933) substitution curve or Matyas's (1985) capital-intensity function, both of which show the correlation between the isoquant and the elasticity of substitution. The concept of isoquant was invented by Wicksteed (1910), though the term isoquant was coined by Frisch (1935), while the concept of elasticity of substitution was invented by Hicks (1932). It was on the analogy of indifference curve of consumption that Johnson (1913) constructed indifference curve of production, which is renamed as isoquant. This article is a tribute to Philip H. Wicksteed (1844-1927) for the introduction of the concept of isoquant in the Common Sense of Political Economy (1910). In praise of Wicksteed, Herbert Foxwell described him as a born economist. Lerner derived the substitution curve (SC) from isoquant ( $IQ$ ).

The SC shows the geometric relationship between  $m (= MP_L / MP_K)$  and  $l (= L / K)$  for a given  $IQ$ , where  $MP_L =$  marginal product of  $L$  and  $MP_K =$  marginal product of  $K$ . It can be represented by the function  $m = m(l)$  for a given  $IQ$ . The SC is the mapping of  $IQ$  from the input space ( $L, K$ -space) into the relative input - relative marginal product space ( $m$ -space). Following Lerner, the relationship among the  $IQ$ , SC, and elasticity of substitution ( $\sigma$ ), denoted by  $\sigma$ , can be shown in terms of figures 1 and 2. The SC denoted by  $m_l$  in figure 2 is the mapping of  $IQ$

denoted by  $Z_1$  in figure 1 from  $L, K$ -space into  $m$ -space. Lerner (1933) points out that the ES is inversely related to the curvature of the  $IQ$  ( $= d^2K/dL^2$ ), which is reflected in the shape and curvature of SC indicated by  $m(l)$  and  $m'(l)$ .

Figure 1: Set of Isoquants denoted by  $ZI = f(L, K)$

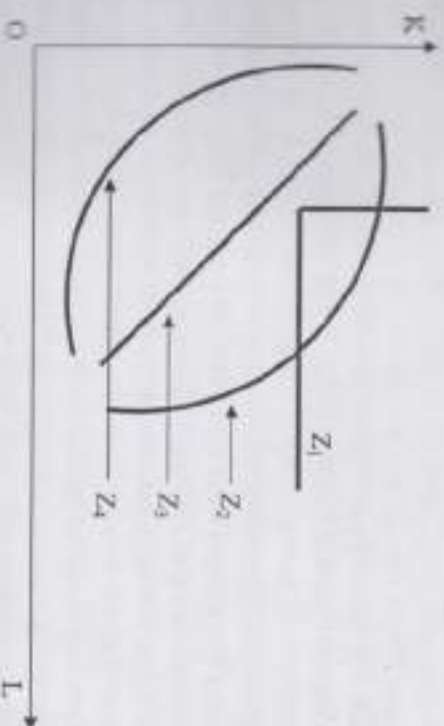
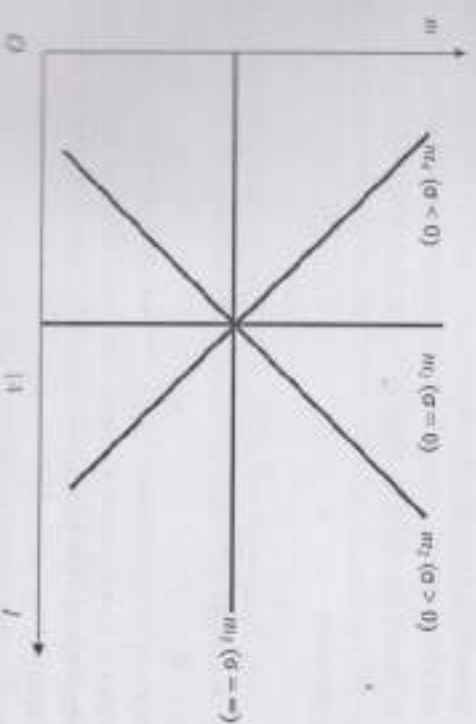


Figure 2: Lerner's Substitution Curves denoted by  $m_l = f(l)$



The necessity of introducing the surrogate substitution curve lies not in the newness of its name, but also in its wider, simpler and economical applications in the theory of firm's behavior. Lerner's SC is derived only from  $IQ$ . But surrogate substitution curve can be derived not only from  $IQ$ , but also from isocost ( $IC$ ), coined also by Frisch (1935), and other similar iso-curves or iso-functions. Henceforth, the surrogate substitution curve derived from the  $IQ$  will be called "isoquant substitution curve" ( $IQSC$ ) and by analogy, the surrogate substitution curve derived from the  $IC$  will be called "isocost substitution curve" ( $ICSC$ ). Thus we can obtain isorevenue, isobudget, isoprofit and isoexpenditure substitution curves or similar curves.

The age of isoquant and isocost used as traditional tools of analyzing firm's behavior is almost hundred years. We are well acquainted with their derivation and application. Their application has been found inadequate in some new, neglected or conflicting areas. This inadequacy of their application can be compensated by the newly derived two tools such as  $IQSC$  and  $ICSC$ . This paper seeks to substitute almost a century old isoquant and isocost with the new but derivative tools such as  $IQSC$  and  $ICSC$ .

Here  $IQSC$  and  $ICSC$  are called derivative tools, as they are derived from  $IQ$  and  $IC$  respectively. But the application of the new tools to the new, neglected or conflicting areas of firm's behaviour has deliberately been bypassed in this paper due to space constraint. The newness of application of the new tools will be considered in another article. In this paper, our analysis will be confined to the derivation of  $IQSC$  and  $ICSC$  and their different applications to the conventional areas of the theory of firm's behavior.

The substitution of new tools ( $IQSC$  and  $ICSC$ ) for old tools ( $IQ$  and  $IC$ ) is based on the remarks of the following three economists:

- (i) According to Koopmans (1957), "The test of suitability of a tool of reasoning is whether it gives the most logical and economical expression to the basic assumptions appropriate to the field in question...."

- (ii) Schinokler (1965) writes - "...if we need new tools, we can get them in the same way that we got the old tools: by making them or borrowing them from some neighboring discipline".

- (iii) Tobin argues that "What is wrong with the economics is not so much the putting together of the pieces (tools).... what is wrong is the poor quality of pieces (tools) that we put together in such models" (Koopmans 1957).

### 2.2. Derivation of Isoquant Substitution Curve ( $IQSC$ )

If the  $IQ$  is represented by  $Z_g = F(L, K)$  or  $K = K(L, X_g)$ , the  $IQSC$  can be denoted by  $k = f(m, X_g)$  or simply,  $k = f(m)$ , where  $Z =$  firm's level of output,  $L =$  input -  $L$ ,  $K =$  input -  $K$ ,  $k = (K/L)$  and  $m = (MP_L/MP_K) = (dK/dL)$ . The  $IQSC$  denoted by  $k = f(m)$  is the mapping of  $IQ$  from  $LK$ -space into  $m$ - $k$ -space given the level of output  $Z$ . In other words,  $IQSC$  is the locus of various combinations of  $m$  and  $k$  along which the "isoneess" of  $Z$  is maintained. Needless to say,  $k$  is the slope of the ray drawn from the origin to a point on the  $IQ$  for a given level of output, say,  $Z = Z_g$ , while  $m$  is the absolute slope of  $IQ$  in the  $LK$ -space in which  $L$  and  $K$  are measured along the horizontal and vertical axes respectively. If  $k = f(m)$  is called  $IQSC$ ,  $f'(m)$  will be called "marginal  $IQSC$ " ( $MIQSC$ ) and  $f(m)/m$  will be called "average  $IQSC$ " ( $AIQSC$ ).

### 2.3. Mathematical Derivation of $IQSC$

Now let us see how  $IQSC$  can be derived mathematically from  $IQ$ :

For the production function  $[PF]$  given by  $Z = F(L, K)$ , we have:

$$dk = (F_L \cdot L + F_K \cdot K) dL / F_K \cdot L \quad (1)$$

$$dm = -(dF_{LL} \cdot L \cdot F_L - F_{LL} \cdot F_L^2 - F_{LL} \cdot F_L^2) / F_L^2 \quad (2)$$

$$\text{So, } (dk/dm) = f'(m) = MIQSC = D \cdot F_L^2 / \Delta L^2 \quad (3)$$

where  $D = (F_{LL} \cdot L + F_{KK} \cdot K) =$  Distributable output between the inputs  $L$  and  $K$  and

$$\Delta = (dF_{LL} \cdot F_L - F_{LL} \cdot F_L^2 - F_{LL} \cdot F_L^2)$$

= Bordered Hessian determinant that determines the curvature of the  $IQ$ .

Note: worthy that equation (3) is obtained by the joint consideration of the equations (1) and (2).

From equation (3) we have

$$\frac{\partial^2 f(m)/\partial^2 \Delta = -DF'_c/\Delta^2 L^2 \quad (4)$$

$$\frac{\partial^2 f'(m)/\partial^2 \Delta^2 = 2DF'_c/\Delta^2 L^2 \quad (5)$$

Equations (3), (4) and (5) state that the MQSC is inversely related to the curvature of the IQ ( $\Delta = \Delta$ ). Further, the higher or the lower the convexity ( $\Delta > 0$ ) or concavity ( $\Delta < 0$ ) of the IQ, the flatter or the steeper will be the IQSC, irrespective of whether the IQSC is positively or negatively sloping. The relationship between the IQ and the IQSC is shown in figures 3 and 4. The IQs denoted by  $F_i$  ( $i = 1, 2, 3, 4$ ) in figure 3 are mapped into the IQSCs denoted by  $f_i$  ( $i = 1, 2, 3, 4$ ) in figure 4.

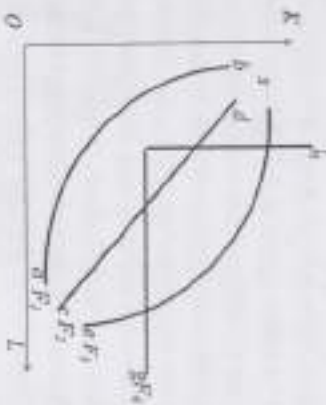


Figure 3: Isoquants:  
 $Z = F_i(L, K)$

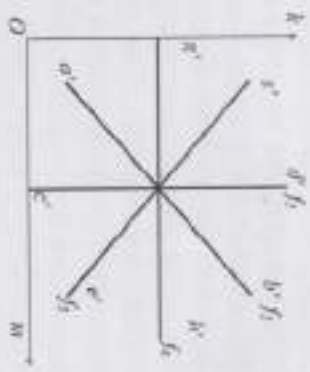


Figure 4: Isoquant Substitution Curves:  $k = f_i(m)$

**2.4. Graphical Derivation of IQSC**

Now let us consider the graphical derivation of IQSC from the IQ, in terms of figures 5 and 6.

From the pair of figures 5 and 6, we get the following results:

- (i) The  $ab$  segment of the IQ is mapped into the  $a'b'$ , which is called IQSC.
- (ii) Point  $a'$  or  $d'$  is the lower ridge point at which  $F'_L = 0 = m$  and the slope of the ray  $oa' = od'$ .
- (iii) Point  $b$  or  $b'$  is the upper ridge point at which  $F'_K = 0, m =$  and slope of the ray  $ob = ob'$ .

(iv) The curve segment  $ab$  or  $a'b'$  is called economic zone or efficient zone within which substitution between  $L$  and  $K$  is possible.

(v) For a movement from the point  $a$  or  $a'$  toward the point  $b$  or  $b'$  along the IQ or IQSC,  $F'_L$  rises, while  $F'_K$  falls and vice-versa.

(vi) The IQSC starts from the positive vertical intercept  $oa' = od'$  = slope of the ray  $oa$ .

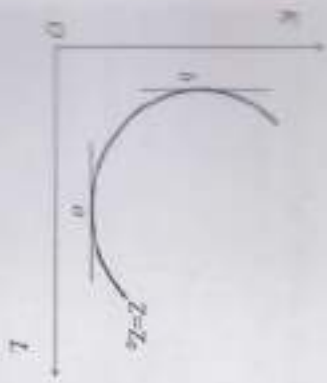


Figure 5: Isoquant for  $Z = Z_0$

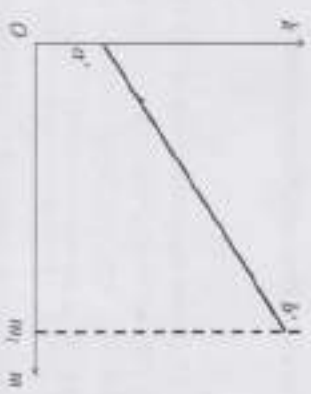


Figure 6: Isoquant Substitution Curve for  $Z = Z_0$

For convex IQs with varying degree of convexity, the positively sloping IQSCs may assume various shapes, positions and curvatures. More specifically, the positively sloping IQSC may also start either from the origin or from the negative vertical intercept depending upon the degree of convexity of the IQ. For example, the positively sloping linear IQSC that starts from the origin, can be derived from the Cobb-Douglas (1928) production function.

Moreover, the shape and the position of IQSCs also depend upon the shape of the ridge lines, as shown in the figures 7 and 8. The convex IQs denoted by  $Z_1$  and  $Z_2$  in the figure 7 are merely imaginary in the sense that they are needed only to represent the array of successive levels of output, where  $Z_1 > Z_2$ , where URL = upper ridge line and LRL = lower ridge line.

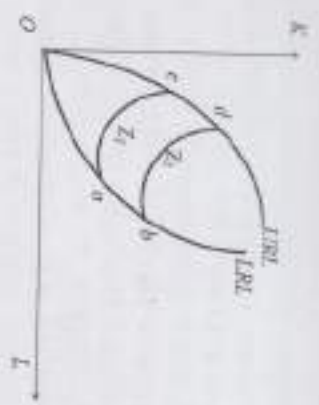


Figure 7: Pair of Ridge Lines

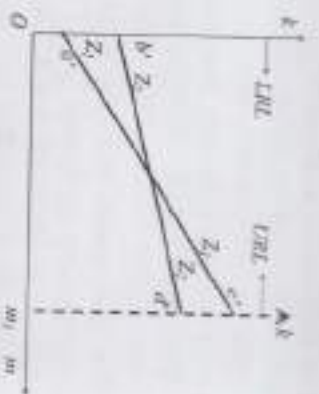


Figure 8: Pair of Isoquant Substitution Curves

**2.5. Multiple Applications of IQSC and ICSC**

The multiple applications of IQSC and ICSC will be confined to the following conventional areas of firm's behaviour, deliberately bypassing unconventional areas.

**2.5.1. Measurement of Elasticity of Substitution (ES)**

The concept of elasticity of substitution (ES) between the inputs was invented by Hicks (1932). The Hicksian elasticity of substitution (HES) is denoted by  $\sigma$ , which is of two types such as  $\sigma_{KL}$  and  $\sigma_{LM}$ , where  $\sigma_{KL}$  = ES of L for K and  $\sigma_{LM}$  = ES of K for L. Noteworthy that HES is still being measured in terms of IQ. But now the HES can be measured in terms of either IQSC or MIQSC and AIQSC. If, following Bishop (1952),  $E_{\text{sub}}$  stands for "m elasticity of k along the IQSC", we have:

$$E_{\text{sub}} = (dk/k) / (dm/m) = (dk/dm) / (k/m) = \text{MIQSC} / \text{AIQSC}$$

But HES =  $\sigma = (dk/k) / (dm/m)$

From equations (6) and (7), it is clear that  $E_{\text{sub}}$  (measured along the IQSC) =  $\sigma$  (measured along the IQ). Form equation (6) we find that for the convex IQ,  $E_{\text{sub}} > 0$ ; for the concave IQ,  $E_{\text{sub}} < 0$ ; for the linear IQ,  $E_{\text{sub}} = 0$  and for the L-shaped IQ,  $E_{\text{sub}} = 0$ . Further it can be shown that  $E_{\text{sub}}$  or  $\sigma$  is inversely related to the curvature of the IQ that is  $\Delta$ . For the PF given by  $Z = F(L, K)$ ,

$$\sigma = E_{\text{sub}} = (F_L \cdot F_K \cdot D) / L \cdot K \cdot \Delta$$

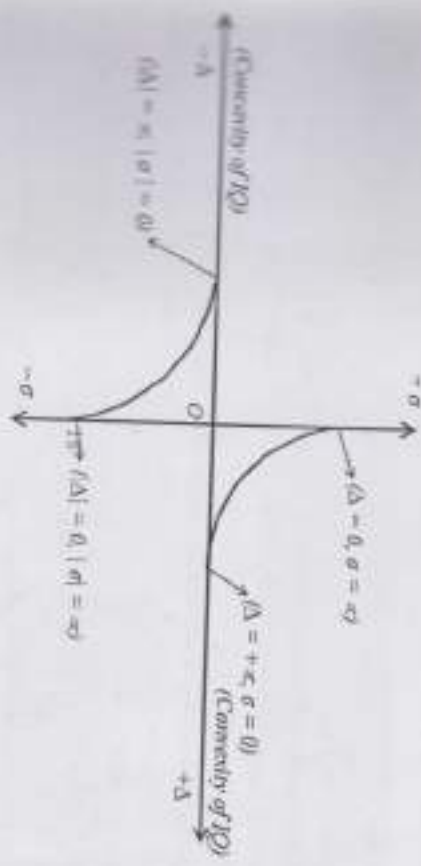
$$\partial \sigma / \partial \Delta = -F_L \cdot F_K \cdot D / L \cdot K \cdot \Delta^2 < 0$$

$$\partial^2 \sigma / \partial \Delta^2 = 2F_L \cdot F_K \cdot D / L \cdot K \cdot \Delta^3 < 0 \tag{10}$$

The inverse relationship between the HES and the curvature of the IQ (see equations (8), (9) and (10)) is shown in figure 9.

From equation (6) it is obvious that  $\sigma = E_{\text{sub}} = \psi$  (MIQSC, AIQSC), where  $\psi$  = functional symbol.

Figure 9: Relation between Curvature of Isoquant and Elasticity of Substitution ( $\sigma$ )



**2.5.2. Measurement of Relative Input Share**

If  $L_1 = F_L \cdot L / Z$  and  $K_1 = F_K \cdot K / Z$ , where  $L_1$  = share of L in Z and  $K_1$  = share of K in Z, so  $K_1 / L_1 = F_L \cdot K / F_K \cdot L = (K/L) / (F_L / F_K) = Km = \text{AIQSC}$  = slope of ray in  $mk$ -space,

$$\tag{11}$$

where  $(K/L)_1$  = relative share of K and  $(L/K)_1$  = relative share of L

$$\text{So } L_1 / K_1 = mk = 1 / \text{AIQSC}$$

$$\tag{12}$$

Then from equation (11) it is amply clear that  $(K_1 / L_1)$  is synonymous with AIQSC, while  $(L_1 / K_1)$  is the reciprocal of AIQSC.

**2.5.3. Relationship between the IQSC and  $|E_{\text{sub}}|$**

If  $|E_{\text{sub}}|$  stands for "absolute L elasticity of k along the IQ", we have



$$|E_{L1}| = |d(K/K) / (dL/L)| = |d(K/dL) / (K/L)| = (F_L/F_K) / (K/L) = F_L L / F_K K$$

$$= L_1 / K_1 = m/k = 1/AIQOSC \quad (13)$$

### 2.5.4. Relationship among $E_{L1}$ , $|E_{L1}|$ , $MIQOSC$ and $AIQOSC$

From equation (6), we have:

$$E_{L1} = \sigma = HES = [d(K/dm)] / (K/m) = MIQOSC / AIQOSC$$

From equations (11) and (12), we have:

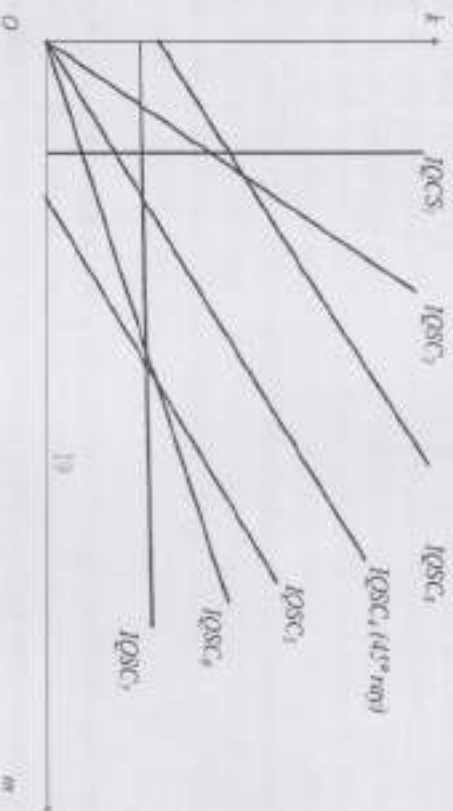
$$K_1/L_1 = K/m = AIQOSC \text{ and } L_1/K_1 = m/k = 1/AIQOSC$$

From equation (13), we have:

$$|E_{L1}| = m/k = L_1/K_1 \text{ So, finally we get [From equations (6) and (11) and (13)]$$

$MIQOSC = dK/dm = E_{L1} / |E_{L1}| = E_{L1} / (L_1/K_1) = E_{L1} \cdot AIQOSC$ . These results can be disclosed in terms figure 10 and table 1, which are interrelated.

Figure 10: Set of Isoquant Substitution Curves:  $k = f(l, m)$



### 2.5.5. Trend in Relative Input Share ( $K_1/L_1$ )

Earlier we have seen that  $K_1/L_1 = K/m = AIQOSC$  = slope of ray in the  $m-k$  space. Now,  $d(K_1/L_1)/dK = (1/m)^{\eta-1} / |E_{L1}|$

$$(14)$$

$$\text{and } d(k/m)/dm = (k/m^2) |E_{L1}^{-1}| \quad (15)$$

From equation (14) we have  $[d(K_1/L_1)/dK] \gtrless 0$  according as  $|E_{L1}| \gtrless 1$ .

But from equation (15), we get  $[d(k/m)/dm] \gtrless 0$ , according as  $|E_{L1}| \gtrless 1$ .

The results of equations (14) and (15) have also been displayed in table 1.

Table 1

Relationship among  $IQSC$ ,  $IQ$ ,  $E_{L1}$ ,  $|E_{L1}|$  and  $(K/L)$

Form of $IQSC$	Nature of $IQ$	$\sigma = E_{L1}$	$ E_{L1} $	$K_1$ Vs $L_1$ , Trend in $K_1/L_1$ or $d(K_1/L_1)/dK$
$IQSC_1$	Linear, $\Delta = 0$	$= \infty$	$= 0$	$K_1 = 1$ , $L_1 = 0$ , $> 0$
$IQSC_2$	Cobb-Douglas type $\Delta > 0$	$= 1$	$< 1$	$K_1 > L_1$ , $= 0$
$IQSC_3$	Convex to origin & $\Delta = \text{higher}$	$< 1$	$< 1$	$K_1 > L_1$ , $< 0$
$IQSC_4$	Cobb-Douglas type $\Delta > 0$	$= 1$	$= 1$	$K_1 = L_1$ , $= 0$
$IQSC_5$	Convex to origin & $\Delta = \text{lower}$	$> 1$	$> 1$	$K_1 < L_1$ , $> 0$
$IQSC_6$	Cobb-Douglas type $\Delta > 0$	$= 1$	$> 1$	$K_1 < L_1$ , $= 0$
$IQSC_7$	L-shaped $\Delta =$	$= 0$	$= \infty$	$K_1 = 0$ , $L_1 = 1$ , $d(K_1/L_1)/dm < 0$

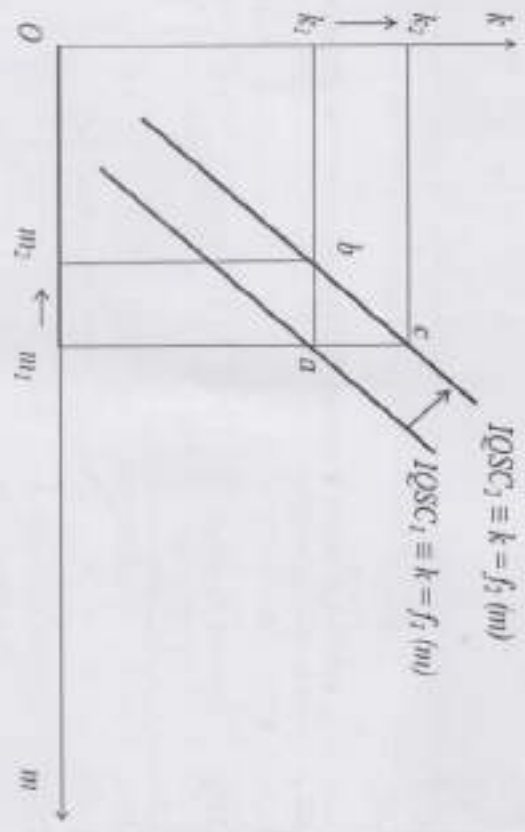
### 2.5.6. Hicksian Technological Progress and its Effects on Relative Input Share and Input Substitution

According to Hicks, technological progress (TP) is said to be  $K$ -intensive,  $L$ -intensive and neutral (or unbiased), if at given  $k (= K/L)$ , it lowers, raises and leaves unchanged the  $m (= F_L/F_K)$  respectively or,

alternatively, if at given  $m$ , it raises, lowers and leaves unchanged the  $k$ , respectively. Now we shall see how Hicksian TP can be represented in terms of the IQSCs and also its impact on the relative input share ( $K/L$ ) and the input substitution (S).

Here we shall assume that the IQs are convex to the origin (excepting the Cobb-Douglas IQs), for which the IQSCs are positively sloping.

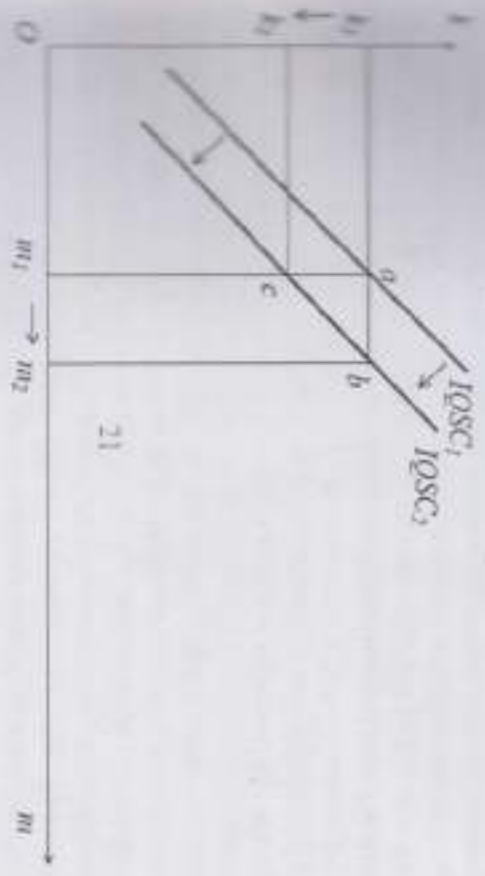
**Figure 11: Hicksian Capital-intensive Technological Progress (HKITP)**



In figure 11, due to Hicksian  $K$ -intensive TP (HKITP), the IQSC shifts to the left, for which at given  $k$ ,  $m$  falls from  $m_1$  to  $m_2$ . As a result,  $(K/L)$  rises, as the slope of the ray  $ob$  becomes higher than the slope of the initial ray  $oa$ .

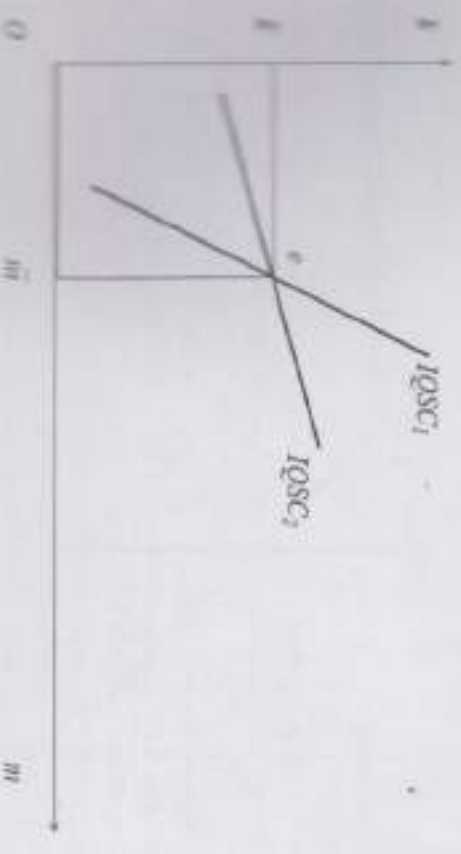
Further due to HKITP,  $k$  rises from  $k_1$  to  $k_2$  at the initial  $m = m_1$ , which means that  $K$  is substituted for  $L$  along the shifting IQSC at the initial  $m = m_1$ . Thus the movement from the point  $a$  to the point  $b$  is called HKITP, while the movement from  $b$  to  $c$  is called input substitution of  $K$  for  $L$ .

**Figure 12: Hicksian Labor-intensive Technological Progress (HLITP)**



In figure 12, due to Hicksian  $L$ -intensive TP (HLITP), the IQSC shifts to the right, for which at given  $k$ ,  $m$  rises from  $m_1$  to  $m_2$ . The movement from the point  $a$  to the point  $b$  is called HLITP, for which  $(K/L)$  falls, as the slope of the ray  $ob$  becomes lower than the slope of the initial ray  $oa$ . Further, the movement from  $b$  to  $c$  is called input substitution of  $L$  for  $K$ , for which  $K$  falls from  $k_1$  to  $k_2$ .

**Figure 13: Hicksian Neutral Technological Progress (HNTP)**



In figure 13, two IQSCs cuts each other at the point  $a$ , for which the  $IC$  is convex to the origin and  $IC$  is concave to the origin. This means that  $k = k^*$  is associated with the given  $m = m^*$ . This means that the Hicksian TP is neutral, which leaves both the  $(K^*/L^*)$

and the input substitution unchanged, as the slope of the ray  $oa$  remains unchanged and the  $k$  remains unchanged at  $k^*$  respectively.

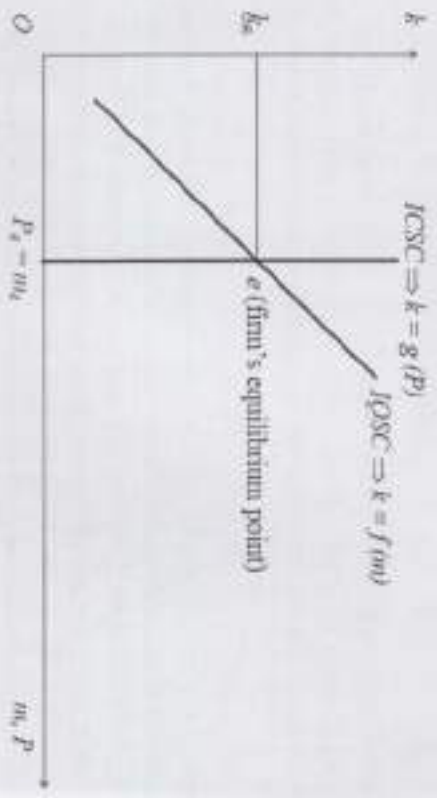
**2.5.7. Equilibrium of the Competitive Firm**

The firm is in equilibrium if the following two conditions are satisfied:

- (i)  $m = F_L/F_K = P_L/P_K$  and (ii)  $(dK/dL) < 0$  and  $(d^2K/dL^2) > 0$ , which means that the IQ is convex to the origin or, alternatively, the IQSC is positively sloping. Here  $P = P_L/P_K =$  absolute slope of the isocost (IC) where  $P_L =$  price of  $L$  and  $P_K =$  price of  $K$ . If the first order condition of firm's equilibrium, given by  $m = P_L/P_K$  is to be satisfied, the IC is to be mapped into "isocost substitution curve" (ICSC), as earlier the IQ has been mapped into IQSC. If the IC is denoted by  $C = (P_L L + P_K K)$ , the equation of the ICSC will be  $k = C/P_L - P/P_K$  such that  $g'(P) = \alpha$ .

This means that the ICSC will be vertical in the  $PK$ -space. Thus given  $k$ , the IQSC and ICSC, the equilibrium of the firm is determined by the point of intersection between the positively sloping IQSC (if IQ is convex to origin) and the infinitely sloping ICSC (if the IC is negatively sloping linear). It is shown in figure 14.

**Figure 14: Equilibrium of Competitive Firm**



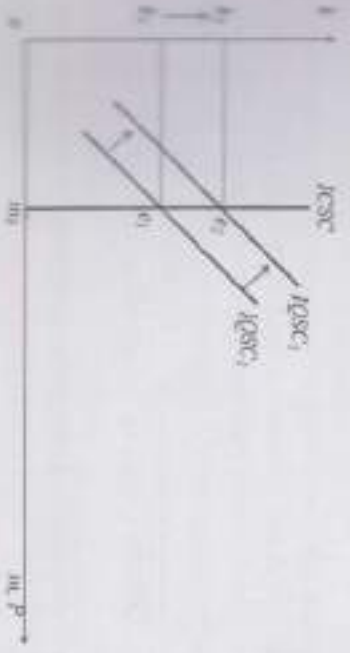
the equilibrium of the firm can also be demonstrated when both IQ and IC are concave. The following three cases, for example, can be considered:

- 1) If both the IQ and IC are convex to the origin, but the degree of convexity of IQ is greater than that of IC, both IQSC and ICSC will be positively sloping. Now the ICSC must be steeper than IQSC, if the stability of equilibrium is to be ensured, that is, if the steeper ICSC cuts the flatter IQSC at the point of equilibrium, the equilibrium will be stable.
- 2) If both the IQ and IC are concave to the origin but the degree of concavity of the IC is greater than that of IQ, both IQSC and ICSC will be negative sloping. But the stability of equilibrium requires that IQSC will be steeper than ICSC.
- 3) If the IQ is convex, while the IC is concave, the stability of equilibrium requires that the positively sloping IQSC cuts the negatively sloping ICSC. But the equilibrium will be unstable, if the converse is true, that is, if IC is convex or ICSC is positively sloping, while IQ is concave or IQSC is negatively sloping.

**Input Inferiority**

The concept of "input inferiority" was also introduced by Hicks (1939). According to Hicks, an optimizing competitive firm "will increase its output in response to a rise in the price of the  $K$ th factor of production, and only if, the  $K$ th factor is inferior". Later on, it was modified by Bort (1962), Bear (1965) and Ferguson (1968). Bear's (1965) diagram for input-inferiority can be reinterpreted in terms of IQSC - ICSC diagram, as shown in figure 15.

**Figure 15: Input Inferiority**



Bear's diagram shows that  $L$  will be inferior, if at given  $m \times B$ ,  $k$  increases, which is the same thing as the Hicksian  $K$ -intensive  $T$ . Here in  $k (= K/L)$ ,  $L$  is inferior and  $K$  is superior, where  $K$  may be treated as aggregate of "all other factors". Noteworthy that Ferguson's (1967) view of input-inferiority is similar to Bear's (1965) view. According to them, an input will be inferior, if its price is positively related to the equilibrium output of the firm. So, Bear's (1965) diagram will be identical to Ferguson's (1967) diagram (See figure 15).

### 2.5.9. An Example of the Relationship among IQSC, AIQSC, MIQSC, $(K/L)$ and $E_{km}(k)$

Let us suppose that the IQSC assumes the explicit form  $k = f(m) = B'm^a$ , which gives rise to the following derivative functions:

$$K/m = B'm = K/L \Rightarrow \text{AIQSC} \quad (16)$$

$$dk/dm = 2k/m > 0 \Rightarrow \text{MIQSC} \quad (17)$$

$$d^2k/dm^2 = 2k/m^2 > 0 \Rightarrow \text{slope of MIQSC} \quad (18)$$

where  $B$  is a positive parameter. From equations (16), (17) and (18) it is obvious that the IQSC must be convex to the  $m$ -axis, which is only possible if the IQSC meets both the  $L$ -axis and  $K$ -axis. Since  $\text{AIQSC} = K/m = K/L$ , so  $\text{AIQSC}$  curve will coincide with the  $K/L$  curve. Further since  $\sigma = E_{km} = (dk/dm)/(k/m) = \text{MIQSC}/\text{AIQSC}$ , so  $\sigma = E_{km} > 1$ , as  $\text{MIQSC} > \text{AIQSC}$ . All these results are reflected in figures 16 and 17.

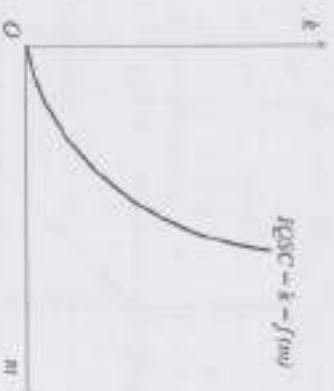


Figure 16: Downward Convex IQSC

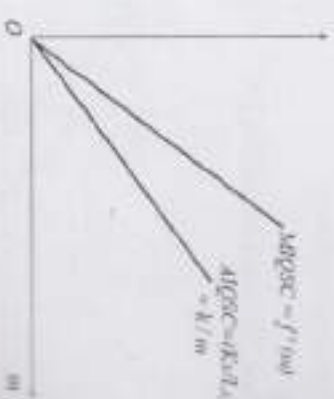


Figure 17: Positively Sloping MIQSC and AIQSC

### 2.6. Concluding Comments

Despite the proliferation of various theories of firm such as neo-classical, average cost pricing, limit pricing, managerial, behavioral, principal-agent, transaction cost, contractual, property rights etc., the neo-classical theory is still persisting at least on heuristic ground. In class-room lectures, the neo-classical theory is very popular for its apparently mathematical simplicity. Almost a century old Isoquant-Iso-cost Model is a constituent part of the neo-classical theory of firm's behavior. This model is also inadequate to theorize the long neglected, conflicting or new aspects of firm's behavior that is why IQSC and ICSC are introduced.

The IQSC and ICSC can be used as the new but derivative tools for theorizing both old and new aspects of firm's behaviour. In this sense, the IQSC-ICSC Model should be conceived as the next expeditive step in the theory of firm's behaviour. Finally, it can further be admitted that the application of the IQSC and ICSC to the new, neglected or conflicting areas of firm's behaviour has deliberately been bypassed in this paper due to space constraint, which will be disclosed in an another article.

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## CHAPTER 3

### 3.1. Introduction

The objective of this article is to reformulate the three selected production functions (PFS) such as (i) Cobb-Douglas production function (CDPF) of Cobb and Douglas (1928), (ii) constant elasticity of substitution production function (CESPF) of Arrow, Chenery, Minhas and Solow (1961), and (iii) the implicit form of linearly homogeneous production function (LHPF). This objective can be achieved through the applications of two new tools such as "isoquant substitution curve" (IQSC) and "isocost substitution curve" (ICSC), introduced by Konar (2009).

### 3.2. A Brief Sketch of IQSC and ICSC

The IQSC, which has been recently introduced by Konar (2009), is the "rehashed version" of Lerner's (1933) "substitution curve" (SC), or Matyas's (1985) "capital-intensity function", both of which exhibit the relationship between the isoquant and the elasticity of substitution. If the isoquant (IQ) is represented by  $X_0 = F(L, K)$ , or  $K = K(L, X_0)$ , the IQSC can be denoted by  $k = f(m, X_0)$ , or simply  $k = f(m)$ , where  $X =$  "name and amount of commodity  $X$ ,  $L =$  input- $L$ ,  $K =$  input- $K$ ,  $k = (K/L)$  and  $m = (F_L / F_K) = (MP_L / MP_K)$ . The IQSC, denoted by  $k = f(m)$ , is the mapping of IQ from LK-space into mk-space, given the  $X$ . In other words, IQSC is the locus of various combinations of  $m$  and  $k$ , along which the "isoneess" of  $X$  is maintained. If  $k = f(m)$  is called IQSC, then  $f'$  ( $m$ ) is called "marginal IQSC" (MIQSC) and  $f(m)/m$  is called "average IQSC" (AIQSC). So, "inverse IQSC", "inverse MIQSC" and "inverse AIQSC" can respectively be denoted by  $m = f^{-1}(k)$ ,  $dm/dk = f^{-1}'(k)$  and  $m/k = f^{-1}(k)/k$ .

If the isocost ( $IC$ ) is denoted by  $C = (p_L L + p_K K)$ , the equation of the ICSC will be  $k = C/p_L L - p = g(p)$  such that  $g'(p) < 0$ , where  $p = (p_L/p_K)$ . This means that the ICSC will be vertical in the  $pK$ -space. Thus, ICSC is the mapping of IC from  $LK$ -space into  $pK$ -space, given the  $C$ , where  $p_L =$  price of input- $L$ ,  $p_K =$  price of input- $K$  and  $C =$  name and amount of total cost of production. In other words, ICSC is the locus of various combinations of  $p$  and  $k$ , along which the "isocostness" of  $C$  is maintained.

### 3.3. Reformulation of CDPF

The general form of CDPF of Cobb and Douglas (1928) can be written as follows:

$$X = F(L, K) = A L^\alpha K^\nu \quad (1)$$

where  $A$  level of technology,  $\alpha = F_L L/X = L_q =$  share of input- $L$  in  $X$ .

$b = F_K K/X = K_q =$  share of input- $K$  in  $X$ ;  $\nu = (\alpha + b) =$  returns to scale, or degree of homogeneity of CDPF;  $\nu > 1$  IRS,  $\nu < 1$  DRS,  $\nu = 1$  CRS.

Following Konar's (2009) methodology, the general form of CDPF:  $X = F(L, K) = A L^\alpha K^\nu$  can be transformed into a single function  $k = f(m) = Bm$ , (2)

where  $k = (K/L)$ ,  $m = (F_L/F_K) = (MP_L/MP_K) = (dk/dL) \cdot B = (b/\alpha) \cdot F_L = MP_L = \alpha(X/L) = \alpha AP_L$  and  $F_K = MP_K = b(X/K) = bAP_K$ . From equation (2) we get the following functions:

$$k = Bm \Rightarrow CDIQSC \quad (3)$$

$$dk/dm = B \Rightarrow CDMIQSC \quad (4)$$

$$k/m = B \Rightarrow CDAIQSC \quad (5)$$

$$B = (b/\alpha) = K_q/L_q = k/m = CDAIQSC = dk/dm = CDMIQSC \quad (6)$$

$$|E_{kL}| = m/k \approx 1, \text{ according as } m \text{ kor } L_q \approx K_q \quad (7)$$

$$E_{km} = \alpha = 1 \quad (8)$$

$$dk/km = |E_{km}|/|E_{kL}| \approx 1, \text{ according as } E_{km} \approx |E_{kL}| \quad (9)$$

where  $|E_{kL}| =$  "absolute  $L$  elasticity of  $k$ " measured along  $CDIQ$  and  $E_{km} =$  "m elasticity of  $k$ " measured along  $CDIQSC =$  "elasticity of substitution" measured along the  $IQ = \alpha$ .

Let us rewrite the general form of CDPF as:

$$X = F(L, K) = A_i L^\alpha K^\nu \quad (10)$$

where the subscript  $i$  designates the  $i$ th "isoquantmap" ( $IQM$ ).

Let us suppose that there are only three  $CDIQMs$  such as  $CDIQM_1$ ,  $CDIQM_2$ , and  $CDIQM_3$ , all of which produce  $X$ . Further, we suppose that  $CDIQM_1$ ,  $CDIQM_2$ , and  $CDIQM_3$  assume the following three specific forms of CDPF respectively.

$$X = F_1(L, K) = A_1 L^\alpha K^\nu, \text{ where } \alpha = b, \Rightarrow CDIQM_1 \quad (11)$$

$$X = F_2(L, K) = A_2 L^\alpha K^\nu, \text{ where } \alpha_2 > b, \Rightarrow CDIQM_2 \quad (12)$$

$$X = F_3(L, K) = A_3 L^\alpha K^\nu, \text{ where } \alpha_3 < b, \Rightarrow CDIQM_3 \quad (13)$$

The  $CDIQM_1$  will be rectangular hyperbolic, while the  $CDIQM_2$ , and the  $CDIQM_3$  will be asymmetrical relative to  $L$ -axis and  $K$ -axis, but roughly be similar in shape to the rectangular hyperbola. However, the three  $CDIQMs$  must be convex to the origin, irrespective of their degree of convexity and asymmetry relative to  $L$  and  $K$  axes. Following one of the properties of homogeneous  $IQM$ , the three different  $CDIQMs$  such  $CDIQM_1$ ,  $CDIQM_2$ , and  $CDIQM_3$  can be reduced to the corresponding three different  $CDIQs$  such as  $CDIQ_1$ ,  $CDIQ_2$ , and  $CDIQ_3$ .

This property says that the slopes of the successive  $IQs$  are equal at the given input-ratio in the  $IQM$  represented by the homogeneous production function of any degree. The transformation of the general form of CDPF:  $X = F(L, K) = A_i L^\alpha K^\nu$  into a single function:  $k = f(m) = Bm$  implies that the three different  $CDIQMs$  such as  $CDIQM_1$ ,  $CDIQM_2$ , and  $CDIQM_3$ , or their reduced forms such as  $CDIQ_1$ ,  $CDIQ_2$ , and  $CDIQ_3$ , in figure 1 can be mapped into the corresponding three different straight lines with different slopes, which start from the origin in the  $m-k$ -space, as shown in figure 2.

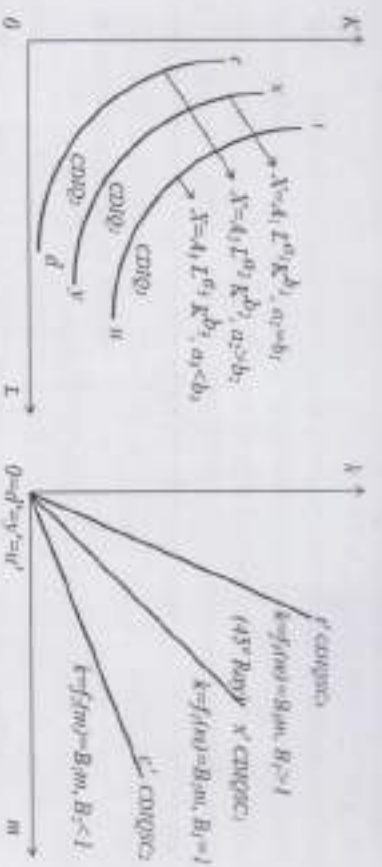


Figure 1: Three CDI/Qs

The new functions:  $k = f_i(m) = B_i m$  ( $i = 1, 2, 3$ ) in figure 2, are the mapping of the CDI/Qs represented by  $X = F_i(L_i, K_i) = A_i L_i^{\alpha_i} K_i^{\beta_i}$ , ( $i = 1, 2, 3$ ) in figure 1 from the  $LK$ -space into the  $m$ -space. The new functions in figure 2 are called CDI/QSCs.

Figure 2: Correspondingly Three CDI/QSCs

Received Nature of Technological Change	Neutral	Neutral	Neutral
Nature of Input-Intensity along the CDI/QSC	$k =$ Intermediate	$k =$ Lower	$k =$ Higher
$K_i/L_i$	$= 1$	$< 1$	$> 1$
Value of $v_i$	$v_i \approx 1$	$v_i \approx 1$	$v_i \approx 1$
Value of $B_i = (b_i/\alpha_i)$	$B_i = 1$	$B_i < 1$	$B_i > 1$

### 3.3.1 Problems of Firm's Equilibrium

On the basis of equations (5) to (13), the comparison among the three CDI/QSCs such as CDI/QSC<sub>1</sub>, CDI/QSC<sub>2</sub>, and CDI/QSC<sub>3</sub> in figure 2 can be briefed in terms of table 1. According to the information encapsulated in table 1, the three different CDI/QSCs such as CDI/QSC<sub>1</sub>, CDI/QSC<sub>2</sub>, and CDI/QSC<sub>3</sub> in figure 2 can be regarded as the three different "paths" faced by the firm, which produces  $X$  with the help of two inputs  $L$  and  $K$ . It is worthy to reiterate that either the whole CDI/QM<sub>1</sub> or the single CDI/Q<sub>1</sub> can be mapped into CDI/QSC<sub>1</sub>. Since the firm is facing the "three paths", given by CDI/QSC<sub>1</sub>, CDI/QSC<sub>2</sub>, and CDI/QSC<sub>3</sub>, so the question is which "path" will be chosen by the optimizing firm in equilibrium? This question involves dual problem: one is "equilibrium determination problem" and the other is the "choice of equilibrium problem" corresponding to the "path".

In the former case, firm's equilibrium requires the balancing of "technical desire" with "economic desire" of the firm. The technical desire of the firm is reflected by the IQ or IQSC, while the economic desire of the firm is reflected by the firm's isocost (IC) function or the ICSC. While the CDI/QSC is a straight line through the origin, the ICSC is vertical. If both CDI/QSC and ICSC are brought together in a single diagram (figure 3), the point of intersection between them will ensure both the first order condition of firm's equilibrium:  $m = p$  and the second order condition of firm's equilibrium: the positive slope of the IQSC that is  $dk/dm > 0$ . In figure 3, the vertical ICSC cuts the three CDI/QSCs at three different points, which are called the firm's equilibrium points. Let  $e_i$  be the equilibrium point corresponding to

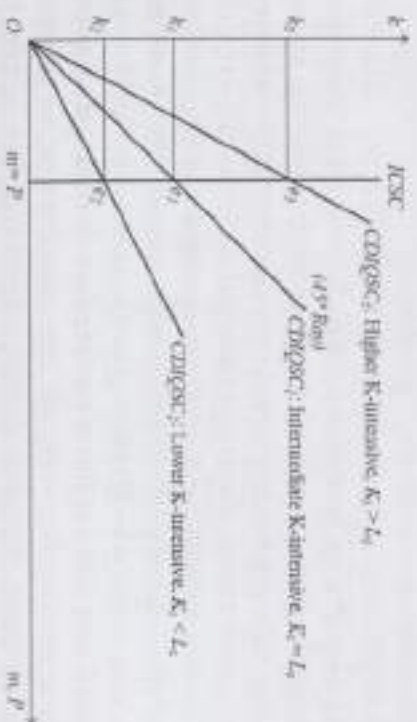
Table 1: Comparison among the Three CDI/QSCs

Nature of CDI/QM <sub>1</sub> or CDI/Q <sub>1</sub>	Rectangular Hyperbola	Similar to Rectangular Hyperbola	Similar to Rectangular Hyperbola
Name of CDI/QM or CDI/Q	CDI/QM <sub>1</sub> or CDI/Q <sub>1</sub>	CDI/QM <sub>2</sub> or CDI/Q <sub>2</sub>	CDI/QM <sub>3</sub> or CDI/Q <sub>3</sub>
Name and Equation of CDI/QSC; $k =$	CDI/QSC <sub>1</sub> ; $k = B_1 m$	CDI/QSC <sub>2</sub> ; $k = B_2 m$	CDI/QSC <sub>3</sub> ; $k = B_3 m$
Relation between $K_i$ and $L_i$	$K_i = L_i$	$K_i < L_i$	$K_i > L_i$
$E_{m_i}(\alpha_i)$ along the CDI/QSC	$E_{m_i} = 1$	$E_{m_i} = 1$	$E_{m_i} = 1$
$ E_{m_i} $ along the CDI/Q	$ E_{m_i}  = 1$	$ E_{m_i}  > 1$	$ E_{m_i}  < 1$

the "ith path" denoted by  $CDI/QSC_i$  ( $i = 1, 2, 3$ ). So,  $e_i$ ,  $e_2$ , and  $e_3$  will be consistent with  $CDI/QSC_1$ ,  $CDI/QSC_2$ , and  $CDI/QSC_3$ , respectively. The "choice of equilibrium path" depends on the desirability of the firm with respect to the relative position of  $K_i$  and  $L_i$  (that is whether  $K_i \leq L_i$ ) on the one hand, and the desirability as well as awareness about the existing three paths of the trade union on the other hand, given the /CSC. If the firm desires to have  $K_i > L_i$  coupled with higher  $K$ -intensity on the assumption that either the trade union is naive, or completely unaware of the existing three paths, the firm will choose the equilibrium points, which is consistent with the  $CDI/QSC_3$  path.

On the other hand, if the trade union leader is sophisticated, and completely aware of the existing three paths, he/she may force the firm to choose the equilibrium point  $e_3$  corresponding to the  $CDI/QSC_3$  path, since trade union knows that the  $CDI/QSC_3$  path involves  $L_i > K_i$ , coupled with  $L$ -intensity. The paths  $CDI/QSC_1$  and  $CDI/QSC_2$  are considered as the two extreme paths. While  $CDI/QSC_3$  path is biased against the trade union, the  $CDI/QSC_2$  path is biased against the firm. But, if neither firm, nor trade union "scoops" before each other, then through the bargaining process, the intermediate path  $CDI/QSC_1$ , which may be looked upon as an "egalitarian path", as along such path  $K_i = L_i$  is ensured, will eventually be chosen by the mutual agreement of both the conflicting parties.

Figure 3: Choice of Firm's Equilibrium



### 3.3.2 Problems of Hicksian Technological Progress (HTP)

From figure 3, we find that along any path or  $CDI/QSC$ , the HTP is neutral, as suggested by the received theory. This means that for  $CDPF$ , the intra- $i$ QM or intra- $i$ QSC technological progress (TP) is neutral in Hicksian sense. But, this neutrality of HTP is vitiated owing to divergence of choice of path,  $CDI/QSC$  or  $e_3$ . This means that the inter-path, inter- $i$ QM or inter- $i$ QSC-TP is non-neutral in Hicksian sense. More specifically, owing to divergence of choice of path, if the  $CDI/QSC$  shifts from its initial position  $CDI/QSC_1$  to the final position  $CDI/QSC_3$ , such shift of  $CDI/QSC$  indicates Hicksian  $K$ -intensive TP (HK/TP), while the shift of  $CDI/QSC$  from  $CDI/QSC_2$  to  $CDI/QSC_3$  indicates Hicksian  $L$ -intensive TP (HL/TP). Thus, the inter-path, inter- $i$ QM or inter- $i$ QSC-TP is always non-neutral, which has not been considered by the received theory.

If the  $CDPF$  is rewritten as  $X = F(L, K) = A \cdot L^\alpha \cdot K^\beta$ , or  $k = B \cdot m$ , where the subscript  $i$  may designate industry, firm within an industry, or the plant within a firm, the movement along any  $CDI/QSC_i$  ( $i = 1, 2, 3$ ) must imply intra- $i$ industry, intra-firm or intra-plant HTP, which is neutral for the  $i$ th industry, firm or plant. But the shift of  $CDI/QSC_i$  in either upward (upward) or downward) involves inter- $i$ industry, inter-firm or inter-plant HTP, which is non-neutral. More specifically, if the  $CDI/QSC$  shifts from  $CDI/QSC_1$  (or  $CDI/QSC_2$ ) to the  $CDI/QSC_3$ , the inter- $i$  HTP will be  $K$ -intensive (or  $L$ -intensive) [Figure 3]. Thus, in fine, intra- $i$  HTP is always neutral but inter- $i$  HTP is non-neutral, where  $i$  may stand for industry, firm within an industry, or plant within a firm. In this context, the contribution of Massell (1961) is noteworthy.

Now, the distinction between the intra- $i$  TP and inter- $i$  TP should be disclosed. While the intra- $i$  TP refers to the improvements in the state of arts and efficiency within  $i$ , which should be termed as invention and/or innovation performed by  $i$ , the inter- $i$  TP refers to the diffusions or spillovers of the technological invention and/or innovation among the  $i$ . Further, the inter- $i$  TP may occur owing to inter- $i$  mobility of inputs because of inter- $i$  inequality of the marginal products of the inputs. Both intra- $i$  TP and inter- $i$  TP contribute to the shift in the PF within  $i$  and among  $i$ , respectively. The inter- $i$  TP results in a further increase in output over and above the increase in output realized in the intra- $i$  TP.



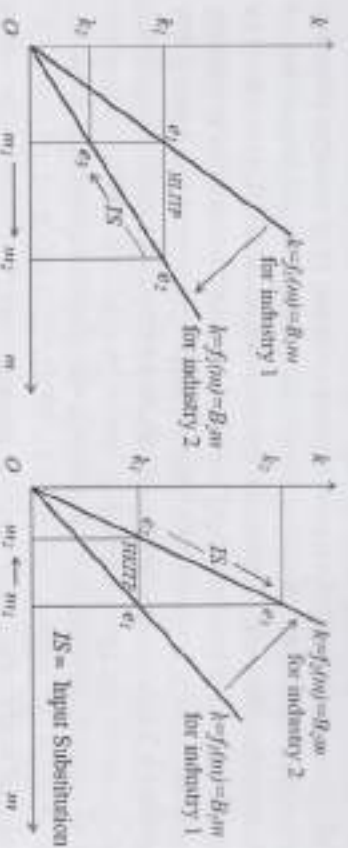


Figure 4: Intra- and Inter-Industry TPL-Intensive)

Figure 5: Intra- and Inter-Industry TP (K-Intensive)

Now, let us consider the effects of Hicksian, non-neutral TP (for example, inter-industry TP) in terms of figure 4 and figure 5. In figure 4, due to inter-industry HITP, the CDIQSC shifts to the right from  $k = f_1(m)$  to  $k = f_2(m)$ , for which at the given  $k = k_2$ ,  $m$  rises from  $m_1$  to  $m_2$ . The movement from the point  $e_1$  to the point  $e_2$  is called "inter-industry HITP", for which the relative share of  $K$  ( $=K_1/L_1$ ) falls for industry 1, as the slope of the ray  $Oe_2$  becomes lower than the slope of the initial ray  $Oe_1$ . Further, the movement from the point  $e_1$  to the point  $e_2$  is called the "increase in substitution of  $L$  for  $K$ ", for which  $K$  falls from  $k_1$  to  $k_2$ .

The movement from the point  $e_2$  to the point  $e_1$  is also called "intra-industry Hicksian neutral TP". But, in figure 5, due to inter-industry HITP, the CDIQSC shifts to the left from  $k = f_1(m)$  to  $k = f_2(m)$ , for which at the given  $k = k_1$ ,  $m$  falls from  $m_1$  to  $m_2$ . As a result, the relative share of  $K$  ( $=K_1/L_1$ ) for industry 1 rises, as the slope of the ray  $Oe_2$  becomes higher than the slope of the initial ray  $Oe_1$ . The inter-industry HITP also leads to a rise in  $k$  from  $k_1$  to  $k_2$  at the initial  $m = m_1$ , which means the "increase in substitution of  $K$  for  $L$ " along the shifting CDIQSC.  $k = f_2(m)$  at the initial  $m = m_1$ . Thus, in figure 5, the movement from the point  $e_1$  to the point  $e_2$  is called "inter-industry HITP", while the movement from the point  $e_2$  to the point  $e_1$  is called the "increase in substitution of  $K$  for  $L$ ", or "intra-industry Hicksian neutral TP".

### 3.4. Reformulation of CESPF

As a serious challenge to the CDPF, the CESPF was devised jointly by Arrow, Chenery, Minhas and Solow (1961). The CESPF was popularized by Uzawa (1962), Mc Fadden (1963) et al. The foregoing two problems of CDPF, indicated by subsection 3.1 and subsection 3.2, equally hold true in the case of CESPF also, that is why deliberately by-passing the repetition of reasoning of the foregoing two subsections, only the nature of CESIQSC has been disclosed, as follows.

By analogy of CDPF,  $X = F(L, K) = AL^\alpha K^\beta$ , the CESPF can be written as:

$X = F(L, K) = A[\alpha L^\alpha + \beta K^\beta]^{-1/\sigma}$ , (14) where  $(\alpha + \beta) = 1$ ,  $\sigma$  returns to scale parameter,  $A$  technological change parameter,  $\sigma$  substitution parameter, while  $\alpha$  and  $\beta$  refer to distributional parameter.

From equation (14) we get two derivative functions such as (15) and (16):

$$F_L = [A^{-1/\sigma} \alpha^\sigma X^{(\sigma+1)/\sigma}] / L^{1/\sigma} \quad (15)$$

$$F_K = [A^{-1/\sigma} \beta^\sigma X^{(\sigma+1)/\sigma}] / K^{1/\sigma} \quad (16)$$

From equation (15) and (16) we get:

$$K = B^\sigma m^\sigma \Rightarrow \text{CESIQSC} \quad (17)$$

From equation (17) we get:

$$K/m = B^\sigma m^\sigma \Rightarrow \text{CESAIQSC} = (K_0/L_0) \quad (18)$$

$$dk/dm = B^\sigma m^{\sigma-1} = (K/m) \Rightarrow \text{CESMIQSC} \quad (19)$$

$$dK/dm^\sigma = \sigma(\sigma-1)(K/m) \Rightarrow \text{slope of CESMIQSC} \quad (20)$$

$$\partial K / \partial B = \sigma B^{\sigma-1} m^\sigma, \quad (21)$$

$$\text{where } E_{mm} = \sigma = \text{CESMIQSC} / \text{CESAIQSC} = [1/(\sigma+1)] = \sigma/(K), \quad (22)$$

$$B = (b/a) = (K/m) K^{\sigma-1+\sigma} = (K_0/L_0) K^\sigma, \quad (23)$$

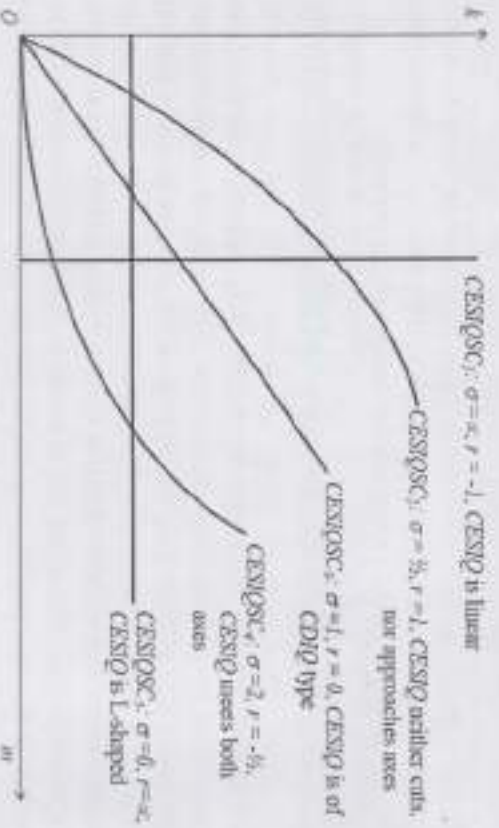
$$\text{since } r = [1-\sigma/\sigma] \text{ and} \quad (24)$$

$$\sigma = (L_1 A^{1-\sigma} L_1^\sigma) / (V X^{1-\sigma}) \text{ (here } L_1 \neq 0, \text{ while in CDPF, } L_1 = 0) \quad (25)$$

$$b = (K_1 A^{1-\sigma} K_1^\sigma) / (V X^{1-\sigma}) \text{ (here } K_1 \neq b, \text{ while in CDPF, } K_1 = b) \quad (26)$$

The CESIQSC assumes various shapes depending upon the nature of CESIQ, which in turn depends upon the values of  $r$  and  $\sigma$  as shown in figure 6.

Figure 6: Five CESIQSCs Corresponding to Five CESIQs

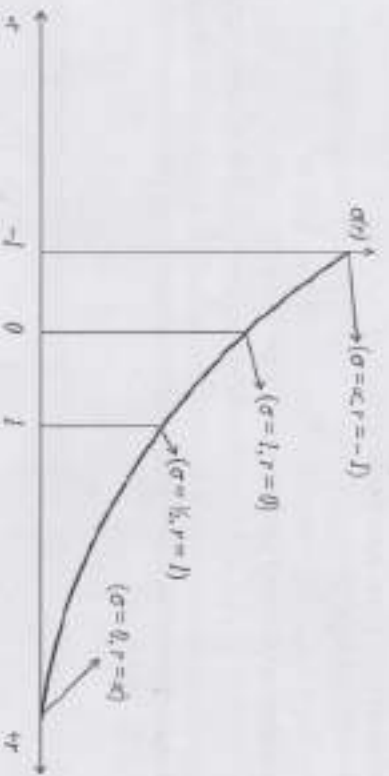


If positively sloping (linear or non-linear) CESIQSCs are substituted for CD/QSCs in figure 3, figure 4 and figure 5 leaving other things intact, it will be evident that the two problems, indicated by subsection 3.1 and subsection 3.2, are equally applicable to the CESPF like CDPF.

On the basis of equation [22] or [24], the 'CES-Curve' can be derived as follows. Since  $E_{L_1} = \sigma = 1/(1+r) = a(r)$ , so  $\sigma'(r) = -a^2 < 0$  and  $\sigma''(r) = 2a^3 > 0$  on the assumption that  $\sigma > 0$ .

This indicates that the 'CES-Curve', which shows the relationship between  $\sigma$  and  $r$ , must be convex to the origin, as shown in figure 7.

Figure 7: CES Curve



### 3.5. Reformulation of LHPF

The objective of this section is to disclose that the implicit form of LHPF can reproduce the basic features of CD, CES and VES production functions. The reproduction of such basic features, which is another basic feature of LHPF, can be executed in terms of Konar's (2009) Isoquant substitution curve (QSC). The implicit form of LHPF:  $X = F(L, K)$  can diagrammatically be represented by an Isoquant map (IQM), which exhibits constant returns to scale (CRS), irrespective of the curvature of the IQM. The three explicit forms of production function (PF), whose basic features can be reproduced by the implicit form of LHPF, are (i) CDPF of Cobb and Douglas (1928), (ii) CESPF of Arrow, Chenery, Minhas and Solow (1961), and (iii) the VESPF of Lu and Fletcher (1968).

Let the implicit form of LHPF be

$$X = F(L, K), \quad (27)$$

which can be rewritten as  $x = t(k)$ ,

$$x = AP = (X/L) / (K/L) = AP, \text{ and } k = (K/L), \quad (28)$$

Equation [27] can also be rewritten as  $X = L t(k)$

$$\text{From equation (29), we get two derivative functions such as (30) and (31):} \quad (29)$$

$$MP_x = F_x = t - kt' = AP_x (1 - k) = AP_x L_x \quad (30)$$

where  $K_x = F_x K/X =$  share of  $K$  in  $X$  and  $L_x = F_x L/X =$  share of  $L$  in  $X$ .

$$MP_x = F_x = t(k) = AP_x K_x \quad (31)$$

From equations (30) and (31) we get:

$$F_x / F_x = m = (t - kt') / t = t' / t(k) \quad (32)$$

which is called "inverse IQSC" of LHPF, while  $k = (t - mt') / t = f(m)$  (33) is called IQSC of LHPF.

From equation (33), we get two derivative functions such as (34) and (35):

$$dk/dm = MIQSC = -t' / t^2 \quad (34)$$

$$k/m = AIQSC = K_x / L_x = kt' / (t - kt') \quad (35)$$

Similarly from equation (32), we get two derivative functions such as (36) and (37):

$$dm/dk = \text{"inverse MIQSC"} = -t' / t^2 \quad (36)$$

$d^2m/dk^2 = (2tt'' - t'^2 t'' - tt' t''') / t^4$ , (37) which is called "slope of inverse MIQSC" of LHPF.

From equations (34) and (35), we get:

$$E_{km} = (dk/k) / (dm/m) = (dk/dm) / (k/m) = (m/k) / (dm/dk) \quad (38)$$

$$= MIQSC / AIQSC = -[t' (t - kt')] / kt^2 = (k) \quad (38)$$

where  $\sigma$  "elasticity of substitution" measured along the IQ, while  $E_{km}$  "m elasticity of  $k$ " measured along the IQSC, though  $\sigma = E_{km}$ .

The trend in with the change in  $k$  can be represented by:

$$d\sigma/dk = d[(m/k) / (dm/dk)] / dk = (m/k) [(1 - \sigma) m / d^2k - (d^2m/dk^2)] / (dm/dk)^2 \quad (39)$$

$$E_{\sigma k} = (dx/x) / (dk/k) = (dx/dk) / (x/k)$$

$$= kt' / t = MP_x / AP_x = F_x K / X = K \quad (40)$$

where  $E_{\sigma k}$  "k elasticity of  $\sigma$ " measured along the AP<sub>1</sub> curve:  $x = t(k)$ . So, the trend in  $k$ , with the change in  $k$  can be given by:

$$dk_x / dk = dE_{\sigma k} / dk = [t' (t - kt') + kt t''] / t^2 = (t' F_x + kt t'') / t^2 = [F_x / AP_x] + (F_{xx} / AP_x^2)] \quad (41)$$

### 3.5.1 Shapes of AP<sub>1</sub> Curve Derived from LHPF

The AP<sub>1</sub> function:  $x = t(k)$  assumes various shapes depending upon the value of  $E_{km}$  and  $t''$ , on the assumption that  $t' > 0$ , which will be obvious from figure 8.

Figure 8: Five AP<sub>1</sub> Curves of LHPF

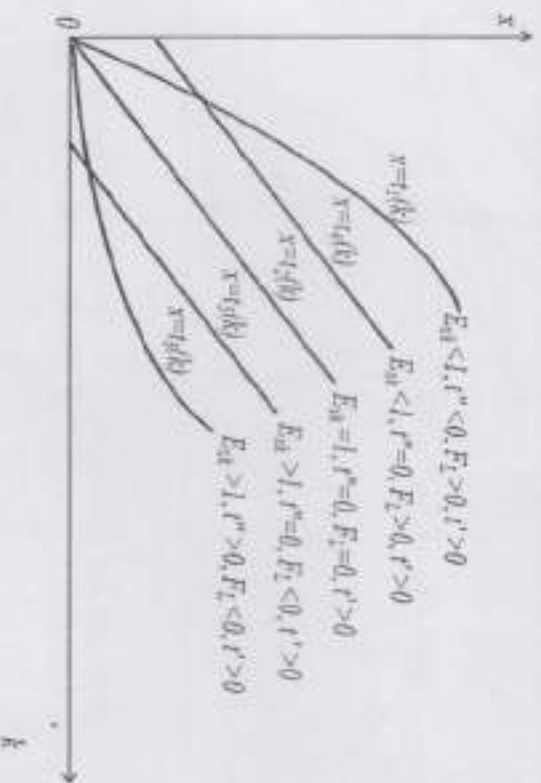


Figure 8 shows that the two AP<sub>1</sub> functions  $t_1(k)$  and  $t_2(k)$  are practically feasible, as  $K_x < 1$  and  $MP_x > 0$ , while the AP<sub>1</sub> function  $t_3(k)$  is theoretically feasible, as  $K_x = 1$  and  $MP_x = 0$ . But the other two AP<sub>1</sub> functions  $t_4(k)$  and  $t_5(k)$  are quite impossible in reality, as  $K_x$  can never be greater than unity and  $MP_x$  can never be negative.

So, for practical purpose, the AP<sub>1</sub> functions  $t_1(k)$  and  $t_2(k)$  can be retained, deleting the rest of the AP<sub>1</sub> functions in figure 8.

### 3.5.2 Shapes of IQSC Derived from LHPF

The slope and curvature of IQSC,  $k = f(m)$ , depends upon  $t'$ ,  $t''$ ,  $t'''$  and, which will be obvious from equations [34], [36], [37] and [38]:

(i) If  $t' > 0$  and  $t'' = 0$ , we get  $dk/dm = \infty$ , which means that the IQSC will be vertical in  $m$ - $k$ -space, which will be consistent with the three  $AP_i$  functions such as  $t_1(k)$ ,  $t_2(k)$  and  $t_3(k)$  in figure 8, irrespective of whether  $E_m = K_1$ . Further, in the case of vertical IQSC, we find that  $\sigma = E_m$  and  $d(k/m)/dk = d(K_1/L_1)/dk > 0$ .

(ii) But, if the  $AP_i$  curve:  $x = t(k)$  is concave to the  $k$ -axis in  $k$ -space (see figure 9), which is possible if  $t' > 0$ ,  $t'' < 0$  and  $E_m = K_1 < 1$ , the  $t'(k)$  function may assume three shapes (see figure 10) depending upon  $t'''(k)$ , for which the IQSC may assume, for example, seven shapes, as shown in figure 11.



Figure 9: Single  $AP_i$  Curve of LHPF



Figure 10: Three  $MP_i$  Curves of Single  $AP_i$  Curve

From equations [34] to [39], and figure 10 and figure 11, the realized results are encapsulated in table 2. Further, the seven IQSCs of LHPF, denoted by  $k = f_i(m)$  [ $i = 1$  to 7] in figure 11 are consistent with the single  $AP_i$  curve in figure 9, from which the derived outcomes are also displayed in table 2.

But, table 3 shows the results, which are derived from figure 8, and equations [40] and [41].

Figure 11: Seven IQSCs of LHPF

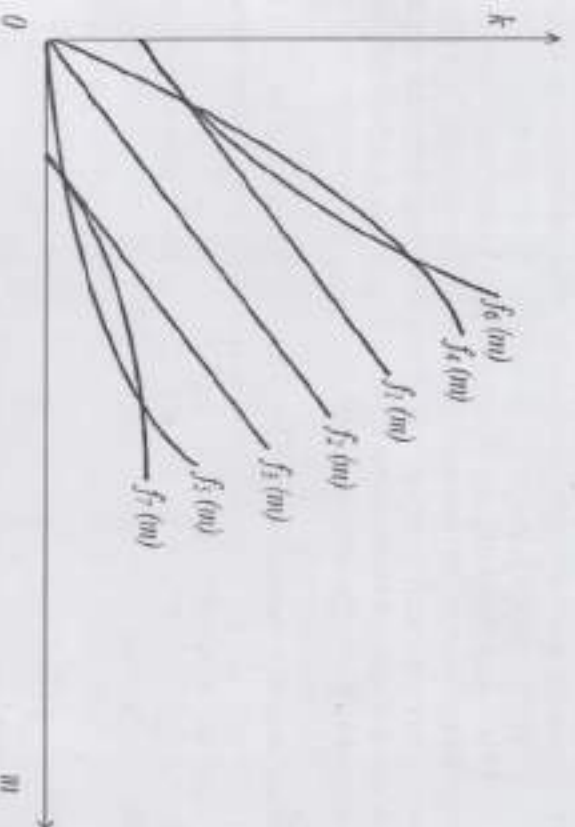


Table 2: Features of Seven IQSCs of LHPF

IQSC: $k = f(m)$ in figure 11	Value of $E_m$	$d/dk$	$f''(m)$	$dm/dk$	$d^2m/dk^2$	$t'(k)$	$t''(k)$	$t'''(k)$	$d(K_v/L_v)/dk$ or $d(f(k)/m)/dk$	Nature of PF
$f_1(m)$	$< 1$	$> 0$	$= 0$	$> 0$	$= 0$	$> 0$	$< 0$	$> 0$	$< 0$	VESPF
$f_2(m)$	$= 1$	$= 0$	$= 0 > 0$	$< 0$	$= 0$	$> 0$	$< 0$	$> 0$	$= 0$	CESPF, CDPF
$f_3(m)$	$> 1$	$< 0$	$= 0$	$< 0$	$= 0$	$> 0$	$< 0$	$> 0$	$> 0$	VESPF
$f_4(m)$	$< 1$	$\approx 0$	$< 0$	$> 0$	$> 0$	$> 0$	$< 0$	$\approx 0$	$< 0$	CESPF, CDPF, VESPF
$f_5(m)$	$> 1$	$\approx 0$	$> 0$	$> 0$	$< 0$	$> 0$	$< 0$	$> 0$	$> 0$	CESPF, CDPF, VESPF
$f_6(m)$	$< 1$	$> 0$	$< 0$	$> 0$	$< 0$	$> 0$	$< 0$	$> 0$	$< 0$	VESPF
$f_7(m)$	$> 1$	$< 0$	$< 0$	$> 0$	$> 0$	$> 0$	$< 0$	$\approx 0$	$> 0$	VESPF

Table 3: Features of Five APL Curves of LHPF

APL Curve: $x = t(k)$ in Figure 8	$AP_v = t'(k)$	$MP_v = AP_v \cdot x / F_v$	$AP_v = x / k$	$MP_v = F_v \cdot F_{xx} = t''(k)$	$F_{xx} = t''(k)$	$E_v = K_v = L_v = MP_v / AP_v$	$L_v = MP_v / AP_v$	$dK_v/dk$	$dL_v/dk$
$t_1(k)$	$> 0$	$> 0$	$> 0$	$> 0$	$< 0$	$< 1$	$< 1$	$\approx 0$	$\approx 0$
$t_2(k)$	$> 0$	$= 0$	$> 0$	$> 0$	$= 0$	$= 1$	$= 0$	$= 0$	$= 0$
$t_3(k)$	$> 0$	$< 0$	$< 0$	$< 0$	$< 0$	$> 1$	$> 0$	$\approx 0$	$\approx 0$
$t_4(k)$	$> 0$	$> 0$	$> 0$	$> 0$	$= 0$	$< 1$	$< 1$	$> 0$	$> 0$
$t_5(k)$	$> 0$	$< 0$	$< 0$	$< 0$	$= 0$	$> 1$	$> 0$	$> 0$	$> 0$

### 3.6. Conclusion

The reformulation of the three production functions such as CDPF, CESPF and LHPF in terms of Konar's (2009) methodology indicates a departure from traditional, received or established framework. So, potential controversy or criticism can not be ruled out, that is why a Nobel laureate economist said: "If, however, a new theory falls outside established paths, it is certain to face general opposition whatever its justification. For all these reasons, it is essential to subject 'established truths' constantly to a critical analysis without indulgence" (Allais, 1997). Noteworthy that Konar's (2009) methodology can also be applied to "similar neglected fronts" in the conventional theories of economic(s) education.

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हिंदी कहानीकारों में शैलेश मटियानी एक सुपरिचीत नाम है। हिंदी कथा साहित्य में प्रेमचंद की परंपरा को आगे बढ़ानेवाले मुकम्मल कथाकारों में निर्विवाद रूप से इनका नाम सबसे आगे लिया जाता है क्योंकि प्रेमचंद के बाद हिंदी कहानी-भंडार को अगर किसी ने अपनी विपुल सृजनात्मक वैभव से सम्पन्न किया तो वे शैलेश मटियानी ही हैं। इनके रचना-भंडार में मौजूद ३० कहानी-संग्रह इसका प्रमाण है। ऐसा भी नहीं है कि प्रेमचंद के बाद केवल कहानियों की संख्या के आधार पर इनको यह पद दिया गया है, बल्कि कहानियों की विपुल संख्यकता के बावजूद भी इनमें कहीं भी एकरसता एवं विषय की पुनरावृत्ति का दोष नहीं मिलता है। इसके अतिरिक्त इन्हें प्रेमचंद के बाद उनकी परंपरा का सबसे बड़ा कथाकार मानने का एक तर्क यह भी है कि इन्होंने अपने समय में कथा लेखन में नवीनता के लिए अन्य समकालीन अधिकांश कथाकारों की तरह अनुभवों और विचारों की जूठन बटोरने के लिए विदेशों में भ्रमण नहीं किया बल्कि प्रेमचंदीय परंपरा के अनुरूप एक भारतीय कथा-परंपरा की खोज में जुटे रहने का काम किया ताकि उन कहानियों के साथ-साथ भारतीय जीवन के निरंतर बदलते हुए यथार्थ और जातीय स्मृति का खजाना भी सुरक्षित होता चला जाए - " यही समझ में आता है कि जिस वक्त हिंदी के ज्यादा कथाकार अनुभवों और विचारों की जूठन बटोरने के लिए विदेशों की ओर भाग रहे थे, उस समय मटियानी यहाँ की मिट्टी के दुखों और गौरव को छानते हुए, उनके बीच किस तरह एक भारतीय कथा-परंपरा की खोज में जुटे थे और उन्होंने जो कुछ लिखा, उसमें कहानियों के साथ-साथ भारतीय जीवन के निरंतर बदलते हुए यथार्थ और जातीय स्मृति का कितना बड़ा खजाना सुरक्षित होता गया है। " 1

कथाकार अपने समाज का कुशल चिन्तेरा होता है। वह अपने इर्द-गिर्द के समाज को सम्पूर्ण संवेदना के साथ अपनी रचनाओं में चित्रित करता है। वह एक ओर समाज से संवेदित होता है तो दूसरी ओर अपनी रचनाओं से समाज को विरचित व संवेदित करने का भी महत्वपूर्ण कार्य करता है। तिसपर जब बात उस कथाकार की हो, जिनमें बाबा नागार्जुन को मैक्सिम गोर्की दिखता हो तो उनकी कहानियों में संवेदना की सांद्रता का आधिक्य स्वतः ही सिद्ध हो जाता है। किसी कथाकार की कहानी में संवेदना की सांद्रता का आधिक्य का उद्रेक ऐसे ही आनायास नहीं हो जाता है बल्कि दम तोड़ती जीवन से संघर्ष कर किसी तरह जी लेनेवाले समुदाय के साथ रहकर मिले जीवनानुभूति से ही संभव हो पाता है और इस जीवनानुभूति से शैलेश मटियानी संपृक्त थे। शैलेश मटियानी की कहानियों का अनुशीलन करने पर हम पाते हैं कि उनकी कहानियों में मूलतः दो समाज रचता-बसता है- 1. कुमायूँ का पार्वत्य-समाज 2. बम्बई-महानगरीय हाशिये का समाज। इस संबंध में उनका खुद का ही कहना है - "एक ओर मेरा अभिष्ट कुमायूँ के जनजीवन, वहाँ की संस्कृति और लोक-साहित्य को उनके अस्तित्व और उनकी आत्मा के अनुरूप शब्द-शिल्प देकर, उन्हें हिन्दी साहित्य के विशाल सागर तक ले आना... तो दूसरी ओर मैं बम्बई के फुटपाथों, कमाठीपुरा के कोठों में चिलबिलाने-बिलखनेवाली बेटियों और गणपत रमन्ना भाऊ तथा उस्ताद पोपटों की अपनी बिरादरी के प्रति वैयक्तिक और साहित्यिक दायित्वों के साथ बँधा हुआ हूँ।" 2

कुमायूँ के पार्वत्य समाज में जन्मे व बाल्यकाल तक पले-बढ़े शैलेश मटियानी को लेखक बनने की चाह के बरक्स अपना गुजारा करने के लिए काम की तलाश ने मुंबई महानगर के गजालत से भरे हाशिये के समाज में लाकर खड़ा कर दिया था। इसके बावजूद भी उनके लेखक बनने की चाह कभी भी खत्म नहीं हुई क्योंकि उनका मानना था - "कोई लेखक जितने कष्ट सहता है, उतना ही बड़ा उसका लेखन होता है।" 3 कहने का तात्पर्य है कि लेखक का वास्तविक जीवनानुभव जितना विशाल होगा, उसका लेखन उतना ही उच्च कोटि का एवं विविधतापूर्ण होगा। यही कारण है कि पार्वत्य समाज के साथ-साथ मटियानी ने मुंबई महानगर में अपने द्वारा भोगे हुए यथार्थ व बहुत करीब से देखे हुए सर्वहारा वर्ग के समाज को भी अपनी कहानियों में काफी जीवंतता के साथ चित्रित भी किया है। सर्वहारा वर्ग कहने का तात्पर्य समाज के हाशिये पर जी रहे चोर-उचक्के, पाकेटमारों, भीखमंगों के समाज से हैं, जिसके बीच मुंबई में उनका जीवन कटा था। इस वर्ग के समाज को चित्रित करनेवाली मटियानी की प्रमुख कहानियों में 'मिट्टी', 'प्यास',

'भय', 'इब्बूमलंग', 'दो दुखों का एक सुख', 'एक कोप चा : दो खारी बिस्किट', 'चील', 'महाभोज', 'रहमतुल्ला', 'अहिंसा', 'इल्लेस्वामी' आदि हैं।

'मिट्टी' कहानी एक भिखमंगे(टुंडे लालमन) और उसके साथ रहनेवाली गनेसी की है। लालमन बिमार है। गनेसी उसे हाथठेले में बिठाकर भीख माँगती है। अपनी बीमारी के कारण लालमन लगातार छीज रहा है। उसे बार-बार निबटने की जरूरत महसूस होती है; परन्तु इस हालत में भी उसकी स्वादिष्ट भोजन खाने की इच्छा कम नहीं होती। गनेसी परेशान है। जितना कुछ भीख में मिलता है उससे लालमन की दवाई एवं खाने-पीने का खर्च किसी तरह निकल जाता है। इस कारण गनेसी कल्पित चिनी की बीमारी का खाका लालमन के आगे खिंचती है ताकि उसका दही-जलेबी खाना छूट जाए। यह प्रेम की अतिशय करुणा और स्थितियों के त्रास से उपजी विरक्ति की कहानी है। इसमें एक ओर तो हिन्दुस्तान के गजालत से भरे तबके का यथार्थ है जो लंबे समय से आजाद भारत की सच्चाई की कलाई खोलकर हमारे सामने रख देता है तो दूसरी ओर गनेसी जैसे गरीब पात्रों की चारित्रिक उज्ज्वलता को भी प्रेषित करता है।

'प्यास' कहानी एक जेबकतरे शंकरिया की कहानी है जिसे जिंदगी के आभाव और अंतहीन तकलीफों ने अपराध की दुनिया में धकेल दिया है। अब वह एक जेबकतरा बन गया है। इस पर भी उसकी तकलीफ खत्म नहीं होती है। एक तरफ तो उसे जेबकतरा नाम की गाली को ढोने का कष्ट है तो दूसरी ओर जेबकतरई के दौरान मिली पिटाई की तकलीफ भी। एक बार सोने की चैन झपटने के दौरान पकड़े जाने और बेदम पब्लिक पिटाई के बाद जब वह अपने को बचाने के उद्देश्य से स्वयं को पलिस के हवाले कर देता है तो फिर उसे पुलिस-तंत्र का दिल दहला देनेवाला घोर अमानवीय व्यवहार को झेलना पड़ जाता है। वह अपने को आवारा कुत्तों से घिरा हुआ बछड़ा सा महसूस करता है और मुर्छित हो जाता है। इस तरह के अति अमानवीय व्यवस्था-तंत्र के प्रतिकार में शैलेश मटियानी का कहना है - "मैं यह नहीं कहता कि एक आदमी को किसी दूसरे आदमी का जेब काटने, चोरी करने या गुंडागिरी फैलाने की छूट होनी चाहिए; मगर मैं यह जरूर कहना चाहता हूँ कि जो सरकार अपने लाखों नागरिकों के लिए रोजी-रोटी की व्यवस्था करने में अपने को निकम्मा पाती हो, उसे ऐसे किसी भी कानून को बनाने का अधिकार नहीं है जो भुखमरी और बेकारी से मजबूर इंसान को रोजी-रोटी देने की जगह नृशंस यंत्रणाएँ देते हों।" 4

'मिट्टी', 'प्यास' की तरह जिन्दगी की तलछट में एकदम गहरे धँसे मटियानी की एक और हृदयबेधक कहानी है 'भय'। इस कहानी में जिंदगी की मजबूर शक्ल को बचाये रखने की चिंता इतनी बड़ी हो जाती है कि उसके आगे नैतिक-अनैतिक,

पाप-पुण्य जैसे सवाल खोखले और बेमानी नजर आने लगते हैं। जहाँ जिन्दगी का सबसे बड़ा भय कोई भूत या दानव नहीं बल्कि आनेवाला कल है, जो अपने साथ भूख की दहशत लिए लगातार पास खिसकता आ रहा है। इसलिए तथाकथित अपराधी समझे जानेवाले कथावाचक की जेब में पड़ा चाकू कोई हथियार नहीं, बल्कि भूख और भय से लड़ने का औजार अधिक है। यही मजबूरी ननकू की घरवाली को एक लावारिस लाश(सीताराम) के पास बैठकर करुणा बटोरने का नाटक करने को उकसाती है। लास के पास बैठे, जोर-जोर से विलाप करती स्त्री को लोग उसकी विधवा समझकर पैसे दे जाते हैं और नाटक खत्म होते ही ननकू की घरवाली लाश पर से पैसे और सीताराम पर ओढ़ाई चादर उठाकर चल देती है। इस अमानवीय कृत्य को दर्शाते हुए मटियानी जी कहते हैं- " सीताराम की लाश पर से चादर हटा लेने के बाद, चुपचाप भाग जाने में दहशत होने का ख्याल उसे दबोच रहा हो- ऐसा भी नहीं है। "5

'इब्बूमलंग' मुंबई के कूड़े के ढेर में गजालत की जिंदगी बितानेवाले इबादत हुसैन का इब्बूमलंग(छद्मी फकीर) बनने की कहानी है और साथ ही हृदय की पुकार पर छद्म फकीरी का चोला उतारते इब्बूमलंग का फिर से इबादत हुसैन बनने की कहानी भी। कहानीकार ने इस कहानी में इबादत हुसैन का इब्बूमलंग(छद्मी फकीर) बनने की प्रक्रिया में शामिल प्रत्येक शक्ति का शिनाख्त करने की कोशिश की है। होटल के जुठे पत्तलों को धोकर मेहनताने में मिलनेवाले चरस की गोलियाँ खाकर दिन बितानेवाले इबादत हुसैन का इस्तेमाल भी धर्म के ठेकेदार(अपराधी नागप्पा) किस बखूबी अंदाज से करते हैं; इसका जीवंत दस्तावेज है यह कहानी। दरअसल इस बात को झुठलाया नहीं जा सकता है कि मुंबई जैसे महानगरों में केवल छद्मी बाबा ही नहीं बल्कि अपराध जगत से जुड़े लोग भी पैसा कमाने के लिए धर्म की ठेकेदारी करने से भी नहीं चुकते हैं। उन्हें यह अच्छी तरह से पता होता है कि यह आसानी से लोगों को मुर्ख बनाकर पैसा कमाने का सबसे सहज धंधा है। इसलिए वे महानगरों की इन झोपड़पट्टियों में इबादत हुसैन जैसे लोगों को ढूँढ़कर उसके मुँह से निकली गालियाँ एवं उसकी अश्लील हरकतों को सट्टे के नंबरों के साथ जोड़कर अपनी साधने में लगे रहते हैं। कहानीकार ने इस कहानी में वक्त के थपेड़ों से मार खाकर लानत की जिंदगी जीनेवालों को घोर अमानवीय कृत्य करनेवाले मशीनों में तब्दील करनेवाली अति चालाक शक्तियों की शिनाख्त करने के बरक्स यह भी बताने की कोशिश की है कि भले ही ऐसे पात्र धर्म के ठेकेदारों द्वारा बनाये जाल में कुछ समय के लिए फँस जाते हैं पर बाद में इनमें से इबादत हुसैन जैसे कुछ लोग इससे बाहर निकल भी आते हैं क्योंकि उसके अंदर की मानवीय भावना पुरी तरह सुख नहीं जाती है।

'दो दुखों का एक सुख' शरीर से अशक्त तीन भिखारियों - मिरदुला कानी, अंधा सूरदास और कोढ़ी करमिया के जीवन संघर्ष की अद्भूत कहानी है। यह एक ओर दारुण अभाव की जिंदगी जी रहे इन पात्रों की अद्भूत जिजीविषा की कहानी है तो दूसरी ओर अपने प्रेमी(अंधा सूरदास) के प्राणों की रक्षा के बरक्स अपनी देह तक से समझौता करती बेबस और लाचार मिरदुला कानी की कहानी भी है। इस बात को नकारा नहीं जा सकता है कि जीवन के तमाम अभावों में भी इतनी ताकत नहीं होती है कि प्रेम की भावना को दबा दें। कहानी के पात्रों की भी यही स्थिति है। उनमें प्रेम त्रिकोण बना हुआ है। अंधा सूरदास और कोढ़ी करमिया दोनों मिरदुला कानी को पाना चाहता है। अंधा सूरदास और कोढ़ी करमिया में झगड़ा हो जाता है और अंधा सूरदास को इस झगड़े का खामियाजा यह भुगतना पड़ता है कि उसे कोढ़ी करमिया के घर से बेघर होना पड़ता है। पर जब कोढ़ी करमिया को इस बात की जानकारी मिलती है कि जगत मिस्त्री सूरदास व मिरदुला को आश्रय देने के नाम पर उन्हें अमानवीय यंत्रणाएँ देता है तो उसे काफी ग्लानि होती है और वह उन्हें पुनः आश्रय देता है। पति सहित आश्रय पाने के एवज में मिरदुला को जगत मिस्त्री के अमानवीय यंत्रणा की तुलना में करमिया से अपनी देह का समझौता करना सह्य लगता है और वह सूरदास और करमिया के बीच नदी सी बह जाती है। बहने के क्रम में वह माँ बन जाती है। उस घोर अंधियारे की जिंदगी में एक संभावनामय नये जीवन को विकसित होते देखने की लालसा सूरदास और करमिया के हृदय को मिला देता है। कुल मिलाकर अंत में कहानी मनुष्य की लालसाओं एवं दुर्बलताओं का चित्रण करनेवाली एक अद्भूत संवेदनात्मक तीव्रता की कहानी बन जाती है। यही कारण है कि प्रकाश मनु इस कहानी को हिंदी साहित्य कालजयी कहानी मानते हुए कहते हैं - " 'दो दुखों का एक सुख' न सिर्फ मटियानी की कालजयी कहानी है, बल्कि यह हिंदी की उन शिखरस्थ कहानियों में से है जिनसे इनकी शक्ति और उँचाई को नापा जा सकता है। सच तो यह है कि अगर मटियानी ने सिर्फ यही एक कहानी लिखी होती तथा कुछ और न लिखा होता, तो भी वे इतने बड़े कहानीकार होते कि इनकी चर्चा के बगैर ह्दी कहानी का इतिहास नहीं लिखा जा सकता था। "6

मटियानी की 'एक कोप चा : दो खारी बिस्किट' मुंबई की फूटपाथी जीवन पर लिखित एक अद्भूत कहानी है। यह दो फूटपाथी प्रेमीयुगल रमन्ना और नसीम की कहानी है। कहानी की सबसे बड़ी खासियत यह है कि पुरी कहानी की पृष्ठभूमि ही मुंबई नहानगर के हाशिये में पड़ी भूखमरी, बेकारी व गंदगी की बजबजाती अंधेरी दुनिया है, जिसमें रमन्ना और नसीम की जिंदगी जुगनु की तरह जलती-बुझती दिखाई पड़ती है। पर जब कहानी में नसीम का प्रसंग आता है तो वहाँ कहानी रोंगटे खड़े कर देनेवाला बन उठता है क्योंकि वहाँ हमें नसीम(फूटपाथी औरत) अपनी पेट

की भूख मिटाने के लिए एक कप चाय व दो खारी बिस्किट के बरक्स अपने जिस्य का सौदा तक करने की मजबूरी और दुःख को व्यक्त करने के लिए रमन्ना से कहती हुई मिलती है - " हम औरत लोगों की जिंदगी भी क्या बदनसीब...में भी कैसी बेशरम हूँ ? रोटी के लिए बोसे भी देना और बोटियाँ भी...थू है ऐसी जिंदगी पर । "7 वास्तव में मटियानी जी ने कहानी के इस चित्र की प्रस्तुति के द्वारा हमारे तथाकथित विकसित समाज के मुँह पर करारा थप्पड़ मारकर मानवीयता की भावना को जगाने के बरक्स पाठकों के हृदय को झकझोरते हुए लज्जित करने का ही काम किया है क्योंकि उनके अनुसार जिस समाज में अपनी पेट की क्षुधा मिटाने के लिए एक गरीब और मजबूर औरत को महज एक कप चाय व दो बिस्किट के भरक्स अपनी देह का सौदा करना पड़े, उसे स्वयं को विकसित कहने का भौंडा मजाक तो नहीं ही करना चाहिए । मटियानी जी को इस नारकीय स्थिति को मिटाने को रास्ता संघर्ष को ही मानते हैं । मटियानी जी को विश्वास है कि इस फूटपाथी नारकीय स्थिति को बदलने का बीड़ा स्वयं इसी वर्ग को ही उठाना पड़ेगा क्योंकि उच्च वर्ग को इससे कोई लेना-देना न था, न है और न रहेगा ही । यही कारण है कि मटियानी जी ने कथा के अंत में रमन्ना को नसीम को हवस का शिकार बनने से बचाने के लिए वर्दीधारी हवलदार का गला दबोचते दर्शाया है । वास्तव में देखा जाये तो कहानी को पढ़ते हुए यहाँ आकर हर पाठक की मनःस्थिति ही हवलदार का गला दबोचनेवाली ही बन जाती है; जो दरअसल हमारी सामाजिक व्यवस्था और सरकारी नीतियों का गला दबोचने की इच्छा को ही बयां करती नजर आती है ।

मटियानी की 'रहमतुल्ला' कहानी में मैली जिंदगी की विडम्बना के साथ-साथ धार्मिक विडम्बनाएँ भी घुल-मिल गई है । यह एक अनाथ लड़के की कहानी है जो अक्सर मस्जिद की सीढ़ियों पर बैठा दिखाई देता है । वह एकदम मैला, गंदा, भौंडा दिखनेवाला अनाथ लड़का है । उसके साथ धर्म के पचड़े, गरीबी और एकाध घमत्कारिक घटना जुड़कर शुभ-अशुभ का ऐसा तालमेल बना देती है कि लोग उससे दूर रहने में ही भला समझते हैं । रहमतुल्ला के पिता मुसलमान व माँ हिन्दू थी । इसलिए वह कभी हिन्दू तो कभी मुसलमान की ओर खिसकता दिखाई देता है । वास्तव में हिंदू-मुसलमान प्रसंग के मार्फत इस सच्चाई से पाठकों को अवगत करवाया है कि गरीबी इंसान का इतना बड़ा अभिशाप है, जिससे हिन्दू या मुसलमान सभी को बदबू आती है । यह कहानी हिन्दू और मुस्लिम धर्म के (मानवीयता के) स्वनामधन्य ठेकेदारों के माथे पर सवालिया निशान लगाती प्रतीत होती है ।

निष्कर्षतः हम कह सकते हैं कि शैलेश मटियानी की कहानियों में मुम्बई नगर के हाशिये का समाज अपने बजबजाते यथार्थ के साथ चित्रित हुआ है । इस समाज से जुड़ी इनकी कहानियों की सबसे बड़ी विशेषता यह है कि इनमें लेखक का अन्य

लेखकों की तरह सहानुभूतिपूर्ण रवैया के बजाय स्वानुभूतिपूर्ण रवैया ही सर्वत्र उद्घासित होता नजर आता है। कहने का तात्पर्य है कि इनकी कहानियों में सर्वत्र भोगा हुआ यथार्थ ही दिखाई पड़ता है। यह कहना समीचीन होगा कि इनकी कहानियों में व्यक्त सामाजिक जीवन का यथार्थ भारतीय समाजिक-व्यवस्था एवं सरकारी नीतियों पर कुठाराघात करता है तथा समाज के उपेक्षित वर्ग, हाशिये पर पड़े वर्ग व परम्परागत पुरुष मानसिकता के शोषण तले दबी स्त्री वर्ग के अंतिम इकाई तक को लड़ने की शक्ति प्रदान करता है। यही कारण है कि प्रकाश मनु इन्हें हाशिये के लोगों को प्यार करनेवाला हिंदी का सबसे बड़ा लेखक मानते हैं - "सच तो यह है कि दलितों व निचले वर्ग के लोगों से प्यार करनेवाला उनसे बड़ा कोई और लेखक हमारे बीच हुआ ही नहीं।" 8

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# NATIONAL SERVICE SCHEME

Perspectives, Transformation  
and Prospects

Savita Mishra | Sudip Bhui





# **National Service Scheme**

## **Perspectives, Transformation and Prospects**

**Dr. Savita Mishra**  
**Dr. Sudip Bhui**



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## Children Education during COVID-19 Pandemic and Related NSS Activities

Dr. Tarun Kumar Barik

### Abstract

During the COVID-19 Pandemic, we are facing a serious living and learning crisis. Children and youth of primary, secondary and higher secondary school age were out of school. Actually, COVID-19 threatens the education system from a bad to worst situation day-by-day and creates a gigantic shock to all education systems in our lifetimes. We have here different crisis and approach to recover children's education system from this hazardous emergency situation and related NSS activities have been summarised in this chapter. The schools, colleges and universities need proper master plan to start reopening and stabilising the education system slowly but more carefully. The present analysis suggests to emphasis on the maintenance of hygiene level, following digital systems and regular basis online counselling of school children are required on priority basis. School authorities are most responsible to upgrade their digital systems timely and make a long-term resilience in our education system. NSS volunteers play a prime role to spread the awareness through online and one to one personal communication about the importance of hand hygiene, respiratory hygiene, social distancing, importance of mask wearing in the public places and also the importance of COVID-19 vaccination.

**Keywords:** COVID-19; Hygiene, Online Education, NSS.

### Introduction

The shocking Pandemic outbreak of Corona virus disease—2019 (COVID-19) is a severe threat to our human society. COVID-19 is caused by a new type Corona virus, SARS-CoV-2 (Severe acute respiratory syndrome Coronavirus-2) and in the case of infection, most of the people fall sick with mild to moderate symptoms. It becomes deadly serious when virus transmitted to lungs and subsequently occurred complications like acute respiratory failure. The virus spread easily among people by person to person contact (within about 6 feet, or nearly 2 metres), by the droplets released from coughing, sneezing or talking of infected person. Till now, COVID-19 patient's complications, risk factors and prevention strategies are announced and well-documented. Researchers through worldwide have already discovered COVID-19 vaccines; most of them have completed phase-3 clinical trials successfully. Doctors are trying to manage the symptomatic treatment to increase the recovery rate. However, whole World is following the lockdown based option of prevention strategy by staying home as much as possible to stop the spreading in our community. It is recommended to work from home. It is going for long days that will make an immense problem in our society or nation. This is the era of World Wide Web (www), where maximum work can complete by the help of web-based technologies. Therefore, the educational systems have the major role in this period to grow up our nation in a required standard.

The Post-COVID emergence or ongoing the Pandemic scenario have multidirectional consequences on various spheres of life apart from deterioration of human health. The economical cost associated with COVID-19 Pandemic is very high as it inferred from high costs of medical and intensive care, loss of productive working days, major impact on travel and tourism, ban on export of agricultural product from affected regions, etc. Similarly, if the growths of educational systems become weaken that can't be compensated by means of anything else. Students' mental health is also very much important for his learning, appearance and attitude. In this critical situation, the roles of teachers are

extraordinarily important to save our student's health and growth our nation.

### **Sharing of Knowledge on Health and Hygiene**

Hygiene is the attitude, behaviour and practices for the protection of health consequently healthy living. Poor health hygiene practices are the major cause of several communicable diseases. In developing countries, the primary causes of morbidity and mortality among young or school children are the acute respiratory and intestinal infections [1]. School is the only place where students acquire not only education but also provoke their attitude, behaviour and environment. The United Nations Children's Fund (UNICEF) confirmed that knowledge, attitudes, and practices (KAP) are the basic principle of hygiene. Simple hygienic process by washing hands with soap is poorly practised in India and almost no culture in any school, college or university systems. It is necessary to prepare new hand washing facilities including enough knowledge in awareness which may lead to some changes in behaviour and attitude. Lack of resources like soap, sanitising material, and very poor sanitising system in educational institutes in India may be the main reasons not to develop their attitude and behaviour.

Recent awareness regarding the Pandemic outbreak of Corona virus disease (COVID-19) is extremely important due to its pathogenic and contamination nature because it is caused by a virus, SARS-CoV-2. Currently, COVID-19 has caused global health concern. Human to human transfer by contact or through the aerosols from sneezing and coughing is widely confirmed. To reduce the transmission of current outbreak, lockdown emergency is going on including banned the international and domestic flights and social distancing, etc., World Health Organization (WHO) gives a general advice on how to comply with 'social distancing' while also fulfilling family and work responsibilities and provides guidance on the hygiene measures to protect someone from infected patients. All the students must have to follow the points in future and make their attitude to continue with these habitats:

- Wash hands with soap and water before and after meal for at least 20 seconds.

- Wash hands with soap and water after toilet and urination.
- Maintain good respiratory hygiene (covers mouth and nose when coughing or sneezing and immediately disposes of tissues and wash hands).
- Use alcohol-based (>70%) hand sanitisers when necessary.
- Provide basic knowledge about how sanitisers and soap kills the virus (SARS-CoV-2).
- Avoid touching eyes, nose and mouth.
- Clean and disinfect surfaces you use often such as bench tops, desks and doorknobs.
- Increase the amount of fresh air by opening windows or changing air conditioning
- Frequent cleaning of work surfaces and touch points such as door handles etc.
- Use mask when it is necessary to go outside.

The maintenance of personal hygiene is of great importance to decrease the trouble of not only COVID-19 but also from any other infectious diseases.

### **Emphasis on Home School**

Recently, the COVID-19 Pandemic has altered the education system all over the world. Globally, due to Pandemic situation, billions of students are out of their usual classrooms teaching. As a result, education has changed noticeably, with the characteristic rise of e-learning, whereby teaching is undertaken remotely on digital platforms. Recent research suggests that online learning has been shown to increase retention of information, and take less time [2]. While some peoples believe that the unplanned and rapid move to online learning—without proper training, insufficient bandwidth, and little preparation—will result in a poor user experience that is un-conducive to sustain growth. On the other hands, others believe that a new hybrid model of digital education will emerge with significant benefits. According to Wang Tao, Vice-President of Tencent Cloud and Vice-President of Tencent Education "The integration of information technology in education will be further accelerated and that online education will eventually become an integral component of school



education". Again, according to Dr. Amjad, a Professor at the University of Jordan, who has been using Lark to teach his students, says, "It has changed the way of teaching. It enables me to reach out to my students more efficiently and effectively through chat groups, video meetings, voting and also document sharing, especially during this Pandemic. My students also find it is easier to communicate on Lark. I will stick to Lark even after Corona virus, I believe traditional offline learning and e-learning can go hand by hand" [2]. There are, however, challenges to overcome online learning. Some students without reliable Internet access and/or technology struggle to participate in digital learning; this gap is seen across countries and between income brackets within countries. Hence, schools, college, university or government authorities should think about this matter seriously in near future for uniform e-learning [2]. For those, who do have access to the right technology, there is evidence that learning online can be more effective in a number of ways. Some research shows that on average, students retain 25-60 per cent more material when learning online compared to only 8-10 per cent in a classroom. This is mostly due to the students being able to learn faster online; e-learning requires 40-60 per cent less time to learn than in a traditional classroom setting because students can learn at their own swiftness, going back and re-reading, skipping, or accelerating through concepts as they choose [2]. But the effectiveness of online learning varies amongst age groups. BYJU's Mrinal Mohit says, "Over a period, we have observed that clever integration of games has demonstrated higher engagement and increased motivation towards learning especially among younger students, making them truly fall in love with learning". It is clear that this Pandemic has completely disrupted the education system, while some worry that the hasty nature of the transition online may have hindered the goal, others plan to make e-learning part of their 'new normal' after experiencing the benefits first-hand [2]. Like, e-commerce post-SARS, it is yet to see an inflection point for rapid innovation occurs in case of e-learning post-COVID-19.

The horror of COVID-19 outbreak has shut-down schools, colleges and universities in India. Preliminary data analysis about online teaching indicates that it is a non-starter for most students and institutions in India. Maximum students of India comes from

backward class of rural or urban area, where less possibility of access home Internet. Actually, it is easy to connect to one set of students, reaching others through the Internet would be tough. The digital divide should be evident in teaching resources but every student must have access to it. Few privileged educational institutions in India have good platform of e-learning because of their maximum students come from a creamy society but other have to struggle with inequality for successful implementation of digital drive of e-learning at home. However, Internet access at home is pitifully low in India. This is a combination of low Internet coverage in India as well as the fact that many households do not own smart phones that can get them on the Internet. As the COVID-19 infections rise in India, and there is justified pressure to keep educational institutions closed, one must be mindful of these numbers when suggesting online teaching. While the long-term strategies may involve increasing ethernet connectivity, or subsidising data on mobiles, it would seem that device ownership is as much a worry, especially for children coming from rural places. If universities remain closed for a long time, it is important for the universities to subsidise cheap smart phones for students to get on with the business of teaching. This is in addition to any subsidies that need to be paid for bandwidth (assuming that it is a surmountable problem). Without such help, online teaching is a non-starter for most institutes of India. Central-and state-governments, different NGOs and every hearty peoples of India should come forward and work together to solve this inequality in the post Pandemic situation and should fulfil the dream of digital India.

At the time of nationwide lockdown schools, colleges and universities are depending on the online mode of teaching in order to maintain the continuity of education. Schools are launching apps, conducting classes over Google meet/ Google Hangouts/Zoom/Teams, and sending interactive worksheets and videos for learning in WhatsApp or facebook groups. Even though Internet-based teaching is the most appropriate stop-gap arrangement now, it has highlighted the inequalities in the education system in major portion of India. A majority of the student population is being left out in the pursuit of basic education. Many schools, colleges and universities of India are

using WhatsApp or facebook groups, to connect to their students or guardians. Teachers have been asked to make WhatsApp group of all parents in their respective classes and send those lessons so that students can learn at home. Teachers are taking help from the central government's digital learning portal DIKSHA, which has lessons in multiple languages for all classes from primary to UG/PG. Some teachers are also making videos on practical concepts and these videos are then shared on the WhatsApp groups to connect to their students. As for example, nearly 50 per cent school students (of class-V to Class-XII) and 75 per cent college or university students of Medinipur municipality, Paschim Medinipur, West Bengal, India are accessing this facility. The students below the class-V of the above locality have accessed e-learning facilities only 20 per cent. On the other hand, the situation of rural students of Paschim Medinipur district is very bad compared to students of urban area [This is the approximate data survey by the author in his district]. Table-1 shows the list of e-learning resources, platforms and educational applications to help parents, teachers, school/college/university administrators, and students during the COVID-19 outbreak [3].

### **Resource Generation by Teachers**

School teachers have to be more conscious about their teaching and course work generation. It may not be the same as in practical class teaching. School teachers can sign up to provide their teaching material to enrolled students with full and free access or make web-based industry partners. They must be careful about a long-term plan for web-based virtual learning classes and accordingly design their course work. Few important points are discussed below to sharing the knowledge and resource management—

- **Design an Online Course:** Develop online course tutorial for classroom, planning and designing online lessons following modern and advanced educational tools.
- **Be an Online Tutor:** Self-practice necessary training to teaching about online education processes. Follow several online teaching modules like Online Learning Technology Landscape, e-learning management tools, and communication and creation tools.

- **Directory of Open Educational Resources:** There are over 7000 resources on higher education, open schooling, teacher education, and technical and vocational skills development, anyone can take help.
- **Open Resources for English Language Teaching** is intended to support classroom activities for teachers.
- **COL's Institutional Repository** provides access to a large number of resources on online learning and guides to help teachers plan, design, develop and offer quality online learning.
- **Digital/ WhatsApp and Facebook educator information hub** may consider engaging with your students on WhatsApp and make group. Be part of what's happening around the world in real-time, no matter where you are.

#### **Build up the Longer-term Resilience of Education Systems**

It is commonly accepted that countries demand well-built education systems that advocate knowledge, life skills, and social consistency. However, systems sometimes fail to deliver education services in adverse situation such as natural disaster, political crisis, health epidemic, invasive violence, and armed quarrel, etc. Ironically, education can also lend a hand to take the edge off the risks of such hardship and help students to succeed over the situation despite of unremitting challenges. This is one aspect of the kind of pliability of individuals, communities, and the institutions that providing development to convalesce and understanding positive change in the face of hardship. The Education Resilience Approaches (ERA) programme applied by World Bank Group (WBG) is an important tool in facing this hardship [5]. This programme is designed to provide relative analysis of resilience processes in education system based on local statistics on adversity, school-neighbourhood relations, education policies, and services in adverse situation. Several countries have been using 'Systems Approach for Better Education Results (SABER)' to analyse various aspects of their education systems [6]. WBG launched the 'Education Sector Strategy 2020: Learning for All', in 2011, with the aim to 'Invest early, invest smartly, and invest for all' [7]. The strategy "holds that investments in education should achieve learning for all because growth,

development and poverty reduction depend on the knowledge and skills that people acquire, not the number of years that they sit in a classroom." The main theme of SABER is to provide 'Learning for All' by targeting on three main pillars; (i) "Public access to systematic, accurate, and comparable data on the quality of countries' education policies and the quality of implementation of those policies", (ii) "Awareness and utilisation of these data by countries and development partners in sector analyses, policy dialogue, and planning processes", (iii) "More informed global discussion and debate about strengthening education systems to increase countries' learning for all". These areas are supposed to take part in a big role in education system reforms on both for a country and global level also. There are thirteen domains that are currently evaluated through SABER, and education resilience is a major domain among these. The thirteen areas are: (i) Early Childhood Development (ECD), (ii) Education Management and Information Systems (EMIS), (iii) Education Resilience (ERA), (iv) Engaging the Private Sector (EPS), (v) Equity and Inclusion (E&I), (vi) Information and Communication Technologies (ICT), (vii) School Autonomy and Accountability (SA&A), (viii) School Finance (SF), (ix) School Health and School Feeding (SH&SF), (x) Student Assessment (SA), (xi) Teachers (T), (xii) Tertiary Education (TE), (xiii) Workforce Development (WfD). The initial focus of SABER is to evaluate education environments by investigating the existing documented education policies. Then assess the efficacy of these policies and institutions in practice at the classroom level, and to identify policy implementation gaps within and across countries. SABER then propose a new tool to explicate the linkages between these gaps to explore an overall systems approach. Knowledge regarding human development and learning has grown at a rapid pace; the opportunity to shape more effective educational practices has also increased.

Even before the COVID-19 Pandemic, the world was living a learning crisis. Before the Pandemic, 258 million children from primary and secondary-school age, were out of school education system. Another adverse impact is of low schooling quality which means many students, who were in school learned too little. It can be defined as 'Learning Poverty'. The Learning Poverty Rate

in low and middle-income countries was 53 per cent before COVID-19 Pandemic, meant that more than half of all 10-year-old children couldn't read and comprehend a simple story. Even worse, the most underprivileged children had the worst access to schooling leads to highest dropout rates, and the largest learning deficits. It proves that, the world was already far behind the target of 'Sustainable Development Goal (SDG)', which include, "all girls and boys complete free, equitable and quality primary and secondary education." The COVID-19 Pandemic added new challenges in this context. The Pandemic has created a deep impact on education by closing schools almost everywhere in the world. It has impacted nearly 1.57 billion learners out of school and 191 country-wide school closures, impacting 91.3 per cent of the world's total enrolled learners as per UNESCO estimation up to April 20, 2020. Drop-out rates across the globe are likely to rise as a result of this massive disruption to education access [8, 9]. It has created a severe dent to all education systems in our lifetimes. The damage will become even more rigorous as the COVID-19 pandemic will be translated into global recession. Out of school, children are more likely to be exposed to risks like child labour, family violence, forced marriage, trafficking and exploitation and so many. For the most vulnerable children, education is life saving drug, it also inculcate hope for a brighter future. However, it is possible to counter this damage, and to turn emergency in to opportunity. The first step is to manage effectively with the school closures, by protecting health-safety and doing what they can to prevent students' learning loss using remote learning. Secondly, countries need to start planning for reopening of school with a proper framework. That means preventing dropout, ensuring healthy school conditions, and using new techniques to promote rapid learning recovery, once the students are back in school. Teachers have a major role in framing out the new system, within the school as well as the government systems, and also to implement them effectively at earliest. And during the Lockdown, continuing education through alternative learning pathways must also be a top priority right now, to ensure the interruption to education is as limited as possible. We urgently need to support teachers, parents/caregivers, innovators, communications experts and all those who are positioned to

provide education, whether through radio programmes, home-schooling, online learning and other innovative approaches.

The list of e-learning resources, platforms and educational applications below to help parents, teachers, school/college/university administrators, and students during the COVID-19 outbreak [3].

#### *Digital Learning Management Systems*

- Century Tech
- ClassDojo
- Edmodo
- Edraak
- EkStep
- Google Classroom
- Moodle
- Nafham
- Paper Airplanes
- Schoology
- Seesaw
- Skooler

#### *Systems Built for use on Basic Mobile Phones*

- Cell-Ed
- Eneza Education
- Funzi
- KaiOS
- Ubongo
- Ustad Mobile

#### *External Repositories of Distance Learning Solutions*

- UNHCR
- UNEVOC Resources
- Organisation internationale de la Francophonie
- Koulu.me
- Keep Learning Going
- Global Business Coalition for Education

- European Commission Resources
- EdSurge
- Education Nation
- Brookings Common Sense Education Commonwealth of Learning

*Massive Open Online Course (MOOC) Platforms*

- Alison
- Canvas
- Coursera
- European Schoolnet Academy
- EdX
- iCourse
- Future 8. Learn
- Icourses
- TED-Ed Earth School
- Udemy
- XuetangX

*Self-directed Learning Content*

- British Council
- Byju's
- Code It
- Code.org
- Code
- Week
- Discovery Education
- Duolingo
- Edraak
- Facebook Get Digital
- Feed the Monster
- Geekie
- Khan Academy
- KitKit School



- LabXchange
- Mindspark
- Mosoteach
- Music Crab
- OneCourse
- Polyup
- Quizlet
- Siyavula
- Smart
- History
- YouTube

#### *Mobile Reading Applications*

- African Storybook
- Biblioteca
- Digital del Instituto Latinoamericano de la Comunicación Educativa
- Global Digital Library
- Interactive
- Learning Program
- Reads
- Room to Read
- Story Weaver
- Worldreader

#### *Collaboration Platforms that Support Live-video Communication*

- Dingtalk
- Lark
- Hangouts Meet
- Teams
- Skype
- eChat Work
- Whats App
- Zoom

*Tools for Teachers to Create of Digital Learning Content*

- Trello
- Squigl
- Pear Deck
- Nearpod
- Kaltura
- EduCaixa
- Ed Puzzle
- Buncee
- Thinglink

**Regular Basis Online Counselling**

The Pandemic has radically changed the concept of traditional education in the past few months and virtual learning will be the new future of education. Before the Pandemic, technology was just considered as a means of entertainment. Today, keeping teachers and the students engaged in learning process has become the priority during lockdown, and virtual classes have proved to be helpful in these difficult times. This powerful medium has diversified the field of teaching. Earlier, teachers were not so familiar with online teaching at the school level, except for the computer lectures. Now, along with teachers, every profession has chosen the virtual platform, providing precious opportunities to both new learners and experts. There appears to be no deficiency of online resources of academic value. And therefore, online teaching is more an opportunity than a challenge for teachers today. Mental health of students is the topic of major concern during COVID-19 Pandemic, especially when school and colleges and other academic institutes are closed due to 'Lock Down'. The overall education is not only dependent on academic curriculum but also on his mental health. Disturbances in the mental health have an extreme negative impact to a student and also on the community. Today's student is the future citizen of the country; contributing to the development of a nation by serving various roles like teacher, engineers, doctors, nurse, etc. Hence, the mental health of the students has to be given at most importance. Till date, there is no proven treatment to manage the

Novel Corona virus disease, though some vaccines are in trial, lockdown is the only option available to slowdown the rate of spreading the infection by restricting community-infection path. In this process, all the education institutes suddenly were declared 'locked down'. The students were in different phases of their academic year. It is well known that the students experience lots of stress especially before and during the examinations [10, 11].

The students were preparing the examinations especially the entrance examinations for years together. For example, in India, NEET is the common entrance examination to enter into the professional colleges. Students will be preparing for this exam since two years as the scores will decide their admission criteria. Some students might be allotting an extra year to get through the entrance examinations. These students are in high anxiety because their pre-examination phase will prolong till they complete their examination, further, as there is no proclamation of the date of exam. There is quiet improbability about their future. Parents may add up more anxiety to the system, as they are equally undergoing stress regarding their kid's career in future. Though, many of the educational institutes have launched online classes, adaptation of the student to the sudden change from habitual teaching method to a new system is stressful. This is true chiefly in case of the slow learners. The fear of Corona Pandemic will add up to their stress. There for, the need of psychiatrist, in this circumstance to keep the mental balance of the students is extremely necessary. Every educational institution may think of establishing a mental health cell, or student counselling centre that comprises of psychiatrist(s) or psychologist(s) with a proper management system. Regular online counselling should be planned along with the online teaching classes. Importance should be given to counsel the parents with equal importance along with students. Regular monitoring of the stress levels using different online tools can be done to prevent the student to enter into the state of depression. And teacher, who is a pivot of this whole system, simultaneously be counselled in handling the students with the new teaching process. The student should be priory convinced that there will not be any loss of academic year. The entrance examinations may be planned to conduct online as majority of the universities/institutes throughout the world is

already following the same. The counselling cell should also monitor the students even after the lockdown as it takes time for the students to normalise himself after the long, unexpected break of his studies. Continuous monitoring, offering counselling to the needy students will help to keep the students mentally sound and do well in personal and professional life. For example, to uphold student's mental health during the lockdown the Student Counselling Unit (SCU) of Unit-Fort Hare University (UFHU) has moved its services to an online platform [13]. By visiting the SCU facebook page, students are able to engage with qualified Psychologists in a safe and confidential space. The SCU of UFH University is managed by a psychologist on a daily basis. The platform allows psychologists from the unit to participate in live chats and offer one-on-one assistance via private online sessions. Psychological advice on how to manage lockdown related stress and anxiety is also shared on the page. The SCU also suggested their students to stay connected with their peers, share study materials and approaches in order to feel connected with like-minded people. They also suggested some following tips [13] to their students to remove stress during and make one feel goal-directed during lockdown.

- To prepare a special routine during lockdown and maintain it.
- Planning of study sessions and including break time.
- Self-care is an important aspect
- Never stay in empty stomach, intake meal in regular time
- Drink sufficient water time to time
- Listening to good music and engaging in dance once in a while can have a positive impact on mental health
- Not spending too much time on social media, especially at night, as this may lead to sleep problems and fatigue.

In our India, Calcutta University has started free online psychological counselling [14] service for all its students to beat any stress during the COVID-19 lockdown. The university has also issued a circular with the name and number of the faculty members whom the students may call at specified time slots for counselling services. Thirteen teachers—five from the Department

of Psychology and eight from the Department of Applied Psychology—is provide counselling session to students of undergraduate and postgraduate courses available for 12 hours daily.

### **Teaching to Children of Migrant Labour**

Refugees, displaced and migrant children, often fall between the cracks as national policies might not necessarily include these helpless groups. They must be included and provided for in any global responses to this crisis. While, we are practising social distancing, and trying to practice work from home, in the hope of a better tomorrow, there is a possibility that a significant number of children would appear as victims of such measures. One impact would be an increase in the number of child workers. Along with the health crisis, the Pandemic has generated a huge shock on the economic and labour market. And millions of child labour would be in vulnerable condition which needs serious attention. According to ILO (International Labour Office), the Global Estimates of Child Labour: Results and Trends (2012-2016) presented in Geneva in 2017 [16], there were 152 millions child labourers worldwide, of which 73 million were in hazardous work. Among these 152 millions, 88 million are boys (58%) and 64 millions are girls (42%). Among these children, 48 per cent are 5-11 years-olds, 28 per cent are 12-14 years-olds and only 24 per cent are 15-17 years-olds. In another statistics, 70.9 per cent of these children were engaged in Agriculture sector, 11.9 per cent in Industry and 17.2 per cent in Service sector. If we do address this issue with immediate and accelerated efforts, we are going to lose the battle of eliminating all forms of child labour by 2025, a commitment under the SDG. And the bare fact is that, a very large number of children in child labour are completely deprived of education.

Children of the age group 5-14 years, there are 36 million are in child labour who are out of school, which is 32 per cent of all those in child labour in this age range. It is one of the most important indicators to address of the impact of child labour on sustainable livelihood prospects. The crisis created by the Pandemic of COVID-19, will push millions of vulnerable

children into child labour, specially the children of migratory labour. The Government of India has also declared for a countrywide school closure. UNESCO also estimates that around 32 crore learners are had an effect of it, of which 16.2 crore are boys 15.8 crore are girls. The bulk of these students are enrolled in primary and secondary schools (86%), followed by tertiary (10%) and pre-primary (4%) level of education [8]. Governments have adopted a variety of hi-tech, low-tech and no tech solutions to assure the continuity of learning during this period. Most of the focus has been on online learning platforms, though nearly half of our country has no Internet access. We can't think about Internet in case of children living in remote village, staying at foot-path or in slams. The MHRD (Ministry of Human Resource Development) of Govt. of India has suggested that all schools should connect with their students through digital platforms to compensate for the loss of school hours. But the fact is that, as of now, mostly private schools (Generally CBSE and ICSE affiliated schools) and selected Govt. schools like Kendriya Vidyalaya have started online classrooms. However, most state government schools do not have the technology and equipment to provide online teaching. Moreover, the majority of students do not have access to internet, smart phones or a computer. Therefore, a large number of children studying in public schools remain cut off from online education. The Lock Down will inexplicably affect children who already experience barriers in accessing education. This includes children with disabilities, students in remote locations, children of migrant workers, and children from the poor family. The millions of children who will be victims of the COVID-19 Pandemic need immediate attention from states and communities. The starting point should be the parents; coordinated policy efforts should be taken income support to all informal sector workers, migrant workers to stimulate their family needs. As a direct measure, states should prioritise efforts to continue education for all children, using all available technology. But school teachers have a vital role to address this issue. Teachers have the direct relation with students in education process. So, they will take initiative to discuss with school authorities and need to ensure that every

student will have free lunches at home until schools open. Special efforts should be taken to identify children orphaned due to COVID-19, and arrangements of shelter and foster care for them should be made on a priority basis. Apart from teaching process, teachers have a roll to support the Govt. policies adopted during this Pandemic period. States are also working on food distribution to all Govt. school children. For example, while Kerala and Delhi governments are delivering food packets as a part of mid-day meals for government school children at their doorsteps, West Bengal and Andhra Pradesh are providing dry rations to children. But distribution of foods in terms of food packets or dry rations can be smoothly organized with the help of teachers. Another hard problem for migrant children is to adopt the language of education. As their parents are migrant labour, they have to move around with their parents, thorough the India, which is multilingual country. In COVID-19 pandemic, when most of the migrant labours are coming back to their home state, both students and teacher will face a problem to use the common language for education. Kerala [16] can be a model in this situation. Kerala's economy is dependent on migrants. Kerala sending out large numbers of workers overseas (2.4 million in 2013, based on a May 2018 report by the Centre for Development Studies) it needs migrants from other Indian states for Kerala's economic activities. The exact number of migrants coming to Kerala is unknown. According to 2017 estimations by CMID, (Centre for Migration and Inclusive Development, an Ernakulam-based non-profit organisation) as much as 11 per cent of the population of Kerala) would be migrant and the figure may turn to 3.5~4 million. The Kerala Government has been more proactive compared to other states to address situation as their economy is directly relate to it. There are three types of migrant workers at Kerala; those who come for work and settle down, those who look for work temporarily, and seasonal migrants, and the migrant due to natural calamities. The migrant student drop-out rate depends on the nature of migration. The problem starts with the language barrier first. Kerala Government through Sarva Shiksha Abhiyan (SSA) has appointed a large number of volunteer to

help these students understand Malayalam, which is the medium of education in all Government schools. These measures will no doubt respond to the emergency created by COVID-19 directly or indirectly to some extent. However, it is clear that more needs to be done to prevent children from lapsing into child labour and teacher as a main pillar of education system, has a major role to address this situation.

### **Role of NSS Volunteers in COVID-19 Outbreak**

Maximum schools, colleges and universities of India have National Service Scheme (NSS) volunteers since 1969. The number of NSS volunteers was 40,000 in 1969 and 3.8 million in March 2018. A NSS volunteer is a student of school or college or university who has enrolled his/her name in the National Service Scheme. The roles of the NSS volunteers are very significant according to the National Service Scheme because they are the main beneficiaries of the programme. It provides the opportunity to the youth students of class-XI and XII in schools and graduate and post graduate students of colleges and university level of India to take part in various community service activities and programmes. The slogan of NSS is Not Me But You [4]. The NSS programme aims to encourage social welfare in students, and to provide service to society without bias. NSS volunteers work to ensure that everyone who is needy gets help to enhance their standard of living and lead a life of dignity. In doing so, volunteers learn from people in adopted villages how to lead a good life despite a shortage of resources. The first thing NSS provide is to develop their own thought process by doing community services. Society is a group of persons who may have different ideology. NSS volunteers through their skills and dedication build it a homogeneous ideological group. NSS volunteers also provide help in natural and man-made disasters by providing food, clothing and first aid to the disaster victims. NSS volunteers take care of cleanliness, blood donation, health awareness issues, child education, and many other activities. NSS is always trying to bring smiles on innocent faces through empowering the deprived with education. In this way NSS makes its volunteer a good human being. While studying, these student volunteers undertake community development activities which



help to build their personality as well as develop the belongingness towards the society. The NSS volunteers are performing the role of mediator between the education system and the community which is helpful for the nation building. They are developing their qualities of leadership, skills to become an organiser, and an administrator and to attain the multi-faceted development of their personality as a whole. Whenever there is a need, the NSS volunteers appear themselves to serve the nation. NSS volunteers always take up relief and rescue operations on priority whenever a natural disaster occurs in any part of the country. It may be the issue of environment enrichment, malnutrition, immunization, or the issue of natural disaster; NSS volunteers are becoming the saviours for the victims [17].

Recently, Maximum NSS volunteers with their NSS Programme Officers and Coordinators have completed iGOT (Integrated Govt. Online Training) courses about COVID-19 Pandemic on DIKSHA platform. There are different iGOT courses about COVID-19 like Basic of COVID-19, Infection Prevention and Control, Clinical Management of COVID-19, ICU Care and Ventilation Management, Infection Prevention through PPE, Management of COVID-19 cases, Quarantine and Isolation, Psychological care of patients with COVID-19, etc. The trained volunteers are also trying to attract the attention of the other students of the school, college or university towards these courses about COVID-19 outbreak awareness activity.

National Service Scheme (NSS) volunteers in India have taken up different awareness activities about basic infection, prevention and control of COVID-19 in war-footing basis to the common people in the lockdown period of COVID-19 Pandemic. Different NSS units across the India are fully involved in the relief activities to the poor. The NSS volunteers are sanitising the affected area, preparing food packets for the flood victims, running common kitchen and distributing medicines. The NSS volunteers and other functionaries are distributing food packets to the affected people at various places and are also helping in rescue operations with the health workers. They are collecting items of daily uses like dry ration, drinking water, clothes, soaps, medicines, sanitary napkins, milk powder, bleaching powders, hand wash, sanitisers

etc. These volunteers work tirelessly to mobilise relief materials and work for the smooth distribution of the collected materials in the affected area in close coordination with the district administration. They are also collecting money for the PM Relief Fund and CM Relief Fund of different states of India. As for example, Md. Salauddin Ansari, a NSS volunteer (Unit-III) of Achhruram Memorial College, Jhalda, Purulia, West Bengal, India participated in different COVID-19 related activities [see Fig.-1] to aware and help the common people. At present about 41 lakh volunteers are enrolled in this programme in 426 universities of India covering about 32000 institutions. NSS nodal or programme officers circulate and forward materials including COVID-19 facilitators guide, packet book and awareness posters etc. to all NSS volunteers and then they in-turn forward these materials through email, whatsapp and other social media platforms to all other NSS volunteers and students of University/ Directorate/college/schools/institutions to propagate the right messages on Corona virus and clear all myths, misconceptions, stigma and discrimination about COVID-19. At this critical juncture, NSS play the prime role to spread the awareness through online and one to one personal communication about the importance of hand hygiene, respiratory hygiene and minimum 1 metre social distancing in the public places. Students of the National Service Scheme are not discouraged by the lockdown, and are doing their bit by spreading awareness on COVID-19 via posters, videos, quizzes, etc. The NSS coordinators are performing their responsibility to train volunteers about mask preparation, hand sanitiser preparation or the simple practices such as converting old newspapers into little napkins that can be used to open the gate or correct method of sorting groceries and even ways to handle those under home quarantine. Also some educational institutions have started creating quizzes or webinar about COVID-19.



**Fig. 1:** Some COVID-19 related NSS activities performed by Md. Salauddin Ansari, NSS volunteer (Unit-III) of Achhruram Memorial College, Jhalda, Purulia, West Bengal, India.

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National Service Scheme in India keeps a well tuned relationship between stake holders of academic institutions and communities from its inception. Researches and academic discourses are the plethora for strengthen one concept and practices. Contributors of this edited volume have direct experiences, erudition and vision at different levels like Program Coordinators, Program Officers, NSS Volunteers and Researchers also cutting across the interdisciplinary cross sections. This volume has the certain potentialities to usher and extend ideas and concept for further practices and support newly taken initiatives to establish NSS as an academic wing. Participants, thinkers, planners and collaborators of this scheme will get enormous impetus to be active par excellence with this avenue for bring a more healthy and sustainable relationship between learners, faculty and common mass of our beloved country.



**Dr. Savita Mishra** is a Professor at Vidyasagar College of Education, Phansidewa, Darjeeling, West Bengal. She has impeccable records of eighteen years of teaching and research activities. She has written more than hundred research articles in reputed National and International journals and authored 60 books. She has also developed a psychological tool for assessing Attitude towards Science. She is the Vice-President of Council of Teacher Education (Eastern Zone); Scientist, IAEC; Member of Board of Studies, National resource person of MGNCRE, Ministry of Education, Government of India, members of advisory and editorial board of national and international journals, Founder and Secretary of Ranidanga Yashoda Educational Society and Visiting Professor of some of the Universities including Academic Staff Colleges. She has awarded Best Teacher Award 2010 from Sikkim central University, Best Principal award 2020, Best Academician Award 2020, Celebrity writer award 2020, Excellent Achiever award 2020, Women Researcher Award 2021, Best Teacher Award (Higher Education) 2021, India Prime Top 100 Women Icon Award 2021 and Outstanding Scientist Award 2021. She has been conferred the title of 'Leading Educationists of the World' by IBC, Cambridge, London.



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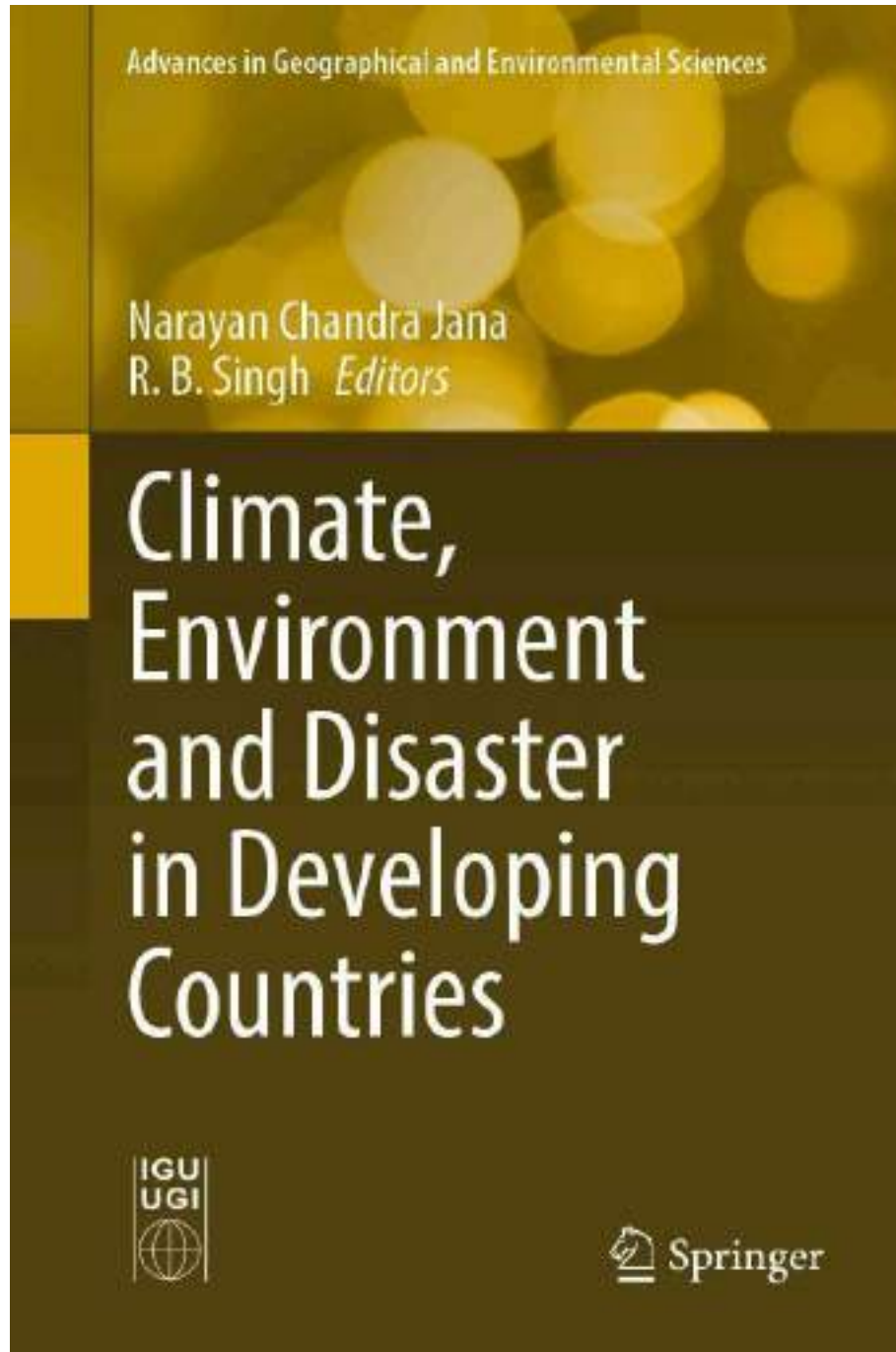
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# Chapter 10

## Mapping and Reclamation of Wastelands in Drought-Prone Purulia District of West Bengal, India Using Remote Sensing and GIS



Manoj Kumar Mahato  and Narayan Chandra Jana 

**Abstract** Wastelands mapping and reclamation studies has been carried out in Purulia District in western most part of West Bengal, India using high-tech tools of geoinformatics. Purulia District provides vast tracts of wastelands, which covers 28.41% of total wastelands area of West Bengal and 7.51% of total geographical area of the district in 2015–16. About six categories of wastelands were identified, viz. Badland wasteland, Gravelly wasteland, Mining & Industrial wasteland, Rocky or stony wasteland, Degraded forestland, and Degraded land under plantation crop. The main objectives of the present research are to study the spatial distribution of different types of wastelands and to suggest the appropriate measures for the reclamation of various categories of wastelands. The wastelands of the Purulia have been identified and categorized through the SOI toposheets of 1:50,000 scale, SRTM DEM LISS-III, Landsat-8 OLI/TIRS C-1 Level-1, and Google Earth images by GIS software's with rigorous field survey. Based on the analysis of secondary and primary data and information the authors in the present context have given appropriate suggestions toward the reclamation of Wastelands of Purulia district.

**Keywords** Wastelands · Purulia District · Geoinformatics · Spatial distribution · Reclamation

### 10.1 Introduction

Land resource is a precious natural resource and it functions as a key for the sustenance of humankind (NCA 1976; De and Jana 1997; Ramachandra 2007; Rawat et al. 2018). Excessive exploitation of land resources results in a significant change of the landforms, which has unfavorable effect to the environment (Rawat et al. 2018). The excess population pressure, growing industrialization, rapid urbanization, and extensive agriculture have put abundant stresses on land properties, resulting into the significant reduction of agricultural land and other natural resources (Grunwald 2013).

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Enormous population pressure is also guiding to deforestation and natural resource degradation that has distressed environmental balance of terrestrial systems (Chandramohan and Durbude 2002; Sharma et al. 2007). Land is turning into wasteland due to various natural and anthropocentric factors like rainfall deficit, drought conditions, soil erosion, wind erosion or deposition, water logging, salinity or alkalinity of soil, floods, deforestation, and unscientific techniques of cultivation (Crosbishley and Pearce 2007; Basavarajappa and Manjunatha 2014).

Wastelands are denoted as degraded land and recently laying unutilized (NRSA 2007; Chaturvedi et al. 2014; Basavarajappa et al. 2015; Sreekala and Neelakantan, 2015) due to inherent or imposed incapability related to geographical location, environment, soil fertility, water availability and current financial constraint (NRSA 2007; Basavarajappa et al. 2015). National Wastelands Development Board (NWDB 1987) defines wasteland as degraded land which can be brought under the purview of vegetative cover by reasonable effort, and which is currently underutilized; deteriorating for lack of suitable water and soil management or on account of natural causes (Rao et al. 1991; Kohli et al. 2018). National Atlas and Thematic Mapping Organization (NATMO 2010) have expressed their views regarding wasteland as “those areas which are not utilized to their full potential and whose productivity could be increased by making reasonable efforts and investment”. Different sectors define the wasteland according to their land use pattern. Agriculture land lying fallow for more than two years can be termed as agricultural wasteland (NCERT 2016). Lands under the control of Revenue Department are not fit for agriculture lying barren can be termed as Revenue wasteland (Singh 2012). Similarly, grasslands and lands under the control of Forest Department, which do not have tree cover, can be termed as forest wasteland (Luna 2006; Chaturvedi et al. 2014).

Although there are different perspectives on wastelands marking but it is largely accepted that wastelands are the areas which are underutilized and which produce less than 20% of its biological productivity (Mishra et al. 2013). The wastelands have characterized degraded, fallow, uncultivated, and common land as (i) lands not obtainable for cultivation, barren, and uncultivable wastes, (ii) other appendicular land apart from fallow, permanent pastures, culturable waste and land under various trees, (iii) fallows under wastelands.

The drought-prone Purulia District in West Bengal, India provides no exceptional picture from the previously mentioned scenario. High rate of deforestation, unscientific plantation, water crisis, and lack of irrigation facilities are mainly responsible for the formation of vast tracts of wastelands in the study area. According to Wasteland Atlas of India 2019, the total wasteland in West Bengal in 2015–16 was 1654.99 km<sup>2</sup>, of which Purulia alone has 470.19 km<sup>2</sup> (28.41%). Land degradation and drought condition are the serious problem of the study area, which can accelerate the amount of wasteland. These problems can be controlled by conserving land surface and ground water in the wasteland area (Rawat et al. 2018) as well as through scientific tree plantation programs (Dwivedi et al. 1997; HARSAC 2006) on wastelands in rocky and shallow deep soils. Thus, the current and appropriate information about the location and spatial arrangement of vacant or wastelands has played an emergent role for better planning of trees and treatment to exterminate the negative effects



of land degradation (Contador et al. 2008; Nawar et al. 2015). Hence, there is a significant requirement for wasteland identification and reclamation in many countries around the world (Chandramohan and Durbude 2002) and also in the district of Purulia of West Bengal.

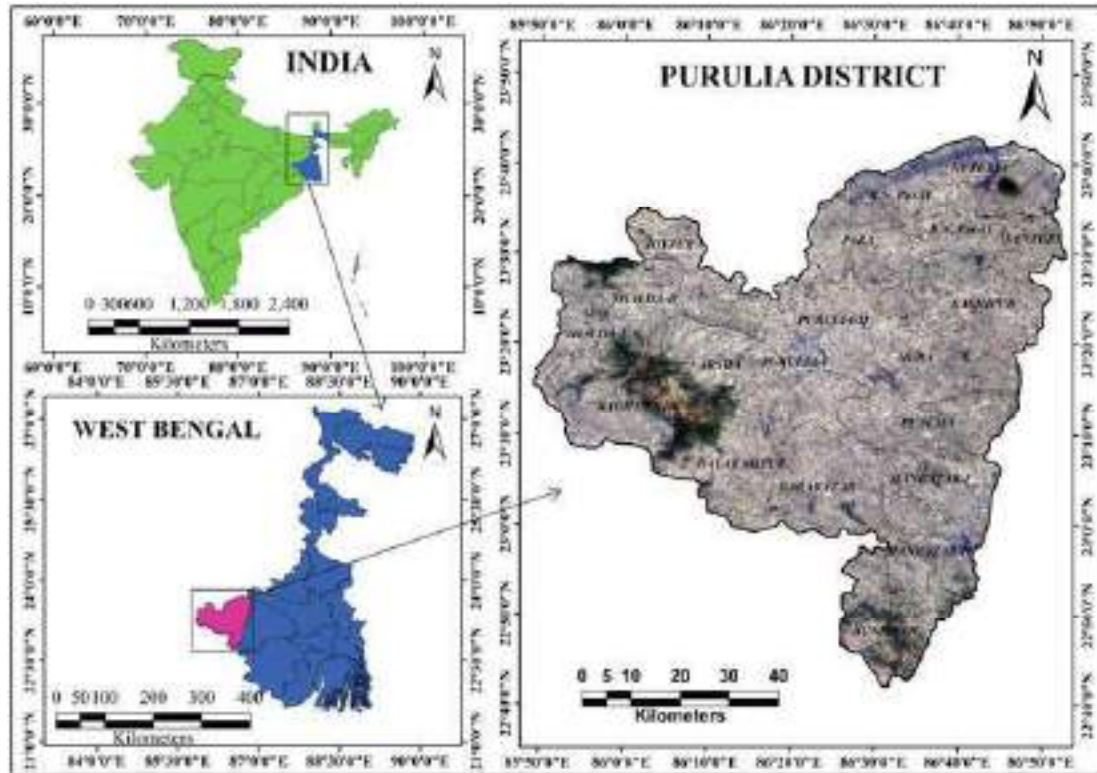
Recent developments in geographical mapping consent the researchers to work out the location aspects and distribution pattern of land use/land cover (LULC), which is shown in more accurately by using geospatial techniques (Saha et al. 1990; Sugumarman et al. 1994; Rao 1999; Singh 2006). Numerous studies have recognized the applications of RS & GIS in natural resources monitoring and management (Pramila 1994; Metternicht and Zinck 2008; Mulder et al. 2013). The satellite imageries are currently being used extensively in mapping of various land features with the help of GIS technique (Basavarajappa and Dinakar 2005), such as LULC mapping (Singh et al. 2014; Srivastava et al. 2014), LULC modeling (Singh et al. 2015; Mustak et al. 2015), groundwater (Singh et al. 2010), lake and wetlands (Thakur et al. 2012a, b), crop suitability (Mustak et al. 2013), slope estimation (Szabo et al. 2015), landscape ecology (Singh et al. 2017), urban land use dynamics, forest mapping (Singh et al. 2012), soil characterization (Paudel et al. 2015) and watershed management (Yadav et al. 2014). Further, Remote Sensing technology has proven its application in wasteland assessment and its temporal monitoring (Jain et al. 1991; Barchyn et al. 2014). Wasteland reclamation and development can be possible by RS & GIS technology and accurate field monitoring, through appropriate strategies (Breunig et al. 2008; Basavarajappa et al. 2016). The present study has been adopted to investigate different wasteland categories and their reclamation in Purulia District using applications of RS & GIS and conventional data.

## 10.2 Materials and Methods

### 10.2.1 Study Area

Bounded by the latitudes of 22°40' N to 23°42' N and longitudes of 85°49' E to 86°54' E, in the eastern fringe of the Chotonagpur plateau (Fig. 10.1), funnel shaped Purulia District is located in the western part of the West Bengal. It is surrounded by the state of Jharkhand in north, west, and south; and in the eastern part by the districts of Bardhaman, Bankura, and Jhargram of West Bengal, India. Total geographical area of the district is 6,259 km<sup>2</sup>.

Various stratigraphic units ranging from the oldest Archaeans (Pre-Cambrian) to the younger Tertiary-Quaternary formations constitute the study area (Dunn 1929). Topographically, this area is very much diversified with dome-shaped inselbergs, spurs, escarpments, undulating upland, and erosional plain (Mahato and Jana 2019). As a part of the Chhotanagpur Granite-gneiss tract, the Purulia did not experience any severe diastrophic disturbance in its long geological history, but it could not escape the impact of orogenic forces (Dunn 1929; Singh 1969; Ray 1982; Ghosh



**Fig. 10.1** Location of the study area

2012). The study area occupies the eastern part of the Pre-Cambrian Granite-gneiss tract (Singh 1969).

Climatologically, Purulia District is characterized by sub-tropical Monsoon type of climate with very high day temperatures during the summer months reaching up to 46 °C, whereas the winter months are plentiful cooler with lowest temperatures of up to 3 °C (Bhattacharya et al. 1985). The evaporation rate of the district is very high during the summer months due to the mean monthly average temperature of 32 °C, while the mean monthly temperature of the winter months is 13 °C. The mean long-term annual rainfall for the period of 1960–1961 to 2014–15 is 132 cm of which 80% rainfall occurs during June to September (Bhattacharya et al. 1985; Datta and Chakraborty 2015). The soil of the area is infertile laterite and red gravelly type, which is characterized by infertile, unproductive, erosion prone, lack of soil nutrients, and lower water holding capacity (NBSS and LUP 2010).

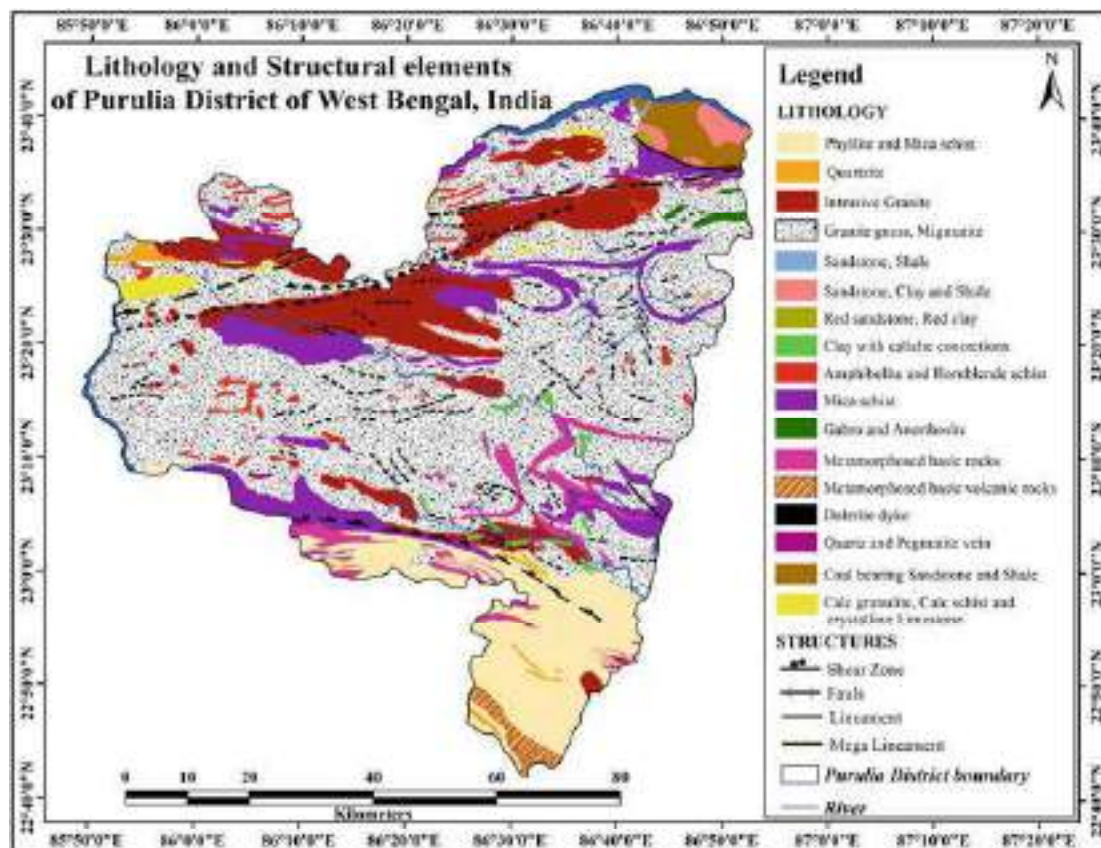
### 10.2.2 Lithology

In eastern fringe of Chhotanagpur gneissic complex, Purulia District generally represents an Archaean complex region (Dunn 1929). The parent rock of this area is Granite-Gneiss with its varying composition (Dunn 1935). The entire study area is covered mostly by Chotonagpur granite gneisses (Dunn 1929), which include quartz

biotite granite gneiss, prophyroblastic granite gneiss, massive granite composite gneiss, augen gneiss, and migmatites (Chatterjee 1946). The Chotanagpur granite gneiss holds the enclaves of metasedimentaries that include mainly the mica schists, garnetiferous sillimanite biotite schist, amphibolites, etc. (Baidya et al. 1987). The Lithology and Structural elements map of the Purulia District (Fig. 10.2) shows that most of the area (71% of the total area) is covered by Chotanagpur granite-gneiss.

Structurally the studied area is considered as one of the ancient (Pre-cambrian/Proterozoic) stable landmass of the Indian Peninsula that has not been affected by any folding movement created within the earth during later geological periods (Ball 1981). Tectonically, the study area is an old land surface, which suffered tectonic turbulences due to Gondwana drifting from Permo-Carboniferous to Jurassic period (Singh 1969).

The Pre-Cambrian, the oldest rock formed at the lowermost, which was the most dominant among the various rock types. In Permian age, lower Gondwana rock groups such as Sandstone and Shale of Kulti Formation and Coal bearing sandstone and shale of Raniganj Formation situated over the Archaeans rocks. The upper Gondwana rocks of Triassic and Lower Cretaceous age are Sandstone, Clay and Shale of Panchet Formation, Red sandstone and Red clay of Mahadeva Formation and Clay with caliche concretion of Sijua Formation deposited unconformably over the lower



**Fig. 10.2** Lithology and structure of Purulia District, West Bengal, India. *Source* Geological Map, published by Geological Survey of India, Kolkata, 2001

Gondwana in the northeastern part of the district, i.e., along the Damodar River (Geological Survey of India, Kolkata 2001) (Fig. 10.2).

### ***10.2.3 Topographical Characteristics***

Purulia district is formed steeply sloping from west to east between the Chhotanagpur plateau and the Damodar plain. In terms of topography and structure, Purulia is a fragment of the Ranchi peneplains (Singh 1978). The elevation of different parts of Purulia ranges between 78 to 699 m above the mean sea level with its great diversity of the polycyclic landscape through the undulating Archean plateau (Dunn and Dey 1942). The diversity of landforms in the district has been caused by different cycle of erosion and lithological structures. Purulia district made up a portion of the Precambrian metamorphic terrain of the southeastern Chotonagpur plateau consisting mainly of granites, gneisses, quartzite, etc. rocks, and Gondwana sediments. The main hills of the study area are Ajodhya (669 m.), Panchet (643 m.), and Joychandi (305 m.). Besides these, monadnock like residual hills, hillocks, dome-shaped inselbergs, spurs, escarpments, dissected valleys, and rocky out crops are general features. The remaining part of the district is undulating and rolling land consisting of laterite. The major lithological and geomorphic structures have exhibited striking differences in the physiography. Physiographically, this area is divided into five divisions such as (i) Hilly tract, (ii) Highly gradient rugged upland, (iii) Rugged upland, (iv) Moderately gradient rugged terrain, and (v) Low gradient rugged terrain (Fig. 10.3).

### ***10.2.4 Drainage System***

Originating from the hillocks of the Chhotanagpur plateau, several rivers flow from east to west through Purulia District. Among these Kangsabati (Kasai /Cossey/ Kansai), Kumari, Dwarakeswar, Subarnarekha, and Damodar are the important ones. The main drainage of the district is controlled by river Kasai, which drains more than three-fifth of the district's water. Apart from these main rivers, there are numerous tributaries and *Jora* (in those channels water flows only during monsoon) in the district. Most of the channels of the district are non-perennial which contain water for three to four months (Fig. 10.4). The perennial rivers like Kangshabati and Kumari are sustained water around the year but not in flowing condition. A number of Non-perennial River, *Jhor*, *Bandh* (artificial created water body), and a few check dam are the significant surface water bodies in the study area. All the water bodies in the study area are depend on rainwater. During pre-monsoon period, all the water bodies are dried up and drought condition prevails all over the district.

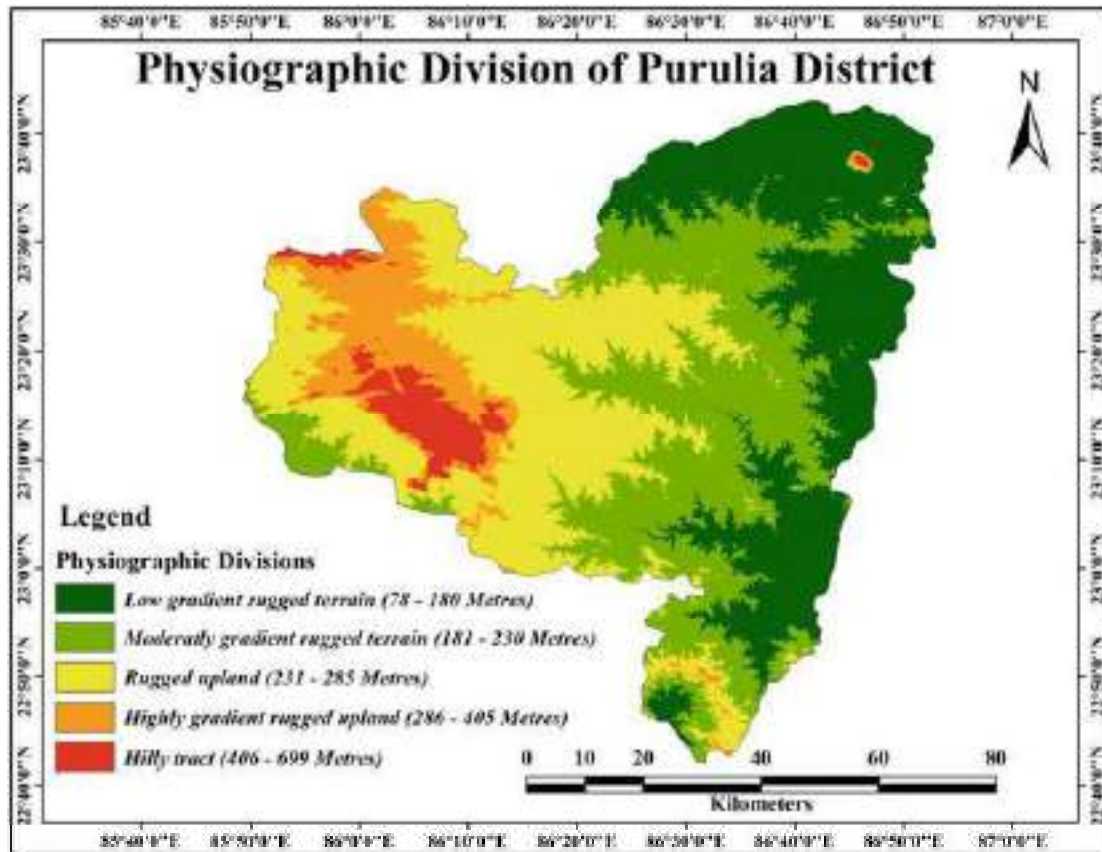


Fig. 10.3 Physiographic division of Purulia District. Source ASTER DEM, September 2014

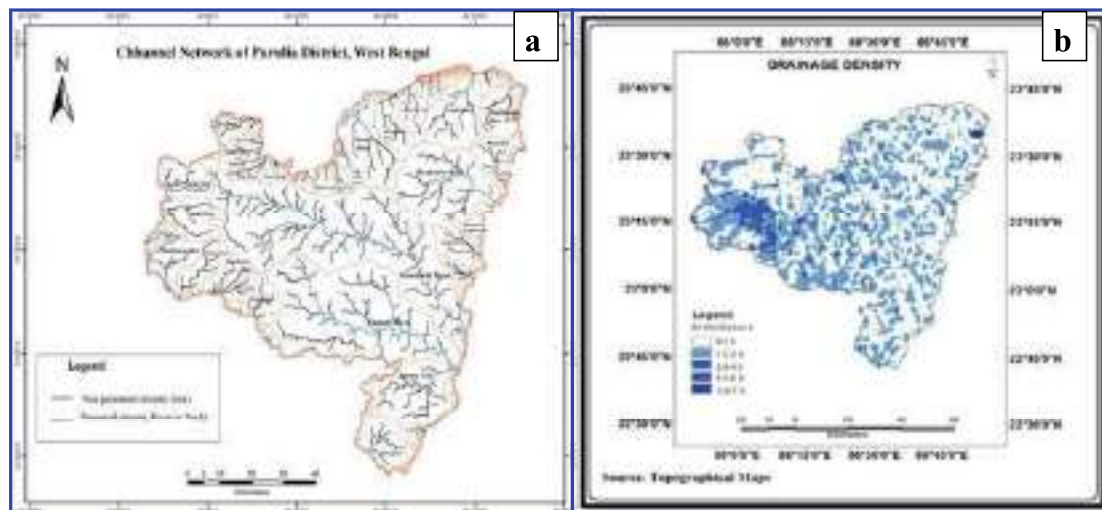


Fig. 10.4 Drainage System of Purulia District, **a** showing the channel network of Purulia District; mainstream of Kangsabati, Kumari, and Dwarakeswar river are perennial. Apart from these main-streams, all the tributaries of these rivers are non-perennial. **b** is showing the drainage density of the district

## 10.2.5 Data Used and Analytical Procedures

### 10.2.5.1 Geospatial Data

For detailed study, the wastelands of Purulia District, West Bengal have been delineated and mapped through digital image analysis of high resolution satellite data and digital interpretation of SOI toposheets (Table 10.1), which are verified during the field visits.

**Table 10.1** Geospatial data sources and analytical techniques

Analytical features	Data source	Techniques
Lithology	Geological Map, published by Geological Survey of India, Kolkata, 2001	Vector mapping for different Lithological and Structural elements
Physiography	ASTER DEM, Spatial Resolution 30 m., September 2014, USGS Earth Explorer	Vector mapping of different physiographic divisions
Drainage	ASTER DEM, Spatial Resolution 30 m., September 2014, USGS Earth Explorer	1. Raster creation for Perennial Non-perennial drainage system, 2. Drainage density raster creation by <i>Drainage length/area in sq.km</i>
Land use /Land cover (LULC)	Landsat-8 OLI/TIRS C-1 Level-1 (11 bands), Spatial Resolution- 30 m, Date of Acquisition- 20 & 29 May, 2019, USGS Earth Explorer	Land use/land covers (LULC) classification by supervised techniques
Wastelands Distribution	1. Landsat-8 OLI/TIRS C-1 Level-1 (11 bands), Spatial Resolution- 30 m, Date of Acquisition- 20 & 29 May, 2019, 2. SOI Toposheets: 73E/15, 73E/16, 73I/2, 73I/3, 73I/4, 73I/6, 73I/7, 73I/8, 73I/10, 73I/11, 73I/12, 73I/14, 73I/15, 73I/16, 73 J/1, 73 J/5, 73 J/6, 73 J/9, 73 J/10 on 1:50,000 scale, new edition 2010, Source: (NakshePortal) <a href="http://www.soinakshe.uk.gov.in">www.soinakshe.uk.gov.in</a>	Overlay of Final LULC Map and Thematic Map of SOI toposheets through GIS Application for Spatial distribution of Existing Wastelands and Zonal distribution of different types of Wastelands

### 10.2.5.2 Reports and Records

- West Bengal District Gazetteers, Purulia, Government of West Bengal, Published by Narendra Nath Sen, State Editor, West Bengal District Gazetteers, Calcutta, 1985.
- District Census Handbook of Purulia District: 1991, 2001 and 2011.
- District Statistical Handbook, Purulia (2013, 2014 and 2015), Published by Government of West Bengal.
- Daily newspapers and periodicals for the information regarding the recent work on wastelands,
- Administrative Reports regarding policy measures at the Government level toward the reclamation of wasteland.

### 10.2.5.3 GIS Softwares

ArcMap, version 10.4 and Erdas Imagine, version 2013.

### 10.2.5.4 GPS

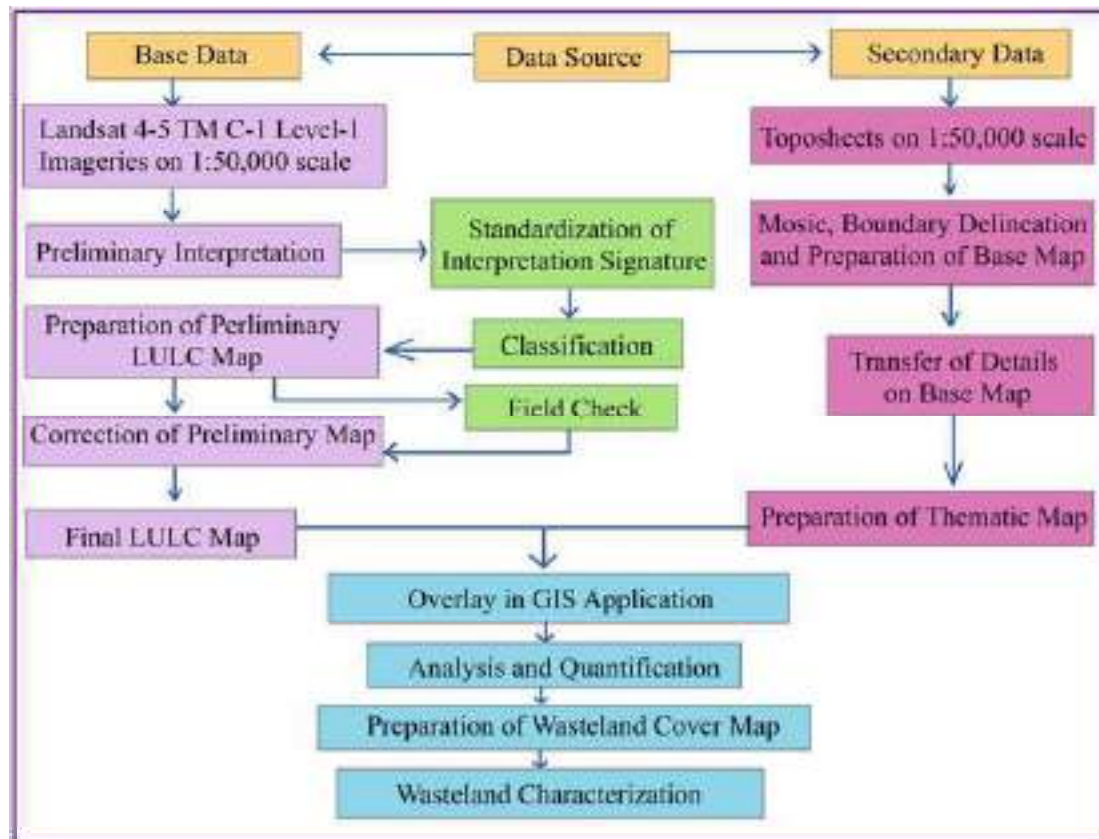
A handheld GPS Garmin-12 is used to record the exact locations and extent specific wasteland categories in the study area.

## 10.2.6 *Methods*

Geoinformatics techniques include SOI toposheets, Remote Sensing Satellite data, Global Positioning System (GPS), and GIS Software for mapping of forest cover, vegetation, lithology, physiography, drainage systems, and land use/land cover pattern in measuring the wasteland reclamation and management (Basavarajappa et al. 2015). With the help of satellite imageries and SOI toposheets, identification and delineation of wastelands has been done in three steps, viz. preliminary analysis, ground truth verification, and final interpretation (Fig. 10.5).

### 10.2.6.1 Preliminary Analysis

Visual analysis of Landsat-8 OLI/TIRS C-1 Level-1 on 1:50,000 scale geocoded data has been accepted for the mapping techniques of this study. In the first step, the base map of the study area have been prepared from SOI toposheets on 1:50,000 scale taking forest boundaries, roads, rivers, visible water bodies, district, state, and C. D.



**Fig. 10.5** Flow Chart showing an overview of wasteland mapping methodology

Block boundaries are taken from census handbooks of Purulia District and superimposed on the base maps. The base map and C. D. Block boundaries have been digitized in ArcMap software. Universal Transverse Mercator (UTM) with WGS-84 datum, 45° N Projection system have been taken to project all these maps. Satellite images of Landsat-8 OLI/TIRS C-1 Level-1 have been loaded on ArcMap software for visual interpretation. Based on the standard image interpretation keys like tone, texture, site, situation, pattern, shape, size and association, images were classified on supervised method using Maximum Likelihood Classification. By functioning the classifier panel of the ERDAS IMAGINE, training signatures of the target, i.e., Wastelands were identified. In this study, certain categories of wastelands like Rocky or stony wasteland, degraded forestland, and Gravelly wasteland are fluently delineated by asset of their pattern, location, and spectral separability. Besides them, Badland waste and Mining & Industrial wastelands are delineated with moderate success. However, degraded land under plantation crop could not be simply delineated because of its merging with fallow land, which is widely appeared throughout the district.



### 10.2.6.2 Ground Truth Verification

In the study area, accuracy has been verified on actual appearance of ground surface with the delineated wastelands of preliminary analysis phase. Particularly the areas where confusion in the preliminary interpretation has been thoroughly verified with the GPS recorded data.

### 10.2.6.3 Final Interpretation

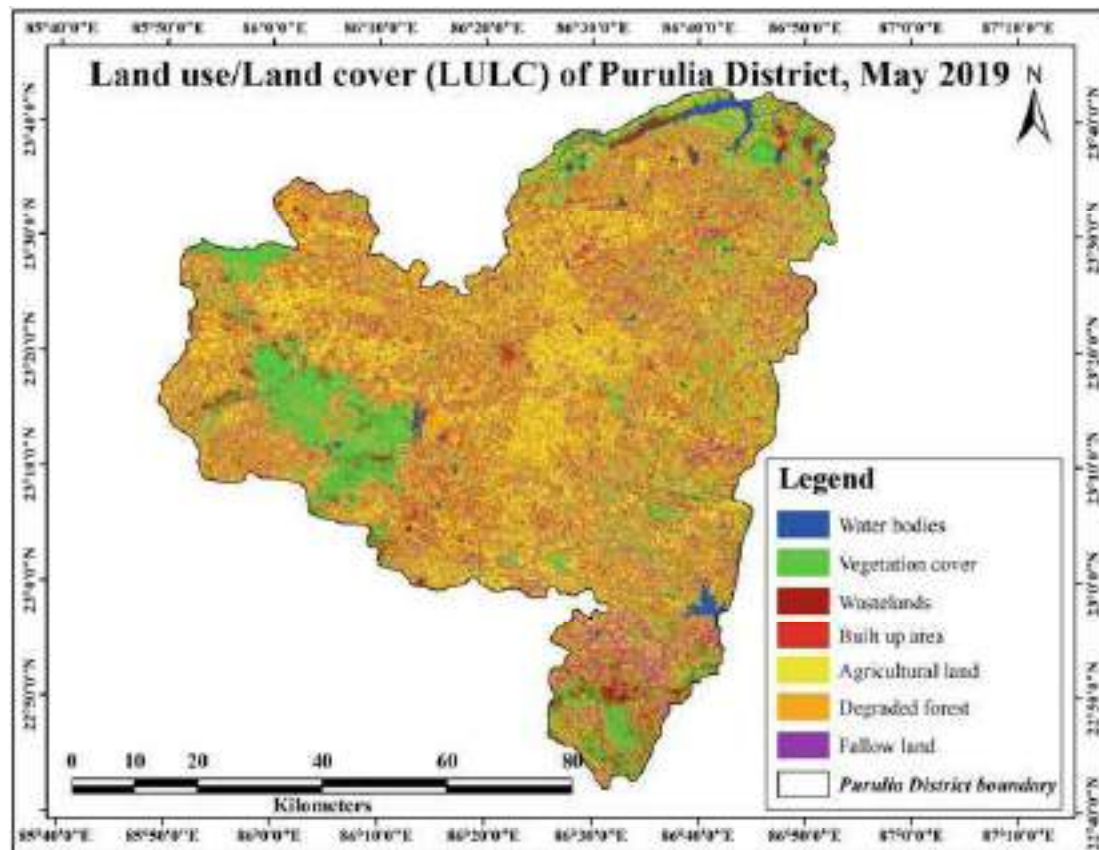
At this stage the interpretation of the image through ground check has also been further developed. With the help of these, final interpretation is completed. Through this exercise, demarcation of wastelands as well as coverage area under particular types of wastelands has been finalized. In this way, maps have been prepared for ready to the cartographic work.

## 10.3 Results and Discussion

### 10.3.1 *Land Use/Land Cover (LULC) Pattern of the Purulia District*

Land use refers to multiple uses of land, which are directly related to human activities (Anderson et al. 1976) and land cover refers to natural vegetation, soil, rocks, water bodies, agricultural area, artificial land cover, and others resulting due to land transformation (NRSA 1987; Basavarajappa et al. 2016). In general, land use is of a rapidly changing nature because it takes on complex forms in the context of socio-economic, technological, and environmental changes. Land use refers to responding the advantages and deficiencies of the physical environment based on human economic potential (Bhattacharya 1965). In India, rapid industrialization, urbanization, and massive population growth have resulted in depletion of natural resources, water crisis, declining agricultural lands, and increasing wastelands (Government of India, Department of Agriculture 2016; Roy and Inamdhar 2018).

Delineation of various land use/land cover categories of Purulia is made using Visual Image Interpretation Techniques on Landsat-8 OLI/TIRS C-1 Level-1 satellite images in combination with collateral data like SOI toposheets. The major classes of land use/land cover have been identified following the supervised method using the bands 2, 3, 4 & 5 of satellite imageries. In the present study, a total of seven land use/land cover classes have been taken for study which include Built-up area, Vegetation cover, Degraded forest, Agricultural land, Fallow land, Wasteland, and Water Bodies (Fig. 10.6). A total number of 145 section points were used to check the accurateness of the classification. The overall accuracy and kappa coefficient value of the classification are 96.67 and 95.87, respectively.



**Fig. 10.6** Land use/Land cover (LULC) of Purulia District. *Source* Landsat 8 imagery, May 2019

Most of the land in Purulia is under agriculture; nearly 50.93% of the total geographical area of the district was agricultural land in 2019. Most of the agricultural land in the district is dependent on monsoon rainfall, so these lands remain vacant during the pre & post-monsoon season. Vegetation cover is 16.26% of the total area, most of which is observed in the western and southern parts of the district. The amount of wasteland is 7.54% and fallow land is 17.61% of the total geographical area. The amount of fallow land affects the seasonal diversity of the wasteland, which is varying in different years due to the nature of monsoon rainfall and irrigation condition. In addition, other land use areas are relatively less, such as 2.03% of degraded forestlands, 3.12% of water bodies, and 2.51% built-up area (Table 10.2). Irregular and scattered type of rural settlements is found all over the district, but in several parts, agglomerated urban settlements are also observed.

### ***10.3.2 Identified Categories of Wastelands in Purulia District***

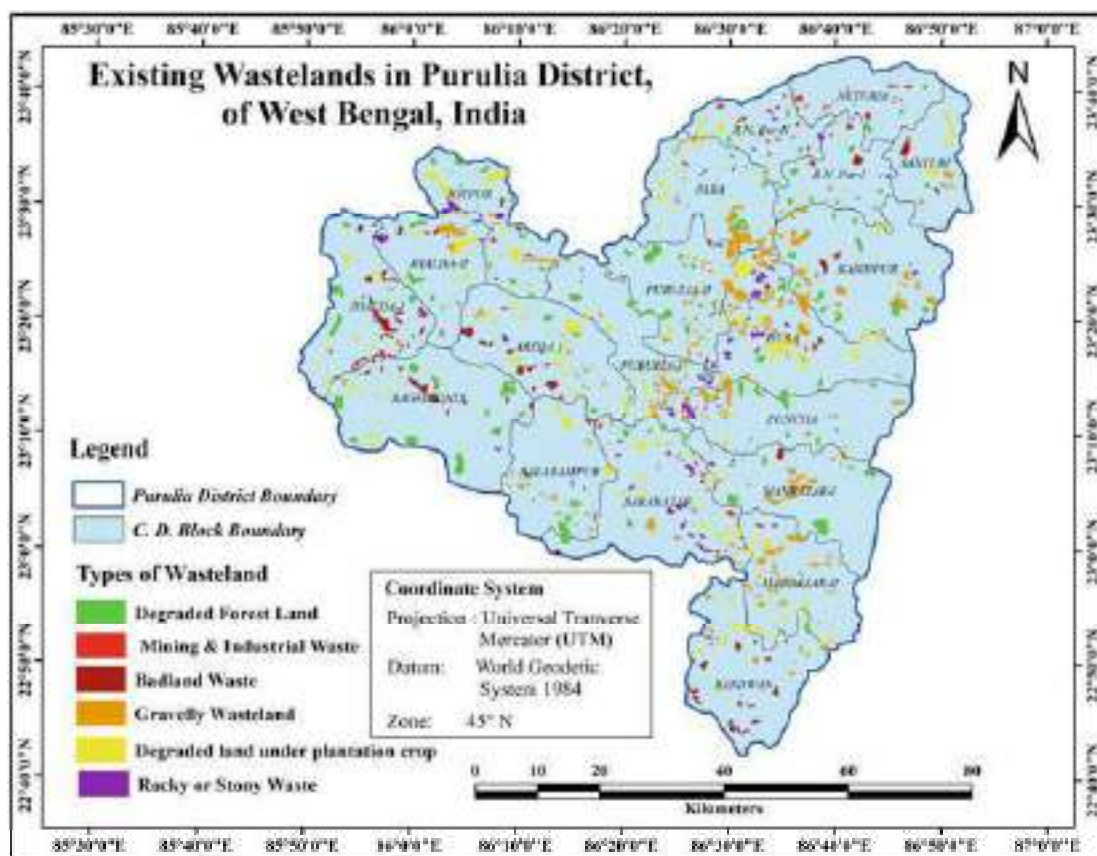
Wasteland is a type of land cover that can not be used for agriculture or any other profitable purpose under the ongoing conditions of land management (Jha 1987; Khatun and Debnath 2014). In Purulia District six categories of wasteland have been

**Table 10.2** Land use/Land cover pattern in Purulia District, West Bengal (May, 2019)

Land use types	Area in km <sup>2</sup>	Percentage
Built-up area	157.1009	2.51
Water bodies	195.2808	3.12
Wastelands	471.9286	7.54
Vegetation cover	1017.7134	16.26
Degraded forest	127.4321	2.03
Agricultural land	3187.4495	50.93
Fallow land	1102.0947	17.61
Total geographical area	6259.00	100.00

Source Landsat-8 OLI/TIRS C-1 Level-1 imageries, May 2019

identified, they are badland waste, gravelly wasteland, mining & industrial wasteland, rocky or stony wasteland, degraded forestlands, and Degraded land under plantation crop (Fig. 10.7). The categories of the wastelands are identified and digitized using SOI topographical maps of 1:50,000 scale and restructured from Landsat-8 OLI/TIRS C-1 Level-1 satellite images of 1:50,000 scale through ArcMap and Erdas Imagine (NRSC/ISRO 2012).



**Fig. 10.7** Different categories of existing wastelands of Purulia District. Source SOI toposheets, Landsat-8 OLI/TIRS C-1 Level-1 satellite images and field survey

**Table 10.3** Identified categories of wasteland in Purulia District in 2019

Categories of wasteland	Wasteland area in sq. km	% to Total Wastelands	% to Total Geographical area
Badland waste	11.2790	2.39	0.18
Degraded forestland	127.4207	27.00	2.03
Gravelly wasteland	113.0268	23.95	1.81
Mining & Industrial wasteland	9.0138	1.91	0.14
Degraded land under plantation crop	169.1864	35.85	2.71
Rocky or stony wasteland	42.0016	8.90	0.67
Total	471.93	100.00	7.54

Source Landsat-8 OLI/TIRS C-1 Level-1 satellite images, SOI toposheets and field survey

Being the most wasteland prone district of West Bengal, the total amount of wasteland in Purulia is 471.93 km<sup>2</sup>. (in 2019) that occupies 7.54% of the total geographical area of the district. Out of total wasteland, Plain Degraded land under plantation crop alone covers 35.85% followed by degraded forestland (27.00%), gravelly wasteland (23.95%), rocky or stony wasteland (8.90%), badland waste (2.39%), and mining & industrial wasteland (1.91%). Only three categories of wastelands, i.e., Plain drought-prone, degraded forestland, and gravelly wasteland jointly cover most (86.8%) of the wasteland areas of the district (Table 10.3).

### 10.3.3 Spatial Distribution of Wastelands in Purulia District

The geo-database formed using ArcMap and screen digitization techniques shows the types, extension and spatial distribution of different categories of wasteland existing in the study area (Fig. 10.9). In respect to total geographical area, the intensity of wasteland is highest in Arsha C. D. Block, which is 18.01 percent to total geographical area of the block. Moreover, Hura, Joypur, and Barabazar C. D. Blocks also have high intensity of wastelands covering to 16.19%, 14.43%, and 13.40% of the total geographical area, respectively. These four C. D. Blocks cover more than 46% of the total wasteland area of the district. Jhalda-I, Arsha, Joypur, Barabazar and Hura C. D. Blocks have more than one-half of the total wasteland area in the district for the predominance of hill slope, escarpments, hillocks, intrusive granite features. The C. D. Blocks that having significant percentage sharing of wasteland are Kashipur (6.43%), Manbazar-II (5.72%), Purulia-II (4.68%), Jhalda-II (4.58%), Bandwan (3.59%), Para (3.17%), and Balarampur (3.01%). The amount of wasteland in these C. D. Blocks is high due to water crisis, prolonged drought, massive soil erosion, and extensive deforestation. Table 10.4 and Fig. 10.8 show the coverage

**Table 10.4** Spatial Pattern of wastelands in the Purulia District

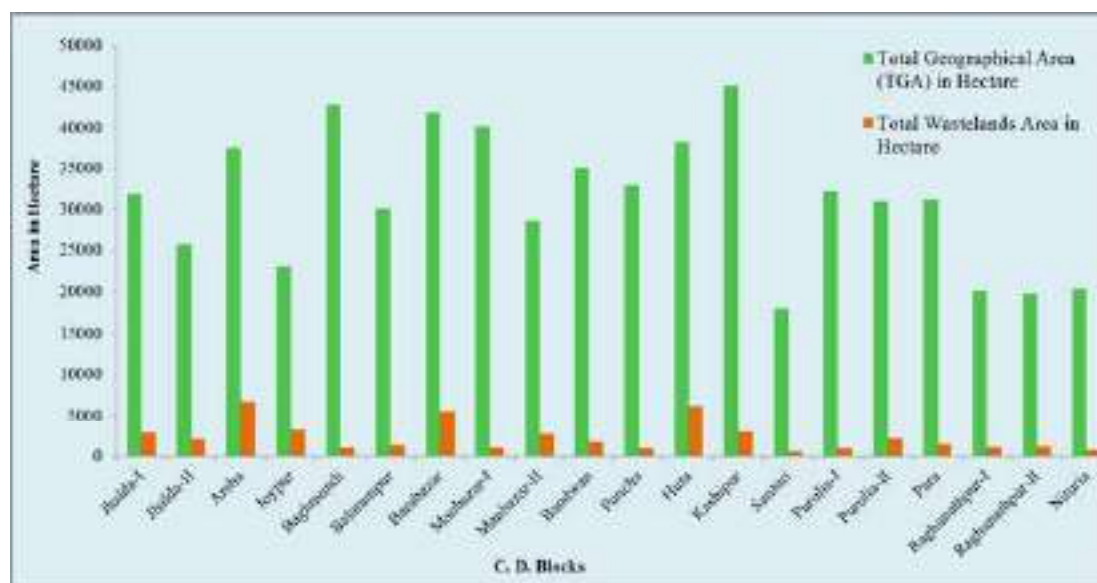
Sl. no	C. D. blocks	Total geographical area (TGA) (in Hectare)	Total wastelands area (in Hectare)	% to TGA	C. D. Block wise share in %
1	Jhalda-I	31,909	2841.0186	8.90	6.02
2	Jhalda-II	25,661	2161.4394	8.42	4.58
3	Arsha	37,504	6753.3183	18.01	14.31
4	Joypur	23,047	3327.1065	14.43	7.05
5	Baghmundi	42,795	1061.8425	2.48	2.25
6	Balarampur	30,088	1420.5093	4.72	3.01
7	Barabazar	41,806	5601.8091	13.40	11.87
8	Manbazar-I	40,132	1057.1232	2.63	2.24
9	Manbazar-II	28,581	2699.4396	9.44	5.72
10	Bandwan	35,125	1694.2287	4.82	3.59
11	Puncha	33,011	1000.4916	3.03	2.12
12	Hura	38,221	6187.0023	16.19	13.11
13	Kashipur	45,131	3034.5099	6.72	6.43
14	Santuri	17,969	556.8774	3.10	1.18
15	Purulia-I	32,337	991.053	3.06	2.1
16	Purulia-II	31,010	2208.6324	7.12	4.68
17	Para	31,259	1496.0181	4.78	3.17
18	Raghunathpur-I	20,182	1142.0706	5.66	2.42
19	Raghunathpur-II	19,767	1231.7373	6.23	2.61
20	Nituria	20,365	726.7722	3.59	1.54
	Purulia District	625,900	47,193.00	7.54	100.00

Source Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

area, intensity (% to TGA) and percentage sharing of wasteland according to the different C. D. Blocks of Purulia District.

**N.B.:** % to GTA = Total Wastelands Area / Total Geographical Area  $\times$  100; C. D. Block wise share in % = Total Wastelands Area of specific C. D. Block/grand total wasteland area (47,193.00)  $\times$  100.

Table 10.5 and Fig. 10.9 show the intensity of wasteland in the district in four grades. These grades are allocated as low (<4.00%), medium (4.01–8.00%), high (8.01–12.00%) and very high (>12.00%). Very high range wasteland found in Arsha, Hura, Joypur, and Barabazar C. D. Blocks. As the Arsha C. D. Block is located on the escarpment zone of the Ajodhya hill, the steeper slope and the faster soil erosion are responsible for the creation of wasteland. Whereas, Hura, Joypur, and Barabazar C. D. Block are existed on highly gradient rugged upland of the district. There are



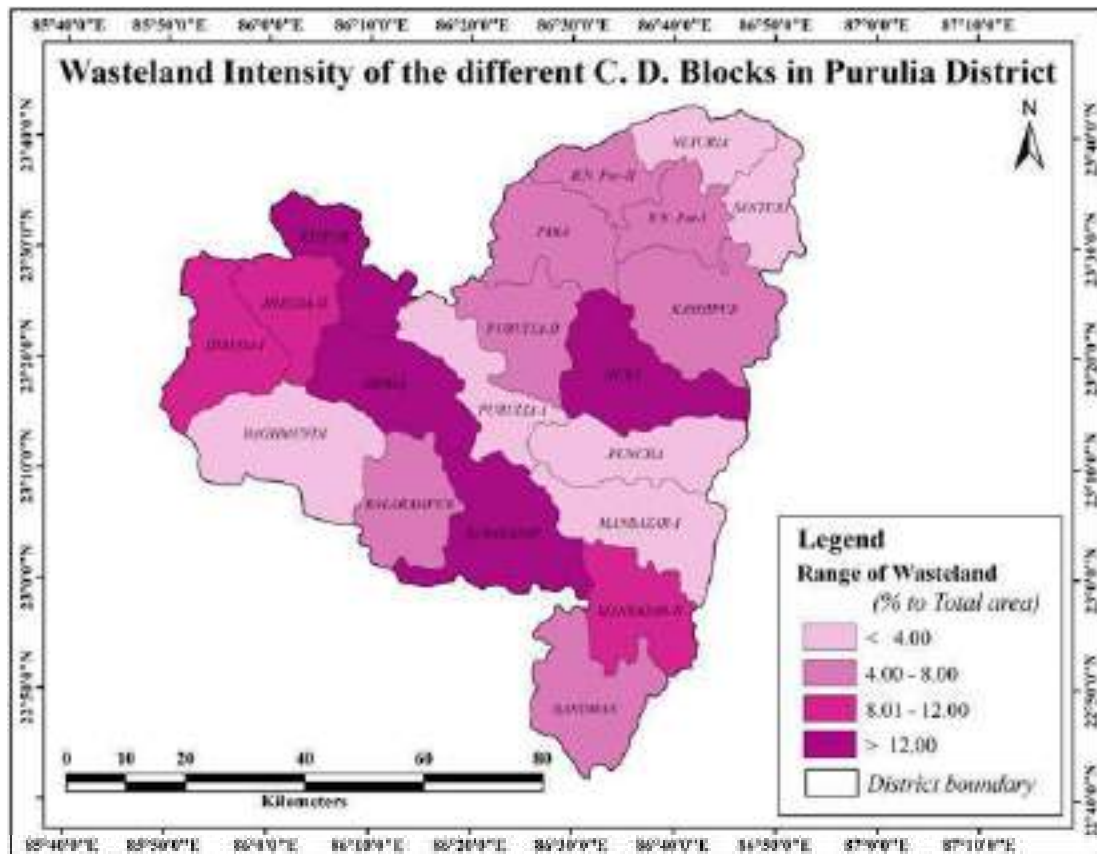
**Fig. 10.8** Amount of wasteland to the total geographical area of the Purulia District. *Source* Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

**Table 10.5** Wasteland intensity categorization

Range of wastelands (% to TGA)	Grades	Existing C. D. Blocks
<4.00	Low	Baghmundi, Manbazar-I, Puncha, Santuri, Purulia-I, and Nituria
4.00–8.00	Moderate	Purulia-II, Kashipur, Raghunathpur-I & II, Bandwan, Balarampur, and Para
8.01–12.00	High	Manbazar-II, Jhalda-I, and Jhalda-II
>12.00	Very high	Arsha, Hura, Joypur, and Barabazar

several small hills in these blocks and Pre-Cambrian rocks have been exposed in different places, which is the main reasons for the very high-level of wasteland.

High-grade wasteland is found in Manbazar-II and Jhalda-I & II C. D. Blocks due to the presence of highly rugged topography with numerous hillocks. Besides, the other C. D. Blocks of the district are characterized as moderate to low range wasteland because of the capacity of the land to be used is high in the moderate to low gradient rugged terrain. Overall, the main causes for uneven distribution of wasteland in Purulia District are variations in topographic complexity, water crisis, rapid soil erosion, excessive deforestation, unscientific plantation, and other anthropogenic activities.



**Fig. 10.9** Intensity of wasteland of the different C. D. Blocks in Purulia District. *Source* Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

### 10.3.4 Details of Category-Wise Wasteland Distribution

Multi-spectral data and maps show the magnitude, spatial distribution, and extent of the six categories of wastelands in Purulia District (Table 10.6). The categories of wastelands are quantified and mapped based on the characteristics of satellite imageries such as tone, color, shape, size, texture, pattern, and association (Fig. 10.10). In the Purulia District, the category-wise wasteland distribution has shown that most of the total geographical area (TGA) is covered by degraded land under plantation crop (2.71%) followed by degraded forestland (2.03%), gravelly wasteland (1.81%), rocky or stony wasteland (0.67%), badland wasteland (0.18%) and mining & industrial wasteland (0.14%), respectively (Fig. 10.11).

#### 10.3.4.1 Degraded Land Under Plantation Crop

Degraded land under plantation crop is found sporadically scattered all over the district. The concentration of this category is found to be maximum in Arsha C. D. Block i.e., 5.52% to the total geographical area (TGA) due to the higher elevation of

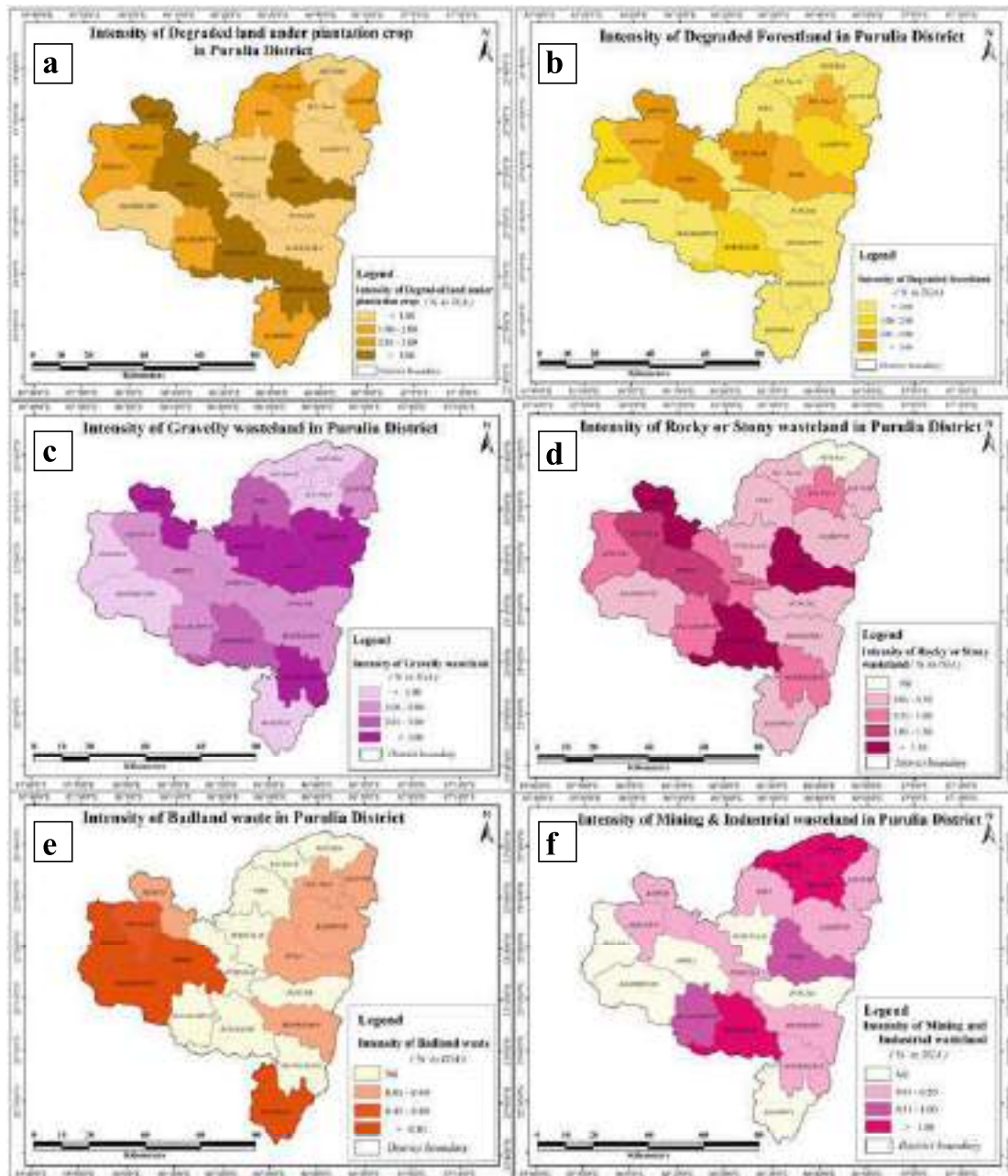
**Table 10.6** Category-wise wasteland distribution among the C. D. Blocks

Sl. no	C.D. blocks	Percentage to total geographical area (TGA) of the C.D. Block						Total % to TGA
		Degraded forestland	Degraded land under plantation crop	Gravelly wasteland	Rocky or stony wasteland	Badland wasteland	Mining & industrial wasteland	
1	Jhalda-I	1.84	2.00	0.60	0.66	3.80	0.00	8.90
2	Jhalda-II	2.49	2.84	1.30	1.06	0.56	0.17	8.42
3	Arsha	3.02	5.52	1.80	1.28	6.39	0.00	18.01
4	Joypur	3.80	4.13	3.48	2.70	0.15	0.17	14.43
5	Baghmundi	0.73	0.40	0.08	0.07	1.20	0.00	2.48
6	Balarampur	0.90	1.04	1.21	1.30	0.00	0.27	4.72
7	Barabazar	1.71	4.23	2.86	1.99	0.00	2.61	13.4
8	Manbazar-I	0.80	0.31	1.37	0.09	0.04	0.02	2.63
9	Manbazar-II	0.20	3.41	5.02	0.78	0.00	0.03	9.44
10	Bandwan	0.09	1.10	0.28	0.19	3.16	0.00	4.82
11	Puncha	0.70	0.51	1.41	0.41	0.00	0.00	3.03
12	Hura	2.54	5.13	4.10	3.42	0.12	0.88	16.19
13	Kashipur	1.80	1.00	3.28	0.24	0.36	0.04	6.72
14	Santuri	0.21	1.43	1.24	0.11	0.08	0.03	3.10
15	Purulia-I	0.40	0.72	1.90	0.63	0.00	0.09	3.74
16	Purulia-II	3.15	0.49	3.04	0.44	0.00	0.00	7.12
17	Para	0.32	1.96	2.13	0.27	0.00	0.10	4.78
18	Raghunathpur-I	2.14	0.17	0.24	0.65	0.32	2.14	5.66
19	Raghunathpur-II	0.50	2.33	0.00	0.27	0.00	3.13	6.23
20	Nituria	0.72	0.00	0.32	0.00	0.00	2.55	3.59
	Purulia	2.03	2.71	1.81	0.67	0.18	0.14	7.54

Source Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

Ajodhya foothill, lack of ground and surface water resources, and limp & infertile soil. Besides, Hura (5.13%), Barabazar (4.23%), Joypur (4.13%), and Manbazar-II (3.14%) C. D. Blocks also have high intensity (>3% to GTA) of this category of wasteland because of water crisis and poor soil. This is followed by Jhalda-II (2.84%), Raghunathpur-II (2.33%), Jhalda-I (2.00%), Para (1.96%), Balarampur (1.04%), Bandwan (1.10%) and Santuri (1.43%) C. D. Blocks. The intensity of this category in Purulia-I & II, Puncha, Manbazar-I, Kashipur, Neturia, and Baghmundi C. D. Blocks is much less (<1.00%) because the main rivers of the district like Kangsabati, Kumari, Dwarakeswar, and Damodar are flowing along these C. D. Blocks.





**Fig. 10.10** Distribution of categories of wasteland; **a** distribution of degraded land under plantation crop among the C. D. Blocks, **b** distribution of degraded forestland among the C. D. Blocks, **c** distribution of gravelly wasteland among the C. D. Blocks, **d** distribution of rocky or stony wasteland among the C. D. Blocks, **e** distribution of badland waste among the C. D. Blocks, **f** distribution of mining & industrial wasteland among the C. D. Blocks

### 10.3.4.2 Degraded Forestland

The degraded forestland has covered more than 3 percent of the total geographical area in Joypur (3.80%), Purulia-II (3.15%), and Arsha (3.02%) C. D. Blocks indicating the high intensity of this category. Others C. D. Blocks having more geographical area under the degraded forestland are Hura (2.54%), Jhalda-II (2.49%),



**Fig. 10.11** Different categories of wastelands in Purulia District; **a** shows the degraded land under plantation crop in Kalimati Mouza of Baghmundi C.D. Block. Soil quality is good and water holding capacity is moderate but this tract is not utilized due to lack of water. **b** Degraded forestland of Deuli Mouza of Hura C.D. Block. *Sonaijhuri* plantation for long time creates this wasteland. **c** Gravelly wasteland of Palsara Mouza of Kashipur C. D. Block. **d** Rocky wasteland of Hirbahal Mouza of Purulia-II C.D. Block. **e** *Sonaijhuri* Plantation on Maghuria Pahar (hill) in Hura C. D. Block. This type of plantation promotes soil erosion and increases rocky field. **f** Badland wasteland in Gurahata Mouza of Arsha C.D. Block and **g** Badland wasteland of Sharangdi Mouza of Baghmundi C. D. Block are found in foothills of Ajodhya Range. Soil erosion is rapid which needs adequate plantation. **h** Heaps of industrial wastes (ash) in Durmut Mouza of Neturia Block, which converts the agricultural land into wastelands. **i** Sponge iron industry and adjoining wasteland of Kashiberia Mouza of Natundih G.P. in Raghunathpur-II C. D. Block. **j** Rock mines in rocky and gravelly wastelands of Latpada Mouza in Barabazar C.D. Block, which accelerates soil erosion & deforestation and creates mining wasteland. **k** Stone-chips industry of Hinjla Mouza in Barabazar C. D. Block, **l** *Panjanian Granite Mine Project* (Hura Block) of WB Mineral Development & Trading Corporation Ltd. It accelerates rapid soil erosion, which is deposited on the agricultural field of lower part

Raghunathpur-I (2.14%), Jhalda-I (1.84%), and Kashipur (1.80%). These C. D. Blocks have a higher rate of economic development than the other blocks in the district, which is the main reason for the increase in their degraded forestlands. The people of these blocks always use the land profitably. In the rest of the blocks, the amount of this category of wasteland is negligible percentage (<1.00%).

#### **10.3.4.3 Gravelly Wasteland**

High concentration of gravelly wasteland is found in Hura (5.13%), Manbazar-II (5.02%), Joypur (3.48%), Kashipur (3.28%) and Purulia-II (3.04%), C. D. Blocks due to the occurrence of high-level weathered materials of granite-gneiss, migmatite, and mica-schist. Other C. D. Blocks having more area under this category are Para, Barabazar, Jhalda-II, Purulia-I, Arsha, Balarampur, Manbazar-I, and Santuri. The intensity of wasteland in these blocks is “between” 1% to 3% to the total geographical area.

#### **10.3.4.4 Rocky or Stony Wasteland**

In case of rocky or stony wasteland, Hura again tops among all the C. D. Blocks followed by Joypur, Barabazar, Balarampur, Arsha, and Jhalda-II. Their percent to total geographical area of respective blocks are 3.42%, 2.70%, 1.99%, 1.30%, 1.28% and 1.06%, respectively. In the study area, the main reason for the formation of this category is the rapid soil erosion resulting in exposure to the parent rocks on the surface soil. Rest of the C. D. Blocks in Purulia District, the amount of this category of wasteland is either negligible percent or nil.

#### **10.3.4.5 Badland Waste**

Although the badland wasteland of the district is much less than the other wastelands, it is highly intense in Arsha (6.39%), Jhalda-I (3.80%), Bandwan (3.16%), and Baghmundi (1.20) C. D. Blocks. Arsha, Jhalda-I, and Baghmundi C. D. Blocks are located in the hilly tract of Ajodhya Pahar. On the other hand, there are many hills and hillocks along the entire Bandwan C. D. Block. Therefore, the high elevation, hill slope, escarpment, and highly rugged terrain of these areas are the fundamental causes for generating badland waste. The less intensity (0.01–0.40%) of badland wasteland is seen in Raghunathpur-I, Hura, Kashipur, Manbazar-I, Santuri, and Joypur C. D. Blocks as there are some hills like Jaychandi (Raghunathpur-I), Panjania, Tilaboni (Hura), Belamu (Joypur), Senera (Santuri), Bahadurdih (Kashipur), Parasa (Manbazar-I), etc. but in the rest of the nine C. D. Blocks is nil.

#### **10.3.4.6 Mining and Industrial wasteland**

Mining wasteland refers to those lands where waste rubbish is accumulated after extraction of raw materials; land is useless after excavation of rocks, stone, sand, gravel pits, and soil (Wastelands Atlas of India, 2019). Industrial wastelands are industrial waste disposal areas (Wastelands Atlas of India, 2019) and adjoining unused lands covered by industrial ash. Mining wasteland and industrial wasteland have been shown together because small-scale industries have also developed in all the areas where mining is done in the district. The maximum area under mining & industrial wasteland is observed in Raghunathpur-II (3.13%) Block due to the presence of thermal power plants and multiple small-scale sponge iron industries. The Nituria C. D. Block has maximum wasteland in this category (2.55% out of 3.59%) because of its coal extraction and many sponge iron industries. Besides, the Raghunathpur-I (2.14%) Block has a higher intensity of this category of wasteland for the predominance of small-scale industries. On the other hand, the massive rock quarrying and predominance of the stone chips industries in the Barabazar (2.61%) C. D. Block is the main reason for the formation of this category of wasteland. Among the other C. D. Blocks, Hura, Balarampur, Joypur, Jhalda-II, Para, Purulia-I, Kashipur, Santuri, Manbazar-I & II represent less intensity (<1.00%) of this category of wasteland due to excavation of rocks, stone, gravel pits, and soil; but it is not seen in the remaining six C. D. Blocks at all.

### **10.4 Recommendations for Wasteland Reclamation**

To meet the demands of increasing population and many other developmental activities, there is an urgent need to reduce the trend of wastelands generation and transform wastelands to their productive capacity. There are six categories of wastelands in the study area of which degraded land under plantation crop, badland, degraded forestland, and mining & industrial wastelands can be reclaimed by taking suitable management measures. Therefore, the recommended measures will be obligate for the reclamation and alteration of wastelands to the productive lands (Table 10.7).

### **10.5 Conclusion**

This study shows the identification and monitoring of wastelands with the help of satellite imageries and SOI toposheets. GIS analysis provides accurate information and data on different categories of wasteland identification, validation, area demarcation, and mapping. The potentiality of satellite imagery for providing accurate baseline information is currently well recognized and emerging. The study carrying out determination of wasteland at the district level can be utilized for various reclamation measures in effective manner.

**Table 10.7** Reclamation strategies and suggested land use for the different categories of Wastelands in Purulia District

Categories of wasteland	Reclamation methods	Suggested land use
Degraded land under plantation crop	Increased assurance of surface water and ground water through rain water harvesting and construction of check dams, Providing irrigation facilities	Cultivated crops through suitable crop selection, Continuous cropping
Degraded forestland	Restrict illegal forest cutting, Regulate grazing activity	Plantation of native plant, Permanent plantation
Gravelly wasteland	Natural generation of grassland, Plantation of indigenous trees	Pasture development with proper channel, Natural regeneration of vegetal cover
Rocky or Stony wasteland	Regular grazing activity, Building materials	Pasture development
Badland waste	Leveling of gullies or ravines, Construction of earthen check dams, Providing diversion bunds or trench above the head	Afforestation, Agro-horticulture for food and fuel, Grassland cover
Mining & Industrial wasteland	Removal of waste materials of industries and mines for the uses of road, buildings and mine fills, Construction of infiltration wells and open wells	Sow the early successional species of plants and grasses, Use groundcovers that are consistent with growing trees

From the above analysis, it can be said that the district has the enormous potential to be developed with the conversion of a significant proportion of degraded land under plantation crop into arable lands. Apart from this, degraded forestland, gravelly wasteland, and badland waste may be used for other than agricultural activities such as livestock farming like goat rearing, piggery, poultry, etc., agro-based and cottage-based industries. The rocky or stony wasteland is expected to be the most profitable for the district to use in the brick kilns (the soil for making bricks should be brought from barren uncultivated lateritic tracts of the district) and stone chips industry.

The above recommended measures can be effective only, if the State and Central Government take the initiative along with the participation of local community. However, the role of State Government especially the Forest Department, in Purulia District is very disappointing. They have no such suitable planning for the enhancement of degraded forestlands. *Acacia auriculiformis* (*Sanajhuri*) is being planted in the degraded forestlands and as a results soil health is being severely deteriorated. Because, *Acacia auriculiformis* species has been most dangerous for soil health and forest ecosystem through reduction of soil moisture, soil fertility, and under growth. Therefore, it is necessary to plant the native tree species like *Dalbergia sissoo*

(*Shisham*), *Butea frondosa* (*Palash*), *Schleichera trijuga* (*Kusum*), *Zizyphus xylopyra* (*Kul*), *Bassia latifolia* (*Mohul*), *Shorea robusta* (*Sal*), *Carissa spinarum* (*Karamcha*), *Terminalia arjuna* (*Arjun*), etc. instead of *Acacia auriculiformis* species on these lands.

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# বহুমাত্রিক রবীন্দ্রনাথ : নতুন ভাবনা



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## ॥ বিষয় সূচি ॥

● রবীন্দ্রনাথ ঠাকুর ও মহাত্মা গান্ধীর জাতীয়তাবাদী দর্শনের মতপার্থক্য ও সৌজন্যতাবোধ-প্রসঙ্গে সমকালীন শ্রেয় ও শমিকা	ড. কতরত গোস্বামী	১৩
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## ॥ রবীন্দ্রনাথের 'সোনার তরী' কাব্যে নদীর স্থান ॥

শুভাশিস গোস্বামী

১৯২৬ বঙ্গাব্দের অগ্রহায়ণ মাসে (নভেম্বর, ১৮৮৯) রবীন্দ্রনাথকে জমিদারি তদারক  
ক রক্ষণাবেক্ষণের ভার নিতে হয়েছিল। তদানীন্তন উত্তরবঙ্গে ঠাকুর পরিবারের তিনটি  
বৃহৎ পরগণার জমিদারি ছিল—বিরাহিমপুর, কালিগ্রাম ও সাজাদপুর। বিরাহিমপুর পরগণার  
কাছারি ছিল শিলাইদহে, কালিগ্রাম পরগণার কাছারি পতিসরে আর সাজাদপুর গ্রামের  
নামেই পরগণা। ১৯২৬ বঙ্গাব্দের ১১ অগ্রহায়ণ পত্নী মৃগালিনী দেবী, তাঁর এক সহচরী  
(মমলা দাশ), কন্যা বেলা, পুত্র রবীন্দ্রনাথ ও ভ্রাতৃপুত্র বলেন্দ্রনাথকে নিয়ে যাত্রা  
করলেন শিলাইদহ। এর আগে একাধিকবার শিলাইদহে এলেও, পদ্মা নদীর সঙ্গে পরিচয়  
ঘটলেও প্রগাঢ় প্রণয় তখনও ঘটেনি। এবার শিলাইদহ অঞ্চলের পদ্মাপ্রকৃতি তথা গ্রাম  
বাঙ্গার এক অনন্য সৌন্দর্য নতুনভাবে ধরা দিল তাঁর চোখে। ইন্দ্রিরাদেবীকে লিখেছেন—

"শিলাইদহে অপরপারে একটা চরের সামনে আমাদের বেটি লাগানো আছে। প্রকাণ্ড  
চর—ধু ধু করছে—কোথাও শেষ দেখা যায় না—...পৃথিবী যে বাস্তবিক কী আশ্চর্য  
সুন্দরী তা কলকাতায় থাকলে ভুলে যেতে হয়। এই যে ছোট নদীর ধারে শান্তিময়  
গাছপালার মাঝে সূর্য প্রতিদিন অস্ত যাচ্ছে, এবং এই অনন্ত ধূসর নির্জন নিঃশব্দ চরের  
উপরে প্রতি রাত্রে শত সহস্র নক্ষত্রের নিঃশব্দ অভ্যুদয় হচ্ছে, জগৎ সংসারে এ-যে কী  
একটা আশ্চর্য মহৎ ঘটনা তা এখানে থাকলে তবে বোকা যায়।"<sup>১</sup> এমনই এক  
বিশ্বয়-বিমুক্ত সৌন্দর্য দৃষ্টি নিয়ে রচিত হল রবীন্দ্র কবিজীবনের সবচেয়ে বড় অধ্যায়।  
শিলাইদহে কবি দেখেছেন প্রকৃতি ও মানুষের বিচিত্র বর্ণালী। আবিষ্কার করেছেন আপন  
অস্তরের সত্যকে। গ্রামের ঘাটে বাঁধা থাকত তাঁর বেটি 'পদ্মা'। শুনেতেন নদীর কলধ্বনি  
মেশানো মানুষের ছোট ছোট সুখদুঃখের কথা। অব্যাহত ধান ক্ষেতের উজ্জল বাতাস,  
মিষ্টি মধুর ঘ্রাণ ভরিয়ে তুলত তাঁর প্রাণমন। এখানকার প্রকৃতির স্তব্ধ নির্মলতা, সীমাহীন  
ঘননীল আকাশ তাঁর মনে কখনো কখনো জন্ম দিয়েছে এক উদাসীনতারও।

কর্মসূত্রে টানা একটা দশক এখানকার পল্লীপ্রকৃতির সান্নিধ্যে অতিবাহিত করেছিলেন  
কবি। কিন্তু এই মুহূর্তের পর্বটিকে আজীবন ভুলতে পারিনি। 'সোনার তরী' থেকে  
'জন্মদিনে' পর্যন্ত নানা কাব্যে প্রত্যক্ষ বা পরোক্ষভাবে তাঁর কবিতায় উঠে এসেছে পদ্মা  
নদী তথা শিলাইদহ অঞ্চলের প্রকৃতির কথা। মৃত্যুর এক বছর পূর্বে লেখা 'সোনার তরী'



## ॥ পারিবারিক সম্পর্কের বিন্যাস ও 'গোরা' উপন্যাস ॥

অসীমকুমার মুখার্জী

রবীন্দ্রনাথ ঠাকুরের 'গোরা' উপন্যাসটি সামাজিক ও রাজনৈতিক ভবনার শ্রেষ্ঠ শিল্প রূপ হিসেবে পরিগণিত হবে। বিশ শতকের গোড়ার দিকে অশান্ত সমাজ এবং বিক্ষুব্ধ রাজনৈতিক চেতনার আঘাতে তাঁর উপন্যাস এবার বিশালতর পটভূমিকায় জীবনের বৃহত্তর সমস্যার সমাধানে এসে দাঁড়ায়। যুগ ধর্ম নরনারীর জীবনকে কিভাবে প্রভাবিত করতে পারে এবং রাজনীতি, স্বদেশিকতা ও সমাজ সমস্যার উদ্বেল তরঙ্গমালা বাঙালি জীবনকে কতটা সংকুচিত করেছিল তার প্রকৃষ্ট উদাহরণ 'গোরা' উপন্যাস। 'গোরা' থেকেই রবীন্দ্রনাথ হৃদয়গত সমস্যার সঙ্গে বুদ্ধিবৃত্তিগত নানা সমস্যাকে মিলিয়ে নিয়ে কাহিনী গ্রহণ করেছেন। পরবর্তীকালে 'মরে বাইরে' এবং 'চার অধ্যায়ে' তার বিস্তার ঘটেছে। 'গোরা'র কাহিনী কেবল গোরা—সূচরিতা, বিনয়—ললিতার প্রেম কাহিনী নয়, তৎকালীন বাংলার ধর্ম আন্দোলনের পটভূমিকায় জাতীয়তা, মানবতা ইত্যাদির সঙ্গে এর যোগাযোগ নিবিড়।

পারিবারিক কাঠামোকে বজায় রেখে কালোপযোগী এক নতুন জীবন ছন্দের কথা বলতে চেয়েছেন রবীন্দ্রনাথ। স্বামী-স্ত্রীর বোঝাপড়া, পরিবার ভুক্ত অন্যদের সঙ্গে বোঝাপড়াতেও একটা নতুন ধারণার আভাস পাওয়া যায় তাঁর উপন্যাসে। বৌদ্ধ দায়িত্বই হল পরিবার চেতনার আদর্শ ভিত্তি। আর এই ভিত্তি নির্মিত হয় পারিবারিক সম্পর্কের সুদৃঢ় বন্ধনে। 'গোরা'র কাহিনী গ্রহণেই এই পরিবার বন্ধ জীবনের নানা সম্পর্কের কথা ব্যক্ত হয়েছে, যা আমাদের আলোচনার প্রধান বিষয়।

স্বামী-স্ত্রী: কৃষ্ণদয়াল ও আনন্দময়ী

'গোরা' উপন্যাসটি যে গোত্রেরই হোক না কেন, তাতে পারিবারিক জীবনের কথা মালার মতো গোঁথে রয়েছে। এই উপন্যাসে দুটি পরিবারের পরিচয়ই প্রধান হয়ে উঠেছে। কাহিনীর সূত্রপাত, বিস্তার ও পরিণতিও ঘটেছে এই পরিবার দুটিকে কেন্দ্র করে। উনিশ শতকের শেষ দিকে হিন্দু—ব্রাহ্ম বিরোধের পটভূমিতে একটি হিন্দু ও অপরটি ব্রাহ্ম পরিবারের চিত্র আছে। উভয় ক্ষেত্রেই পরিবার জীবনের আন্তর-ক্রিয়ার



# স্বাধীনতা উত্তর বাংলা কবিতা: চর্চার বহুরৈখিকতা

সম্পাদনা

ড. প্রণবকুমার মাহাতো

কবিতিকা

Kabitika

স্বাধীনতা উত্তর বাংলা কাবিতা: চর্চার বহুরীক্ষিকা  
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ড. অরুণাভ মুখার্জী

আধুনিক বাংলা কবিতার জগতে 'নীললোহিত' ওরফে সুনীল গঙ্গোপাধ্যায় এক অনন্য সাধারণ নাম। তাঁর 'আত্মিক অভিজ্ঞান' ও 'অন্তর্দৃষ্টি', সব থেকে গাঢ় ও গূঢ় তাঁর কবিতায়। সাম্প্রতিক বাংলা কবিতা জগতের সুবিখ্যাত কবি সুনীল গঙ্গোপাধ্যায় ২৩ অক্টোবর ২০১২ খ্রিস্টাব্দে আমাদের কাছ থেকে চিরবিদায় নিয়েছেন, যার জন্ম ১৯৩৪ খ্রিস্টাব্দের ৭ সেপ্টেম্বর অধুনা বাংলাদেশের ফরিদপুরে। বাংলা কবিতার জগতে তাঁর প্রথম আত্মপ্রকাশ ১৯৫১ সালে 'দেশ' পত্রিকায় 'একটি চিঠি' কবিতা প্রকাশের মধ্য দিয়ে। এরপর 'কৃষ্ণিবাস' (১৯৫৩ খ্রিস্টাব্দ, ১৩৬০ বঙ্গাব্দ, শ্রাবণ) ত্রৈমাসিক পত্রিকার মধ্য দিয়ে বাংলা কবিতা আন্দোলনের রূপরেখা নির্মাণ করেছেন, কবিতার আন্দোলনকে বয়ে নিয়ে গেছেন শক্তি চট্টোপাধ্যায়ের সঙ্গে। 'কৃষ্ণিবাস' পত্রিকায় সমকালীন "তরুণ কবিরা জেনেশুনেই কাল-পরিবেশ মন্বনজাত বিষ আকর্ষণ করে বাংলা কবিতার নতুন মোড় ফেরানোর আন্দোলন শুরু করলেন— অস্বীকার করলেন পূর্ববর্তীদের কায়দায় কবিতা বানানোর খেলা খেলতে। এঁদের কবিতা 'লেখা লেখা খেলা' নয়, এঁদের কবিতায় রক্তাক্ত জীবন যাপন"।<sup>১</sup> সুনীল গঙ্গোপাধ্যায় লিখেছেন—

“শুধু কবিতার জন্য এই জন্ম, শুধু কবিতার  
জন্য কিছু খেলা, শুধু কবিতার জন্য একা হিম সঙ্কোবেলা  
ভুবন পেরিয়ে আসা, শুধু কবিতার জন্য  
অপলক মুখশ্রীর শান্তি একঝলক;  
শুধু কবিতার জন্য তুমি নারী, শুধু  
কবিতার জন্য এতো রক্তপাত...।”<sup>২</sup>

# हिन्दी नाटक के विविध आयाम



डॉ. बिजय रवानी

# के कला दिने साप्ताह इतिहास

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## जाति आधारित सामंतवाद, काव्यात्मक न्याय और संवैधानिक न्याय-व्यवस्था

(संदर्भ : कोर्ट मार्शल)

गौतम सिंह राणा

आधुनिक हिंदी नाटककारों में स्वदेश दीपक का नाम कोई परिचय का मोहताज नहीं है। ये हिंदी के उन कुछ एक नाटककारों में से हैं, जिन्हें संगीत नाटक अकादमी पुरस्कार (सन् 2004) मिला हुआ है। ऐसा भी नहीं है कि इन्होंने बहुत अधिक संख्या में नाटक लिखा है, जिसके लिए ये सम्मानित हुए हैं। बल्कि ये हिंदी नाटक के क्षेत्र में कालजयी कहानीकार गुलेरी जी के सदृश हैं, जिन्होंने केवल पाँच नाटकों के लेखन के बल पर आधुनिक हिंदी कालजयी नाटककारों की फेहरिस्त में खुद को शामिल किया है। इनके द्वारा लिखित पाँच नाटक हैं — बाल भगवान (1989), कोर्ट मार्शल (1991), जलता हुआ रथ (1998), सबसे उदास कविता (1998) और काल कोठरी (1999)।

‘कोर्ट मार्शल’ स्वदेश दीपक कृत एक ज्वलंत नाटक है। ज्वलंत इसलिए है क्योंकि नाटककार ने जाति आधारित सामंतवाद के मजबूत तंतुओं की पड़ताल भारतीय सेना जैसी उस सरकारी संस्थान में की है, जहाँ जाति आधारित आरक्षण की व्यवस्था ही नहीं है। इस तरह नाटककार ने इस नाटक के मार्फत आजादी के बाद से लेकर अब तक सरकारी संस्थानों में संविधान प्रदत्त जाति आधारित आरक्षण को खत्म करने या, फिर लागू रखने के विवाद पर पुनर्चर्चा का एक प्लेटफार्म प्रदान किया है जो कि देश के अन्यतम ज्वलंत मुद्दों में से एक है। इस नाटक के कथानक के मूल में अपराधी जवान रामचंद्र है। वह दलित वर्ग से संबंधित है। उस पर कोर्ट मार्शल की कार्रवाई चल रही है। उसने कैप्टन वर्मा और कैप्टन कपूर पर गोली चलाने का अपराध किया है, जिसमें कैप्टन वर्मा की मृत्यु हो गई है और कैप्टन कपूर मरने से बाल-बाल बचा है। सभापति जज कर्नल सूरत

जिरह के समक्ष सरकारी वकील मेजर अजय पुरी बारी-बारी से अपने गवाहों को पेश करता है। वह अपने उद्देश्य को बड़ी आसानी से प्राप्त कर लेता है क्योंकि इसमें अपराधी जवान रामचंदर का गुनाह—ए—इकबाल बड़ी भूमिका निभाता है। बचाव पक्ष का वकील कैप्टन बिकाश राय भी इस बिंदू को झूठलाने की रसीभर भी कोशिश नहीं करता है क्योंकि उसका उद्देश्य हत्या के मूल के निहित सच्चाई को सामने लाने का होता है न कि रामचंदर को हत्या के मामले से बरी करने का। वह अपने वाक् पटु जिरह के मार्फत इस हत्या के पीछे निहित कड़वी सच्चाई को सबके समक्ष लाने में सफल होता है। सच्चाई यह निकलती है कि कैप्टन वर्मा और कैप्टन कपूर ने जाति आधारित सामंतवादी मानसिकता से ग्रसित होकर जवान रामचंदर को घोर अमानवीय मानसिक पीड़ा देने का काम करते हैं और वह पीड़ा असहनीय होकर तब प्रतिकार के रूप में सामने आती है, जब उसके गौरवर्णा होने के कारण उसके माता के चरित्र पर कीचड़ उछाला जाता है। यह पीड़ा उसके लिए असहनीय हो जाता है और वह अपनी नौकरी व जान की परवाह किये बिना उन दोनों स्वर्ण अफसरों पर गोली चला देता है। कोर्ट परिसर में इस सच्चाई के सामने आने से परेशान होकर कैप्टन कपूर नेपथ्य में जाकर आत्महत्या कर लेता है। बावजूद इसके सेना कानून से बंधे जज सूरत सिंह इस मृत्यु को काव्यात्मक न्याय की संज्ञा देते हुए रामचंदर को अगले दिन फाँसी की सजा देने का निर्णय कर लेता है। नाटक का समापन इसी स्थिति में हो जाता है।

पूरे कथानक की बुनावट की सबसे बड़ी खासियत यह है कि इसके सभी अफसर पात्र रामचंदर से अपेक्षाकृत उच्च वर्ण से संबंधित हैं और उनमें से अधिकांश जाति आधारित सामंतवादी मानसिकता से ग्रसित हैं। कैप्टन कपूर, कैप्टन वर्मा, डॉक्टर कैप्टन गुप्ता आदि ऐसे ही पात्र हैं। कैप्टन कपूर और कैप्टन वर्मा की इस मानसिकता का सबसे अमानवीय और निकृष्टतम रूप उस समय सामने आता है, जब वे अपने घर पर चल रहे एक बर्थडे पार्टी में जवान रामचंदर को भरी महफिल में एक बच्ची के टट्टी को साफ करने का आदेश देता है और रामचंदर द्वारा उस आदेश को मानने से मना करने पर कैप्टन कपूर कहता है — “जात का चूहड़ा और टट्टी उठाने में शर्म आती है। तुम्हारे पुरखे पुश्टों से हमलोगों की टट्टी की टोकरी अपने सिर पर उठा रहे हैं।” डॉक्टर कैप्टन गुप्ता तो सेना में एक डॉक्टर होने के बावजूद कैप्टन कपूर की बातों में आकर अपने कर्तव्य के विपरित जवान रामचंदर



के साथ अन्याय करता है। हो सकता है कि नाटककार ने अपने उद्देश्य की पूर्ति के बरक्स पात्र परिकल्पना की ऐसी परिपाटी बनाई हो। बावजूद इसके इस बात को खारिज तो नहीं ही किया जा सकता है क्योंकि सरकारी आँकड़े बहुत हद तक इसी बात की गवाही देते हैं।

जाति आधारित सामंतवादी मानसिकता की सबसे बड़ी खराबी यह है कि इससे ग्रसित लोग स्वयं को समाज में मान्य समस्त सम्माननीय पदों एवं कार्यों का जन्मना अधिकारी समझ बैठते हैं और साथ ही साथ स्वयं को रुलिंग क्लास का भी समझने लगते हैं। प्रस्तुत नाटक में इस मानसिक रोग का भी चित्रण मिलता है। नाटक के एक स्थल पर बचाव पक्ष के वकील कैप्टन बिकाश राय के तर्कपूर्ण प्रश्नों से परेशान होकर कैप्टन कपूर अपनी गलती का एहसास करने के बजाय कह ही बैठता है — “अब खानदानी लोग फौज में भरती नहीं होते। नीची जाति के लोगों को भरती किया जाएगा तो यही होगा। बात-बात पर शिकायत और शीमिंग।”<sup>2</sup> इस पर जब बिकाश राय कैप्टन कपूर से उसके खानदानी होने के बारे में जानना चाहता है तो कैप्टन कपूर बड़े गर्व से कहता है — “यैस। पिछली चार पुश्तों से हमारे पुरखे राज कर रहे हैं। आई.सी.एस., आई.एफ.एस., आर्मी, नेवी, एअरफोर्स। सब जगह अफसर हैं हमारे खानदान के लोग। वी बिलांग टू रुलिंग क्लास।”<sup>3</sup>

जाति आधारित सामंतवादी मानसिकता के संदर्भ में इस बात को झूठलाया नहीं जा सकता है कि इस मानसिकता से ग्रसित लोगों में एक मजबूत भाईचारे का रिश्ता होता है, जिसे वे सभी बड़ी ईमानदारी के साथ निभाते भी हैं। नाटक में यह भाईचारा कैप्टन कपूर, कैप्टन वर्मा और डॉक्टर कैप्टन गुप्ता के बीच देखने को मिलता है। वे सभी एक दूसरे के साथ मिलकर इस मानसिकता के अनुरूप कार्य भी करते हैं और साथ ही वे एक दूसरे की कारस्तानियों को छिपाने के लिए एक दूसरे के साथ खड़े भी मिलते हैं। नाटक के विभिन्न स्थलों पर इस मानसिकता का खुलासा होते देखा जा सकता है। मसलन कैप्टन वर्मा का कैप्टन कपूर द्वारा रामचंद्र पर अमानवीय मानसिक यातना देने में सहभागी होना और डॉक्टर कैप्टन गुप्ता का कोर्ट में कैप्टन कपूर के पक्ष में गवाही देना। पर जहाँ कैप्टन कपूर इसी भाईचारे की उम्मीद लेकर कैप्टन बिकाश राय से पहल करता है तो प्रत्युत्तर में मिले जवाब से वहाँ यह और भी स्पष्ट रूप में प्रकट होता दिखता है— “कैप्टन कपूर ! इस अफसरोंवाले हरामी भाईचारे को भूल जाओ।”<sup>4</sup>

हम इस बात को भी नकार नहीं सकते हैं कि भारतीय समाज में पितृसत्ता

की भावना जाति आधारित सामंतवादी मानसिकता के समानांतर अपेक्षाकृत तीव्र वेग से चली आ रही है। बहुत लंबे काल से आलम तो यह बना हुआ है कि जाति आधारित सामंती मानसिकता जहाँ समाज के केवल तथाकथित उच्चवर्णीय लोगों तक सीमित एक मानसिक रोग है, वहीं पितृसत्ता की भावना से तो समाज के सभी वर्णों के पुरुष ग्रसित हैं। हाँ, पितृसत्ता की भावना के संदर्भ में यह बात लक्षित किया जा सकता है कि इस भावना का घनत्व उच्चवर्णीय पुरुषों में अपेक्षाकृत अधिक होता है। प्रस्तुत नाटक के पात्र कैप्टन कपूर में हमें यह घनत्व देखने को मिलता है। एक रात जब कैप्टन कपूर की पत्नी नशे में धुत होने के वजह से उसके साथ सोने से मना करती है तो प्रत्युत्तर में दिये गये कैप्टन कपूर के व्यवहार में इस तथ्य को लक्षित किया जाता है। कैप्टन कपूर अपनी पत्नी का गाउन फाड़ डालता है और कहता है — "आई हैव लाइसेंस टु स्लीप वीद यू। चुपचाप आ जाओ बिस्तर पर। जानती नहीं मैं कौन होता हूँ? कपूर!" यही कारण है कि उच्च वर्ण और दुराचार के बीच के संबंध के संदर्भ में पेरियार ई.वी. रामासामी का भी कहना रहा है — "अगर यह बात सत्य है कि दुराचार नाम की कोई वस्तु है और अगर चोरी, झूठ और मक्कारी उस दुराचार के अंग समझे जाते हैं तो इन दुराचरणों के शिकार गरीब तथा अनपढ़ जनता की अपेक्षा राजा-महाराजा, पुरोहित, व्यापारी, वकील, राजनीतिज्ञ आदि व्यक्ति अधिक होते हैं। शोषक वर्ग ही गरीब जनता को सताते, धोखा देते, नीचा दिखाते तथा उनकी उन्नति में बाधा पहुँचाते हैं। यह अतिशयोक्ति नहीं होगी, यदि मैं यह कह डालूँ कि सामान्य रूप से दुराचरण इस शोषक वर्ग का अंग-प्रत्यंग है।"

हमें इस बात को मानने में लेशमात्र भी संदेह नहीं होना चाहिए कि जाति व्यवस्था और उससे जुड़ी जाति आधारित सामंतवादी मानसिकता ने हमारे देश और समाज का बहुत ही अहित किया है। समाज में निहित इस जाति व्यवस्था ने हमारे समाज को सदियों से अपने-अपने सामुदायिक हितों के रक्षार्थ एक दूसरे से अनवरत युद्ध करने वाले बहुतेरे छोटे-छोटे समूहों में बाँटकर रखने का काम किया है, जो कि एक नितांत समाज और देश विरोधी तत्व के रूप में काम करता आया है। इस संदर्भ में भीमराव अंबेडकर का मानना है — "समाज-विरोधी भावना जाति व्यवस्था का सबसे निकृष्टतम लक्षण है। यह समाज विरोधी भावना, अपने हितों की रक्षा करने की यह भावना विभिन्न जातियों के एक-दूसरे से विलगाव में जितने स्पष्ट रूप में

प्रकट होती है, उतने ही स्पष्ट रूप से राष्ट्रों के बीच एक-दूसरे से विलगाव में।" बात केवल सामुदायिक हित तक सीमित हो तो भी वह समाज और देश के लिए उतना अधिक अहितकर नहीं होता है। पर जब बात किसी भी समुदाय से संबंधित व्यक्ति की उस प्रतिभा की हो, जिससे समाज और देश का मान बढ़े और साथ ही साथ आनेवाली पीढ़ियों को प्रेरणा मिले तो उस संदर्भ में जाति आधारित सामंतवादी मानसिकता देश और समाज के लिए बहुत ही अहितकर साबित होती है। नाटककार ने प्रस्तुत नाटक में इस संदर्भ पर भी बात की है। रामचंद्र एक अच्छा एथलिट है। उसमें अंतर्राष्ट्रीय स्तर पर पाँच हजार मीटर की दौड़ में कुछ अच्छा करने की अपार संभावना है। पर उससे एक अपराध हुआ है कि उसने एक दलित के घर जन्म लेकर इस स्पर्धा में रेजिमेंट के पूर्व चैम्पियन कैप्टन कपूर का रिकार्ड तोड़ दिया है। इसके लिए उसे खामियाजा यह भुगतना पड़ता है कि कैप्टन कपूर उसे अच्छे से ट्रेन करने के बहाने अपने घर की संतरी की ड्यूटी लगाकर उसकी प्रतिभा को खत्म करने का षड़यंत्र रचता है और उसमें वह अपने सहयोगियों के मदद से सफल भी होता है। वही रामचंद्र जिसमें एशियाड के रिकार्ड को तोड़ने की संभावना है, वह सेना के उत्तरी कमान के खेलों में सेना तक का रिकार्ड तोड़ नहीं पाता है। इसके बाद तो वह हादसा ही हो जाता है। इस बात का खुलासा तब होता है जब कैप्टन बिकाश राय के जिरह के दौरान गवाह लेफ्टिनेंट कर्नल ब्रजेंद्र रावत कह बैठता है—“सेना का क्या, रामचंद्र एशिया का रिकार्ड तोड़ सकता था। लेकिन इंटर-कमांड मुकाबलों से पहले ही यह हादसा हो गया। ही कुड हैव वन एशियन गोल्ड मैडल फॉर अस। मेरी रेजिमेंट का रामचंद्र, एशिया का सबसे तेज दौड़नेवाला रामचंद्र।”

प्रस्तुत नाटक में नाटककार ने केवल जाति आधारित सामंती मानसिकता के कुप्रभावों का ही चित्रण नहीं किया है, बल्कि उसने आजादी के पूर्व से लेकर आज तक अंग्रेजों ने व तत्पश्चात् भारतीय संविधान ने इस मानसिकता को खत्म करने के लिए जो कठोर कानून बनाये हैं, उनकी मौजूदगी के बावजूद इस मानसिकता के बने रहने के कुछ एक कारणों का पर भी प्रकाश डाला है। यह निर्विवादित सत्य है कि आजादी के बाद से लेकर आज तक भारत सरकार की लोककल्याण नीति के तहत अनुसूचित जाति के लोगों की साक्षरता दर में काफी बढ़ोतरी हुई है, बावजूद इसके इनके दबू, डरपोक व कायर स्वभाव में बहुत ज्यादा फर्क नहीं आ पाया है। ये पढ़-लिखकर साक्षर तो

बन गये हैं पर शिक्षित होने (चेतना-जागृति) के मामले में आज भी बहुत पिछड़े हुए हैं। इनमें से अधिकांशतः अपने संवैधानिक अधिकारों से अनभिज्ञ हैं और जो भिन्न हैं, वे भी अपने दबू, डरपोक व कायर स्वभाव के कारण इसका इस्तेमाल करने से चूक जाते हैं। नाटककार ने इस सत्य का उद्घाटन नाटक के उस स्थल पर किया है, जहाँ बचाव पक्ष का वकील कैप्टन बिकाश राय रामचंद्र से कुछ सवाल पूछने के मार्फत पूरे प्रकरण के भीतर छुपे सत्य को सबके समक्ष लाने की कोशिश करता है और रामचंद्र कुछ भी बताने से मना कर देता है तो क्रोधित होकर बिकाश राय कह बैठता है - 'तुम छोटे लोगों को कानून और संविधान चाहो बराबर के अधिकार दे, लेकिन तुम हमेशा वही के वही रहोगे। दबू ! डरपोक ! कायर !'<sup>9</sup>

आजादी के इतने वर्षों बाद भी भारतीय समाज की एक बहुत बड़ी विडंबना है कि संविधान प्रदत्त अधिकारों व अनुसूचित जाति उत्पीड़न के लिए कठोर दंडविधान के प्रावधान के बावजूद भी दलित शोषण के मामले में उतनी कमी नहीं आई है, जितनी उम्मीद संविधान बनाते समय की गई थी। इसका मूल कारण जाति आधारित सामंती मानसिकता ही है। इसके कारण ही समाज में बड़े-छोटे का भेदभाव है और संविधान प्रदत्त बराबरी का दर्जा एवं अधिकार का हनन हुआ है। बड़ों ने छोटों को कभी भी बराबरी का दर्जा नहीं दिया है जो किसी भी समाज के आस्तित्व के लिए खतरे का संकेत है। नाटककार ने अपनी इस चिंता को भी इस नाटक में शामिल किया है। इसे वे नाटक के पात्र बिकाश राय के इस कथन के मार्फत प्रकट करते हैं - 'कानून और संविधान ने सबको बराबर का दर्जा, बराबर का अधिकार दे दिया। लेकिन बड़े आदमी ने छोटे आदमी को, ऊँचे आदमी ने नाचे आदमी को, यह अधिकार नहीं दिया। बिल्कुल नहीं दिया। जो व्यवस्था, जो समाज जाति-भेद के आधार पर चलेगा, ऊँच-नीच के तराजू में आदमी को तौलेगा, उसकी आयु कभी लंबी नहीं होती। बिल्कुल नहीं होती।'<sup>10</sup>

प्रस्तुत नाटक का सबसे महत्वपूर्ण स्थल नाटक का समापन है। नाटक का समापन स्थल प्रत्येक पाठक के मन में एक टीस छोड़ जाने का काम करता है। पूरे प्रकरण के भीतर निहित सत्य के सामने आने के बाद कैप्टन कपूर द्वारा आत्महत्या करने तक के मामले को तो प्रत्येक सहृदय पाठक स्वीकार कर लेता है, पर रामचंद्र के लिए मुकर्रर फौसी की सजा उनके मन को टीस दे जाने का काम करती है। संवैधानिक न्याय-व्यवस्था की परिपाटी से बैधा हमारा मस्तिष्क भले ही रामचंद्र के लिए मुकर्रर फौसी

की सजा को मान लेता है, पर मन नहीं मान पाता है और यही से हमारे मन में संवैधानिक न्याय-व्यवस्था के अधुरेपन की भावना बलवती हो उठती है। मन में यह सवाल बड़ी तेजी से उठता है कि क्या सभ्यता की इतनी लंबी यात्रा तय कर लेने के पश्चात् भी हमें उचित न्याय के लिए संवैधानिक न्याय-व्यवस्था की उपस्थिति के बावजूद सभापति जज सूरत सिंह के इस कथन(पोएटिक जस्टिस वाले) पर आश्रित रहना पड़ेगा - "जब दुनिया की अदालत इंसाफ न कर सके तो कभी-कभी ऊपरवाला इंसाफ कर देता है।"<sup>11</sup> कहने का तात्पर्य है कि जिस जाति आधारित सामंती मानसिकता ने रामचंद्र को अदृश्य रूप में कई बार मृत्यु के घाट उतारने का काम किया है, उसके लिए आज भी उसे काव्यात्मक न्याय पर निर्भर क्यों रहना पड़ेगा? हम समय रहते इस सच्चाई के प्रति क्यों नहीं चेत जाते कि यह मानसिकता केवल भारत ही नहीं पूरी दुनिया में किसी न किसी रूप में मौजूद है और पूरी दुनिया को खोखला बनाने का काम कर रही है।

निष्कर्षतः यह कहा जा सकता है कि जाति आधारित सामंतवाद, काव्यात्मक न्याय और संवैधानिक न्याय-व्यवस्था के त्रिकोण में रचित प्रस्तुत नाटक भारतीय सेना में निहित जाति आधारित सामंतवाद के तंतुओं की शिनाख्त के मार्फत् पूरी दुनिया में व्याप्त वर्ण, जाति और श्रेष्ठताबोध के घातक दुष्परिणामों के प्रति अपनी चिंता व्यक्त करता है। यह चिंता पूरे विश्व में संपूर्ण मानवता की स्थापना की चिंता है और एक सच्चे कलाकार-नाट्यकार का यह कर्तव्य ही होता है कि इस तरह की चिंताओं के मूल में निहित सच्चाई को सबके सामने लाने का संघर्ष बड़ी शिष्टता और ईमानदारी से करे और स्वदेश दीपक ने यही किया भी है। यही कारण है कि इस नाटक के संदर्भ में पाकिस्तान के ख्यातिलब्ध नाट्य-निर्देशक सुनिल शंकर का कहना है - "यह नाटक महज सेना में जाति व्यवस्था के बारे में नहीं है। नाटक का मुख्य किरदार कहता है, 'मैं रामचंद्र को बचाने के लिए नहीं लड़ रहा हूँ, मैं सच्चाई के लिए लड़ रहा हूँ।' कभी-कभी मुझे लगता है स्वदेश दीपक भी यही करने की कोशिश कर रहे थे।"<sup>12</sup>

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Edited by  
Snehamanju Basu  
Gupinath Bhandari



# SOCIETY, PEDAGOGY, POLITICS

A Multidimensional Approach to COVID-19

# Society, Pedagogy, Politics

A MULTIDIMENSIONAL APPROACH TO COVID-19

Edited by

**Snehamanju Basu**

and

**Gupinath Bhandari**



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# A STUDY ON THE IMPACT OF THE COVID-19 PANDEMIC ON THE MENTAL STRESS OF STUDENTS IN PURULIA DISTRICT

Sharmistha Mukherjee<sup>1</sup>, Shubham Ghosh<sup>2</sup>,  
Soumili Dutta<sup>2</sup>, Gupinath Bhandari<sup>3</sup>

## Abstract

During a pandemic, stress, anxiety, grief, and worry are inevitable additions to physical threats, since people are faced with great uncertainties. Therefore, it is reasonable to assume that impressionable young students are experiencing stress in the context of the COVID-19 pandemic. Added to the fear of contracting the virus in this situation, the significant changes to our daily lives and the restrictions imposed upon our natural movement to slow the spread of the virus is also causing a lot of stress. Faced with the new realities of working from home, temporary unemployment, home-schooling of children, and a lack of physical contact with other family members, friends and colleagues, it is important that we look after our mental health in addition to our physical health. The WHO is continuously providing advisory guidelines for the public during the COVID-19 pandemic, and especially for groups such as health workers, managers of health facilities, people looking after children, older adults, and people in isolation, in order to help us look after our mental health. This paper tries to examine how young people

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are being affected mentally and facing stress during extended periods of home quarantine.

**Key words:** *mental stress; isolation; online studies; pandemic*

## Introduction

Since December 2019, the COVID-19 pandemic has posed a substantial threat to human civilisation with the high mortality, infection rates, and risk of psychological stress associated with it. Just as other sections of society, a large number of students have been affected due to the prolonged break from academic activities and staying at home. (Chhetri et al. 2020) A pandemic is not just a medical phenomenon; it affects individuals and society and causes disruption, anxiety, stress, stigma, and xenophobia. The behaviour of an individual as a unit of society or a community has marked effects on the dynamics of a pandemic that involves the level of severity, degree of flow, and aftereffects. Rapid human-to-human transmission of the SARS-Cov-2 resulted in the enforcement of regional lockdowns to stem the further spread of the disease. Isolation, social distancing, and the closure of educational institutions, workplaces, and entertainment venues consigned people to their homes to help break the chain of transmission. COVID-19 affected everyone at global level. (Yasmin et al. 2020) However, the restrictive measures have undoubtedly affected the social and mental health of individuals across the board. As more and more people were forced to stay at home in self-isolation to prevent the further spread of the pathogen at the societal level, governments were required to take the necessary measures to provide mental health support as prescribed by the experts. The psychological state of an individual that contributes towards the community health varies from person to person and depends on his/her background as well as his/her professional and social standings. (Javed et al. 2020)

## Objectives

The objectives are:

1. To find the source and magnitude of stress related to the COVID-19 pandemic situation on the minds of undergraduate students of Sidho Kanho Birsha University in Purulia.

2. To know the extent of students' experience of anxiety, distress, social isolation, and an abusive environment, which can have short- or long-term effects on their mental health.
3. To find some common changes in learners' behaviour and their difficulties with concentration and attention.
4. To find the changes in, or avoidance of, activities that young learners enjoyed in the past, or also changes in their eating and sleeping habits.

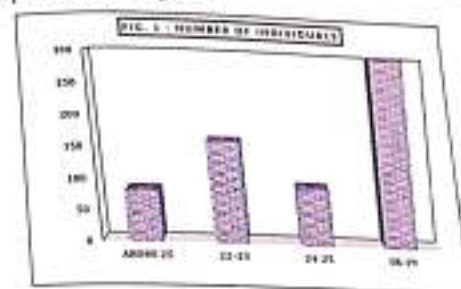
#### Methods Of Study

We randomly selected 630 undergraduate (UG) students from practical and theory-based disciplines who had previously dropped out due to financial reasons but have now returned to the mainstream. We prepared a google form and conducted most of the surveys through emails. Classifying the study into three parts, we first conducted a thorough quantitative and qualitative survey for six months at a stretch (June 2020 to November 2020). At the next stage, we analysed the data to make a comprehensive quantitative study on the real and proper situation of homebound students. The statistical scores for the samples of those who responded were calculated and the statistical variables analysed. During the final stage, we conducted personal interrogation and evaluation to determine which cases were more complicated, so as to understand the rationale behind them and find possible methods for alleviation where needed.

#### Present State and Situation

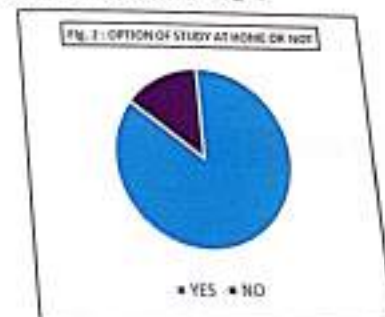
The COVID-19 pandemic has had a major effect on all our lives. Many of us are facing challenges that can be stressful, overwhelming, and can cause strong emotions. Public health actions, such as social distancing, are necessary to reduce the spread of COVID-19, but they can make us feel isolated and lonely and can increase stress and anxiety. Stress among UG students can cause the following: 1. Increased feelings of fear, anger, sadness, worry, numbness, or frustration. 2. Changes in regular going out. 3. Difficulty concentrating and making decisions. 4. Lack of guidance and cooperation. 5. Worsening of the study environment. 6. Worsening of mental health conditions. 7. Increased use of tobacco, alcohol, and other substances due to lack of other entertainment. 8. Family members may witness any of the following changes to the behaviour of older relatives: (a) irritability and shouting; (b) change in their sleeping and eating patterns; and (c) emotional outbursts.

We have tried to understand the effects of the COVID-19 outbreak on the mental health of various age groups of students, depending on their clinical features, transmission patterns, and management.



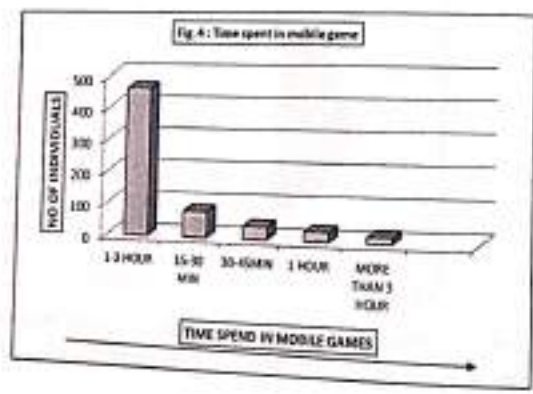
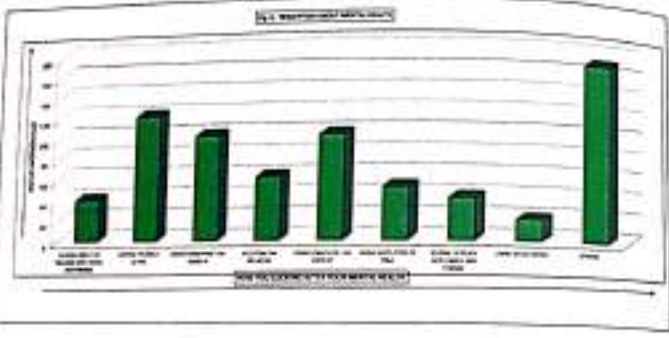
#### Data Interpretation and Analysis

Among the 640 students surveyed, most were 19 years old or less (Fig. 1) and 87% of them were living with their family. Of the total sample studied, 57% of the live in rural areas, while 30% live in urban areas and the rest live in the suburb. We came to know through the survey that 540 of them, which means 77% of our sample, have had the opportunity of studying from home. (Fig. 2)

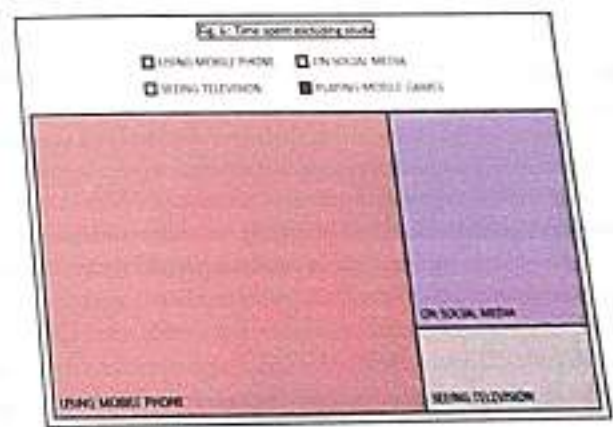
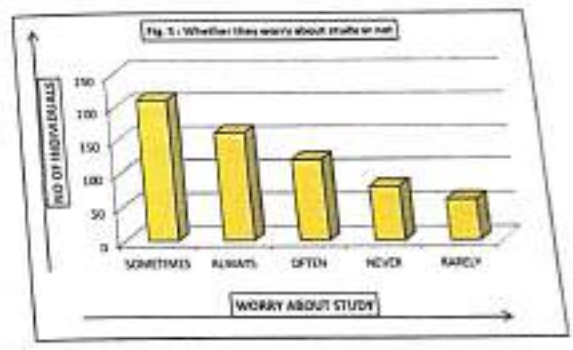


Of the total number, 85% thought that the pattern of study became stressful, while the rest do not think so. Similarly, 66% of students understood the topics

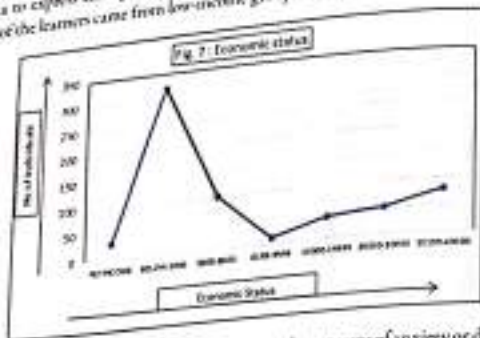
discussed through online study while 33% do not. This depicts a picture that demands a rethink. The students who do not think that the pattern of study was successful, and who understood their studies online, had facilities like electricity, smartphones and internet connectivity. The COVID-19 pandemic and the resulting economic recession negatively affected the mental health of numerous people and created new barriers for people already suffering from mental illness. In our study too we found that most of the respondents tried to keep themselves engaged with mobile surfing and social media. (Fig. 3) Spending time with family members, including children and elderly people (only 6%), involvement in different healthy exercises and sports activities (13%), following a schedule/routine (19%), and taking a break from traditional and social media can all help to overcome mental health issues. (62%)



Of the respondents, 75% dedicated time to playing video games for more than three hours. The remaining 25% used online games for less than one hour. (Fig 4) When the question was put to the respondents as to whether they were worried about their futures or careers, we found that astonishingly only 33% of the respondents sometimes thought about their future. This indicates they are not worried about their careers or had lost interest in thinking about the future. This is an interesting finding, which shows us that home isolation had made most students pessimistic and disappointed. Only 25% of the respondents believed that there could a serious problem in the future because the normal flow of offline study has been disturbed. (Fig. 5)

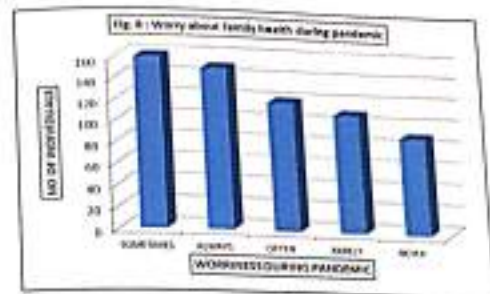


Further, another added fact that is quite surprising is that 100% of respondents used mobiles and computers for surfing the internet when they are not studying or doing their regular jobs. Out of 630 samples, 310 learners used Facebook and other social media to express their grievances, joys and disappointments. (Fig. 6) Surprisingly, 60% of the learners came from low-income groups. (Fig. 7)



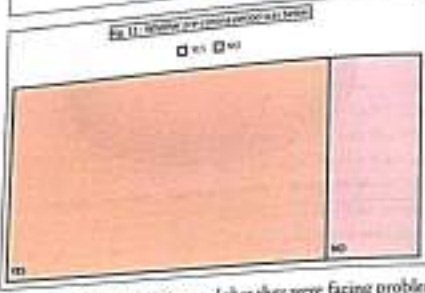
During the pandemic, students have reported symptoms of an anxiety or depressive disorders. A very interesting behavioural pattern has been revealed through their responses, which finds that 25% of the students thought that there was nothing to do by worrying about the pandemic situation. They feel that they have no control over the spread of the coronavirus because they cannot make everyone conscious about the disease at once, being confined to their homes themselves. So, they only sometimes think or worry about the real situation of the world outside. Of those surveyed, 60% of respondents stated that they were worried during the pandemic, while the rest of the students were totally indifferent. (Fig. 8) Many students reported specific negative impacts on their mental health. As the pandemic wears on, ongoing and necessary public health measures expose many people to situations linked with poor mental health outcomes, such as isolation and job loss. In our study, we have seen that 82% of respondents were suffering from negative impact and social disorders caused by the pandemic. Among them, 20% reported being really hopeless. (Fig. 9)

Some of them considered leaving home to find a safer place, which is often practically unfeasible. We have maintained personal contact with such respondents and provided as much as possible career counselling and support from our institution



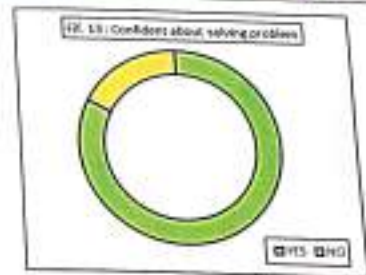
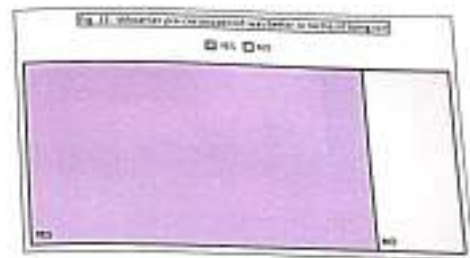
as possible. Of all the respondents, 73% of are very prone to losing their temper, and only 27% have reported being capable of controlling their emotional outbursts. (Fig. 10)

We asked the respondents whether the pre-corona period was better in terms of mental peace and life outside the home. For both questions, we found that that most people considered that the period before the pandemic was better for their mental peace because they were confined to their homes, could not go anywhere, and especially because they were barred from going to tuition or college on an overcrowded bus or train. They could study safely only from home. The percentage of respondents who thought that the corona period was better for mental peace totals 20%. The rest

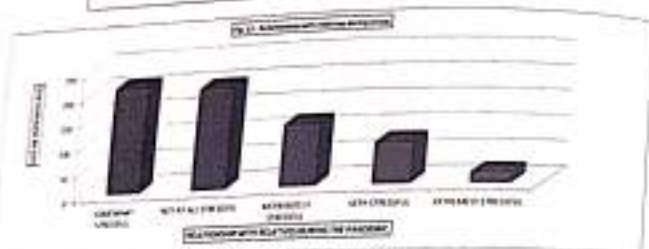
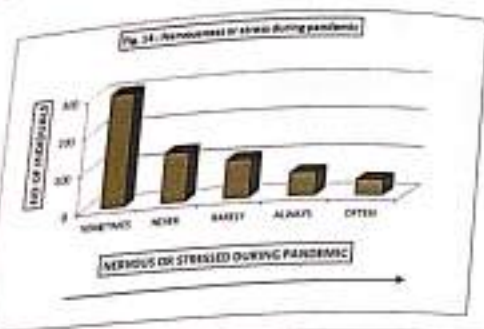


of the respondents, adding up to 80%, stated that they were facing problems or were under mental stress during the pandemic. (Fig. 11)

At the same time, a similar portion of the sample survey stated that the pre-corona period was not better for staying outdoors because of crowded streets. Now, however, they could go out safely with masks and sanitizers, maintaining social distancing norms. (Fig. 12) Consequently, the same number of students who were under mental stress (80%) responded that they were now more confident of solving their own problems in spite of the stress of the situation. (Fig. 13) When we asked them about how they felt overall during the pandemic, that is, whether they were



stressed or nervous, 79% respondents said that they panicked either sometimes or often and the rest of the respondents never felt these things. (Fig. 14) During periods of elevated stress, they noticed abnormal behaviour towards relatives. Physical isolation at home among family members could also put elderly and disabled persons at serious risk of mental health issues. This could cause anxiety, distress, and induce a traumatic situation for them. Elderly people depended on younger ones for their daily needs, and self-isolation had the possibility of critically damaging a family system. Of our respondents, 7% behaved very roughly and 54% showed moderate to some harsh behaviour towards their older relatives. (Fig. 15) Physical distancing due to the COVID-19 outbreak could have extremely negative effects on the mental health of the respondents. A study reveals that 64% of people surveyed were worried about their income and financial condition as they thought that the period after the

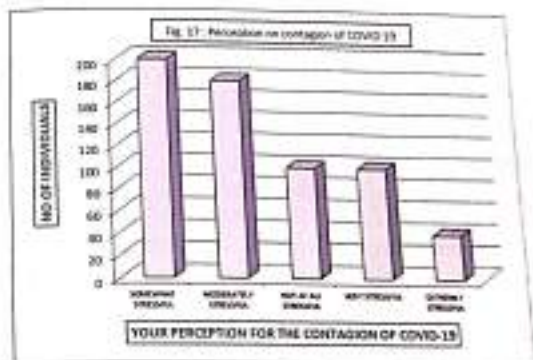
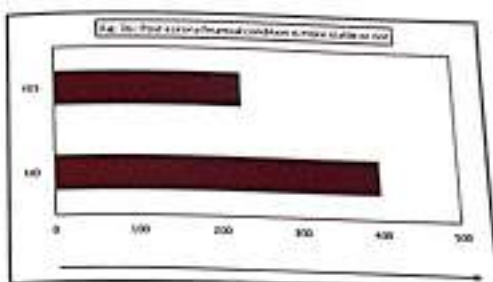


pandemic would be stressful, and the situation would be even harder in the future. The rest of the respondents were dependent on their parents from the very beginning and did not share the feelings of the former group. (Fig. 16)

Negative impacts on social well-being, such as difficulty sleeping (36%) or eating (32%) conversely increased alcohol consumption or substance use (12%) and the worsening of chronic conditions (12%) due to worry and stress over the coronavirus. Most of the students understood the full magnitude of this infective viral pandemic. The percentage of students who could and could not fully comprehend the situation stood at 84% and 16% respectively.

**Outcome of the Study**

Quarantine and self-isolation can most likely cause a negative impact on one's mental health. (Liu et al. 2020) A review published in *The Lancet* said that separation from loved ones, loss of freedom, boredom, and uncertainty could cause a deterioration



in an individual's mental health status. We can specifically say that a homebound situation that extends for a long time definitely has an adverse effect on a person's mental health and well-being. Students have been forced to change their way of living life unexpectedly (WHO 2021), and this uncertainty has led to indifference. As we observe the events around the outbreak of the coronavirus stretch over time, it would not be strange to perceive increasing stress and panic. A medical bulletin from a renowned hospital has the following quote: 'As the days go by, the stress can add up and affect you both physically and mentally.' The information reaching us from different sources about the pandemic can be both overwhelming and scary. Studen



are experiencing anxiety and fear simply adjusting to the new situation. Therefore, managing stress around the outbreak and keeping ourselves in a positive frame of mind is necessary for our well-being. Simple steps like these can help bring us a sense of normality and help us cope with the changing environment. (WHO 2021) The following suggestions are being made to instructors and administrators based on the findings of the present study:

- Encourage students to reach out to a counsellor over the telephone if they are unable to manage their anxiety on their own.
- Advise the students to do exercise, maintain a healthy and immunity-boosting diet, become organised and practice good hygiene, and provide the necessary support so that they are able to follow through on these.
- Encourage the students to help others wherever possible, especially when a neighbour is sick or panicked.
- Suggested that students connect with others and find positive and constructive ways to express themselves. (CDC 2020)

### Conclusion

To overcome the extraordinary situation created by the pandemic, measures at both the individual and the societal levels are necessary. Students across the country are experiencing a complex mixture of emotions. They might be put in a situation or environment that could be new and potentially damaging to their health. (Javed et al. 2020) Students, kept away from their colleges and friends, and forced to stay at home, may have many questions about the outbreak and they would naturally look towards their parents or caregivers for answers. Conversely, it must be remembered that not all children and parents respond to stress in the same way. The COVID-19 pandemic and its adverse social outcomes, can also result in increased stress, anxiety, and depression among teenagers already dealing with mental health issues. However, media coverage has highlighted COVID-19 as a unique threat, rather than one of many which have all added to panic, stress, and the potential for hysteria. (Moukaddam and Shah 2020) Therefore, public awareness campaigns focusing on the sustenance and improvement of good mental health for the duration of the pandemic, as well as afterwards when we have emerged from it, are urgently required.

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# Peasant & Labour Movement in Bengal



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### Peasant & Labour Movement in Bengal

*Edited by:*

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and Every Chapter of This Book

**This Book is Dedicated to**  
The Peasant & Labourer  
to sacrifice their life for  
the Society

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- <sup>42</sup> Islam, Sirajul, *Banglar Itiha-Upanobeshik Shason Kathana*, p.334
- <sup>43</sup> *Ibid*, pp.335-336
- <sup>44</sup> Kaviraj, Narahari, *A peasant uprising in Bengal*, Peoples Publishing House, New Delhi, 1992, p.39
- <sup>45</sup> Roy, Shubhrayoti, *Transformation on the Bengal Frontier: Jalpaiguri, 1765-1948*, Routledge, 2002, p.39

## ঔপনিবেশিক কালে জঙ্গলমহলে আদিবাসী বিদ্রোহের বিভিন্ন পর্যায় ও ধকৃতি

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কৃষিকা ও ধেক্ষাপট:- ঔপনিবেশিক বাংলার লক্ষণ-প্ৰতিয় সীমান্ত অঞ্চলের আয়গনপূর, মুন্সের, ধলকুম, মানকুম, লিংকুম, কাঁকড়া ও সাঁওতাল পরগণার বিক্ৰীর্ অঞ্চল নিয়ে "জঙ্গলমহল" অঞ্চল গড়ে ওঠে ছিল। আট্টালকাল থেকেই শাল, ময়ূরা, পলাশ, অন্যান্য বিশাল বৃক্ষরাজি ও উঁচি পাছাড় ধারা "জঙ্গলমহল" আঁড়ত ছিল।<sup>১</sup> এর বৃহৎ অংশের কুম্ভ ও কুম্ভের। এই অঞ্চলের নিয়ে কাটকয়ুত পাণ্ডুরের জাপর বিকৃত রয়েছে। প্রাকৃতিক ও সাংস্কৃতিক বৈচিত্র্য এই অঞ্চলের অন্যতম বৈশিষ্ট্য। জঙ্গলমহলে রয়েছে শুভলিয়া, কাজমহল, লনমা, অসোখা, জয়চলী, যাবর, নিমনি প্রকৃতি উল্লেখযোগ্য পাছাড়। উঁচি ও চায়যোগ্য কৃষি জমির স্বল্পতা ও জঙ্গলকট এই অঞ্চলের স্বল্প-জলবিশাল্যের অন্যতম কারণ হিসাবে চিহ্নিত করা গেতে পারে।

ঐতিহ্যের জগার স্ব পূর্বে "ভরাই জঙ্গলমহলে" সীততল, মুতা, বীরধর, কুম্ভিজ, খেঁরিকা-শবর, কোল, তিল, শাট চমুখ আদিয় জলজাতির মানুষ বসবাস করছে। পর্বতলীকালে তারা ঔপনিবেশিক শোষণ-নিপীড়কে উদ্বেগ ও অস্থিবাণ করে নিজ জাতির যাত্ৰুজমির স্বাধীনতা বারংবার বজায় রাখার চেষ্টা করেছে। বাংলার সামসাময়িক রাজনৈতিক পরিপ্রেক্ষিতে এতন অঞ্চলে আদিয় জলজাতির মানুষ ঔপনিবেশিক শাসক এবং তাদের অনুসারী আনন্দার, মহাজন ও পুলিশ শক্তির বিরুদ্ধে যে বিদ্রোহ বিদ্রোহ ও আন্দোলন সংগঠিত করেছিলেন তা আধুনিক ভারতের ইতিহাসে একটি উল্লেখযোগ্য পরিবর্তন নিয়ে এসেছে। মূলত ইন্টাই ডিয়ার কোম্পানির "ধ্বংসাত্মক অধীনীতি" ও অর্থাধ্বংসী কৃষি বণেশবৎ উভয়ের অন্যয় আঘাতে সহজ সরল আদিবাসি প্রৌচীর দুঃখ দুর্দশা অবলম্বীয় হয়ে উঠেছিল। আট্টাল শতাব্দীর দ্বিতীয়ার্ধের শেষের দিকে বাংলা তথা জঙ্গলমহলের অধিষ্ঠিত ও কৃষি সঞ্চদের উল্ল ভায়েলের সংস্কৃতির ধ্বংস হতেছিল অকলবিধ আদিবাসি প্রৌচীর যাত্র। বিশেষতঃ এ শাল জলজাতির কুম্ভে কুম্ভই বিদ্রোহের আতন ধুমধিত হয়েছিল। ১৭৬৫ ট্রিপটরখে ইন্টাই ডিয়ার কোম্পানি কোল সন্ন্যাসি প্রৌচীর শব্দ আশ্রয়ের দিকটি থেকে প্রকারিক ২৩ লাখ টানা গণদের জিনিসেরে প্রৌচীরি লাভ করেছিল। প্রৌচীরি লায়ে

পরেই ইস্ট ইন্ডিয়া কোম্পানির একমাত্র লক্ষ্য ছিল মুক্তি ও আইনের মাধ্যমে সর্বত্রের পরিমাণে রাজস্ব বৃদ্ধি করা। এই পক্ষে কোম্পানির পরিচালক গোষ্ঠী অধিকে ব্যতিত করে, অন্যায়নীতি গ্রহণ করে, বন্যপ্রাণকে খণ্ডিত করে, নদী ও সাগর তীরবর্তী ও বন্যা প্লাবিত সমভূমি কৃষিকারকে আতঙ্কিত করে, কোম্পানি তাঁদের অর্থনৈতিক লাভানুভবে পরিপূর্ণ করতে চেষ্টাছিল। ক্রম ও অনুবরণ জঙ্গলমহলের হতদরিদ্র আদিবাসি গোষ্ঠীগুলিকে পরিত্যক্তভাবে নিঃস্বপিত করেছিল। এছাড়াও কোম্পানি রেশমপথ নিষেধের মাধ্যমে আদিবাসি শ্রমীর জীবন জীবিকার উৎসস্থল অরণ্যভূমিকে সম্পূর্ণ ধ্বংসসাধনের এক অস্বস্ত পরিচরনা করেছিল, একথা বলা যেতে পারে। ফলে এই অঞ্চলে অক্ষয় বৃদ্ধি পায়, নানা রোগের উদ্ভব ঘটে, বিভিন্ন বন উষ্মার অবলম্বিত ঘটে। সমাজের মূল স্রোত থেকে বহুসংখ্যক কন্যাসকলি আদিবাসি শ্রমীর স্বাচ্ছন্দ্য, চিকিৎসা, অর্থনৈতিক ও পরিবেশের স্থিতিশীলতার অবনমন ঘটে। আর্থ-সামাজিক সংকট তাঁদেরকে তীব্র, ধনুক, ক্রম ইত্যাদি নিয়ে বর্বর ষৈশ্যচরী শাসক শ্রেণীর বিরুদ্ধে বিদ্রোহ ঘোষণা করতে বাধ্য করে।<sup>১০</sup> Nam Chandra Guha in his article and subsequently in his book assessed that in the pre-British period, there was little or no interference with the customary use of forest and forest produced in opposition to the argument propounded by Gaddul and Guha that Imperial needs for timber and ship building propelled scientific forestry with its associated bureaucracy.

মূলত ১৭৫৭ থেকে ১৭৬৫ খ্রিস্টাব্দের মধ্যে রাজনৈতিক ও অর্থনৈতিক ইতিহাসে যে পলায়নজন ঘটছিল তার অধরেই জঙ্গলমহলের ব্রিটিশ বিরোধী ইতিহাসের মূল কার্যকরন সূত্র নিহিত আছে। ১৭৫৭ সালের পূর্বে ইস্ট ইন্ডিয়া কোম্পানির কলিকাতা মুর্শিদাবাদে কামিন্যবাজারের স্থানীয় রেশম শিল্পীদের নিকট থেকে দানন নিয়ে ব্যবসা করতেন। পরে কলিকাতা মুর্শিদাবাদে "নবাবী আমলে মুর্শিদাবাদ" হচ্ছে লেখিয়েছেন যে, মুর্শিদাবাদ কামিন্যবাজারের কাঁচা রেশমের বাজারে সেনীয় ভারতীয় ব্যবসায়ীদের একত্রিত নাগরিক ছিল যে, তাঁদের কোনাকাটার ওপরেই বাজারের নাম খেঁচা নামা নির্ভর করত, ইন্ডোরাধী কলিকাতা এই বাজারে গ্রাহ নীর পরীক্ষা করেই থাকত। ১৭৭৩ সালে কামিন্য বাজারের ইংরেজ কুঠি জানায় যে, কাঁচা রেশমের নাম নির্ভর করছে এনীয় ভারতীয় কলিকাতার চাহিদার ওপরেও এটাকে নিয়ন্ত্রণ করা তাঁদের ক্ষমতার বাইরে। এর ১১ বছর পরেও (১৭৭৪ খ্রিস্টাব্দে) অবস্থার কোনো পরিবর্তন হয়নি। কোম্পানির কামিন্যবাজার কাউন্সিল কলিকাতায় এক পত্র প্রেরণ জানায় যে, কাঁচা রেশমের নাম অনেক বৃদ্ধি পেয়েছে কিন্তু এ বাণ্যের জন্য সম্পূর্ণ অসহায়। কারণ কাঁচা রেশমের বাজার নিয়ন্ত্রণ করা তাঁদের সাধ্যাতীত। কিন্তু পরবর্তীকালে এই ইংরেজ ব্যবসায়ী গোষ্ঠী বাংলায় তিন চাকসার গয়া, বরহান, মৌলভীবুর ও চট্টগ্রামের কলিকাতার অধি মনন নিয়ে বাধ্য করে। এইভাবে বণিকের মননও রাজস্বসংক্রমে দেখা দিল। এই প্রেক্ষাপটে জঙ্গলমহলে নিদ্রা ও স্থিতিশীলতা নানা পর্যায়ক্রমে বিভিন্ন স্তরে ও অঙ্গোঙ্গনে ক্রমশঃ পূর্ণ, জঙ্গলমহলে মাক, ঔপনিবেশিক সমাজ, অর্থনৈতিক, প্রশাসন ও রাজস্ব সম্পর্কে সংশ্লিষ্ট আন্দোলন না করলে আন্দোলন বিদ্রোহ মূল ঐতিহাসিক চিত্রভাবনার বৃত্ত অসম্পূর্ণ থাকবে।

মাক-ঔপনিবেশিক জঙ্গলমহলে:- ১৭৫৭ সালের পূর্বে জঙ্গলমহলে সম্পূর্ণ পৃথক আর্থ-সামাজিক ও প্রশাসনিক কাঠামোর অস্তিত্ব ছিল। স্থানীয় রাজা মহারাজার বা মালস্বত্বের মাধ্যমে কামিন্যবাজারের বিদ্যে পথ নির্দেশনা দেয়নকারী পথিক করেছিল।

এর প্রধান উদ্দেশ্য ছিল স্থানীয় শক্তি সূক্ষণ ও বহিঃশত্রুর আক্রমণ থেকে সংশ্লিষ্ট এলাকা তথা সাম্রাজ্যকে রক্ষা করা। আক্রমণের শমনকালে মূলে রাখার উদ্দেশ্যে পরামর্শ ছিল এবং স্বেচ্ছানুভবে কোথায় শত্রুটি রাজস্ব আদায় করত, মুর্শিদাবাদি খার শাসনকালে বাংলার সুবাদে ১৭টি চাকসারে বিভক্ত করা হয়। চাকসার শাসকগণ 'চাকসার' নামে পরিচিত ছিল। চাকসারগণ ইজারাদারদের নিযুক্ত করে রাজস্ব আদায় করত। পরবর্তীকালে আদিবাসীগণ বাংলার কৃষি, কৃষক ও কৃষক সমাজের অঙ্গ নিয়ন্ত্রিত হিসাবে আবির্ভূত হয়।

মাক-ঔপনিবেশিককালে 'মূল কুসুম' নামক এলাকাটি মৌলভীবুর চাকসার অর্গত ছিল। এছাড়া মাদপুর, পাবনা, আধকানগর, মনাতুহ, পলা যার্মাঙ্গা, ধলভূম ইত্যাদি অঞ্চল গুলি বর্ধমান ও মৌলভীবুর চাকসার অর্গত ছিল। অষ্টাদশ শতাব্দীর মাঝের দশক পর্যন্ত সমগ্র বাংলা নবাবের শাসনাধীন ছিল।<sup>১১</sup> ১৭৬৫ থেকে ১৭৭০ সালের মধ্যে বাংলার শাসন আইন ও রাজস্বের অধিকার কোম্পানির নিয়ন্ত্রণে হয়। ইতিপূর্বে কিছু জঙ্গল মহলের সমাজ ব্যবস্থার মুখ্য মতল, প্রধান, মাঝি, খাটোয়াল প্রভৃতির মাধ্যমে ছিল। তাঁরা আদিবাসীদের নিয়ে নিজ নিজ সৈন্য বাহিনী গঠন করত এবং সংশ্লিষ্ট অঞ্চলে শান্তি শৃঙ্খলা বজায় রাখত। সরকারি কলিকাতার অধিবাসন অনুসারে বলা হয় যে, স্থানীয় প্রবীণদের অহতা ধ্বংস করে কোম্পানি নিজ স্বাধীনতাকে অহতা বৃদ্ধির যত্নে নিজে ছিল।<sup>১২</sup> Bengal Districts Record Midnapore, ১৭৬৩ থেকে ১৭৬৭ জানুয়ারি মে, On 13th January, 1767, John Graham, the Resident of Midnapore, wrote a letter to John Fergusson in which he referred to the powerful and very large tract of the Country lying westward of Midnapore, with a view to bring these Independent Zamindars to obedience and to reduce them to a proper subjection to the Company of Just Revenue John Graham Directed Fergusson to carry Arms against them.<sup>১৩</sup> এই ঘটনাক্রমে মূল মর্শি ধল - জঙ্গল মহলের আদিবাসীগণের কোম্পানির নিয়ন্ত্রণে এনে তাঁদেরকে সরকারি রাজস্ব নিতে বাধ্য করা। কেউ অধিবাসন করলে তার বিরুদ্ধে সামরিক অভিযান চোরণ করে তাতে পড়তে পারে। ১৭৬৭ সালে কোম্পানি কর্নওয়ালের রানী শিরোমণি পাইক ও সন্ন্যাসীদের সাহায্য নিয়ে অসামান্য বিদ্রোহী জমিদারগণকে পরাজিত করেছিল। A. K. Jemhson এর অধিবাসন থেকে জানা যায় যে, "..... The Lieutenant Ferguson employed in his expedition against the Jangal Rajas were supplied from Midnapore Estate of Rani Siromoni that these Retainers were not paid a 'Pesh kesh' quite Bent."<sup>১৪</sup> এই জায়ে কোম্পানির অহতা ও স্থানীয় লক্ষ্যের মার্কিনিকতার বিরুদ্ধে জঙ্গল মহলে বিদ্রোহের আভন প্রস্তুত করে।

মর্শি ধল:- মাক ঔপনিবেশিককালে বিস্তৃত জঙ্গল মহলের ক্রমশঃ নানা উপক্রান্তি ও ঘটনা সেনীয় উপক্রান্তি গোষ্ঠীগুলির মধ্যে ব্যক্তি ছিল। তাঁদের মধ্যে অসংখ্য আদিবাসিনার ধর্ম ব্যক্তিগত ছিল। উপক্রান্তি গোষ্ঠীগুলির মধ্যে মৌলভীবুর রাজস্ব প্রধা চাক ছিল। মল্লভিত্তিক মাধ্যমে মল্লভিত্তিক সংগঠিত রাজস্ব জমিদারদের রাজস্ব খাতে জমা হত। এই রীতি মাধ্যম জায়ে মাজল বা মজলী রাজস্ব প্রধা নামে খ্যাত ছিল। এই ব্যবস্থায় সামবাসীগণ মাধ্যমে সীমানা নির্ধারণ করতেন। মজলের কোম্পানীগণ রাজস্ব সমগ্র করে নির্দিষ্ট রাজস্বের পরিমাণ, নির্দিষ্ট সময়ের মধ্যে আদিবাসীদের সমগ্র করে রাখতেন।

ছিলেন। মতলপতি মতলের শ্রমি শৃঙ্খলা বজায় রাখতে অন্য উৎসপ ছিলেন। জঙ্গলমহলের অন্যাব্দী, পতিত ও অরণ্য পরিষ্কার করে তাকে চাষযোগ্য করে নতুন গ্রাম পত্তন করা হত। এই পত্তনের যাবতীয় দায়িত্ব জমিদারই বহন করত এবং নতুন ব্যক্তির আবাস কর জমিদারের প্রাপ্য ছিল। এইভাবে জননূন্য অন্যাব্দী অঞ্চলে গ্রামের পত্তন দেখান হইয়াছিল যেমনি এর নামকরণ জমিদারই করত। মতলের ব্যতত ও জমিদারের মধ্যে রোবাপত্তার সম্পর্ক ছিল। মতল নির্মীতনে ও গ্রামের উন্নতি, ব্যবসা ব্যয়িত্য, মসিদার স্থাপনা ও পরিচালনা শ্রমীয়া শীতি বীতি ও উৎসব পালন, নানাজিক শীতি বীতি উৎসাপন প্রভৃতির ক্ষেত্রে মতল প্রবীণ ব্যক্তির কৃত্ব থাকলেও জমিদার ছিলেন মতলের দরবয় কর্তা।<sup>১৮</sup>

**চাষ জোত প্রথা:**- মতল প্রধান জমিদারদের অনুমতি ব্যাপক্ষে মতলী ব্যবস্থা বাস্তবায়িত করতেন। Law Report Commission-1817 অনুসারে মানুসুয়, সিংসুয়, ধলসুয়, মজাসুয়, বরাসুয় ইত্যাদি অঞ্চলের 'চাষ জোত' প্রথার প্রচলন ছিল। এই প্রথার নানা জর বিবরণ ছিল। ঐতিহাসিক Nicholas B. Dirks তাঁর নিখাত "Caste of Mind" গ্রন্থে মানুসুয়ের এই ভূমি বন্দেশকল্পে "Kolarian o Dravidian" জমি ব্যবস্থার স্যবস্থাী রূপ হিসাবে অতিমত প্রকাশ করেছেন। তাঁর মতে, বন জঙ্গল কেটে নতুন গ্রাম পত্তন ও তাঁর পরিচালনা গ্রাম প্রধানরাই বংশানুক্রমিক ভাবে পরিচালনা করতেন। পরবর্তীকালে বহিরাগত শ্রমিকগণ কোলাসিওয়ান ব্যবস্থাকে সম্পূর্ণ ধ্বংস না করে, উৎসব লক্ষতির দিনন ঘটরে 'চাষ জোত' ব্যবস পদ্ধতির প্রচলন করেন। Nicholas B. Dirks এর মত্ব থেকে জানা যায়, তৎকালীন ব্রিটিশ শ্রমি বিদেশকল্প B.H. Baden Powell এই ব্যবস্থার বর্ণনা নিচে গিরে বজছেন, "Originally its seemed that a lot was Reserved for the old tribe Marathi and his called 'Majhas; the Bhuihar of the original families of the village Head their Allotments .....The Allotment for the Laboures who cultivated the Ro-al farm and their Allotment ware Held Revenue Free"<sup>১৯</sup>

**পাইকান সম্পত্তি:**- পাক-উপনিবেশিক শাসনাঙ্কালে বাংলা তথা জঙ্গল মহলের জলুকগুলিতে শ্রমি শৃঙ্খলা রক্ষণ ও বৃদ্ধি শত্রু আক্রমণ মোকাবিলা করা, রাজস্ব আদায় প্রভৃতি ক্ষেত্রে পাইকানদের শারীরিক শক্তিকে ও কৃত্ব নিয়ো তাঁদেরকে সেনা বাহিনীর সাথে নিয়োগ হতো। বিনিময়ে তাদের বিনা খাজনার বা শেখরেশা নামে জায়গীর ভোগ করার অধিকারী হতেন। Jemison এর "Survey and Settlement Report" এ উল্লেখ আছে যে, "To the Jungle Rajas as to the border- chieftains in all times and in all countries fighting was the normal state of existence was mere interlude. Even it any of them was not by nature himself of a predatory de position, he could't record a similar mildness at his next door neighbour and has to be read at amoments Notice to turn out and Defend his properly and Lives of the Dependants..... A nominal rent."<sup>২০</sup>

জঙ্গলমতল বিক্রয় মতল বিক্রয় সামন্তসুতনের মতল সূত্র বিস্ব বিক্রয়বিদের ঘটনা ছিল। যারা সূত্র অংশগ্রহণ করত সেই মোকদ্দমের পরিপ্রেক্ষিতে পুরস্কারপ্রাপ্য করত্বক্রে যে জমি মাল জতা হত তা "পাইকান জমি" নামে পরিচিত। ১৮৮৩ সালে Mr. Grant

রচিত "Analysis and Finance in Bengal" গ্রন্থে উল্লেখ করেছেন যে, মৌলিনীপুর ও জলেশ্বর চাকলায় জমিদারদের অধীনস্থ পাইকের সংখ্যা ছিল প্রায় ৮,৬৭৫ জন এবং তাদের অধিকারসূত্র জমির পরিমাণ ছিল ১,৪৮,৫৯১ বিঘা।<sup>২১</sup>

**খাটোয়ালি প্রথা:**- দীর্ঘকাল ধরে জঙ্গলমহলের নানা মহলগায় বা তালুকের খাটোয়ালি প্রথা প্রচলিত ছিল। বিষ্ণুপুরের মতল রাজারা মারাঠা আক্রমণ প্রতিরোধের জন্য খাটোয়ালি প্রথা প্রবর্তন করেন। আটালন শতাব্দীতে রাজা বীরহাথীর এই প্রথা প্রবর্তন করেন। তিনি খাটোয়ালি সম্প্রদায়কে মতল সৈন্যবাহিনী গঠন করার জন্য তাদেরকে নিয়োগ করেছিলেন। তাদের ক্ষতিগ্রস্ত শৌখিনীর কারণে তারা শাসকের নৃষ্টি আকর্ষণ করেছিল। খাটোয়ালি সামন্তিক কর্মচারীগণ 'পঞ্চধিক' নামে করসূত্র জমি জোগ করতেন। স্যার জনল গ্রান্ট এর তথ্য অনুযায়ী, মতল রাজাদের সৈন্যবাহিনীর ২,২৯৯ জন খাটোয়ালি নিয়ুক্ত ছিলেন এবং তাদের জন্য করসূত্র জমির পরিমাণ ছিল ৩৫,২৮৩ বিঘা। যে সময় খাটোয়ালি অধিকারসূত্র জমি রাজসৈন্যিক ও অর্থনৈতিক কারণে অন্য রাজসৈন্যিকের খাওতাভুক্ত হত, সেই খাটোয়ালি করসূত্র ভূখণ্ডকে 'পঞ্চাধিক খাট' নামে অভিহিত করা হতো। এই ভূখণ্ডের সংশ্লিষ্ট রাজা বা জমিদার কর আদায় করতে পারতেন না।

হোটোনাগপুরের অঙ্গলত সিংসুয়, হাজারীবাগ, নোহারনাগ ও মলসুয় জেলায় এই খাটোয়ালি প্রথা প্রবর্তিত ছিল। ১৮-৭৯ সালে Bengal Act প্রবর্তিত হওয়ার পর ইস্ট ইন্ডিয়া কোম্পানির বিভিন্ন তালুক বা মহলের সামন্তগণকে সংশ্লিষ্ট ভূখণ্ডের খালিক কলে স্বীকৃতি দিনে এই প্রথা অবসান ঘটে।

**ব্রিটিশ জমি বন্দেশকল্প:**- ১৭৬৫ খ্রিস্টাব্দে ইস্ট ইন্ডিয়া কোম্পানি রাজস্ব আদায়ের পাশাপাশি জমির ক্ষেত্রে নিতানতুন পল্লীশ্রম-নিরীক্ষা শুরু করেন। জাভা একশালা ও পাঁচশালা বন্দেশকল্প কার্যক্রমের পর লর্ড কর্ন ওয়েলিং ১৭৯৩ সালের জমি বন্দেশকল্প চিরস্থায়ী বন্দেশকল্পের পরিপ্রেক্ষিতে, যা ইতিমধ্যে "Permanant Settlement" নামে খ্যাত।<sup>২২</sup>

১৮১৯-১৮২০ খ্রিস্টাব্দে ইস্ট ইন্ডিয়া কোম্পানি বাংলা তথা জঙ্গলে বিভিন্ন গ্রামে জমির উর্বরতা ওন্দর জরিপ করে, মহুয়া বা তালুকের আধিপতি আবার কখনও কখনও স্যেপ শাসা সূত্র সম্পাদন করে নিতানতুন রাজস্ব ব্যবস্থা চালু করলে সেনে ধনী থেকে গরীব সকল স্তরের মানুষ অপরূপীয় ক্ষতির শিকার হয়। ১৮১৯ খ্রিস্টাব্দে কোম্পানির জঙ্গলমহলে পত্তন আইন ও অন্যান্য আইনের জাভা সেনাীয়া জমি বন্দেশকল্প বাতিল বলে ঘোষণা করে। মতল জঙ্গলমহলে জমি বন্দেশকল্পে অর্থ-সামাজিক স্থিতিশীলতার সম্পূর্ণ অবসান ঘটে। কোম্পানি অতিরিক্ত মূল্যফা অর্জনের স্বার্থে জাভা অসুগতশীল একটি মৌলী তৈরি করে। জমিদার, ইজারাদার, পত্তনদার, দরপত্তনদার প্রভৃতি মধ্যবৃত্তোজাী দল সমগ্র বাংলা তথা জঙ্গলমহলে যে অত্যাচার ও শোষণের নারকীয় কুশাসনের সূচনা করেছিল জাভা সেনে 'মতলী', 'মাকি', 'খাটোয়ালি', 'পাইকান' ও 'সামন্তের অন্যান্য স্তরের মানুষ সর্বপ্রথম হয়ে যায়। সেই সত্রে প্রাক-ব্রিটিশ সূত্রের কৃষির অধার অবসান ঘটে। সুতরাং অষ্টাদশ শতাব্দীর খ্রিস্টাব্দে সেনাীয়া শাস্তির স্থানে ব্রিটেনি ইস্ট ইন্ডিয়া কোম্পানির শাসন কার্যক্রমী করল মতল জঙ্গলমহলের আদিবাসীদের অতিবিশ, অতিরোষ, বিদ্বেহ ও আত্মশয়ন প্রভৃ প্রকার কারণগুলি নিহিত আছে।<sup>২৩</sup>

**মুন্সীফ বিঘোষ:**- আটালন শতাব্দীতে মতলজমি করসূত্র, মতলগায় সেনাীর এককোটীয়া

আধিপত্য ও শোষণ কৃষকদের উপর সাময়িকের নিপীড়ন, শহিক শ্রেণীর আর্থিক দুর্দশা ও স্বেচ্ছায় ইত্যাদির ফলে দেশের সম্পদ উৎপাদনকারি শ্রেণি সব থেকে বেশী ক্ষেত্রিত ও নিপীড়িত হয়েছিল। ইস্ট ইন্ডিয়া কোম্পানির নতুন শাসনতন্ত্রে জমিদারদের খাটোয়ান, তরফদার, পত্রিনিদার, পাইকান ইত্যাদি শ্রেণির পাশাপাশি অধিবাসী সম্প্রদায় অর্থনা ও সাধারণ অধীন হয়ে তাদের অসহযোগের আশ্রয় নিয়ে অসহযোগের মধ্য গতিতে ছড়িয়ে পড়ে। কোম্পানি জমিদারদের অসহযোগের পত্রিষ্ঠিত বিচার করে বিভিন্ন অঞ্চলে সৈন্য মোতায়েন করে। ইস্ট ইন্ডিয়া কোম্পানির প্রধান উদ্দেশ্য ছিল দেশীয় জমিদারগণকে জোরপূর্বক রাজস্ব প্রদানে বাধ্য করা এবং তাদের দুর্গভঙ্গি সম্পূর্ণ ধ্বংস করা।<sup>১৯</sup> ১৭৬৭ সালে কোম্পানির এই যত্নসূত্র প্রকাশিত হলে প্রায় বিদ্রোহের আশঙ্কা ছুঁতে গঠে। তৎকালীন মেদিনীপুরের রেসিডেন্ট গ্রাহাম সাহেবের নির্দেশে সেক্টরন্যাট ফারওয়ান একদল সৈন্য বাহিনী নিয়ে রামগড়, শাখাগড়, আমবানি, শীলদার, বেলাবা প্রভৃতি মহলের জমিদারগণকে প্রত্যাহারের পরামর্শ করে। শুধু তাই নয়, ইংরেজ সৈন্যপতি বারোজ সিংহুম, মালকুম ও মজুমদার অঞ্চলের সীমান্তবর্তী রাজস্বদারগণকে কোম্পানির নিকট পরাজয়ের স্বীকার করতে বাধ্য করে। যদিও ১৭৭০ সালে খাটোয়ান রাজা ব্রিটিশ বিরোধী আক্রমণে ব্যর্থ হলেও এতে তেমন ভেঙে পড়ে।<sup>২০</sup>

উপরিউক্ত বিদ্রোহগুলিতে প্রায়শ্চাত্যের বিখ্যাত কবি বহু ইংরেজ সৈন্য হত্যা করেই মারা যায়। গোপাল চন্দ্র বসু 'মেদিনীপুরের ইতিহাস' গ্রন্থে লিখেছেন যে, খাটোয়ান জমিদার অত্যন্ত বীর বিক্রমে ইংরেজদের বিরুদ্ধে লড়াই করেছিল। যদিও বৃদ্ধ জমিদার পরাস্ত হয়েছিল ও জালাখাঁর খান খাটোয়ান রাজস্বদার আধিপত্য হলে, ১৭৭৬ খ্রিস্টাব্দে স্থানীয় সাহেব খাটোয়ান 'মোকব্বাতি' কৃষি বন্দোবস্ত চালু করেন।<sup>২১</sup> এর ফলে কৃষক, জমিদার ও অধিবাসীদের মধ্যে নির্দোষ জার ও বৃদ্ধি পায়। জমিদার ও কৃষকদের মধ্যে ঐক্যবাদের সম্পর্ক তৈরি হলেই ইংরেজ সরকার ছিল অত্যন্তাচারী ও শোষণকারী। বঙ্গবীর সমাধার 'Memory, Identity, Power Politics in the Jungles of Mahal: 1890-1950' গ্রন্থে প্রায়শ্চাত্যের লড়াই ও বীরত্ব সম্পর্কে বলেছেন যে, "এই মাটির প্রায়, চাঁকি ও স্তম্ভ নিয়ে লড়াই করেছিল, রক্ত দিয়েছিল মাথা নাড় না করে ইংরেজদের আক্রমণে মেনে নেয়নি।"<sup>২২</sup>

১৭৬৮-৬৯ সালে প্রায় বিদ্রোহ ভয়ঙ্কর রূপ পরিগ্রহ করে। মূলত প্রায়শ্চাত্য জমিদার আধিকার বিলোপ ও আভির্ভুক্ত রাজস্ব বৃদ্ধি এই বিদ্রোহের প্রধান কারণ। প্রায়শ্চাত্যের দলবদ্ধিত কৃষি ইংরেজ ইস্ট ইন্ডিয়া কোম্পানি জোরপূর্বক দখল করলেও এই বিদ্রোহে পাইকান ও গোপাল করে। ফলে তাদের আন্দোলনের উত্তীর্ণতা আরও বৃদ্ধি পায়। তারা ধর্মীয় স্বেচ্ছায়দার, বসিকজাল খোষ হত্যা করে। কিন্তু ১৭৬৯ সালে ১৫ই ডিসেম্বর প্রায় বিদ্রোহ ক্রমশই স্থিতিশীল হয়ে পড়ে।

১৭৬৮ সালে এই বিদ্রোহে পালাক্রমে প্রায়শ্চাত্য থেকে ক্রমশ বস্তু তামার, পালাক্রমে ও বরগুণে ছড়িয়ে পড়ে। বহুস্থিত জমিদারদের নির্দিষ্ট সময়ে রাজস্ব পরিদর্শন করতে বাধ্য হলে কোম্পানি অধিবাসীদের শোষণকারী আর্থিকায়িত বেসেইন যোগ্য করে। অন্যভাবে আশ্রয়, গরম ও পালাক্রমে জমিদার রাজস্ব প্রদানে বাধ্য হয়। ইতিমধ্যে মাথা আধিপত্য দখল নিয়ে পালাক্রমে রাজস্ব সাপেক্ষে কোম্পানির বিরোধী ক্রম আকারে ধারণ করে। ১৭৬৯ খ্রিস্টাব্দে ইংরেজ সরকার পালাক্রমে জমিদারগণকে নিগাদায় তোলে। পালাক্রমে রাজস্ব কোম্পানির এই নিগাদায়কে কোম্পানি নতুন শোষণ করে বিদ্রোহ করে। এই সময় পালাক্রমে

রাজ কুম্ভিজ রাজস্বদার একত্রিত করেন এবং বিক্ষুব্ধ জমিদাররা তার সঙ্গে একত্রিত হলে ইংরেজদের দল দুর্বল হয়।<sup>২৩</sup> এইভাবে রাজস্ব আদায় সংক্রান্ত কারণে প্রায়শ্চাত্য বিদ্রোহ আলদা, মালকুম, চাষ, বঙ্গকুম, সুপুর, অধিবাসনগর ইত্যাদি অঞ্চলে দখলদারদের মত ছড়িয়ে পড়ে।

১৭৬৭-৬৮ খ্রিস্টাব্দে প্রায় বিদ্রোহ মালকুম, ধলকুম ও মজুমদার হয়ে কর্ণওয়াল্ড পর্যন্ত ছড়িয়ে পড়ে। এই বিদ্রোহের প্রধান নেতৃত্ব দিয়েছিলেন রায়পুরে জমিদার দুর্জন সিংহ। তিনি বিদ্রোহীদের সজ্ঞাভুক্ত করে প্রতিশোধের আশ্রয় সর্বত্র ছড়িয়ে দেয়। বিদ্রোহীরা রায়পুরের তৎকালীন রাজস্বদার খান সরকারের সঙ্গে অসহযোগের আন্দোলনে রায়পুর জাগ করেন। ১৭৬৮ খ্রিস্টাব্দে মার্চ মাসে দুর্জন সিংহ তার অনুচরদের নিয়ে রায়পুর পরগণায় ওঠে যাওয়ার উপর নিজের আধিপত্য স্থাপন করেন। তাজডা, তিনি জমিদারদের সমর্থন গ্রহণের উপর অত্যন্ত অসহযোগ করে এবং অসহযোগ করে। ফলে প্রায়শ্চাত্য তাদের জমি জারগা ঘর কাড়ি দখল করে নেয়। যে মাসে দুর্জন সিংহ সৈন্য বাহিনী রায়পুরের জমিদারদের কাছাড়ের বাড়িতে স্ট্রাটন্যাট ও অগ্নিসংযোগ করলে কোম্পানির সৈন্যগণের সঙ্গে বিদ্রোহীদের তুমুল সংঘর্ষ শুরু হয়। অন্যদিকে জৈনের গররখান দিকপাতির নেতৃত্বে বিদ্রোহীরা অসহযোগের আন্দোলন শুরু করেন। এই বিদ্রোহ মেদিনীপুরের বিক্রান্ত অঞ্চলে ছড়িয়ে পড়ে। অবশেষে দুর্জন সিংহকে তারা বন্দী করলে ও উপায়ুক্ত গ্রামের অস্ত্রের ইস্ট ইন্ডিয়া কোম্পানি তাকে মুক্ত লিভে বাধ্য হয়।<sup>২৪</sup>

এই বিদ্রোহে নতুন ইংরেজরা বার বার বাধ্য হয়। তারা নিজেদের কৃটি বিঘ্নিতর অপেক্ষা দেশীয় জমিদারগণকে এই বাধ্যতার জন্য দায়ী করে। কারণ কোম্পানি মনে করত এই বিদ্রোহের পশ্চাতে জমিদারদের ঋণগ্রস্তত্ব সন্দেহ আছে। এই সন্দেহের কারণে তারা বন্দী প্রতিরোধিতক বন্দী করে কলকাতার বিচারে জন্য নিয়ে আসে, পরে বন্দী নির্দেশ প্রমাণিত হলে তবে মেদিনীপুরের ফিরিয়ে আনা হয়।<sup>২৫</sup> ১৭৬৯ খ্রিস্টাব্দ এই বিদ্রোহের উত্তীর্ণতায় স্বেচ্ছায় ও অসহযোগের নানা প্রায়শ্চাত্য বিদ্রোহ ক্রমের অভ্যন্তর মত সংক্রান্ত ছিল।

এই বিদ্রোহের ফলে কোম্পানির বিক্রম আইন, 'কালেক্টরের আইন', 'কেন্ডা আইন' ইত্যাদি পরিবর্তিত হয়। শুধু তাই নয়, রাজস্ব আন্দোলনে জমিদারি নিগাদায়ের আইনটি অবলম্বিত দাবি জানানো হয়। এই ভাবে মালকুম, ধলকুম, বঙ্গকুম ও রায়পুরে প্রায়শ্চাত্যের বিদ্রোহ কোম্পানির নিয়ন্ত্রণের বাইরে চলে যাওয়ার ফলে ইস্ট ইন্ডিয়া কোম্পানি জমিদারদের সঙ্গে অসহযোগ করতে বাধ্য হয়। এই বিদ্রোহের ফলে জমিদারি নিগাদায় বাবদ অসহযোগ, অসহযোগের ক্রম গঠন, মালকুমের অসহযোগের ফলে জমিদারদের নিজ নিজ অঞ্চলে ঘরকা, পাইক ও সন্দারদের নিয়োগ করার স্বাধীনতা, জমিদারদের পৃথক আইনের বাবদ, পাইকান প্রায়শ্চাত্যের পুনঃস্থাপন ইত্যাদির স্বাধীনতা উপভোগ্য অর্জন করে নেয় নিজ বিদ্রোহের ক্ষতিতে।<sup>২৬</sup>

**সাঁওতাল বিদ্রোহ:** ঔপনিবেশ শতাব্দীর দ্বিতীয়ার্ধে সংঘটিত অন্যতম রক্তক্ষয়ী সাম্রাজ্য বিদ্রোহে সাঁওতাল বিদ্রোহকে বিবেচিত করা হতে পারে। এই বিদ্রোহের পটভূমি অর্থ সামাজিক, রাজনৈতিক, ধর্মীয়, পরিবেশ ও ভাষার ভিত্তিক বিশেষভাবে উল্লেখযোগ্য। সাঁওতাল ইন্ডিয়া কোম্পানির শাসন প্রতিষ্ঠার পর থেকেই দেশীয় জনগোষ্ঠীর ওপর নিয়ন্ত্রণ কঠোর করার উদ্দেশ্যে করা হচ্ছিল। এই প্রক্রিয়ার অংশ হিসেবে ব্রিটিশ শাসন আধিবাসীদের সমাজের মূল স্তরে প্রতিষ্ঠিত। কোম্পানি খাটোয়ান আধিবাসী আধিপত্য অঞ্চলগুলিকে



ঔপনিবেশিক শাসনের নিয়ন্ত্রণে নিজে আঙ্গার উদ্ধার করেছিল। পরবর্তীকালে সার্বিক ভূমি ব্যবস্থাবলয় স্থলে ঔপনিবেশিক ভূমি বন্টনবলয় ও রাজনীতি কেন্দ্রপূর্বক চাপিয়ে দেওয়া হয়। এই পর্বে আদিবাসী সমাজে জাতিগত, মহাজন, বানশানার ও টিকানার সীতলাপ পত্রগণনা অঞ্চলে বিদ্রোহের পটভূমি তৈরি হয়। এই অঞ্চল বহিরাগত বা নিবৃত্তা স্ত্রীরা আদিবাসীদের নানা কৌশলে স্বপ্নজালে আবদ্ধ করে তাদের সর্বস্বয় করে, অংশদিকে খ্রিষ্টান অনুগত জাতিগতগণ তাদেরকে জরি ও খাঙ্ক থেকে উৎখাত করে তাদেরকে নিজ স্থলে পরমর্ষী করে তোলে। সেইসঙ্গে বনাঞ্চলের ধ্বংস সাধন ও তার ফলস্বরূপে বিক্রয় বোপের খণ্ডকর্ষ ব্যক্তি, তক্তা ব্যক্তি, পরিখারী আদিকদের সংখ্যা বৃদ্ধি, মুক্তিপ, মহামারী, পুঞ্জিদের অত্যাচার, নারী নির্যাতনের ঘটনা, বেনিয়া প্রেপির শোষণ-নির্পীড়ন ইত্যাদি অর্থ-সামাজিক, রাজনৈতিক ও পরিবেশ সংক্রান্ত কারণগুলি সীতলাপ বিদ্রোহকে অনিবার্য করে তুলেছিল।

ইতোমত শাসন শীতি ও জাতিগত, মহাজন, কবচস্বীনের অকথা উৎপীড়ন আদিবাসীদের জীবনে এক অঘটক আঙ্গের সঞ্চয় করে। এই অনায়াহ অত্যাচার, অনায়াহ-অনিচার ও নিজ জাতি সম্প্রদায়ের মর্ষণ পুনঃপ্রতিষ্ঠার উদ্দেশ্যে সঞ্চয় সীতলাপ আদিবাসীগণ সিধু, কানু, রাঁপ ও উৎকলের নেতৃত্বে বিদ্রোহের পথে অঙ্গার হয়েছিল। আদিবাসী সীতলাপ বিদ্রোহকে গণ আন্দোলন হিসেবে চিহ্নিত করা সেরে পারে। সিধু ও কানুর ধর্মীয় জাতিগতের নিনাচি তুলে এই বিদ্রোহকে সর্বাঙ্গুর করতে চেয়েছিল। তারা পবিত্র শাল পাঙ্কের ডান (পীঠা) প্রতিটি গ্রামে প্রেরণ করে মানুষকে ঐক্যবদ্ধ করার আহ্বান জানিয়েছিলেন। এই পবিত্র ধর্মীয় আহ্বানে সাজা দিয়ে যায় ১০,০০০ সীতলাপ আদিবাসীবৃন্দ আপনাজিই আঙ্গের বট বৃক্ষের নিচে শয়নিত হয়েছিল। এ প্রসঙ্গে মাকসেফ সাঙ্কেব লিখেছেন, "দেবলম্বাহ্রা সায়ন-ই-কোহ থেকে নয়, বীরভূম, ভাগলপুর, হাভারীবাগ, মানকুম ইত্যাদি অঞ্চল থেকে হাজার হাজার সীতলাপ সিধু, কানুর আহ্বানে সাজা দিয়েছিলেন। এরপর ১৮৬৫ সালে ওয়েল স্থান হাজার হাজার সীতলাপ সম্প্রদায়ের মানুষ অগ্নিহুঁড়ি থেকে কলকাতার উদ্দেশ্যে অভিব্যক্ত কর করে। W. W. Hunter এর মতে, এই অজিগানের কেবলমাত্র নেতৃত্বের সঙ্গে যায় ৩০০০০ সীতলাপ জনগণ তাদের সঙ্গে নেহরুজী হিসেবে অভিব্যক্ত করেছিল। মাকসেফ সাঙ্কেব এই অভিব্যক্তের বর্ণনা এখানে বলেছেন যে, এই অজিগানে একমাত্র উদ্দেশ্য হল ঐক্যবদ্ধভাবে কলকাতায় গিয়ে গভর্নর জেনারেল লর্ড জনরৌসির নিকট সাহায্যের আবেদন করা। ২৪ কারতবার্ষক বৃষক আন্দোলনের ইতিহাসে বোধ হয় এই প্রথম গণ গণমর্ষা ছিল। অবশ্যই এই গণজাগরণ ও গণ গণমর্ষা জগতবহুতের আদিবাসীদের ইতিহাসকে মহামর্ষিত করে তুলেছিল। খ্রিষ্টান সম্রাজতাবাদ তার পেশীশক্তি ও আধুনিক অঙ্কের ধারা হাজার হাজার সীতলাপ কৃষক ও আদিককে ভূমিহীন, ব্যয়হারা করেছিল। তাদের অর্থনীতি জীবনজীবিকাগে সম্পূর্ণভাবে ধ্বংসপ্রাপ্ত করেছিল। সিধু, কানু ও তাদের অনুসারী হাজার হাজার সীতলাপ কৃষক নিয়ে নিজ স্থলে বেরে থেকে থাকার চেয়ে আরোমত জাতিগতজিন্দগ জোশ্মানি নিকট, কিম্ব নরকার তার বিনিময়ে তাদেরকে স্থিতিস্থাপ মানুসে পরিণত করেছিল। এই বিদ্রোহ ছিল তার বিদ্রোহের গণমর্ষিতরোধ।

গরুতলুকে কলকাতা অভিব্যক্তের সময়কালে বিদ্রোহী সীতলাপগণ পেশীর অধঃশঙ্ক দিয়ে গে অর্ধাতি গ্রহণ করেছিল, গোটাই রেখেয় থাকেই ইতিহাসে "অথবা সন্দেহ আন্দোলনের আধঃকাল, অলকালিকে এ আন্দোলনকে শুধু কবর জমা কৃষাক মতেশ মারোয়া সিধু ও কানুকে প্রোথার করে। মারোয়া তাঁর উদ্দেশ্য গোপন করেছিলে বিদ্রোহীরা তার ভূমিকের পরে। বিদ্রোহী মারোয়া তার মত মতকর প্রোথারের নিবেশ দেয়। কিম্ব মারোয়ার মেশ

হওয়া মাত্র ঐ স্থানে সময়বত সীতলাপগণ মারোয়াকে বাঁধা, বিচার করিয়া সিধু নিজ স্থলে স্থানীত পরাধন মারোয়াকে হত্যা করে। তখনই সীতলাপ বিদ্রোহীগণ উল্লুৎ আকর্ষণে ত্রুভু নিবেশ করি সন্দেহ আন্দোলনের সূত্রপাত করেন। কিম্ব সীতলাপগণ সিধু, কানুর প্রথমীয় নেতৃত্বে মতেশ মারোয়াকে হত্যা করে এবং তারপর এই অঞ্চলে জাতিগত, মহাজন, মুলখোচাদের একে একে হত্যা করে নিজ মাতৃভূমির স্বাধীনতা, পুনরুদ্ধার ও পূর্ব শিথিল স্থাপন করে। এখানেই তারা ঋজু হননি, এরপর বিদ্রোহী সীতলাপগণ বরা বাজার আক্রমণ লুট করে মহাজনের ঘরবাড়ি, মালকুটি, দেপল কুটির, শস্য ভাতার লুপ্তি ক্ষেত্রে আগুণপ্রয়োগ করে জ্বালায়ে দেয়। এই বারহের বাজার আক্রমণ করার মহা দিহেই তারা নিজে জাতের 'আহাম্বালা' ও নিজ স্থলে 'আহাম্বালা'দের অধিকার পুনঃপ্রতিষ্ঠা করে। শুধু তাই নয় তারা দলবদ্ধভাবে সিধু কানুকে অভিব্যক্ত জাতিগত তাদের নেতৃত্বধ্বংসকে বরণ ও সম্পাদিত করে। তারা জানত যে, খ্রিষ্টান সম্রাজতাবাদ ও তার অনুগত জাতিগত শ্রেণী পক্ষ থেকে প্রতি আত্মপন ও অত্যাচার নিশ্চিত। তাই তারা একদল লুটকু সীতলাপ বাহিনী পাঙ্ক তেজে খ্রিষ্টান সম্রাজতাবাদের মোকাবিলা করার জন্য। সীতলাপ নেতৃত্বকৃষক গোমা থেকে আহাম্বালা 'বীক' বা শলা পাঙ্ক পাঠিয়ে সীতলাপদেরকে এই বিদ্রোহে স্বতঃস্ফূর্তভাবে অংশগ্রহণ করার জন্য একমত আরোমত জানায়, '৯ সিধু কানুর নিবেশে এই বিদ্রোহের কর্মীবৃন্দ গন রচনা করে হামবাসীকে অধুখাণিত করার হাঙ্গাম চালায়। ধূমায়িত এই বিদ্রোহের খবর পাঙ্ক মাইক অগ্নিগুণের কর্মিশালার সি.এক. রাউন এই অঞ্চলে জরমাত সামরিক অফিসার H. W. Barrows কে অভিব্যক্ত আগলপুর ও রাজমহলের অশান্ত পরিবেশে শঙ্ক করার নির্দেশ দেয়। কিম্ব ব্যারোজ রাজমহলের পথ হয়ে কাছা অঞ্চলে উল্লুৎ হয়ে তিনি সত্য উপলব্ধি করলেন যে, বিশাল সীতলাপ বাহিনী প্রতিহত করা একেবারেই অসম্ভব। তাই তিনি অধিক সৈন্য প্রেরণ করার জন্য গভর্নর জেনারেল লর্ড ডালহৌসিকে এক পাঙ্ক প্রেরণ করেন। ইতিমধ্যে সীতলাপ বিদ্রোহ দাবানলের মতো নানা অঞ্চলে ছাড়াই পঙ্ক এবং বিদ্রোহের সংখ্যাও ক্রমশ বাড়তে থাকে। এই আন্দোলনের শক্তি বৃদ্ধির ওপর একটি কারণ হওয়া ব্যস্তা ও বিহারের গর্ভীয় পেশীয় মানুষ স্বতঃস্ফূর্তভাবে অংশগ্রহণ করে এর শক্তি বৃদ্ধি করছিল। এ প্রসঙ্গে হাকীরের উক্তিটি যথার্থ বলে মনে হয়। তিনি লিখেছেন, "সীতলাপ ও সিধু সম্প্রদায়ের মহামর্ষী আদিবাসী শ্রেণি, এমনকি নিম্নবর্গের দরিদ্র হিন্দুকও সীতলাপ বিদ্রোহে প্রেরণিত করেছিল"। তাই মূলকাল কায় তাঁর গবেষণালব্ধ হাঙ্ক বলেছেন যে, "সীতলাপ বিদ্রোহ কেবলমাত্র সীতলাপের বিদ্রোহ নয়, আববা সামানা একটা স্থানীয় ঘটনাও নয়, এই বিদ্রোহ ইংরেজ শাসন ও শোষণের বিরুদ্ধে আরোমত পূর্বাঞ্চলের দলিত শিষ্ট নীন মজুর, গর্ভীয় শ্রমি, ঐক্যবহুত ও কর্মহিত জাতিগতদের সক্রিয়তা বিদ্রোহ"। এই বিদ্রোহের ধারা ইংরেজ সরকার আমলার ও মহাজন গোষ্ঠীকে সাধনবরণ শয়ু হিসেবে চিহ্নিত করা হয়।

**বিদ্রোহের ধারা:** - অগ্নিমহুত ও তার পার্শ্ববর্তী অঞ্চলে এই বিদ্রোহের সূত্রপাত হলেও তা অধিব্যক্ত পাকুর, কালিকাপুর, ব্রহ্মকপুর, নবীনপুর এবং শাহবাহুপুর, কালিকাপুর, বীরভূম, মুলনিবাসন ইত্যাদি অঞ্চলে ছাড়াই পঙ্ক; তারা নীলকর সাঙ্কেবদের কাজারি জাতিগত দেয়। বিদ্রোহীরা বীরভূমের বিজীর্ন অঞ্চলে বিস্ময় করে মালকুটি, কামপুরবাট, নবর, নিউজি, লাকুলিয়া, বর্জর ওল্লুৎ অঞ্চলে ইংরেজ শাসনকে নিশ্চিক করে দেয়। কালকাতা হিউডে, ১৮৬৫ সালের ২০শে জুলাই এক প্রতিবেদনে জানায় যে, বীরভূমের মজুর, পাঙ্করা মাতৃ মাতৃ বেরেই অন্যর ডান অঙ্গ থেকে স্ফিটিয়া এবং অগ্নিগুণ ও রাজমহল পথের বিদ্রোহীদের অভিব্যক্ত অধিব্যক্ত ছিল। ১৭ সম্প্রদায়িক শাসনক্রমে থেকে



শ্রেণীর বিনাময় খুঁচা বাজারে মুক্তা বাজা প্রতিষ্ঠার সংকল্পে অটল ছিলেন।

জনাবান বিবসার ক্রমশ জনপ্রিয়তা বৃদ্ধি, তাঁর বাতুল্পনুসৃত্ত্ব, বুদ্ধিদীপ্তি নেতৃত্ব, জগদীশ্ব ইত্যাদি কারণে ব্রিটিশ সরকার অত্যন্ত ভীত হয়ে তাকে দুবছরের জন্য সশাস্য কারাবন্দে লিপ্ত করল। কিন্তু আরও বেশি বাস্তবসুখী ও বিপ্লবী চেতনা নিয়ে জেল থেকে মুক্তি লাভ করেন। এরপর ১৮৯৮-১৮৯৯ সালে পতীর জঙ্গলে একটি বৈপ্লবিক সভা আয়োজন করে মুক্তাদের দৃষ্ট দূর্দশা বৃদ্ধিকারী শ্রেণী, যথা- ঠিকাদার, মহাযাজা, হকিম ও খ্রিস্টান মিশনারীদের হত্যা করার জন্য তাঁর অনুসারীদের ঘটি একাঙ অঙ্কন জানান। ৩০

জনাবান বিবসার নির্দেশ মতেই বিপ্লবীরা খালি, গির্জা, শস্যভোজ, সরকারি কর্মকর্তা ও মিশনারীদের ওপর তীব্র আক্রমণ শুরু করে। ১৮৯৯ সালের বড়দিনে আক্রান্তে মুক্তা বিদ্রোহীরা বাঁচি ও সিংহুয় জেলার বিভিন্ন ধানার এলাকাগুলিতে অগ্নি সংযোগ ঘটায়। ১৯০০ খ্রিস্টাব্দে তারা খানাজেলিতে অক্রমণ করে বিদ্রোহের ধর্মাত্মকে জনমত পঠনের ব্যয়স চানায়। ইতিমধ্যে ওজর ছড়ায় যে, ৮ই জানুয়ারি তারা বাঁচি আক্রমণ করবে। এই ভয়ে ব্রিটিশ সৈন্য তাদের সর্বশক্তি নিয়ে বিদ্রোহীদের পরাস্ত ও বিবসার মুক্তাকে বন্দী করে। বন্দি অবস্থায় জনাবান বিবসার মৃত্যু হয়। এরপর ৩৫০ জন মুক্তাকে বিচারে দোষী সাব্যস্ত করে যাবজ্জীবন কারাবন্দে দণ্ডিত করা হয়। এদের মধ্যে তিনজনের ফাঁসি হয় এবং ৪৪ জন মুক্তা বিদ্রোহীর ষ্ট্রীপাঙ্করে সাজা হয়। জঙ্গলমহলে মুক্তা জাতিব এই ব্যাপক অস্বাভাবন ব্যর্থ হলেও এই বিদ্রোহ অসমতর্কিত জাতীয় আন্দোলনের সৃষ্টি হয় অনুপ্রেরণা হিসাবে কাজ করেছে। সরকার বাধ্য হয়ে ১৯০২-১৯১০ সালের মধ্যে জরিপ করণ করে মুক্তাদের নাবিনভ্যায় প্রত্যেকের চেষ্টা চানায়, ৩৯ ১৯০৮ সালে ব্রিটিশ সরকার 'Nagpore Tenancy Act' পনশ করে তাদের চিরচিরিত খুঁচকটি আধিকারের স্বীকৃতি দেয়। এই আইনের ফলে সেন্সার অধা সম্পূর্ণ নির্মিত হয়। এইভাবে জেটনাগপুরের মুক্তা বিদ্রোহীরা নিজা মাতৃভূমির স্বাধীনতা অর্জনের যে আশা আকাঙ্ক্ষার সৈনিক ও যৌদ্ধিক সংগ্রাম গড়ে তুলেছিল তা অবশেষে স্বাধীনতা আন্দোলনের মধ্য গতিতে যথেষ্ট পরিমাণে তীব্রতর করোঁছল বগের মনে হয়।

**বিদ্রোহের শ্রেণী চরিত্রের চেতনার বিকাশ:-** ঐপনিবেশিক আমলে সংগঠিত বিদ্রোহগুলিকে কৃষক আন্দোলন হিসাবে অধ্যয়িত করা যেতে পারে। ঐতিহাসিক কাব্যলিন পণ্ডের মতে, ঐপনিবেশিক সময়কালে উদ্ভূত কৃষক বিদ্রোহগুলির ধর্মাত্মকে পাঁচটি ভাগে ভাগ করেছেন। যথা- (১) কৃষক স্থাপন মূলক বিদ্রোহ, (২) ধর্মীয় আন্দোলন, (৩) সামাজিক আন্দোলন, (৪) সাজাস মূলক প্রতিরোধ আন্দোলন, (৫) গন অস্বাভাবন। পরবর্তী কালের নিম্নবর্ণিত ঐতিহাসিকগণ এই কৃষক বিদ্রোহগুলিকে নতুনভাবে সেন্সার চেষ্টা করেছেন। রঞ্জিত ওই কৃষকদের নিজস্ব যাজ্ঞৈতিক চেতনা এবং চেতনার এক বিশেষ কাঠামো আছে বলে প্রতিপত্ত প্রকাশ করেছেন। এই কাঠামোগুলি হল- (১) সেন্সেল, (২) জামনিভাইটি, (৩) ম্রীলনিশন, (৪) মডার্নিটি, (৫) শপিডারিটি, (৬) টেরিটোরিয়ালিটি। এই ধারণার ঐতিহাসিকগণ বিদ্রোহগুলির সংগঠনের ক্ষেত্রে ধর্ম সম্প্রদায় ও জাতিগত মিলগুলি তুলে ধরার চেষ্টা করেছেন। ৩৯

ঐপনিবেশিক বাংলার কৃষক বিদ্রোহগুলির মধ্যে 'শ্রেণি ধারণা', 'কৃষক ধারণা' ও 'বিদ্রোহের ধারণা' প্রধান পোষক। এখানে শ্রেণি ধারণা মূলত মার্কসীয় দ্বিভাষ ক্রমকে অধির্ভিক

সম্পর্ক ও অধৈনৈতিক অবস্থা বিশেষভাবে ব্যবহৃত হয়েছে। তবে এটা বৃত্ততে হলে যে, 'শ্রেণি শ্রেণী' শব্দটি একটি শ্রেণীর সচেতনতা গাও হতে পারে এবং 'শ্রেণী' শব্দটি একটি শ্রেণীর মধ্যে নিজস্ব শ্রেণিচেতনা এবং এখান থেকে উদ্ভূত হয়ে নিজের থেকে পৃথক চেতনা বিকাশের বেখানো হয়েছে। এখানে কৃষক শ্রেণী' বলতে মধ্যবিত্ত, নিম্নবিত্ত এবং ত্রিবিধীন কৃষক অংশগুলিকে বোঝানো হয়েছে। আবার কৃষক বিদ্রোহ করতে শোষণের নিয়ন্ত্রণে কৃষক শ্রেণীর যৌধ প্রতিবাদ, পনি ইত্যাদিকে বোঝানো হয়েছে। ঐতিহাসিক রিডফোর্ড না দিয়ে উপজাতি বিদ্রোহগুলিকে তিনিও ভাগ করা যেতে পারে। যথা- (১) প্রক মাইবিদ্রোহ পর্যায়, (২) প্রথম বিশ্বযুদ্ধ পূর্ববর্তী পর্যায়, (৩) প্রথম বিশ্বযুদ্ধ পরবর্তী পর্যায়। ৩০

প্রক মাইবিদ্রোহের পূর্বে উপজাতি বিদ্রোহগুলির মধ্যে কোল, জিন, সাঁওতাল প্রমুখ ইত্যাদি বিদ্রোহগুলি বিশেষভাবে উল্লেখযোগ্য। অংশ সেকন্টেন্ট গভর্নর হেলিগেট বলেছেন যে, এই বিদ্রোহের উৎসে ছিল ব্রিটিশ শাসনের অবমান ঘটনো। উপজাতি বিদ্রোহগুলি ছিল কৃষক বিদ্রোহ। সাঁওতাল বিদ্রোহের কেন্দ্রমাত্র সাঁওতাল আদিবাসীপন অংশগ্রহণ করেনি, স্থানীয় ফরোয়, বেলি, কর্কাব, মুনজিম তাঁতি, চামার, ডোম যাদুতি সম্প্রদায় ও সেন্সার মনুষ্যের সক্রিয়ভাবে অংশগ্রহণ করে। এই বিদ্রোহগুলি কেবলমাত্র জামিনার ও মহাজন বিরোধী ছিল না, এগুলি ব্রিটিশ সাম্রাজ্যবাদের অবমান ঘটতে চেয়েছিল।

আবার প্রক মাইবিদ্রোহের সময় কালে সন্ন্যাসী, ফকির, পাবনা, পাবনাগুহী ও সন্যাসের বিদ্রোহ ছিল গুরুত্বপূর্ণ। তবে এই বিদ্রোহগুলি কৃষক শ্রেণি চরিত্র চেতনা অনেকটা দুর্ভ ছিল। সন্ন্যাসী ও ফকির বিদ্রোহ শ্রেণি চরিত্রের সঙ্গে কৃষক চরিত্র, সামাজিক ঐতিহাসি ইত্যাদি মিলে মিলে এককার হয়ে গিয়েছিল। ১৭৭৮ সালে "স্বপ্নে আদিন আইন" অনুযায়ী কর-ভয়ঙ্কিশ যখন রাজার মুক্ত জরি আধাছনের কথা আশংকা করলেন তখন সন্ন্যাসীদের বিদ্রোহ ও নবিয় কৃষক বিদ্রোহে সংমিশ্রণ লক্ষ্য করা গিয়েছিল। এই ধরনের বিশেষ ভাবে উল্লেখযোগ্য যে, উপজাতি বিদ্রোহগুলির মধ্যে সন্যাসাচল, ফরগত ও জাতিগত চেতনা প্রসন্ন ছিল, অপর্যন্তই সন্ন্যাসী, ফকির, ডোম, কায়দী ইত্যাদি বিদ্রোহের মধ্যে সম্প্রদায়, জাত, গাও, ধর্ম, বর্ণের ধর্মকটতা আধিক ছিল। ৩১

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### ABOUT THE BOOK

Peasants and workers are the main backbone of the society who trying their best without any covetous attitude and selfishness dedicating their lives provides food, cloth and important amenities to the every section of the people in the society through the ages. No society would be existed without their assistance and contribution. In spite of that these peasants and labourer are neglected, exploited, deprived and abhorred by the upper strata of the society who have to tolerate the atrocities of the elite people to be a retrograded class in the society. Their unconditional contribution and dedication to the society and nation in whole over the world is not placed in the history. In the context of the history of Bengal, nay India no sufficient attempt has been taken to explore the contribution and their history of atrocities and life-pain. In the present book an initiative has been taken to explore and expose the history of the neglected and exploited peasants and labourer without any biasness and prejudices.

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