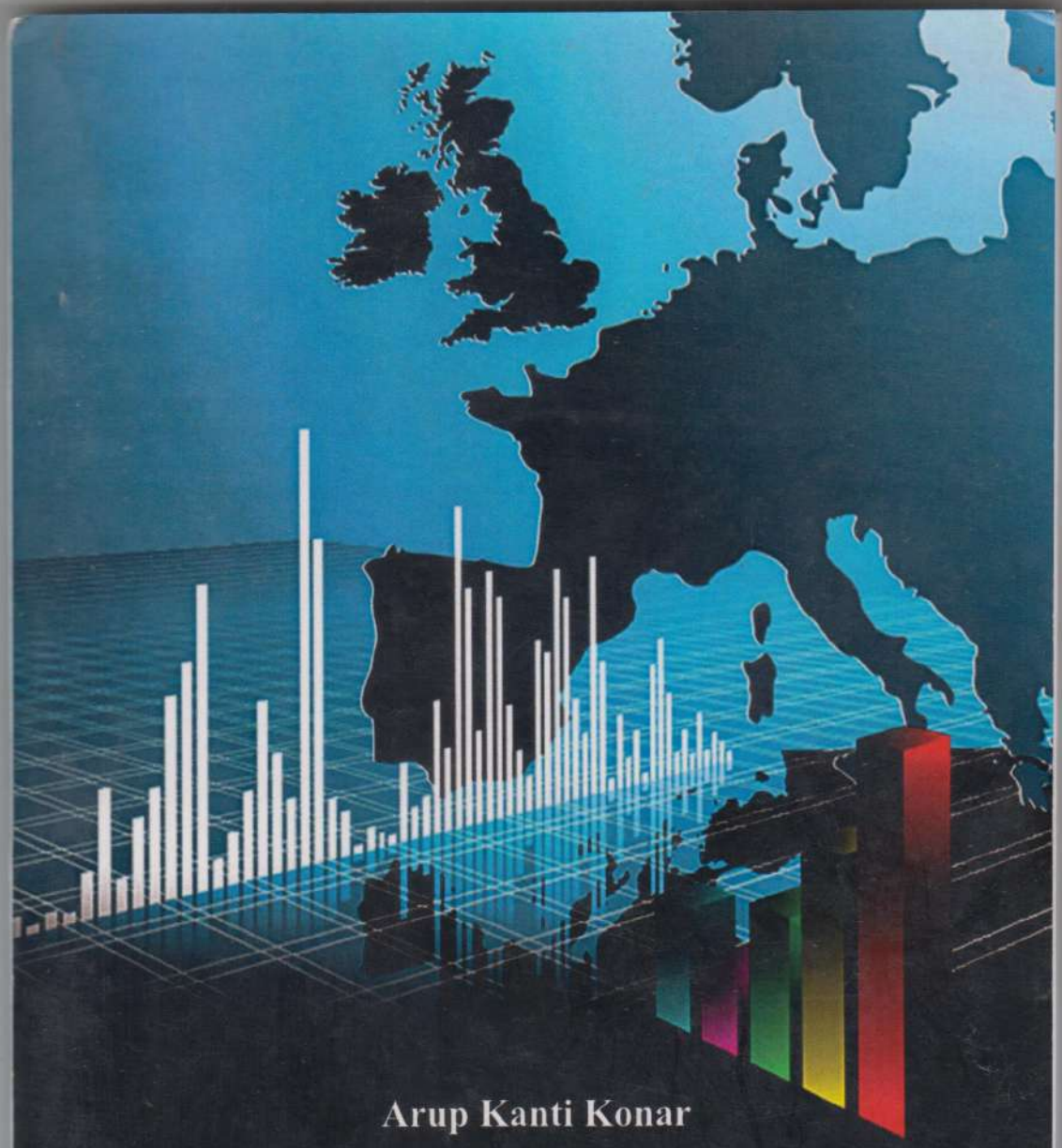

Arup Kanti Konar

Reconstruction of Hydraulic Keynesianism for Macroeconomics of Sustainability

RECONSTRUCTION OF HYDRAULIC KEYNESIANISM FOR MACROECONOMICS OF SUSTAINABILITY

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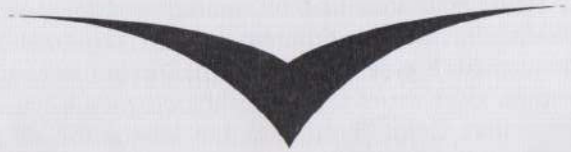
Arup Kanti Konar

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 social unsustainability" or "ecologically unsustainable social instability" through the gradual development "dual capitalism", which implies the coexistence of "ecological capitalism" and "social capitalism". "Ecologically social unsustainability" 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) Simle 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 social sustainability" or "ecologically sustainable social stability", which is renamed as simply "sustainability".



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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 planer 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 4,827th 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". Needful 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 4,827th reconstruction of the GT was executed by Weintraub (1979), yet we must confront with much toil and trouble to assert who executed the *nth* (where *n = 1, 2, 3, 4, 5, 6,……..*) 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 vitiation/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 & Chakrabortty, 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 & Chakrabortty, 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 macrosubsocial 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 macrosubsocial 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 & Chakrabortty, 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 Chakrabortty (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 & Chakrabortty, 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 21st century macroeconomics is radically different from the context of the 19th and 20th 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 21st Century*
7. Harris and Goodwin's (2003) *New Thinking in Macroeconomics*
8. Goodwin's (2003) *Macroeconomics for the 21st 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. Jesperson'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 21st 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 21st 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_1) Developing macroeconomic capability

(A_2) Investing in public assets and infrastructures

(A_3) Increasing financial and fiscal prudence

(A_4) Reforming macroeconomic accounting

(B) Five Steps for Protecting Capabilities for Flourishing

(B_1) Sharing the available work and improving the work-life balance

(B_2) Tackling systemic inequality

(B_3) Measuring capabilities and flourishing

(B_4) Strengthening human and social capital

(B_5) Reversing the culture of consumerism

(C) Three Steps for Responding Ecological Limits

(C_1) Imposing clearly defined resource/emission caps

(C_2) Implementing fiscal reform for sustainability

(C_3) 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 21st 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 no 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 & Chakrabortty, 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 macrosub-social 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:

$\boldsymbol{C}$ ≡ Consumption expenditure by household sector

$\boldsymbol{G}$ ≡ Government expenditure (consumption-oriented)

$\boldsymbol{I}$ ≡ Private investment expenditure in manufactured capital

$\boldsymbol{M}$ ≡ Import by foreign sector

$\boldsymbol{S}$ ≡ Saving by household sector

$\boldsymbol{T}$ ≡ Net tax = (Tax – Transfer payment) collected by government sector

$\boldsymbol{X}$ ≡ Export by foreign sector

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

$\boldsymbol{Y_d}$ ≡ Disposable $\boldsymbol{NI}$ = ($\boldsymbol{Y - T}$)

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

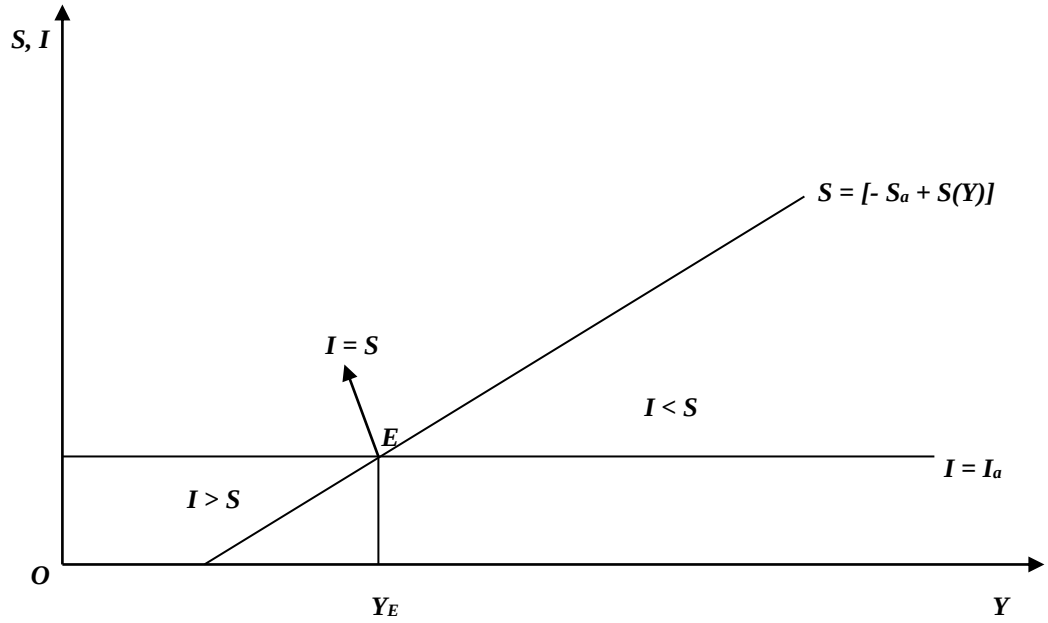
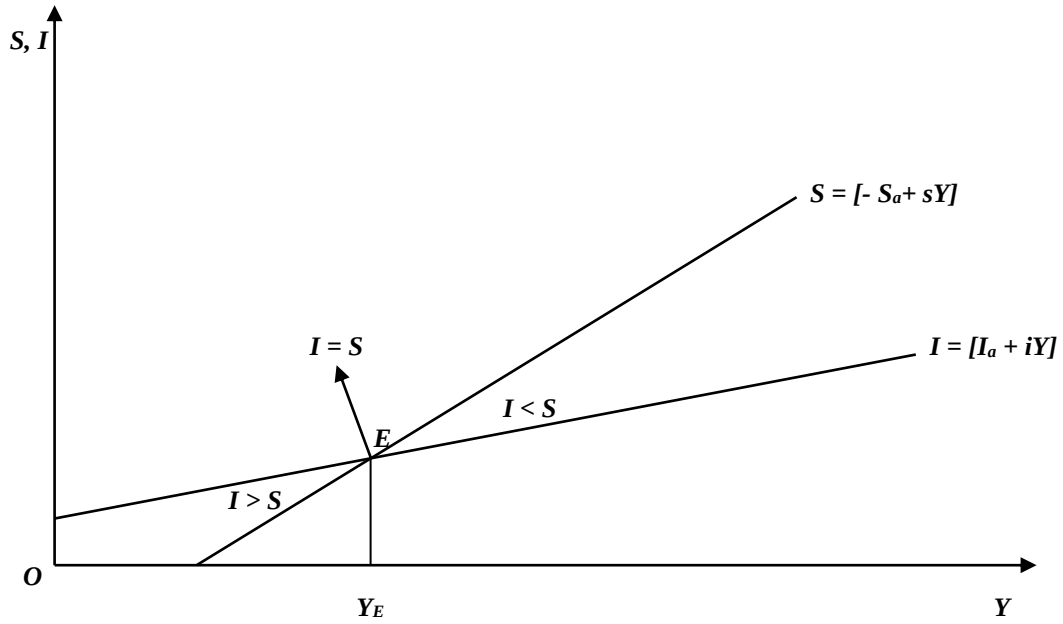


Figure 3.2: Equilibrium in SKM for Two-Sector Closed Economy by Saving-Investment Approach with Induced Investment



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

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).

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

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).

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

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).

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

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).

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

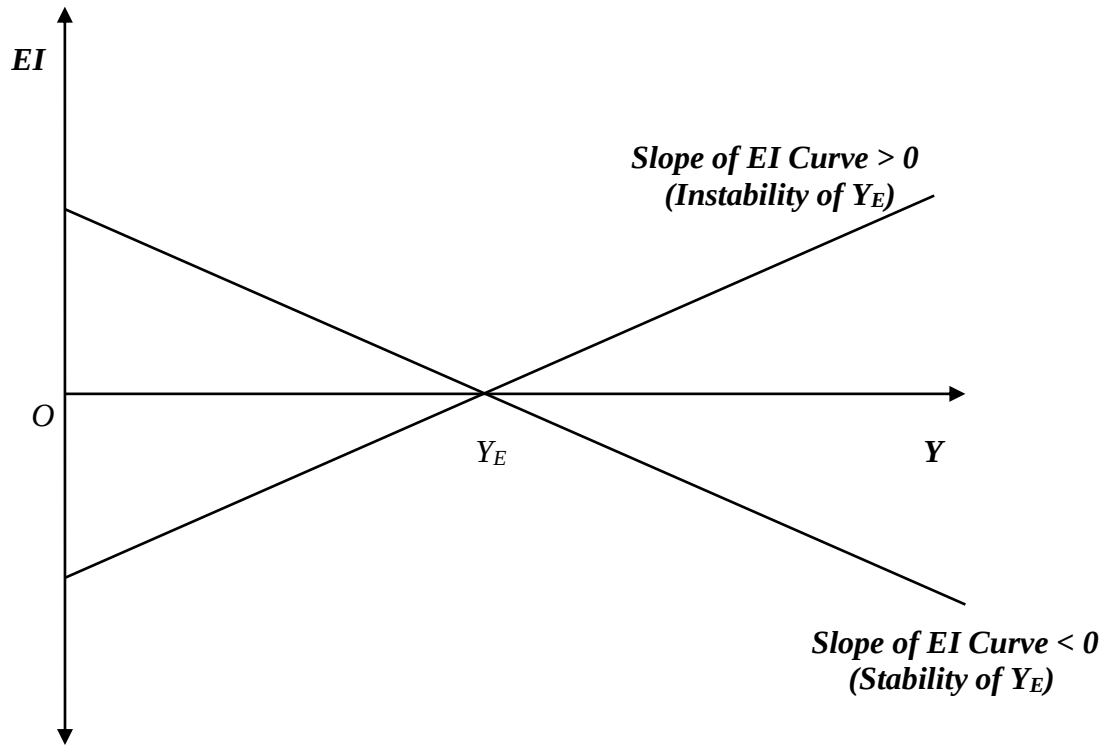
The equilibrium income denoted by Y_E in Figure 3.2 is statically stable, because the condition for static stability of equilibrium income requires that the slope of the *excess investment* (EI) *curve* will be negative, which implies that *MPS* > *MPI*, or $s > i$. This is evident from equation (3.9).

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

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 instable), 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 ≡ Active demand for money = [Transaction demand for money (L_T) + Precautionary demand for money (L_P)], L_2 ≡ Speculative demand for money, M_a^*≡ Autonomous money supply, P_a^* ≡ Autonomous price level, L ≡ Demand for money ≡ Liquidity preference, Y ≡ *NI*, r ≡ 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).

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

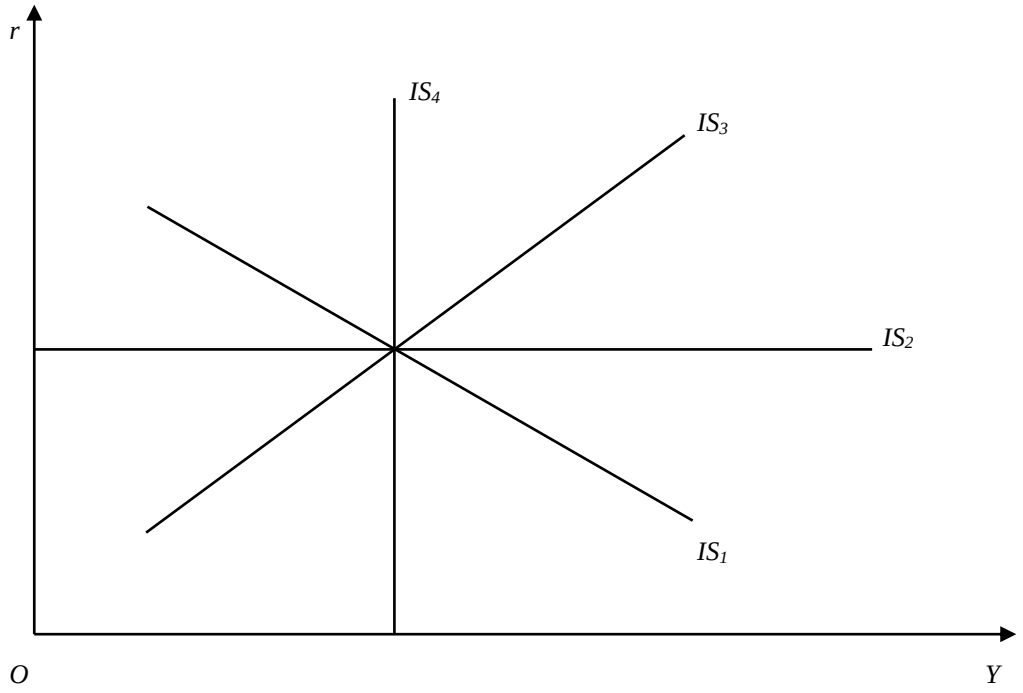
By total differentiation of equation (4.10) with respect to Y, we get equation (4.11).

$$[dr/dY]_{GISC} = [I_Y - S_Y]/[S_r - I_r] \qquad \textbf{(4.11)}$$

= 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.

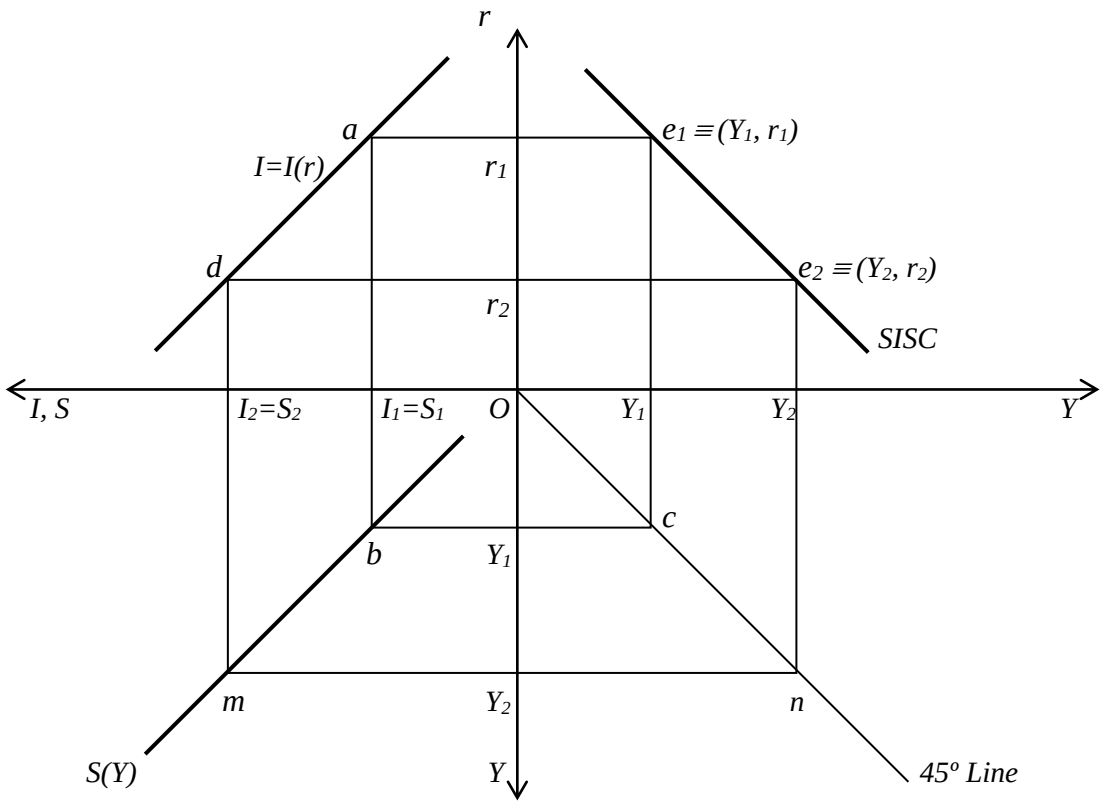
Figure 4.1: Four Slopes of IS Curve



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.

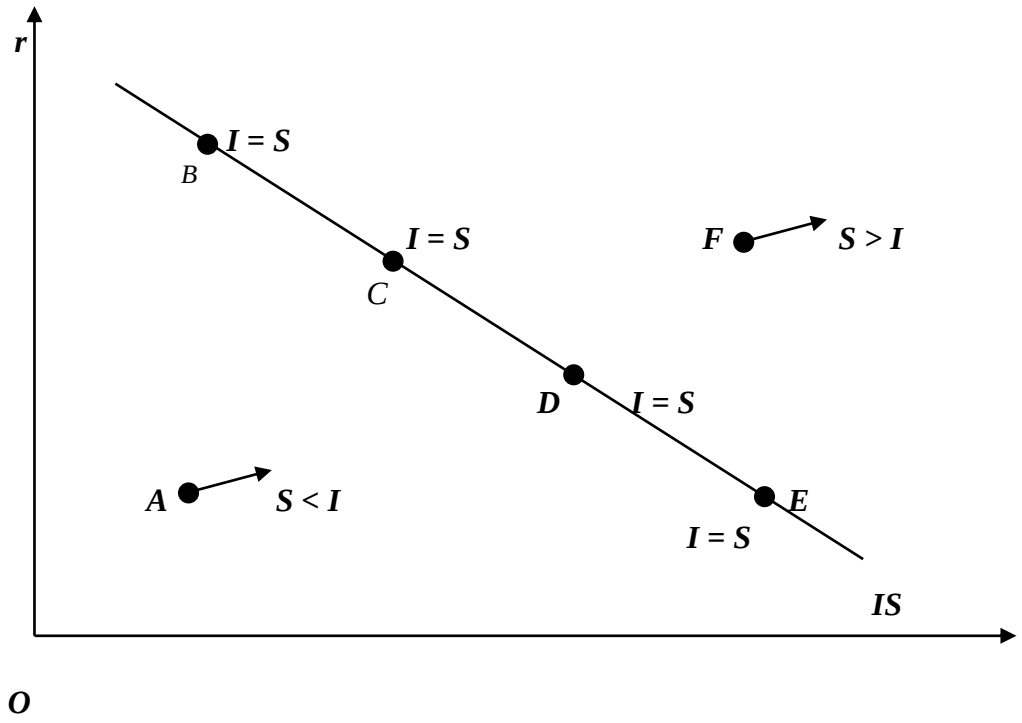
Figure 4.2: Diagrammatic Derivation of SISC



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).

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

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

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

= 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

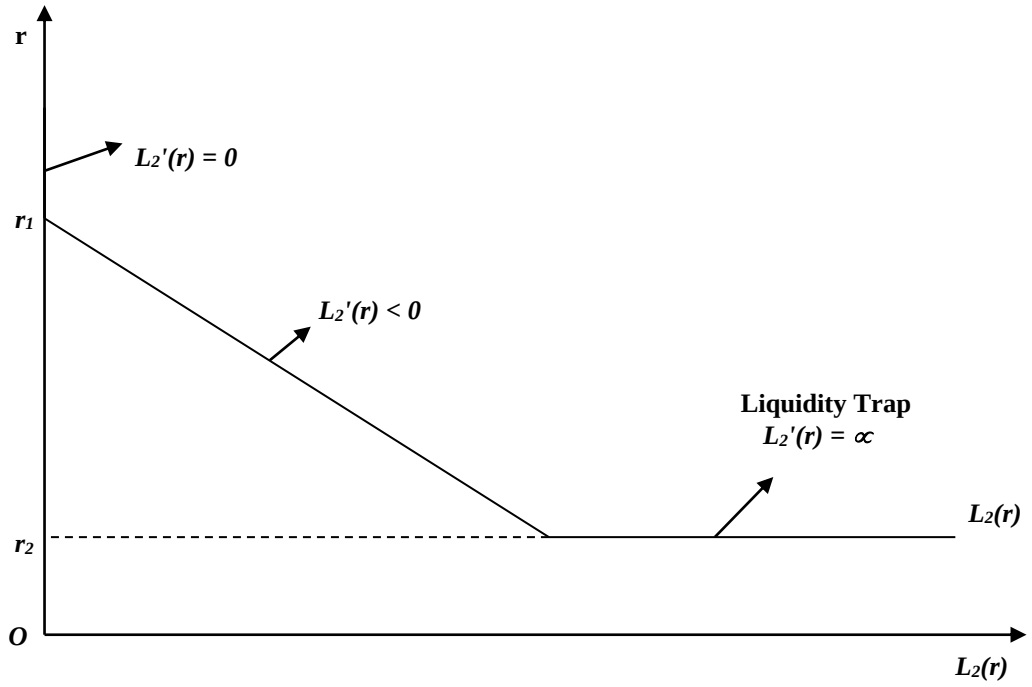
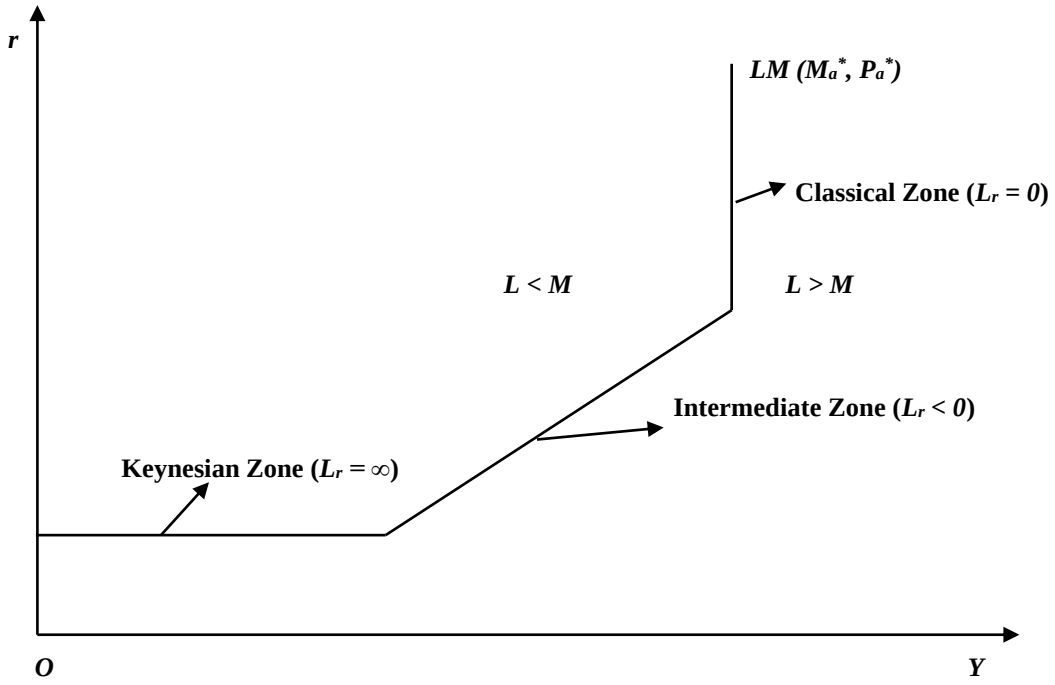


Figure 4.5: Slope/Shape of LM Curve



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*.

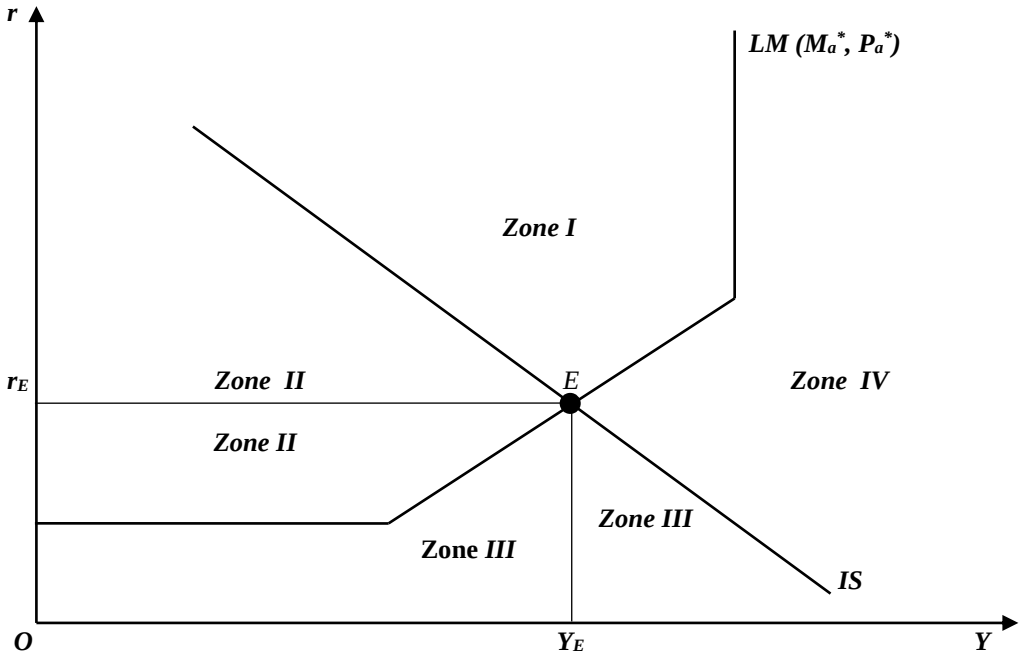
In Zone III, $I > S$ and $L > M$, which lead to rise in both *Y* and *r*.

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:

$\boldsymbol{C} \equiv$ Consumption expenditure by household sector

$\boldsymbol{I} \equiv$ Investment expenditure by private sector firms

$\boldsymbol{G} \equiv$ 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:

$\boldsymbol{C}$ = [(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)]

$\boldsymbol{I}$ = [(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 $GDP \equiv$ Gross Domestic Product, $NDP \equiv$ Net Domestic Product, $D^m \equiv$ 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:

$$ESNI = [NDP - D^n] \quad (5.5)$$

$$SSNI = [NDP - D^s] \quad (5.6)$$

$$ESSNI = [NDP - (D^n + D^s)] \quad (5.7)$$

where $\boldsymbol{D^s}$ ≡ Depreciation of Social Capital and $\boldsymbol{D^n}$ ≡ 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).

$$\boldsymbol{ESNI = [Y_d - D^n]} \quad \textbf{(5.8)}$$

$$\boldsymbol{SSNI = [Y_d - D^s]} \quad \textbf{(5.9)}$$

$$\boldsymbol{ESSNI = [Y_d - (D^n + D^s)]} \quad \textbf{(5.10)}$$

where $\boldsymbol{Y_d}$ ≡ 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).

$$\boldsymbol{ESNI = [NDP - (D^n + E^r + E^a + O^n)]} \quad \textbf{(5.11)}$$

$$\boldsymbol{SSNI = [NDP - (D^s + E^r + E^a + O^n)]} \quad \textbf{(5.12)}$$

$$\boldsymbol{ESSNI = [NDP - (D^n + D^s + E^r + E^a + O^n)]} \quad \textbf{(5.13)}$$

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).

$$\boldsymbol{ESNI = [Y_d - (D^n + E^r + E^a + O^n)]} \quad \textbf{(5.14)}$$

$$SSNI = [Y_d - (D^s + E^r + E^a + O^n)] \quad (5.15)$$

$$ESSNI = [Y_d - (D^n + D^s + E^r + E^a + O^n)] \quad (5.16)$$

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 $C(...)$ and $S(...)$ 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

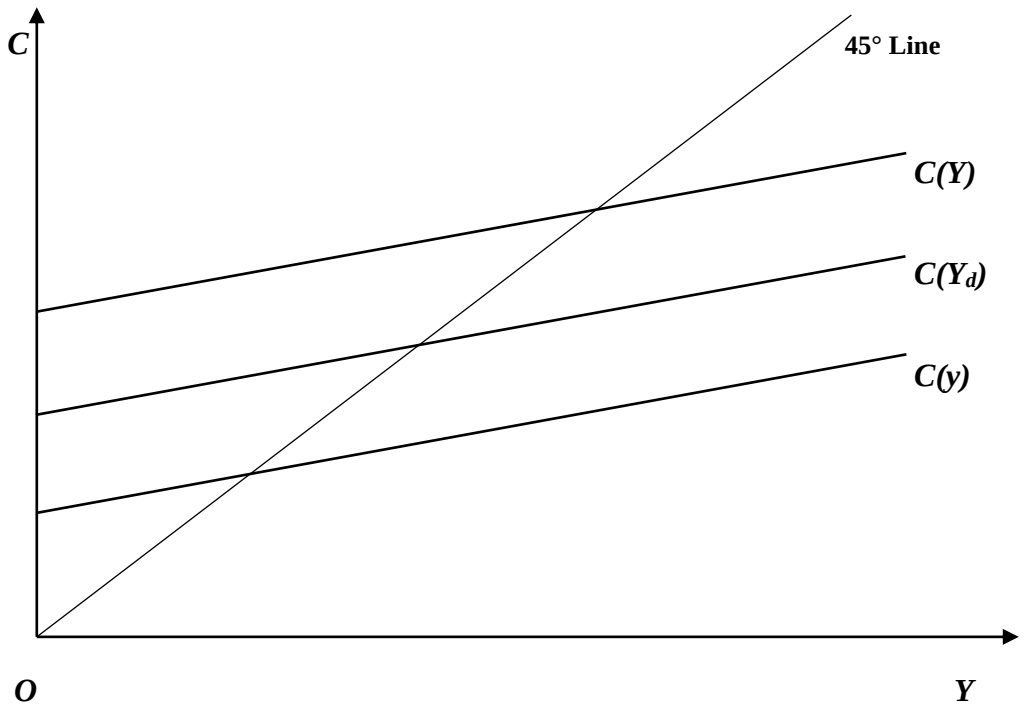
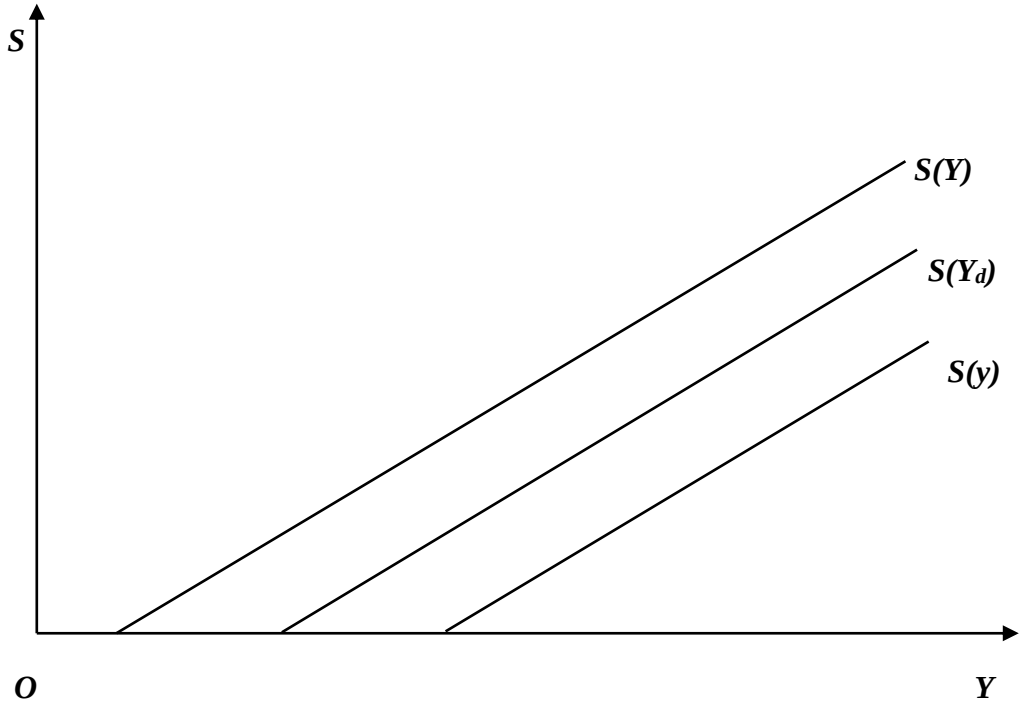


Figure 5.2: Conventional vis-à-vis Sustainable Saving Function



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:

$C(y^{es})$ ≡ Ecologically sustainable consumption function

$C(y^{ss})$ ≡ Socially sustainable consumption function

$C(y^{ess})$ ≡ Ecologically and socially sustainable consumption function

D^m ≡ Depreciation, depletion or degradation of manufactured capital

D^n ≡ Depreciation, depletion or degradation of natural/ecological capital

D^s ≡ Depreciation, depletion or degradation of social capital

$\boldsymbol{G}$ ≡ Government expenditure

$\boldsymbol{G = [G_C + G_I] = [G_C + (G_I^n + G_I^m)]}$

$\boldsymbol{G_C}$ ≡ Government consumption expenditure

$\boldsymbol{G_I}$ ≡ Government investment expenditure

$\boldsymbol{G_I^n}$ ≡ Government investment in natural capital

$\boldsymbol{G_I^m}$ ≡ Government investment in manufactured capital

$\boldsymbol{GDP}$ ≡ Gross domestic product

$\boldsymbol{I^m}$ ≡ Private investment in manufactured capital

$\boldsymbol{I^n}$ ≡ Private investment in natural capital

$\boldsymbol{I^s}$ ≡ Private investment in social capital

$\boldsymbol{M}$ ≡ Import

$\boldsymbol{NDP}$ ≡ Net domestic product

$\boldsymbol{NI}$ ≡ National income

$\boldsymbol{S(y^{es})}$ ≡ Ecologically sustainable saving function

$\boldsymbol{S(y^{ss})}$ ≡ Socially sustainable saving function

$\boldsymbol{S(y^{ess})}$ ≡ Ecologically and socially sustainable saving function

$\boldsymbol{T}$ ≡ Net tax = (Tax – Transfer payments)

$\boldsymbol{X}$ ≡ Export

$\boldsymbol{Y \equiv NI = NDP = (GDP - D^m)}$

$\boldsymbol{Y_d}$ ≡ Disposable $\boldsymbol{NI} = (\boldsymbol{Y - T})$

$\boldsymbol{y^{es}}$ ≡ Ecologically sustainable $\boldsymbol{NI} = (\boldsymbol{Y - D^n})$[when government sector is non-existent] = $(\boldsymbol{Y_d - D^n})$[when government sector is existent]

$\boldsymbol{y^{ss}}$ ≡ Socially sustainable $\boldsymbol{NI} = (\boldsymbol{Y - D^s})$[when government sector is non-existent] = $(\boldsymbol{Y_d - D^s})$[when government sector is existent]

$\boldsymbol{y^{ess}}$ ≡ Ecologically and socially sustainable $\boldsymbol{NI} = [\boldsymbol{Y - (D^n + D^s)}]$[when government sector is non-existent] = $[\boldsymbol{Y_d - (D^n + D^s)}]$[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).

$$\boldsymbol{[S(y^{ess}) + (D^n + D^s)] = [I^m + (I^n + I^s)]} \qquad \textbf{(6.10)}$$

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) $N = (I^n + I^s)$.

$$\boldsymbol{S(y) + D = P + N} \qquad \textbf{(6.11)}$$

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.

$$\boldsymbol{[S_a + S(y)] + D_a = P_a + N_a} \qquad \textbf{(6.12)}$$

$$[S_a + S(y)] + D_a = [P_a + P(Y)] + N_a \quad \textbf{(6.13)}$$

$$[S_a + S(y)] + D_a = P_a + [N_a + N(Y)] \quad \textbf{(6.14)}$$

$$[S_a + S(y)] + D_a = [P_a + P(Y)] + [N_a + N(Y)] \quad \textbf{(6.15)}$$

$$[S_a + S(y)] + [D_a + D(Y)] = P_a + N_a \quad \textbf{(6.16)}$$

$$[S_a + S(y)] + [D_a + D(Y)] = [P_a + P(Y)] + N_a \quad \textbf{(6.17)}$$

$$[S_a + S(y)] + [D_a + D(Y)] = P_a + [N_a + N(Y)] \quad \textbf{(6.18)}$$

$$[S_a + S(y)] + [D_a + D(Y)] = [P_a + P(Y)] + [N_a + N(Y)] \quad \textbf{(6.19)}$$

where $\boldsymbol{a}$ ≡ autonomous part and $\boldsymbol{i(j)}$ ≡ induced part of the $\boldsymbol{i}$ function given by $\boldsymbol{i = i_a + i(j)}$.

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).

$$[- S_a + sy] + D_a = P_a + N_a \text{ or, } [- S_a + s(Y - D_a)] + D_a = P_a + N_a \quad \textbf{(6.20)}$$

Rearranging equation (6.20), we get the ecologically and socially sustainable equilibrium NI (Y_{ess}) by equation (6.21).

$$Y_{ess} = (P_a + S_a)/s + N_a/s - D_a(1 - s)/s \quad \textbf{(6.21)}$$

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).

$$Y_{ess} = [(I_a + S_a)/s] - [D_a(1 - s)/s] \quad \textbf{(6.22)}$$

Further, in equation (6.22), if we put $D = D_a = 0$, we get the conventional equilibrium NI (Y_c) by equation (6.23).

$$\boldsymbol{Y_c = [(I_a + S_a)/s]} \qquad \textbf{(6.23)}$$

Comparing equation (6.22) and equation (6.23), we get the inequality (6.24).

$$\boldsymbol{Y_{ess} < Y_c} \qquad \textbf{(6.24)}$$

as $[D_a(1– s)/s] > 0$ due to the assumption that $0 < s < 1$ 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) $\boldsymbol{Y_{ess} < Y_c}$

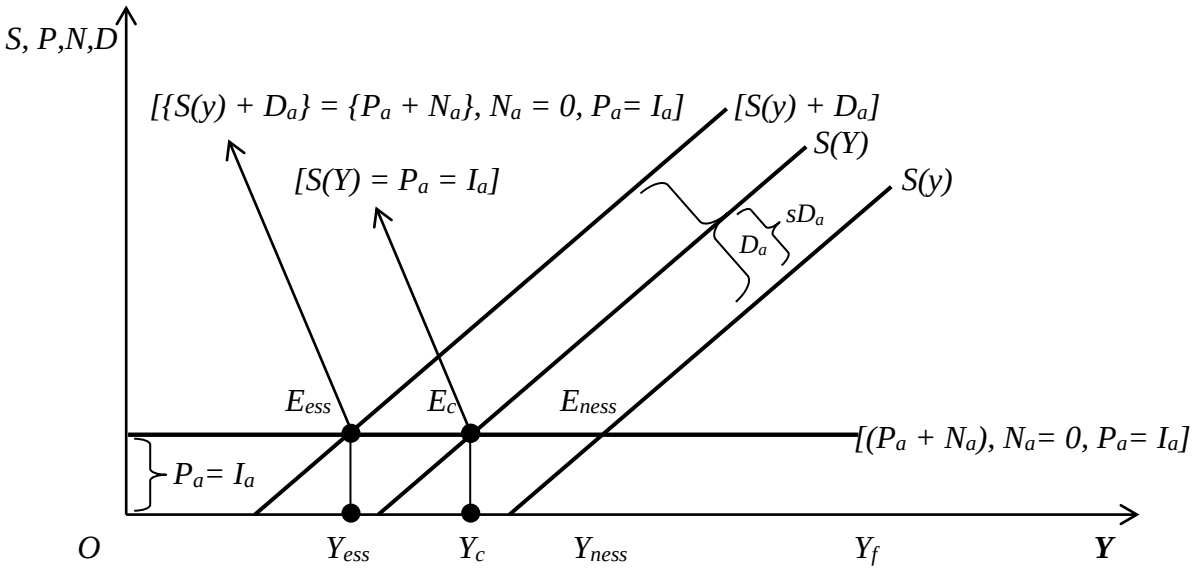
(ii) $\boldsymbol{Y_{ess} = Y_c}$

(iii) $\boldsymbol{Y_{ess} > Y_c}$

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).

$\boldsymbol{S(Y) = I(r)} \Rightarrow$ Conventional Simple IS Curve (IS_c) **(7.1)**

$\boldsymbol{M_a^* = L(Y, r, P_a^*)}, \Rightarrow$ LM Curve (LM), **(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:

$D^m \equiv$ Depreciation, depletion or degradation of manufactured capital,

$D^n \equiv$ Depreciation, depletion or degradation of natural capital

$D^s \equiv$ Depreciation, depletion or degradation of social capital

$G \equiv$ Government expenditure

$G = [G_C + G_I] = [G_C + (G_I^m + G_I^n + G_I^s)]$

$G_C \equiv$ Government consumption expenditure

$G_I \equiv$ Government investment expenditure

$G_I^m \equiv$ Government investment in manufactured capital

$G_I^n \equiv$ Government investment in natural capital

$G_I^s \equiv$ Government investment in social 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

$r \equiv$ Rate of interest

$S(y^{es}) \equiv$ 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

$Y \equiv NI = NDP = (GDP - D^m)$

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

$y^{es} \equiv$ Ecologically sustainable $NI = (Y - D^n)$[when government sector is non-existent] = $(Yd - D^n)$[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} ≡ 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).

$$S(y^{ess}) + [D^n + D^s] = I^m(r) + [I^n + I^s] \quad \textbf{(7.12)}$$

On the basis of the following Simplifying Assumptions, equation (7.12) can be transformed into the equation (7.13).

$$S(y) + D_a = I(r) \quad \textbf{(7.13)}$$

$\Rightarrow$ *Ecologically and Socially Sustainable Simple IS Curve* (IS_{ess})

Simplifying Assumptions

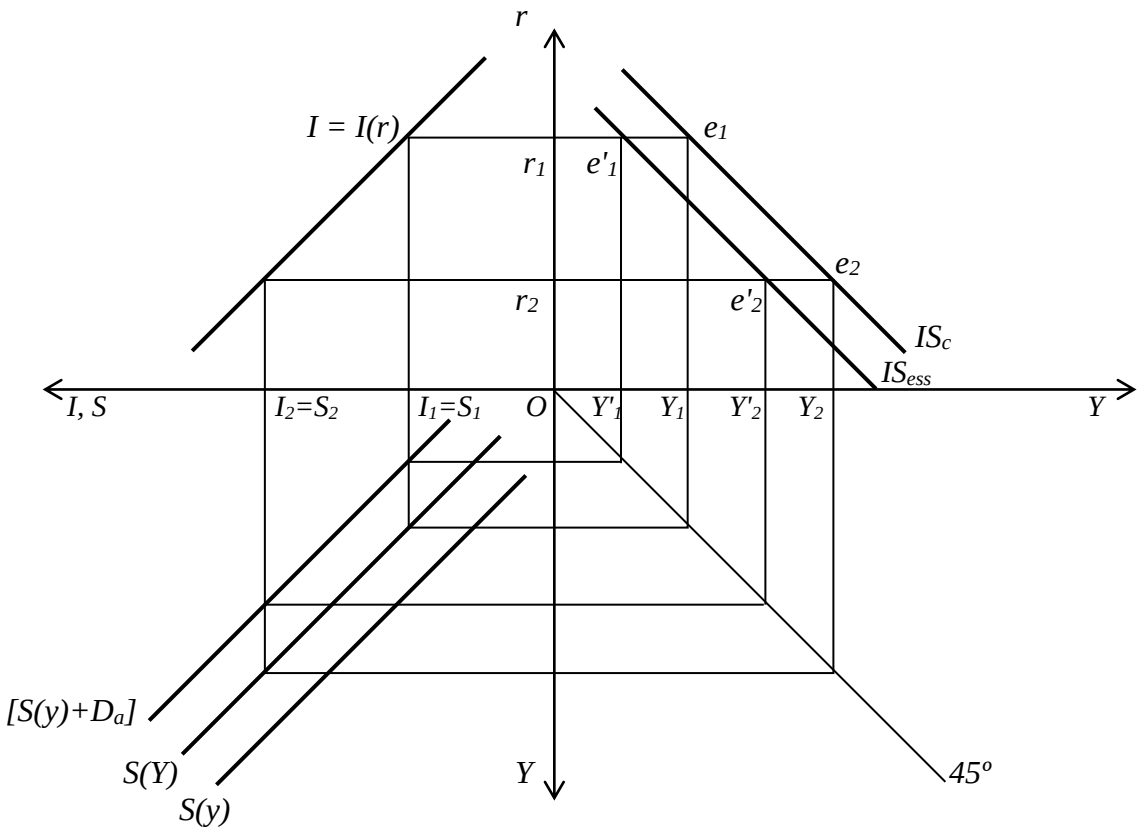
(1) $S(Y)$ is the conventional saving function.
(2) $I(r)$ is the conventional investment function.
(3) y is substituted for y^{ess}, that is, $y = y^{ess} = [Y – (D^n + D^s)]$.
(4) $S(y)$ is the ecologically and socially sustainable saving function.
(5) D consists of D^n and D^s, that is, $D = (D^n + D^s)$.
(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) D function is autonomous, that is, $D = D_a$.

(8) $P = I = I(r)$ and $N = 0$.

Figure 7.1, which is self-explanatory, shows the derivation of both the *conventional simple IS curve* (IS_c) and the *ecologically and socially sustainable simple IS curve* (IS_{ess}) for making a comparison between them. The intrinsic mechanism of Figure 7.1 indicates that IS_{ess} must lie below the IS_c.

Figure 7.1: Simple IS Curve: Conventional vis-à-vis Sustainable



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)]*

$$= \boldsymbol{(dr/dY)_c = S'(Y)/I'(r) < 0}, \quad \textbf{(7.14)}$$

since $S'(Y) > 0, I'(r) < 0$, where $c \equiv$ *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)

$$= \boldsymbol{(dr/dY)_{ess} = S'(y)/I'(r) < 0}, \quad \textbf{(7.15)}$$

since $S'(y) > 0, I'(r) < 0$, where *ess* ≡ *ecologically and socially sustainable*

By definition, $y = (Y - D_a)$. So by its differentiation with respect to Y, we get:

$$\boldsymbol{dy/dY = 1}, \text{ or } \boldsymbol{dy = dY} \quad \textbf{(7.16)}$$

Further, by total differentiation of $S(y) = S(Y - D_a)$, we get:

$$\boldsymbol{S'(y)dy = S'(Y)dY} \quad \textbf{(7.17)}$$

From equations (7.16) and (7.17), we get:

$$\boldsymbol{S'(y) = S'(Y)} \quad \textbf{(7.18)}$$

Thus from equations (7.14) – (7.18), what we get is:

$$\boldsymbol{(dr/dY)_{ess} = [S'(y)/I'(r)] = [S'(Y)/I'(r)] = (dr/dY)_c} \quad \textbf{(7.19)}$$

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.

$$|\boldsymbol{E_{rY}}|_{\boldsymbol{ess}} < |\boldsymbol{E_{rY}}|_{\boldsymbol{c}} \qquad \textbf{(7.20)}$$

where $|\boldsymbol{E_{rY}}|$

$= |\boldsymbol{(dr/r)/(dY/Y)}|$

$= |\boldsymbol{(dr/dY)}|\boldsymbol{/(r/Y)}$

≡ Absolute elasticity of r with respect to Y at a given r on the IS curve,

$|\boldsymbol{E_{rY}}|_{\boldsymbol{ess}}$ ≡ Absolute elasticity of r with respect to Y at a given r on the IS_{ess} curve

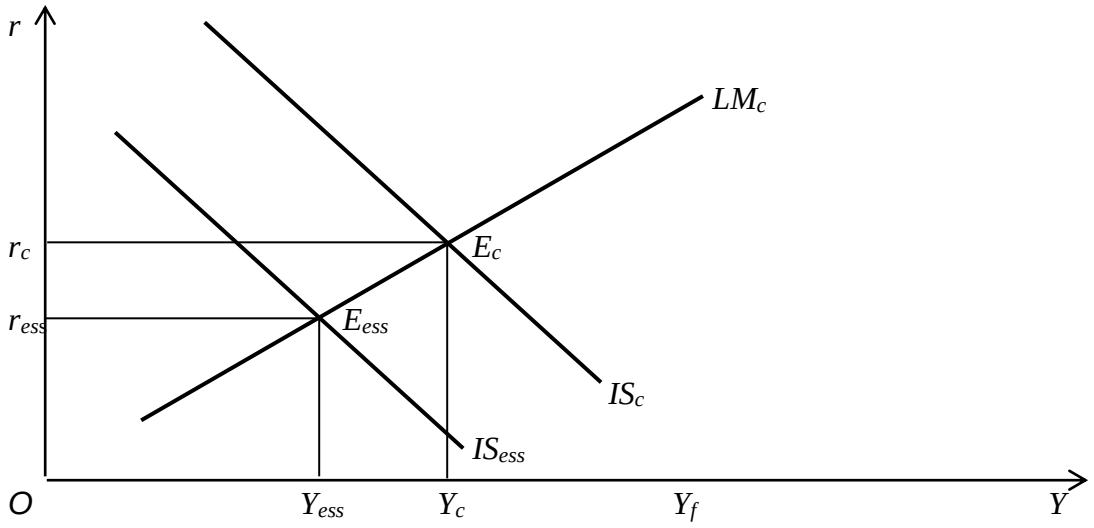
$|\boldsymbol{E_{rY}}|_{\boldsymbol{c}}$ ≡ Absolute elasticity of r with respect to Y at a given r on the IS_c curve

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).

$$dY/dD_a = (S' - 1)/S' < 0 \quad \textbf{(8.1)}$$

$$dy/dD_a = dY/dS_a = dy/dS_a = -1/S' < 0 \quad \textbf{(8.2)}$$

$$dY/dP_a = dy/dP_a = dY/dN_a = dy/dN_a = 1/S' > 0 \quad \textbf{(8.3)}$$

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).

$$dY/dD_a = (S' - 1)/(S' - P') < 0 \quad \textbf{(8.4)}$$

$$dy/dD_a = (P' - 1)/(S' - P') < 0 \quad \textbf{(8.5)}$$

$$dY/dP_a = dy/dP_a = dY/dN_a = dy/dN_a = 1/(S' - P') > 0 \quad \textbf{(8.6)}$$

$$dY/dS_a = dy/dS_a = -1/(S' - P') < 0 \quad \textbf{(8.7)}$$

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).

$$dY/dD_a = (S' - 1)/Z < 0 \quad \textbf{(8.8)}$$

$$dy/dD_a = [(P' + N') - 1]/Z < 0 \quad \textbf{(8.9)}$$

$$dY/dP_a = dY/dN_a = 1/Z > 0 \quad \textbf{(8.10)}$$

$$dy/dP_a = dy/dN_a = (1 - D')/Z > 0 \quad \textbf{(8.11)}$$

$$dY/dS_a = -1/Z < 0 \quad \textbf{(8.12)}$$

$$dy/dS_a = -(1 - D')/Z < 0 \quad (8.13)$$

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 $0 < S'(y) < 1, P'(r) < 0, L'(Y) > 0, L'(r) < 0$.1
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).

$$(dY/dD_a + dY/dP_a) = 1 \quad \textbf{(8.20)}$$

$$(dy/dD_a + dy/dP_a) = 0 \quad \textbf{(8.21)}$$

(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).

$$(dY/dD_a + dY/dS_a + dY/dP_a) = [L'(r)\{S'(y) - 1\}/\Delta] < 0 \quad \textbf{(8.22)}$$

where the determinant $\Delta = [S'(y)L'(r) + P'(r)L'(Y)] < 0$

$$(dY/dD_a + dY/dS_a + dY/dP_a + dY/dN_a)$$

$$= 1/[1 + \{P'(r)L'(Y)\}/\{S'(y)L'(r)\}] > 0 \quad \textbf{(8.23)}$$

$$(dy/dD_a + dy/dS_a + dy/dP_a + dy/dN_a) = -1/[\{S'(y)\,L'(r)\}/\{P'(r)\,L'(Y)\} + 1] < 0 \quad \textbf{(8.24)}$$

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).

By definition, $y = (Y - D)$. **(8.25)**

By differentiation of equation (8.25) with respect to *t*, we get equation (8.26).

$$dy/dt = [dY/dt - dD/dt] \quad \textbf{(8.26)}$$

If it is assumed that $dD/dt = 0$ in equation (8.26), we get equation (8.27).

$$[(dY/dt)/Y] = [(dy/dt)/Y] < [(dy/dt)/y] \quad \textbf{(8.27)}$$

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).

$$[(dY/dt)/Y] = [(dy/dt)/y] = [(dD/dt)/D] \quad \textbf{(8.28)}$$

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) $\boldsymbol{Y} \equiv$ Size of the economy $\equiv$ *GDP*

(2) $\boldsymbol{dY} \equiv$ Change or growth of Y

(3) $\boldsymbol{L} \equiv$ Number of employed persons

(4) $\boldsymbol{L/Y} \equiv$ Labor-intensity of the economy

(5) $\boldsymbol{Y/L} \equiv$ Per capita productivity

(6) $\boldsymbol{y = (Y - D)} \equiv$ SNI and hence, $\boldsymbol{Y = (y + D)}$

(7) $\boldsymbol{D = (D^n + D^s)}$

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).

$$\boldsymbol{d(Y/L) < dY \leftrightarrow dL > 0} \quad \Rightarrow \text{Conventional First Inequality} \qquad \textbf{(8.29)}$$

The *Conventional First Inequality* can alternatively be written as (8.30).

$$\boldsymbol{d(y + D)/L < d(y + D)} \Rightarrow \text{Reconstructed First Inequality} \qquad \textbf{(8.30)}$$

Now let us consider the following three new notations and their notions:

(8) $\boldsymbol{R}$ ≡ Use or consumption of resource

(9) $\boldsymbol{R/Y}$ ≡ Resource intensity

(10) $\boldsymbol{Y/R}$ ≡ 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).

$$\boldsymbol{d(Y/R) > dY \leftrightarrow dR < 0} \Rightarrow \text{Conventional Second Inequality} \quad \textbf{(8.31)}$$

$$\boldsymbol{d(y + D)/R > d(y + D)} \Rightarrow \text{Reconstructed Second Inequality} \quad \textbf{(8.32)}$$

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:

$$\boldsymbol{d(Y/L) < dY < d(Y/R) \leftrightarrow dR < 0 < dL} \Rightarrow \text{Conventional Inequation of Sustainability} \quad \textbf{(8.33)}$$

$$\boldsymbol{d(y + D)/L < d(y + D) < d(y + D)/R} \Rightarrow \text{Reconstructed Inequation of Sustainability} \quad \textbf{(8.34)}$$

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).

$$\boldsymbol{S = S(Y) = sY}, \qquad \textbf{(8.35)}$$

where $s \equiv MPS = APS$

$$\boldsymbol{I = [vdY/dt]}, \qquad \textbf{(8.36)}$$

where $v \equiv$ Capital-output ratio $= (K/Y)$

$$\boldsymbol{S(Y) = I}, \qquad \textbf{(8.37)}$$

$\Rightarrow$ Conventional equilibrium equation of the commodity market

Combining equations (8.35) - (8.37), we get equation (8.38):

$$\boldsymbol{[(dY/dt)/Y]_c = g_c = [s/v]} \qquad \textbf{(8.38)}$$

= *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).

$$\boldsymbol{S = S(y) = sy = s(Y - D)}, \qquad \textbf{(8.39)}$$

$\Rightarrow$ *Sustainable saving function*, where $s \equiv MPS = APS$

$$\boldsymbol{D = uY}, \qquad \textbf{(8.40)}$$

where $u = (D/Y)$

$$\boldsymbol{P = [pdY/dt]}, \qquad \textbf{(8.41)}$$

where $p = (P/Y)$

$$\boldsymbol{N = [ndY/dt]}, \qquad \textbf{(8.42)}$$

where $u > 0, p > 0, n = (N/Y) > 0$

$$\boldsymbol{[S(y) + D = P + N]} \qquad \textbf{(8.43)}$$

$\Rightarrow$ Sustainable equilibrium equation of SKM for two-sector closed economy

Combining equations (8.39) - (8.43), we get equation (8.44).

$$\boldsymbol{[(dY/dt)/Y]_{ess} = g_{ess} = [s - sD + u]/[p + n]} \qquad \textbf{(8.44)}$$

= Rate of change in sustainable equilibrium NI.

If $D = 0 = n$ and $p = v$ in equation (8.44), we get equation (8.45).

$$g_{ess} = [(s/v) + (u/v)], \quad \textbf{(8.45)}$$

which means $g_{ess} > g_c$

If $u = 0$ in equation (8.45), we get equation (8.46).

$$g_{ess} = g_c = (s/v). \quad \textbf{(8.46)}$$

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):

$$[sf(k) - qk] = 0, \quad \textbf{(8.47)}$$

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).

$$[\{sf(k) - qk\} - sD/L] = 0 \text{ or, } [sf(k)w - qk] = 0, \quad \textbf{(8.48)}$$

where $w = (1- u)$ and $u = D/Y > 0$.

Comparing equations (8.47) and (8.48), we get the inequality indicated by (8.49).

$$k_c > k_{ess} \quad \textbf{(8.49)}$$

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).

$$k_c = k_{ess} \quad \textbf{(8.50)}$$

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).

$$Y = K^a L^b \quad \textbf{(8.51)}$$

$\Rightarrow$ Macro production function, where $(a+b) = 1 \Rightarrow CRS$

$$S = sY \quad \textbf{(8.52)}$$

$\Rightarrow$ Macro conventional saving function, where $s \equiv APS = MPS$

$$L = L_o e^{nt} \quad \textbf{(8.53)}$$

$\Rightarrow$ Macro labour supply function

$$dK/dt = I = S \quad \textbf{(8.54)}$$

$\Rightarrow$ Equilibrium equation of the commodity market for two sector closed economy.

From equations (8.52) and (8.54), we get equation (8.55).

$$[(dK/dt)/K] = s(Y/K), \qquad (8.55)$$

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).

$$[(dY/dt)/Y] = [a\,(dK/dt)/K] + [b\,(dL/dt)/L], \qquad (8.56)$$

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).

$$[(dL/dt)/L] = n, \qquad (8.57)$$

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).

$$[(dY/dt)/Y] = [as(Y/K) + bn], \qquad (8.58)$$

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).

$$[(dY/dt)/Y] = [(dK/dt)/K] = [(dL/dt)/L] = n, \qquad (8.59)$$

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).

$$S = sy = s(Y - D) \tag{8.60}$$

From equations (8.54) and (8.60), we get equation (8.61).

$$[(DK/dt)/K] = [sY/K - sD/K], \tag{8.61}$$

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).

$$[(dY/dt)/Y] = [\{as(Y/K) + bn\} - as(D/K)], \tag{8.62}$$

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).

$$[(DK/dt)/K] = [s(Y/K) - s(D/K)] = [(dL/dt)/L] = n \tag{8.63}$$

Hence, from equations (8.62) and (8.63), we get equation (8.64).

$$[(dY/dt)/Y] = [\{as(Y/K) + bn\} - as(D/K)]$$

$$= a[s(Y/K) - s(D/K)] + bn$$

$$= (an + bn) = n(a + b) = n, \tag{8.64}$$

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).

$$\mathbf{(Y/K^s) > (Y/K^c)} \qquad \mathbf{(8.65)}$$

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 $(D/K) > 0$

$$\mathbf{(y/K) < (Y/K)} \qquad \mathbf{(8.66)}$$

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 macrosubsocial 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).

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

A

Adamson, R., et al. (2013). *State of the world 2013: Is sustainability still possible*? Washington, DC: World Watch Institute.

Ahmed, M. & Mallick, S. (1997). Incorporating environment into a Keynesian model for estimation of sustainable income of Pakistan and Bangladesh. *Bangladesh Development Studies*, 25(3-4), 175-195.

Ahmad, Y. J., Serafy, S. E. & Lutz, E. (1989) [Eds.]. *Environmental accounting for sustainable development*. A UNEP-World Bank Symposium, Washington, DC: World Bank.

Antal, M. & van den Bergh, J. (2014). Macroeconomics, financial crisis and the environment: Stategies for a sustainability transition. European Commission, European Research Area, Policy Paper No: 10, February, 1-28.

Aoki, M. & Yoshikawa, H. (2006). *Reconstructing macroeconomics*. Cambridge, UK: Cambridge University Press.

Allais, M. (1997). An outline of my main contributions to economic science: Nobel lecture, December, 9, 1988. *American Economic Review*, 87(6), 3-12.

Ayers, R. U., van den Bergh, J. C. J. M. & Gowdy, J. M. (1998), *Viewpoint: Weak versus strong sustainability*. Tinbergen Institute's Discussion Paper, Amsterdam, Netherlands: Tinbergen Institute.

B

Backhouse, R. & Bateman, B.W. (2010). *Whose Keynes*? In R. W. Dimand, R. Mundell & A. Vercelli (Eds.), *Keynes's General Theory: A reconsideration after seventy years*. London: Palgrave.

Barro, R. J. & Grossman, H. I. (1971). A general disequilibrium model of income and employment. *American Economic Review*, 61(1), 82-93.

Bartlett, A. A. (1997-1998). Reflections on sustainability, population growth, and the environment – revisited. *Renewable Resources Journal*, 15(4/Winter), 6-23.

Bartlett, A. A. (2012). The meaning of sustainability. *Mother Pelican: A Journal of Sustainable Human Development*, 8(5). Retrieved from http://www.pelicanweb.com.

Bataille, G. (1995). *The accursed share*: Vol. I (Translated by Robert Hurley). New York: Zone Books.

Beaud, M. & Dostaler, G. (2005). *Economic thought since Keynes*. London and New York: Routledge.

Blanchard, O. (2000). What do we know about macroeconomics that Fisher and Wicksell did not? *Quarterly journal of Economics*, 115(4), 1375-1409.

Blaug, M. (1983). *Economic theory in retrospect*. New Delhi: Vikas Publishing House.

Blaug, M. (1990). *John Maynard Keynes: Life, ideas, legacy*. London: Macmillan.

Blaug, M. (1991). *The historiography of economics*. Aldershot, UK and Brookfield, USA: Edward Elgar.

Blaug, M. (1994). Not only an economist: Autobiographical reflections of a historian of economic thought. *American Economist*, 38(2/Fall), 12-27.

Boff, L. (2012). An attempt to define sustainability. *Mother Pelican: A Journal of Sustainable Human Development*, 8(3). From from http://www.pelicanweb.com.

Boland, L. (1994). *Scientific thinking without scientific method*. In R. Backhouse (Ed.), *New directions in economic methodology*. London: Routledge.

Boulding, K. E. (1950), *A reconstruction of economics*, New York: Wiley.

Brainard, W. C. & Scarf, H. E. (2005). *How to compute equilibrium price in 1891*. In R. W. Dimand & J. Geanakoplos (Eds.), *Celebrating Irving Fisher: The Legacy of a great economist*. Malden, MA and Oxford, UK: Blackwell.

Brandt 21 Forum (2003). *The macroeconomics of sustainable development*. Philadelphia. Retrieved from http://www.Brandt21Forum.info.

Bretschger, L. (1998). The sustainability paradigm: A macroeconomic perspective. *Revue Region et Developpement*, 7 (2), 1-33.

Brown, J. H. et al. (2013). Macroecology meets macroeconomics: Resource scarcity and global sustainability. *Ecological Engineering*. Retrieved from http://dx.doi.org/10.1016/j.ecoleng.2013.07.071

C

Clower, R. W. (1965). *The Keynesian counter-revolution: A theoretical appraisal*. In F. H. Hahn & F. P. R. Brechling (Eds.), *The theory of interest rates*. London: Macmillan.

Coddington, A. (1976). Keynesian economics: The search for first principles. *Journal of Economic Literature*, 14(4), 1258-1273.

Coddington, A. (1983). *Keynesian economics: The search for first principles*. London: George Allen & Unwin.

Cohn, S.M. (2007). *Rethinking macroeconomics: A critical approach*. New York: M. E. Sharpe.

Costanza, R. R., et al. (1993). Modelling complex ecological economic systems. *BioScience*, 43(8), 545-555.

Courvisanos, J. (2005). A post Keynesian innovation policy for sustainable development. *International Journal of Environment, Workplace and Employment*, 1(2), 187-202.

Cunningham, W. P. & Cunningham, M. A. (2009). *Principles of environmental science*. New Delhi: Tata McGraw-Hill.

Custers, P. (2010). The tasks of Keynesianism today: Green new deals as transition towards a zero growth economy? *New Political Science*, 32(2), 173-191.

D

Daly, H. E. (Ed.) (1973). *Toward A Steady State Economy*. San Francisco, California: W. H. Freeman.

Daly, H.E. (1991). Towards an environmental macroeconomics. *Land Economics*, 67(2), 255-259.

Daly, H. E. (1997). Georgescu-Roegen versus Slow-Stiglitz. *Ecological Economics*, 22(3), 261-266.

Daly, H. E. (2013). The lurking inconsistency. *Mother Pelican: A Journal of Solidarity and Sustainability*, 9(5/May). Retrieved from http://www.pelicanweb.com.

Daly, H. E. & Farley, J. (2004). *Ecological economics: Principles and applications*. Washington, DC: Island Press.

Dalziel. P. (1996). The relevance of Keynesian multiplier process after sixty years. *History of Economics Review*, 25(Winter/Summer), 121-131.

Datta, A. (1997). *For a quiet revolution*. Calcutta: Papyrus.

Davidson, P. (1978). *Money and the real world*. London: Macmillan.

Davidson, P. (1989). Patinkin's interpretation of Keynes and the Keynesian cross. *History of Political Economy*, 21(3), 549-553.

Davidson, P. (1994). *Post Keynesian macroeconomic theory: A foundation for successful economic policies for the 21st century*. Aldershot, UK and Brookfield, USA: Edward Elgar.

Dimand, R. W. & Ben-El-Mechaiekh, H. (2012). General equilibrium reaches North America: The hydraulic simulation model in Irving Fisher's *Mathematical Investigations in Value and Prices* (1891). *Journal of Economic and Social Measurement*, 37(1/2), 97-118.

Dimand, R. W. & Betancourt, R. G. (2012). *Retrospectives: Irving Fisher's appreciation and interest (1886) and the Fisher relation*. *Journal of Economic Perspectives*, 26(4/Fall), 185-196.

Domar, E. (1957). *Essays in the theory of growth*. London: Oxford University Press.

E

Ecologist Magazine (1972). *A blueprint for survival*. Harmondsworth: Penguin.

Eisner, R. (1988). Extended accounts for national income and product. *Journal of Economic Literature*, 26(4), 1611-1684.

Emmanuel, O. (2008). Macrodynamics and pollution in open economy: An IS-LM analysis. *Economic Analysis*, 40(Spring), 11-23.

F

FAO (1995). *Sustainability issues in agricultural and rural development policies*. Vol. 1, Trainee's Reader, Training material for agricultural planning series No. 38/1, Rome: Food and Agricultural Organization of the United Nations.

Fellner, W. (1976). *Towards a reconstruction of macroeconomics: Problems of theory and policy*. American Enterprise Institute.

Fisher, I. (1892). Mathematical investigations in the theory of value and prices. *Transactions of the Connecticut Academy of Arts and Sciences*, 9(July), 1-124.

Fisher, I. (1892/1925). *Mathematical investigations in the theory of value and prices*. Thesis of 1891, New Haven: Yale University Press.

Fisher, I. (1911). *The purchasing power of money*. New York: Macmillan.

Fisher, S. (1988). Recent developments in macroeconomics. *Economic Journal*, 98, 294-339.

Fitzgibbons, A. (2000). *The nature of macroeconomics: Instability and change in the capitalist system*. Cheltenham: Edward Elgar.

Foster, J. B. (2009). *The ecological revolution: Making peace with the planet*. New York: Monthly Review Press.

Foster, J. B. (2011). Occupy denialism: Toward ecological and social revolution. *Mother Pelican: A Journal of Sustainable Human Development*, 7(12/December). Retrieved from http://www.pelicanweb.com.

Fusfeld, D. R. (1985). Keynes and the Keynesian cross: A note. *History of Political Economy*, 17(3), 385-389.

G

Gerrard, B. (1995). Keynes, the Keynesians and the Classics: A suggested interpretation. *Economic Journal*, 105(429), 445-458.

Girma, M. (1992). Macropolicy and the environment: A framework for analysis. *World Development*, 20(4), 531-540.

Gnos, C. & Rochon, L-P. (Eds.) (2009). *The Keynesian multiplier*. London: Routledge.

Gohn, J. B. (Ed.) (1980). *Progress and survival: An essay on the future of mankind*. New York: Praeger.

Goodwin, N. R. (2003). *Macroeconomics for the 21st century*. Global Development and Environment (GDAE) Institute's Working Paper No. 03-02, Tufts University, Medford, USA. Retrieved from http://ase.tufts.edu/gdae.

Goodwin, N. R. (2010). *A new economics for the 21st century*. Retrieved from http://neweconomicsinstitute.org.

Goodwin, N. R., Ananyin, O. I., Ackerman, F. & Weisskopf, T. E. (1997). *Economics in context: The need for a new textbook*. GDAE Working Paper No. 00-02, Tufts University, Medford, USA. Retrieved from http://ase.tufts.edu/gdae.

Goodwin, N. R., Nelson, J. A. & Harris, J. M. (2007). *Macroeconomics and ecological sustainability*. In C. J. Cleveland (Ed.), *Encyclopedia of earth*. Washington, DC: Environmental Information Coalition, National Council for science and Environment.

Goodwin, N. R., Nelson, J. A. & Harris, J. M. (2009). *Macroeconomics in context*. New York: M. E. Sharpe.

Goodwin, N. R., Nelson, J. A., Ackerman, F. & Weisskopf, T. (2009). *Microeconomics in context*. New York: M. E. Sharpe.

Gregory, M.N. (1988). Recent developments in macroeconomics: A very quick refresher course. *Journal of Money, Credit and Banking*, 20(3), Part-2.

H

Hamilton, K. and Lutz, E. (1996). *Green national accounts: Policy uses and empirical experience*. Paper No. 039, Environment Department, Washington, DC: World Bank.

Hansen, A. H. (1936a). Mr. Keynes on underemployment equilibrium. *Journal of Political Economy*, 44(December), 667-686.

Hansen, A. H. (1936b). Underemployment equilibrium. *Yale Review*, 25(Summer), 828-830.

Hansen, A. H. (1938). *Keynes on underemployment equilibrium*. In A. H. Hansen, *Full recovery or stagnation*. London: A & C Black.

Hansen, A. H. (1941). *Fiscal policy and business cycles*. New York: Norton.

Hansen, A. H. (1947). *Economic policy and full employment*. New York: McGraw-Hill.

Hansen, A. H. (1951). *Business cycles and national income*. New York: Norton.

Hansen, A. H. (1953). *A guide to Keynes*. New York: McGraw-Hill.

Harris, J. M. (2001). *Macroeconomic policy and sustainability*. Global Development and Environment Institute's Working Paper No. 01-09, Tufts University, Medford, USA. Retrieved from http://ase.tufts.edu/gdae.

Harris, J. (2007). *Reorienting macroeconomic theory towards environmental stability*. In J. D. Erickson & J. M. Gowdy (Eds.), *Frontiers in ecological economic theory and application*. Cheltenham: Edward Elgar.

Harris, J. M. (2008). *Ecological macroeconomics: Consumption, investment, and climate change*. Global Development and Environment Institute's Working Paper No. 08-02, Tufts University, Medford, USA. Retrieved from http://ase.tufts.edu/gdae.

Harris, J. M. (2009). *Ecological macroeconomics: Consumption, investment, and climate change*. In J. M. Harris & N. R. Goodwin (Eds.), *Twenty-first century macroeconomics: Responding to the climate challenge*. Cheltenham, UK and Northampton, USA: Edward Elgar.

Harris, J. M. (2013). *Green Keynesianism: Beyond standard growth paradigms*. Global Development and Environment Institute's Working Paper No. 10-05, Tufts University, Medford, USA. Retrieved from http://ase.tufts.edu/gdae.

Harris, J.M. & Goodwin, N.R. (Eds.) (2003). *New thinking in macroeconomics: Social, institutional and environmental perspectives*. Cheltenham, UK and Northampton, USA: Edward Elgar.

Harris, J.M. & Goodwin, N.R. (2004). *New thinking in macroeconomics: Social, institutional and environmental perspectives*. Cheltenham and Brookfield: Edward Elgar.

Harris, J. M. & Goodwin, N. R. (2009). *Twenty-first century macroeconomics: Responding to the climate challenge*. Cheltenham, UK and Northampton, USA: Edward Elgar.

Harrod, R. F. (1937). Mr. Keynes and traditional theory. *Econometrica*, 5(1), 74-86.

Harrod, R. F. (1939). An essay in dynamic theory. *Economic Journal*, 49(193), 14-33.

Harrod, R. F. (1948). *Towards a dynamic economics*. London: Macmillan.

Hartwick, J. (1990). National resources, national accounting and economic depreciation. *Journal of Public Economics*, 43(3), 291-304.

Hartwick, J. (2000). *National accounting and capital*. Cheltenham, UK: Edward Elgar.

Hayes, W. (2005). *Economic strategies for sustainability*. (profwork.org/eee/ess/index.html).

Heinberg, R. (2011a). *The end of growth*. Canada: New Society Publishers.

Heinberg, R. (2011b). Five axioms of sustainability. *Mother Pelican: A Journal of Sustainable Human Development*, 7(10). Retrieved from http://www.pelicanweb.com.

Heffernan, G. (2010). *A Life According to Nature: From Ancient Theoretical Ideal to Future Sustainable Practice.* A Concluding Philosophical Postscript to the Conference "Facing the Four Elements: Developing a Transatlantic Approach to Sustainability", German Academic Exchange Service, Alexander von Humboldt Foundation, German Center for Research and Innovation, German Consulate, New York City, 28-30 October 2010.

Heyes, A. (2000). A proposal for the greening of textbook macro "IS-LM-EE". *Ecological Economics*, 32(1), 1-7.

Hicks, J. R. (1937). Mr. Keynes and the Classics: A suggested interpretation. *Econometrica*, 5(2), 146-159.

Hueting, R., Bosch, P. & de Boer, B. (1991). *Methodology for the calculation of sustainable national income*. Voorburg, Netherlands: Central Bureau of Statistics.

I

Ikerd, J. E. (1997). *Towards an economics of sustainability*. University of Missouri.
Retrieved from http://www.johnikerd.com)/(http://web.missouri.edu/ikerdj/papers.

J

Jackson, T. (2009). *Prosperity without growth: The transition to a sustainable economy*. London: Earthscan.

Jesperson, J. (2004). *Macroeconomic stability, sustainable development and full employment*. In L. A. Reisch & I. Rpoke (Eds.), *The ecological economics of consumption*, Cheltenham, UK: Edward Elgar.

K

Keynes, J. M. (1933/1982). *National self sufficiency*. In D. Moggridge (Ed.), *The Collected Writings of John Maynard Keynes*. Vol. 11, London: Macmillan.

Keynes, J. M. (1936). *The general theory of employment, interest and money*. London: Macmillan.

Keynes, J. M. (1938/1973). *Letter to Harrod, 4 July 1938*. In D. Moggridge (Ed.), *The Collected Writings John Maynard Keynes*. Vol. 14, London: Macmillan.

Klein, L. R. (1944). *The Keynesian revolution*. Ph. D Thesis, Cambridge, USA: MIT Press.

Klein, L. R. (1947). *The Keynesian revolution*. New York: Macmillan.

Kohler, G. (1999). Global Keynesianism and beyond. *Journal of World-Systems Research*, 2, 253-274. Retrieved from http://jwsr.ucr.edu.

Konar, A. K. (2010). Ecological remodeling of hydraulic Keynesianism: A heuristic hint. *International Journal of Ecological Economics and Statistics*, 16(W10/Winter), 43-52.

Konar, A. K. (2011). Originators of (post)structuralism: A search for new truth. *IUP Journal of English Studies*, 6(2/June), 14-21.

Konar, A. K. & Chakrabortty, J. (2011). Substantive signification of sustainability. *Mother Pelican: A Journal of Sustainable Human Development*, 7(8/August). Retrieved from http://www.pelicanweb.com.

Konar, A. K. & Modak, B. K. (2010). Socializing snake society: An Indian instance. *Social Change*, 40(2), 157-174.

Kysar, D. A. (2001). *Sustainability, distribution and macroeconomic analysis of law*. Faculty Scholarship Series, Paper No. 458. Retrieved from http://digitalcommons.law.yale.edu/fss_papers/458.

L

Lange, O. (1944). *Price flexibility and employment*. Cowles Commission Monograph No. 8, Bloomington: Principia.

Lawn, P. A. (2003a). Environmental macroeconomics: An introduction to the IS-LM-EE model. *ICFAI Journal of Environmental Economics*, 1(2), 7-19.

Lawn, P. A. (2003b). On Heyes's IS-LM-EE proposal to establish an environmental macroeconomics. *Environment and Development Economics*, 8(1), 31-56.

Lawn, P. A. (2003c). Environmental macroeconomics: Extending the IS-LM model to include an "environmental equilibrium curve". *Australian Economic Papers*, 42(1), 118-134.

Leijonhufvud, A. (1968). *On Keynesian economics and the economics of Keynes: A study in monetary theory*. London: Oxford University Press.

Lerner, A. P. (1944). *The economics of control: Principles of welfare economics*. New York: Macmillan.

Lucas, R. E. (2000). Some macroeconomics for the 21st century. *Journal of Economic Perspectives*, 14(1), 159-168.

Lutz, E. (Ed.) (1993). *Toward improved accounting for the environment*: An UNSTAT-World Bank Symposium. Washington, DC: World Bank.

M

Maler, K-G. (1991). National accounts and environmental resources. *Environmental Resource Economics*, 1(1), 1-15.

Malinvaud, F. (1977). *The theory of unemployment reconsidered*. Oxford: Blackwell.

Mallick, S., Sinden, J. A. & Thampapillai, D. J. (2000). The relationship between environmentally sustainable income, employment and wages in Australia. *Australian Economic Papers*, 39(2), 231-244.

McInnes, N. (1994). John Maynard Keynes: The economist as savior 1920-1937. *National Interest*, Fall. Retrieved from http://findarticles.com)/(http://moneywatch.bnet.com.

Meade, J. E. (1937). A simplified model of Mr. Keynes's system. *Review of Economic Studies*, 4(2), 98-107.

Mesarovic, M. (1982). *Discussion*, in Roberts, P. C., *Resilience, transience, and sustainability*. In G. Bruckmann (Ed.), Proceedings of the 7th IIASA Symposium on Global Modeling. Laxenburg, Austria: International Institute for Applied Systems Analysis.

Mill, J. S. (1846/1848). *Principles of political economy with some of their applications to social philosophy*, Chapter 4 of Book 4. London: John W. Parker.

Modigliani, F. (1944a). *The general theory of employment, interest and money under the assumptions of flexible prices and of fixed prices*. Ph. D Thesis, New School for Social Research.

Modigliani, F. (1944b). Liquidity preference and the theory of interest and money. *Econometrica*, 12(1), 45-88.

Morales, C. A. L. (2007). Environmental macroeconomics: From the IS-LM-EE model to a social welfare approach. *International Journal of Environment, Workplace and Employment*, 3(3-4), 301-315.

Morgan, M. S.(2009). *Modeling as a method of enquiry*, In M. S. Morgan, *The world in the model*. Cambridge: Cambridge University Press.

Morgan, M. S. & Boumans, M. (2004). *Secrets hidden by two-dimensionality: The economy as a hydraulic machine*. In S. de Chadarevian & N. Hopwood (Eds.), *Models: The third dimension of science*. Stanford: Stanford University Press.

Munasinghe, M. (1992). *Environmental economics and sustainable development*. Paper presented at the UN Earth Summit, Rio de Janeiro, Environment Paper No. 3, Washington, DC, USA: World Bank.

Munasinghe, M. (Ed.) (2002). *Macroeconomics and the environment*. Cheltenham, UK: Edward Elgar.

N

Nadal, A. (2010). *Is degrowth compatible with capitalism*? Posted by Alejandro Nadal on 15 July 2010. Retrieved from http://triplecrisis.com.

Nadal, A. (2011). *Rethinking macroeconomics for sustainability*. London: Zed Books.

Nallari, R. & Mba, L. N. (2010). *Rethinking multipliers in a globalized world*. Policy Research Working Paper No. 5277, Growth and Crisis Unit, World Bank Institute. Retrieved from http://econ.worldbank.org.

O

O'Donnell, R. M. (Ed.)(1991). *Keynes as philosopher-economist*. London: Macmillan.

Odum, E. P. & Barrett, G. W. (2006). *Fundamentals of ecology*. Bangalore: Thomson Brooks / Cole.

Ogburn, W. F. (1922/1928). *Social change*. New York: Viking Press.

P

Pasinetti, L. L. (2005). The Cambridge School of Keynesian Economics. *Cambridge Journal of Economics*, 29(6), 837-848.

Patinkin, D. (1948). Price flexibility and full employment. *American Economic Review*, 38(September), 543-564.

Patinkin, D. (1956). *Money, interest and prices: An integration of monetary and value theory*. Evanston, IL: Row Peterson.

Patinkin, D. (1989). Keynes and the Keynesian cross: A further note with a reply by Fusfeld, D. R. *History of Political Economy*, 21(3), 537-547.

Pearce, D., Markandya, A. & Barbier, E. B. (1989). *Blueprint for a green economy*. London: Earthscan.

Phelps, E.S. (Ed.) (1990). *Recent development in macroeconomics*. Aldershot, Hants: Edward Elgar.

Phillips, A. W. (1950). Mechanical models in economic dynamics. *Economica*, 17(67), 283-305.

Pollitt, H., et al. (2010). *A scoping study on the macroeconomic view of sustainability*. Cambridge: Cambridge Econometrics, Sustainable Europe Research Institute (SERI).

R

Rebrov, M. (1989). *Save our earth* (Translated by Anatoli Rosenzweig). Moscow: Mir Publishers.

Richman, S. (2011). Social cooperation, Part 2, *The Freeman: Ideas on Liberty*, 61(10). Retrieved from http://www.thefreemanonline.org.

Robertson, J. (1999). *The new economics of sustainable development: A briefing for policy makers*. London: Kogan Page.

Robinson, J. (1962a). *Economic philosophy*. Chicago: Aldine.

Robinson, J. (1962b). Review of money, trade and economic growth by H. G. Johnson. *Economic Journal*, 72(September), 690-692.

S

Sachs, J. (2009), Rethinking macroeconomics, *Capitalism and Society*, 4(3) Retrieved from http://www.bepress.com/cas/vol4/iss3/art3.

Samuelson, P. A. (1939a). Interaction between the multiplier analysis and the principle of acceleration. *Review of Economic Statistics*, 21(2/May),75-78.

Samuelson, P. A.(1939b). A synthesis of the principle of acceleration and the multiplier. *Journal of Political Economy*, 47(December), 786-797.

Samuelson, P. A. (1946). Lord Keynes and the General Theory. *Econometrica*, 14(3), 187-200.

Samuelson, P. A. (1947). *Foundations of economic analysis*. Cambridge: Harvard University Press.

Samuelson, P. A. (1948). *Economics: An introductory analysis*. New York: McGraw-Hill.

Samuelson, P. A. (1965/1948). *The simple mathematics of income determination*. In M. G. Mueller (Ed.), *Readings in macroeconomics*. New Delhi: Surjeet Publications.

Schumpeter, J. (1954). *History of economic analysis*. New York: Oxford University Press.

Shackle, G. L. S. (1967). *The years of high theory: Invention and tradition in economic thought*. Cambridge: Cambridge University Press.

Shackle, G. L. S. (1974). *Keynesian kaleidics: The evolution of a general political economy*. Edinburgh: Edinburgh University Press.

Sim, N. C. S. (2006). Environmental Keynesian macroeconomics: Some further discussion. *Ecological Economics*, 59(4), 401-405.

Sims, C. (1980). Macroeconomics and reality. *Econometrica*, 48(January), 1-48.

Skidelsky, R. (1992). *John Maynard Keynes: The economist as savior, 1920-1932*, Vol. 2. London: Macmillan.

Skidelsky, R. (2011). The relevance of Keynes. *Cambridge Journal of Economics*, 35(1), 1-13.

Smith, W. L. (1956). A graphical exposition of the complete Keynesian system. *Southern Economic Journal*, 23(October), 115-125.

Snowdon, B. & Vane, H. R. (2005). *Modern macroeconomics: Its origin, development and current state*. Cheltenham, UK and Northampton, USA: Edward Elgar.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1), 65-94.

Solow, R. M. (1997). Reply: Georgescu-Roegen versus Solow-Stiglitz. *Ecological Economics*, 22(3), 267-268.

Spangenberg, J. H (2008). *Growth and sustainable development*. Proceedings of the First International Conference on Economic De-growth for Ecological Sustainability and Social Equity, Paris, 18-19th April, 2008 Retrieved from http://www.degrowth.net.

Spangenberg, J. H., Omann, I. & Hinterberger, F. (2002). Sustainable growth criteria: Minimum benchmarks and scenarios for employment and the environment. *Ecological Economics*, 42(3), 429-443.

Stigler, G. J. (1955). The nature and role of originality in scientific progress. *Economica*, 22(88), 293-302.

Stigler, S. M. (1999). *Statistics on the table: The history of statistical concepts and methods*. Cambridge, MA: Harvard University Press.

Stiglitz, J. E. (1997). Reply: Georgescu-Roegen versus Solow-Stiglitz. *Ecological Economics*, 22(3), 269-270.

Stiglitz, J. E. (2011). Rethinking macroeconomics: What failed and how to repair it. *Journal of European Economic Association*, 9(4/August), 591-645.

Strawson, P. F. (1959). *Individuals: An essay in descriptive metaphysics*. London: Methuen.

Swan, T. (1956). Economic growth and capital accumulation. *Economic Record*, 32(4), 334-361.

Syed, N. I., Tahir, M. S. & Sahibzada, S. A. (2011). Measuring the impact of multiplier to determine the Keynesian model of income in open economy in the context of Pakistan. *African Journal of Business Management*, 5(17), 7385-7391.

T

Taylor, L. (2004). *Reconstructing macroeconomics: Structuralist proposals and critiques of the mainstream*. Cambridge: Harvard University Press.

Thampapillai, D. J. (1995). Environmental economics: Towards filling an empty box. *Indian Economic Journal*, 42(4), 43-58.

Thampapillai, D. J. & Uhlin, H-E. (1996). Sustainable income: Extending some Tisdell considerations to macroeconomic analysis. *International Journal of Social Economics*, 23(4-5-6), 137-150.

Thampapillai, D. J. & Uhlin, H-E. (1997). Environmental capital and sustainable income: Basic concepts and empirical tests. *Cambridge Journal of Economics*, 21(3), 379-394.

Thampapillai, D. J., Wu, X. & Sunderaj, L. R. (2007). Economic growth, the environment and employment: Challenges for sustainable development in China. *International Journal of Environment, Workplace and Employment*, 3(1), 15-27.

U

United Nations Handbook of National Accounting (1993). ST/ESA/STAT/SER.F/SER.F/61, Studies in Methods, Series F, No. 61. New York: United Nations.

United Nations Integrated Environmental and Economic Accounting (IEEA) [1993]. Sales No. E 93XVII.12. New York: United Nations.

United Nations System of Integrated Environmental and Economic Accounting (SEEA) [1993]. Statistical Division, Department for Economic and Social and policy Analysis. New York: United Nations.

United Nations System of National Accounts (SNA) [1993]. Sales No. E94XVII.4. New York: United Nations.

V

Van der Ploeg's, F. (2011). Macroeconomics of sustainability transitions: Second best climate policy, green paradox, and renewables subsidies. *Environmental Innovation and Societal Transitions*, 1(1), 130-134.

Venkatesan, M.(2015). Sustainability in the curriculum and teaching of economics: Transforming introductory macroeconomics. Economics Faculty Publications, Paper No: 12, Bridgewater State University, Bridgewater, Massachusetts. Retrieved from http://vc.bridgew.edu/econ_fac/12.

Victor, P. (2008). *Managing without growth: Slower by design, not disaster*. Cheltenham: Edward Elgar.

Victor, P. (2010). *Macroeconomics for sustainability*. Paper presented at the Tufts University, Medford, USA on 16 February 2010.

W

Walras, L. (1874/1954). *Elements of pure economics* (Translated by William Jaffe). London: Allen & Unwin.

Ward, B. & Dubos, R. (1972). *Only one earth: The care and maintenance of a small planet*. Harmondsworth: Penguin.

Weintraub, E.R. (1979). *Microfoundations.* Cambridge: Cambridge University Press.

Whitehead, A. N. (1925). *Science and the modern world*. New York: Macmillan.

Wilson, E. O. (2012). *The social conquest of earth*. New York: Liveright Publishing Corporation.

Wolff, R. D. (2009). *Reviving Keynesianism: A critique*
Retrieved from http://www.rdwolff.com.

World Commission on Environment and Development (WCED) [1987]. *Our common future*. Oxford: Oxford University Press.

Y

Young, W. L. (1975). The role of desired variables in Keynesian ecosystem: A preliminary approach. *Annals of Public and Cooperative Economics*, 46(3), 213-232.

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ARUP KANTI KONAR

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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 B.C) 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. $d^2K/dL^2 \gtreqless 0$), 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_{KL} 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*.

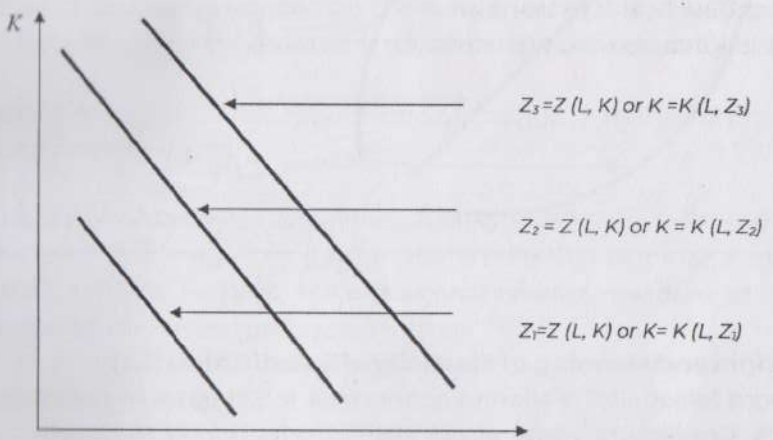
1.2. Origin and Meaning of Iso-Z-Function

The concept of "iso-z-funtion" *(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 polotica* (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, $Z_1, Z_2, Z_3, \ldots\ldots Z_n$, the "iso-z-map" *(IZM)* can be shown in terms of Figure1.

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*.

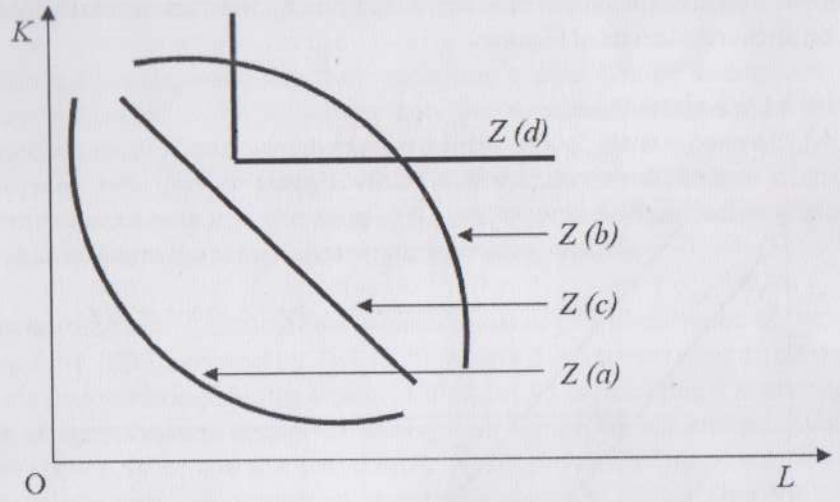
(b) $dK/dL<0$ and $d^2K/dL^2<0 \Rightarrow$ concavity of *IZF*.

© $dK/dL<0$ 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*s 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 form 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:

$E_{DP} = (dD/D)/(dP/P)$
$= (dD/dP)/(D/P)$
= (marginal demand) / (average demand)
$= (P/D)/(dP/dD)$
= (average demand price) / (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 Hick's *ES* (*HES*) was exactly the same as Robinson's *ES* (*RES*).

If the isoquant (*IQ*) for Z_o level of output is denoted by $Z_o=Z(L, K)$ or $K=K(L, Z_o)$, where *L* and *K* are two inputs and *Z* as 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:

σ= (rate of change in input-ratio) / (rate of change in marginal physical product-ratio of inputs).

ES (σ) is of two types: (i) σ_{LK} and (ii) σ_{KL}, where $\sigma_{LK} \equiv$ *ES* of *L* for *K* and $\sigma_{KL} \equiv$ *ES* of *K* for *L*. If $k = (K/L)$, $l = (L/K) = (1/k)$, $m = (MP_L/MP_K) = (Z_L/Z_K)$, $n = (MP_K/MP_L) = (Z_K/Z_L) = (1/m)$, $MP_L \equiv$ marginal physical product of *L* and $MP_K \equiv$ marginal physical product of *K*, then

(I) σ_{LK} (along a given *IQ*)
$= (dk/k)/(dm/m)$
$= (dk/dm)/(k/m)$
= (marginal *k*) / (average *k*)
$= (m/k)/(dm/dk)$
= (average *m*) / (marginal *m*)
(ii) σ_{KL} (along a given *IQ*)
$= (dl/l)/(dn/n)$
$= (dl/dn)/(l/n)$
= (marginal *l*) / (average *l*)
$= (n/l)/(dn/dl)$
= (average *n*) / (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 *IQ*. 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_L/MP_K) or n (= MP_K/MP_L) 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 (LK-space) into the relative input–relative marginal physical product-space (lm-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

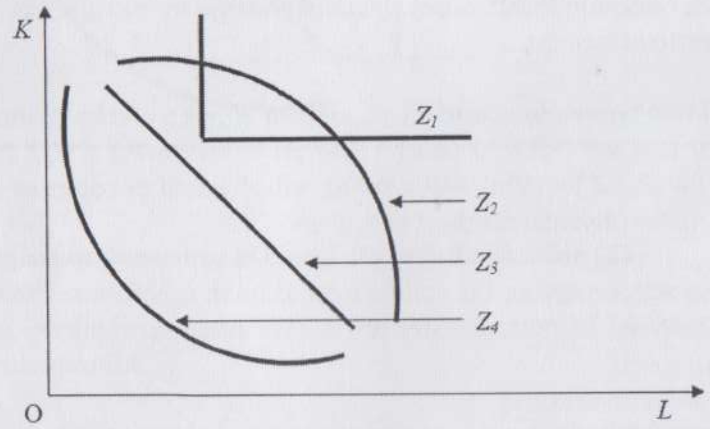
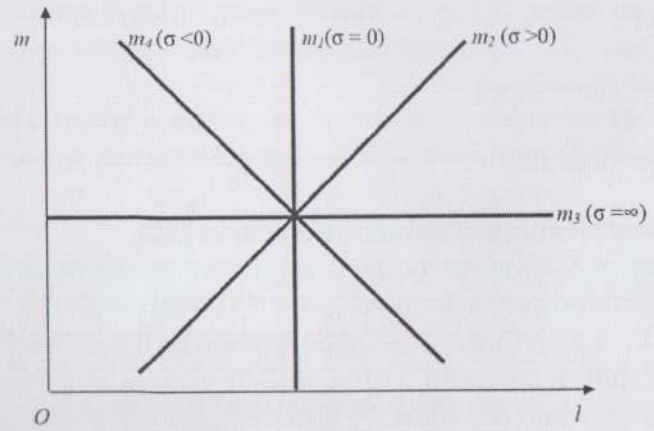


Figure 4: Lerner's *SCs* of Varied *ESs* (σ)



The SC denoted by m, in Figure 4 is the mapping of IQ denoted by Z_i in the Figure 3 from LK-space into lm-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	$m = MP_L/MP_K \equiv$ substitutability of L for K.
D ≡ quantity demanded	$l = L/K \equiv$ substitution or substitutability.
$P \equiv P(D) \Rightarrow$ Marshall's demand function	$m = m(l) \Rightarrow$ Lerner's substitution function.
dP/dD = slope of MDC	dm/dl = slope of SC.
E_{dp} (sign ignored) = $(dD/dP)/(D/P)$ = marginal demand / average demand = $(P/D)/(dP/dD)$ = average (demand) price / marginal (demand) price	E_{lm} (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 = σ.
Eij = elasticity of i with respect to j for the function $i = i(j)$	

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 congealed or concealed in both HES (1932) and RES (1933),

where *MRS* was treated as the "marginal physical product-ratio of inputs", that is, MP_l/MP_K (= *m*) or MP_N/MP_L (= *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_{LK} and (ii) MRS_{KL}. While MRS_{LK} is read as *MRS* of *L* for *K*, MRS_{KL} is read as *MRS* of *K* for *L*.

So $MRS_{LK} = |dK/dL| = MP_l/MP_K = Z_L/Z_K = m$ and $MRS_{KL} = |dL/dK| = MP_N/MP_L = Z_N/Z_L = n$, where the *IQ* is given by $Z_o = Z(L, K)$ or $K = K(L, Z_o)$ and in the diagram of *IQ* map, *L* and *K* are measured along the horizontal and vertical axes respectively.

1.6. References

- Allen, R. G. D. (1938/1979). *Mathematical analysis for economists.* London: Macmillan.
- Chipman, J. S. (1960). The foundations of utility. *Econometrica.* 28(2), 193-224.
- Heath, T. L.(Ed.)[1897]. *On the sphere and cylinder.* In *The Works of Archimedes.* Vol. 1, New York: Dover Publications.
- Hicks, J.R. (1932). *Theory of wages.* New York: Macmillan.
- Hicks, J.R. (1939). *Value and capital.* London: Oxford University Press.
- Hicks, J. R. & Allen, R. G. D. (1934). A Reconsideration of the theory of value. *Economica,* 1(2),196-219.
- Kahn, R. F.(1933). The elasticity of substitution and the relative share of a factor. *Review of Economic Studies* 1(1), 72-78.
- Kennedy, C. (1962). The character of improvements and of technical progress. *Economic Journal,* 72(328), 899-911.
- Lerner, A.P. (1933). Notes on elasticity of substitution: The diagrammatical representation. *Review of Economic Studies,* 1(1), 68-71.
- Matyas, A. (1980). *History of modern non- Marxian economics.* London: Macmillan.
- Robertson, R. M. (1949). Mathematical economics before Cournot. *Journal of Political Economy,* 57(6), 523-536.
- Robertson, R. M. (1951). Jevons and his precursors. *Econometrica,* 19(3), 229-249.
- Robinson, J. (1933). *Economics of imperfect competition.* London: Macmillan.

- Stigler, G. J. (1955). The nature and role of originality in scientific progress. *Economica,* 22(88), 293-302.
- Stigler, G. J. (1966). *The price theory.* New York: Macmillan.
- Sweezy, P. M. (1933). Notes on elasticity of substitution: A note on relative shares. *Review of Economic Studies,* 1(1), 67-68.

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 rehashed version of Lerner's (1933) substitution curve. Analogously, it can be admitted that the present concept of surrogate substitution curve is also the rehashed 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 I (= L/K) for a given *IQ*, where $MP_L \equiv$ marginal product of *L* and $MP_K \equiv$ marginal product of *K*. It can be represented by the function $m = m(I)$ for a given *IQ*. The *SC* is the mapping of *IQ* from the input space (*LK*-space) into the relative input – relative marginal product space (*Im*-space). Following Lerner, the relationship among the *IQ*, *SC*, and elasticity of substitution (*ES*), denoted by σ, can be shown in terms of figures 1 and 2. The *SC* denoted by m_i in figure 2 is the mapping of *IQ* denoted by Z_i in figure 1 from *LK*-space into *Im*-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 $m'(I)$ and $m''(I)$.

Figure 1: Set of Isoquants denoted by Zi = Fi (L, K)

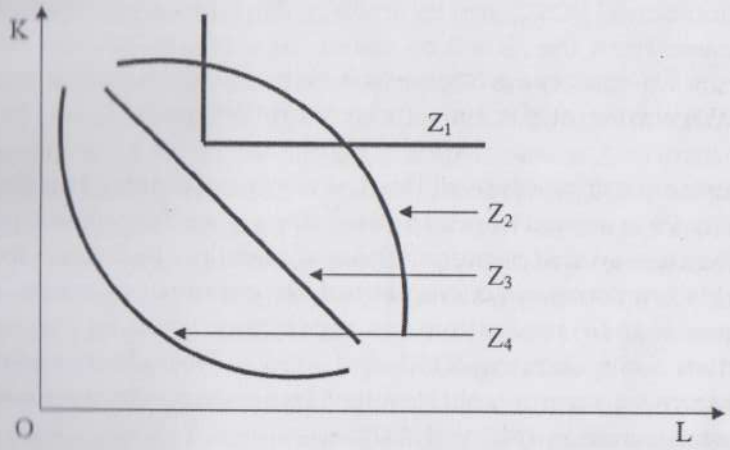
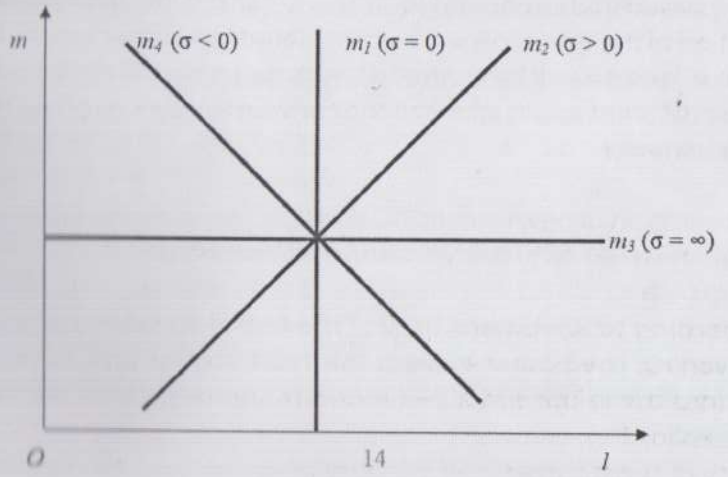


Figure 2: Lerner's Substitution Curves denoted by mi = fi (I)



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 isocurves or isofunctions. 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, isoutility, 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) Schmookler (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 Couve (*IQSC*)

If the *IQ* is represented by $Z_o = F(L, K)$ *or* $K = K(L, X_o)$, the *IQSC* can be denoted by $k = f(m, X_o)$ or simply, $k = f(m)$, where $Z \equiv$ firm's level of output, $L \equiv$ input -*L*, $K \equiv$ input- *K*, $k = (K/L)$ and $m = (F_L/F_K) = (MP_L/MP_K) = |dK/dL|$. The *IQSC* denoted by $k = f(m)$ is the mapping of *IQ* from *LK*-space into *mk*-space given the level of output Z. In other words, *IQSC* is the locus of various combinations of *m* and *k* along which the "isoness" 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, $Z = Z_o$, 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:

$$dk = -[(F_L . L + F_K . K)\,dL]/F_K . L^2 \quad (1)$$

$$dm = -[(2F_{LK}F_L F_K - F_{LL}F_K^2 - F_{KK}F_L^2)\,dL]/F_K^3 \quad (2)$$

$$\text{So, } (dk/dm) = f'(m) = MIQSC = D.F_K^2/\Delta.L^2, \quad (3)$$

where $D = (F_L . L + F_K . K)$ = Distributable output between the inputs *L* and *K* and

$\Delta = (2F_{LK}F_L F_K - F_{LL}F_K^2 - F_{KK}F_L^2)$
= Bordered Hessian determinant that determines the curvature of the *IQ*.

Noteworthy that equation (3) is obtained by the joint consideration of the equations (1) and (2).

From equation (3) we have:

$\partial[f'(m)]/\partial\Delta = -DF_K^2/\Delta^2L^2$ (4)

$\partial^2[f'(m)]/\partial\Delta^2 = 2DF_K^2/\Delta^3L^2$ (5)

Equations (3), (4) and (5) state that the *MIQSC* is inversely related to the curvature of the *IQ*, (= Δ). Further, the higher or the lower the convexity (Δ > 0) or concavity (Δ < 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 *IQCSs* denoted by f_i (i=1,2,3,4) in figure 4.

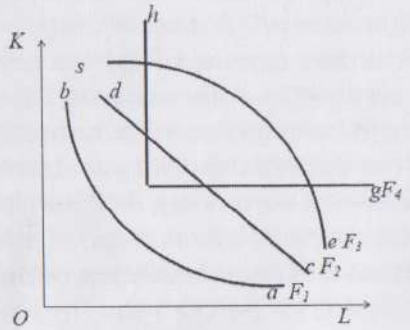


Figure 3: Isoquants: Z = Fi (L, K)

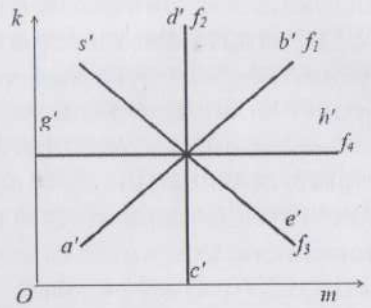


Figure 4: Isoquant Substitution Curves: k = fi (m)

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 *a'* is the lower ridge point at which $F_L = o = m$ and the slope of the ray $oa = oa'$.

(iii) Point *b* or *b'* is the upper ridge point at which $F_K = o$, $m =$ and slope of the ray $ob = m_1b'$.

(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' = slope of the ray *oa*.

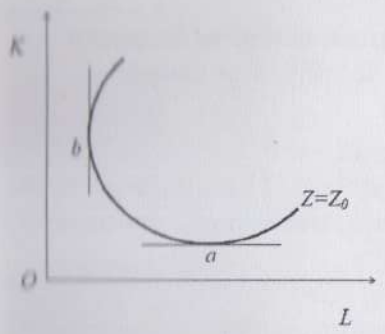


Figure 5: Isoquant for Z = Z0

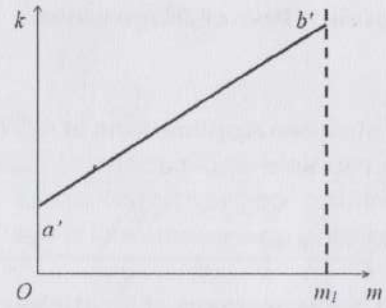


Figure 6: Isoquant Substitution Curve for Z = Z0

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 $Z_2 > Z_1$, where *URL* ≡ upper ridge line and *LRL* ≡ lower ridge line.

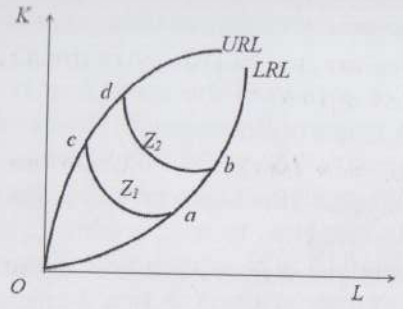


Figure 7: Pair of Ridge Lines

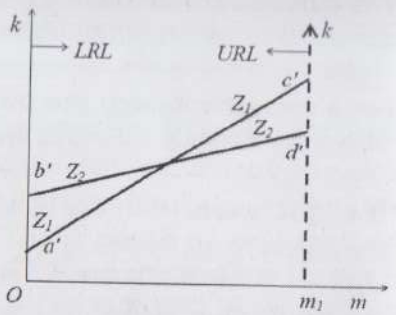


Figure 8: Pair of Isoquant Substitution Curves

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 σ, which is of two types such as σ_{LK} and σ_{KL}, where $\sigma_{LK} \equiv ES$ of L for K and $\sigma_{KL} \equiv ES$ 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_{km} stands for "*m* elasticity of *k* along the *IQSC*", we have:

$$E_{km} = (dk/k)/(dm/m) = (dk/dm)/(k/m) = MIQSC/AIQSC \quad (6)$$

But $HES = \sigma = (dk/k)/(dm/m)$ (7)

From equations (6) and (7), it is clear that E_{km} (measured along the *IQSC*) = σ (measured along the *IQ*). Form equation (6) we find that for the convex *IQ*, $E_{km} > 0$; for the concave *IQ*, $E_{km} < 0$; for the linear *IQ*, $E_{km} =$ and for the *L*–shaped *IQ*, $E_{km} = 0$. Further it can be shown that E_{km} or σ is inversely related to the curvature of the *IQ* that is Δ. For the *PF* given by $Z = F(L, K)$,

$$\sigma = E_{km} = (F_L . F_K . D)/L . K . \Delta \quad (8)$$

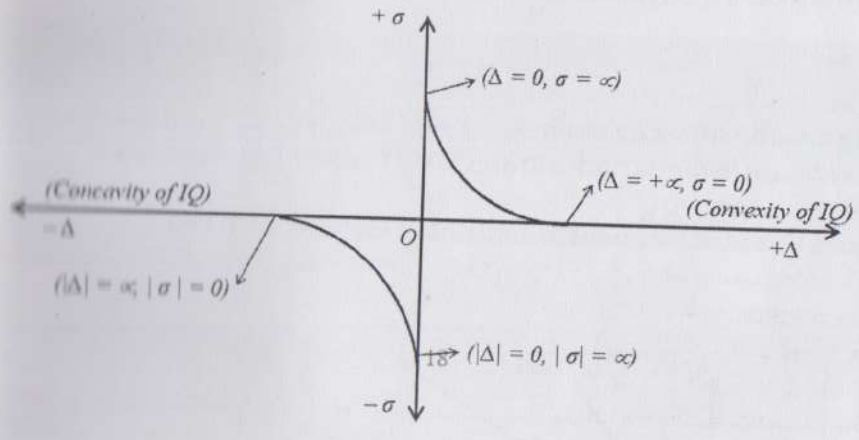
$$\partial \sigma/\Delta = -F_L F_K D/L K \Delta^2 < 0 \quad (9)$$

$$\partial^2\sigma/\Delta^2 = 2F_L F_K D/L K \Delta^3 > 0 \quad (10)$$

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 $\sigma = E_{km} = \phi$ (*MIQSC, AIQSC*), where ϕ = functional symbol.

Figure 9: Relation between Curvature of Isoquant and Elasticity of Substitution (σ)



2.5.2. Measurement of Relative Input Share

If $L_s = F_L . L/Z$ and $K_s = F_K . K/Z$, where $L_s \equiv$ share of L in Z and $K_s \equiv$ share of K in Z, so $K_s/L_s = F_K . K/F_L . L = (K/L)/(F_L/F_K) = k/m = AIQSC$ = slope of ray in *mk*-space, (11)

where $(K_s/L_s) \equiv$ relative share of K and $(L_s/K_s) \equiv$ relative share of L.

So, $L_s/K_s = m/k = 1/AIQSC$ (12)

Then from equation (11) it is amply clear that (K_s/L_s) is synonymous with *AIQSC*, while (L_s/K_s) is the reciprocal of *AIQSC*.

2.5.3. Relationship between the *IQSC* and $|E_{KL}|$

If $|E_{KL}|$ stands for "absolute *L* elasticity of *K* along the *IQ*", we have

$|E_{KL}| = |dK/K)/(dL/L)| = |(dK/dL)|/(K/L) = (F_L/F_K)/(K/L) = F_L.L/F_K.K$

$= L_s/K_s = m/k = 1/AIQSC$ (13)

2.5.4. Relationship among E_{km}, $|E_{KL}|$, *MIQSC* and *AIQSC*

From equation (6), we have:

$E_{km} = \sigma = HES = (dk/dm)/(k/m) = MIQSC/AIQSC.$

From equations (11) and (12), we have:

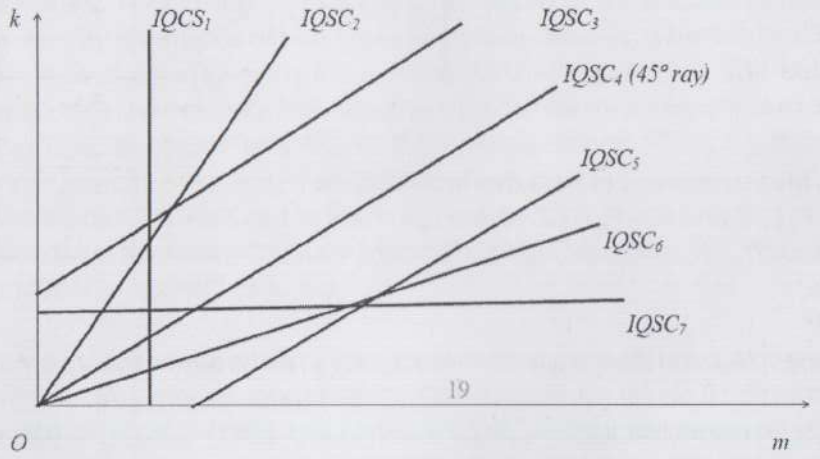
$K_s/L_s = k/m = AIQSC$ and $L_s/K_s = m/k = 1/AIQSC.$

From equation (13), we have:

$|E_{KL}| = m/k = L_s/K_s$ So, finally we get [from equations (6) and (11) and (13)]

$MIQSC = dk/dm = E_{km}/|E_{KL}| = E_{km}/(L_s/K_s) = E_{km}.AIQSC.$ These results can be disclosed in terms figure 10 and table 1, which are interrelated.

Figure 10: Set of Isoquant Substitution Curves: k = fi (m)



2.5.5. Trend in Relative Input Share (K_s/L_s)

Earlier we have seen that $K_s/L_s = k/m = AIQSC$ = slope of ray in the *mk*-space. Now, $d(k/m)/dk = (1/m)[1-1/E_{km})]$ (14)

and $d(k/m)/dm = (k/m^2)[E_{km}-1]$ (15)

From equation (14) we have $[d(k/m)/dk] \gtrless 0$ according as $E_{km} \gtrless 1$.

But from equation (15), we get $[d(k/m)/dm] \gtrless 0$, according as $E_{km} \gtrless 1$.

The results of equations (14) and (15) have also been displayed in table 1.

Table 1
Relationship among *IQSC*, *IQ*, E_{km}, $|E_{KL}|$ and (K_s/L_s)

Name of *IQSC*	Nature of *IQ*	$\sigma = E_{km}$	$\|E_{KL}\|$	K_s Vs. L_s	Trend in K_s/L_s or $d(k/m)/dk$
$IQSC_1$	Linear, $\Delta = 0$	$=\infty$	$= 0$	$K_s = 1$ $L_s = 0$	> 0
$IQSC_2$	Cobb – Douglas type $\Delta > 0$	$= 1$	< 1	$K_s > L_s$	$= 0$
$IQSC_3$	Convex to origin & Δ = higher	< 1	< 1	$K_s > L_s$	< 0
$IQSC_4$	Cobb – Douglas type $\Delta > 0$	$= 1$	$= 1$	$K_s = L_s$	$= 0$
$IQSC_5$	Convex to origin & Δ = lower	> 1	> 1	$K_s < L_s$	> 0
$IQSC_6$	Cobb – Douglas type $\Delta > 0$	$= 1$	> 1	$K_s < L_s$	$= 0$
$IQSC_7$	L – shaped $\Delta =$	$= 0$	$=\infty$	$K_s = 0$ $L_s = 1$	$d(k/m)/dm<0$

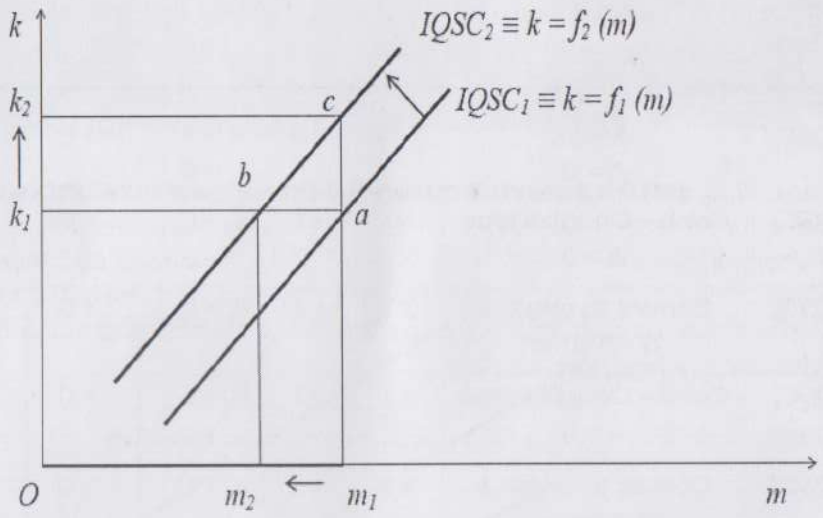
2.5.6. Hicksian Technological Progress and its Effects on Relative Input Share and Input Substitution

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_s/L_s) and the input substitution (*IS*).

Here we shall assume that the *IQs* are convex to the origin (excepting the Cobb – Douglas *IQs*), for which the *IQSCs* are positively sloping.

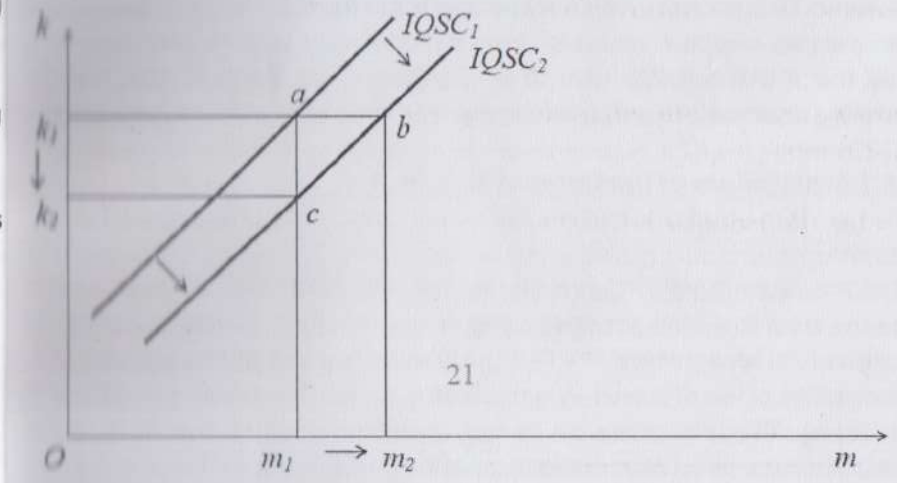
Figure 11: Hicksian Capital-intensive Technological Progress (HKITP)



In figure 11, due to Hicksian *K*-intensive *TP* (*HKITP*), the *IQSC* shifts to the left, for which at given $k = k_1$, m falls from m_1 to m_2. As a result, (K_s/L_s) rises, as the slope of the ray *ob* becomes higher than the slope of the initial ray *oa*.

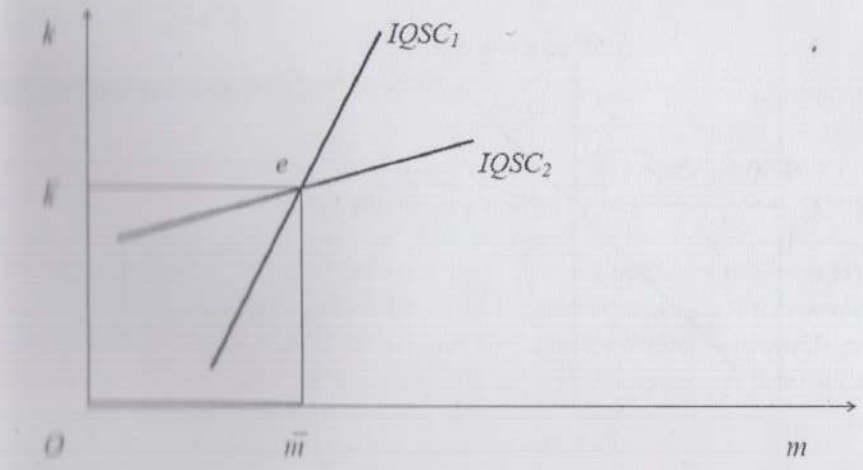
Further due to *HKITP*, k rises from k_1 to k_2 at the initial $m = m_1$, which means that *K* is substituted for *L* along the shifting *IQSC* at the initial $m = m_1$. Thus the movement from the point *a* to the point *b* is called *HKITP*, while the movement from *b* to *c* is called input substitution 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 $k = k_1$, m rises from m_1 to m_2. The movement from the point *a* to the point *b* is called *HLITP*, for which (K_s/L_s) 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 given $k = k^-$ is associated with the given $m = m^-$. This means that Hicksian *TP* is neutral, which leaves both the (K_s/L_s)

and the input substitution unchanged, as the slope of the ray *oa* remains unchanged and the *k* remains unchanged at k^- respectively.

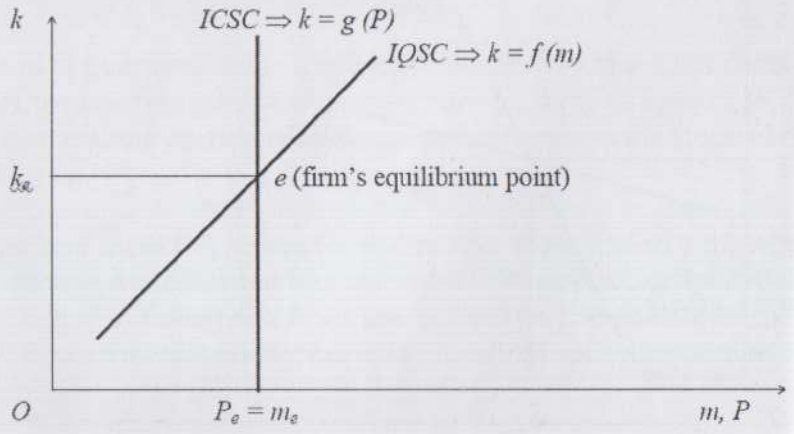
2.5.7. Equilibrium of the Competitive Firm

The firm is in equilibrium if the following two conditions are satisfied:

(I) $m\ (=F_l/F_k) = P\ (=P_L/P_K)$ 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 $P_L \equiv$ price of *L* and $P_K \equiv$ price of *K*. If the first order condition of firm's equilibrium, given by $m = p$, 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 $k = C/P_K L - P = g(P)$, such that $g'(P) = \infty$.

This means that the *ICSC* will be vertical in the *Pk*-space. Thus given 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



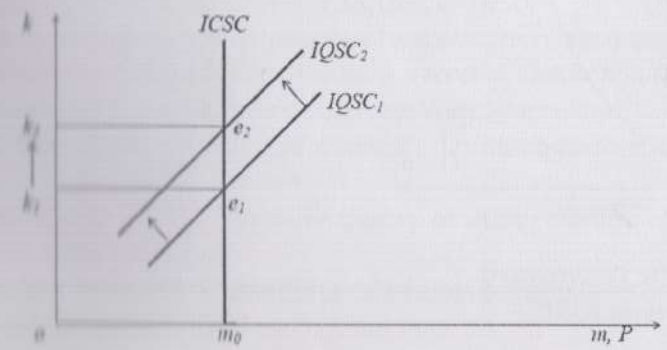
The equilibrium of the firm can also be demonstrated when both *IQ* and *IC* are curvilinear. The following three cases, for example, can be considered:

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.

2.5.8. 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, if and only if, the '*k* th' factor is inferior". Later on, it was modified by Scott (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 $m = P$, k increases, which is the same thing as the Hicksian K- intensive TP. 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_s/L_s) and $E_{km}(\sigma)$

Let us suppose that the *IQSC* assumes the explicit form $k = f(m) = B^2 m^2$, which gives rise to the following derivative functions:

$$k/m = B^2 m = K_s/L_s \Rightarrow AIQSC \quad (16)$$
$$dk/dm = 2k/m > 0 \Rightarrow MIQSC \quad (17)$$
$$d^2k/dm^2 = 2k/m^2 > 0 \Rightarrow \text{slope of } MIQSC, \quad (18)$$

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 *IQ* meets both the L- axis and K- axis. Since $AIQSC = k/m = K_s/L_s$, so *AIQSC* curve will coincide with the K_s/L_s curve. Further since $\sigma = E_{km} = (dk/dm)/(k/m) =$ $MIQSC/AIQSC$, so $\sigma = E_{km} > 1$, as $MIQSC > AIQSC$. All these results are reflected in figures 16 and 17.

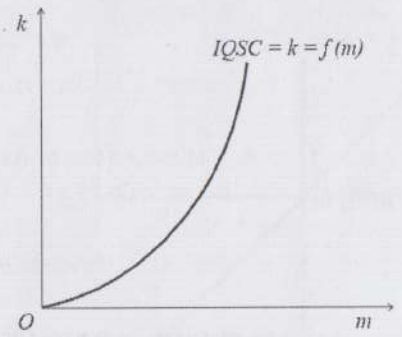


Figure 16: Downward Convex IQSC

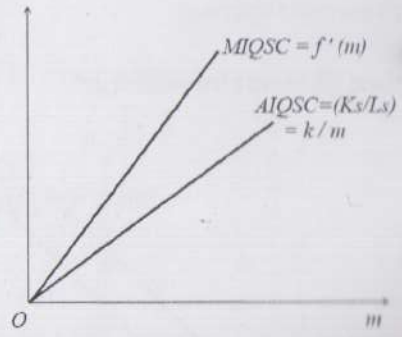


Figure 17: Positively Sloping MIQSC and AIQSC

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-Isocost 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 expletive 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.

2.7. References

- Bear, D.V.T. (1965). Inferior inputs and the theory of firm. *Journal of Political Economy*, 73(3), 287-289.
- Bishop, R.L. (1952). Elasticities, cross elasticities, and market relationships. *American Economic Review*, 42 (5), 779-803.
- Cobb, C.W. & Douglas, P. H. (1928). A theory of production. *American Economic Review*, 18(1), 139-165.
- Ferguson, C.E. (1968). Inferior factors and the theories of production and input demand. *Economica*, 35(138), 140-150.
- Frisch, R.A.K. (1935). The principle of substitution: An example of its application in the chocolate Industry. *Nordisk Tidskrift*, 1, 12-27.
- Hicks, J.R. (1932). *Theory of wages*. New York: Macmillan.
- Hicks, J.R. (1939). *Value and capital*. London: Oxford University Press.
- Johnson, W.E. (1913). The pure theory of utility curves. *Economic Journal*, 23(92), 483-513.
- Kennedy, C. (1962). The character of improvements and of technical progress. *Economic Journal*, 72(288), 899-911.

- Koopmans, T.C (1957). *Three essays on the state of economic science*. New York: McGraw Hill.
- Lerner, A.P. (1933). Notes on elasticity of substitution: The diagrammatical representation. *Review of Economic Studies*, 1(1), 68-71.
- Matyas, A. (1985). *History of modern non- Marxian economics*. London: Macmillan.
- Schmookler, J. (1965). Technological change and economic theory. *American Economic Review*, 55(1/2), 333-341.
- Scott, R.H. (1962). Inferior factors of production. *Quarterly Journal of Economics*, 76(1), 86-97.
- Sweezy, P. M.(1933). Notes on elasticity of substitution: A note on relative shares. *Review of Economic Studies*, 1(1), 67-68.
- Wicksteed, P.H. (1949/1910). *Common sense of political economy*. London: Routledge and Kegan Paul.

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 $X \equiv$ name and amount of commodity X, $L \equiv$ input-L, $K \equiv$ input-K, $k = (K/L)$ and $m = (F_L/F_K) = (MP_L/MP_K) = |dK/dL|$. 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 "isoness" 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 $m = f^{-1}(k)$, $dm/dk = f^{-1\prime}(k)$ 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 $k = C/P_K L - P = g(P)$ such that $g'(P) =$, 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*, $P_K \equiv$ price of input-*K* and $C \equiv$ 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 "isoness" of *C* is maintained.

3.3. Reformulation of *CDPF*

The general form of *CDPF* of Cobb and Douglas (1928) can be written as follows:

$X = F(L, K) = A L^a K^b$, (1)

where *A* level of technology, $a = F_L L/X = L_s$ = share of input-*L* in *X*,

$b = F_K K/X = K_s$ = share of input-*K* in *X*, $v = (a + b)$ = returns to scale, or degree of homogeneity of *CDPF*, $v>1$ *IRS*, $v<1$ *DRS*, $v=1$ *CRS*.

Following Konar's (2009) methodology, the general form of *CDPF*: $X = F(L, K) = A L^a K^b$ can be transformed into a single function $k = f(m) = Bm$, (2)

where $k = (K/L)$, $m = (F_L/F_K) = (MP_L/MP_K) = |dK/dL|$, $B = (b/a)$, $F_L = MP_L = a(X/L) = a AP_L$ and $F_K = MP_K = b(X/K) = b AP_K$. From equation (2) we get the following functions:

$k = Bm \Rightarrow$ *CDIQSC* (3)

$dk/dm = B \Rightarrow$ *CDMIQSC* (4)

$k/m = B \Rightarrow$ *CDAIQSC* (5)

$B = (b/a) = K_s/L_s = k/m =$ *CDAIQSC* $= dk/dm =$ *CDMIQSC* (6)

$|E_{KL}| = m/k \gtreqless 1$, according as $m \quad k$ or, $L_s \gtreqless K_s$ (7)

$E_{km} = \sigma = 1$ (8)

$dk/km = [E_{km}/|E_{KL}|] \gtreqless 1$, according as $E_{km} \gtreqless |E_{KL}|$, (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* = σ.

Let us rewrite the general form of *CDPF* as:

$X = F_i(L, K) = A_i L^a{}_i K^b{}_i$, (10)

where the subscript *i* designates the *i*th "isoquant map" (*IQM*).

Let us suppose that there are only three *CDIQMs* such as *CDIQM*, $CDIQM_2$ 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:

$X = F_1(L, K) = A_1 L^a{}_1 K^b{}_1$, where $a_1 = b_1 \Rightarrow$ $CDIQM_1$ (11)

$X = F_2(L, K) = A_2 L^a{}_2 K^b{}_2$, where $a_2 > b_2 \Rightarrow$ $CDIQM_2$ (12)

$X = F_3(L, K) = A_3 L^a{}_3 K^b{}_3$, where $a_3 < b_3 \Rightarrow$ $CDIQM_3$ (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 correspondingly 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*: $X = F_i(L, K) = A_i L^a{}_i K^b{}_i$ into a single function: $k = f_i(m) = B_i m$ 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 correspondingly three different straight lines with different slopes, which start from the origin in the *mk*-space, as shown in figure 2.

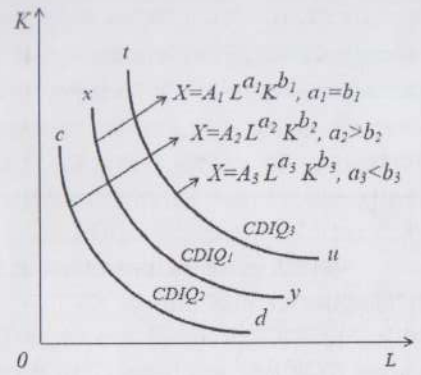


Figure 1: Three *CDIQs*

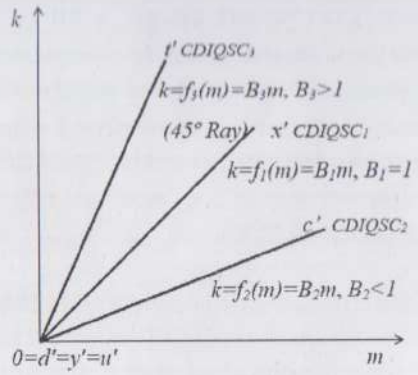


Figure 2: Correspondingly Three *CDIQSCs*

The new functions: $k = f_i(m) = B_i m$ $(i = 1, 2, 3)$ in figure 2, are the mapping of the *CDIQs* represented by $X = F_i(L, K) = A_i L^{a}{}_i K^{b}{}_i$ $(i = 1, 2, 3)$ in figure 1 from the *LK*-space into the *mk*-space. The new functions in figure 2 are called *CDIQSCs*.

Table 1: Comparison among the Three *CDIQSCs*

Nature of *CDPF*: $X = Fi (L, K) = AL^{a}{}_i K^{b}{}_i$	$X = AL^{a}{}_1 K^{b}{}_1$, $a_1 = b_1$	$X = AL^{a}{}_2 K^{b}{}_2$, $a_2 > b_2$	$X = AL^{a}{}_3 K^{b}{}_3$, $a_3 < b_3$
Nature of *CDIQM* or *CDIQ*	Rectangular Hyperbola	Similar to Rectangular Hyperbola	Similar to Rectangular Hyperbola
Name of *CDIQM* or *CDIQ*	$CDIQM_1$ or $CDIQ_1$	$CDIQM_2$ or $CDIQ_2$	$CDIQM_3$ or $CDIQ_3$
Name and Equation of *CDIQSC*	$CDIQSC_1$: $k = B_1m$	$CDIQSC_2$: $k = B_2m$	$CDIQSC_3$: $k = B_3m$
Relation between K_s and L_s	$K_s = L_s$	$K_s < L_s$	$K_s > L_s$
E_{km} (σ) along the *CDIQSC*	$E_{km} = 1$	$E_{km} = 1$	$E_{km} = 1$
$\lvert E_{KL} \rvert$ along the *CDIQ*	$\lvert E_{KL} \rvert = 1$	$\lvert E_{KL} \rvert > 1$	$\lvert E_{KL} \rvert < 1$

Received Nature of Technological Change	Neutral	Neutral	Neutral
Nature of Input-Intensity along the *CDIQSC*	k = Intermediate	k = Lower	k = Higher
K_s / L_s	$= 1$	< 1	> 1
Value of v_i	$v_1 \gtrless 1$	$v_2 \gtrless 1$	$v_3 \gtrless 1$
Value of $B_i = (b_i / a_i)$	$B_1 = 1$	$B_2 < 1$	$B_3 > 1$

3.3.1 Problems of Firm's Equilibrium

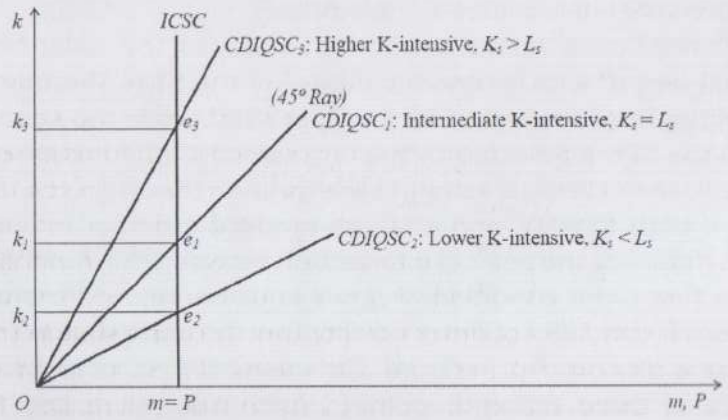
On the basis of equations (3) to (13), the comparison among the three *CDIQSCs* such as $CDIQSC_1$, $CDIQSC_2$ and $CDIQSC_3$ in figure 2 can be briefed in terms of table 1. According to the information encapsulated in table 1, the three different *CDIQSCs* such as $CDIQSC_1$, $CDIQSC_2$ and $CDIQSC_3$ 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 $CDIQM_i$ or the single $CDIQ_i$ can be mapped into $CDIQSC_i$. Since the firm is facing the "three paths", given by $CDIQSC_1$, $CDIQSC_2$ and $CDIQSC_3$, 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 *CDIQSC* is a straight line through the origin, the *ICSC* is vertical. If both *CDIQSC* 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 *CDIQSCs* at three different points, which are called the firm's equilibrium points. Let e_i be the equilibrium point corresponding to

the "*i*th path" denoted by $CDIQSC_i$ (i = 1, 2, 3). So, e_1, e_2, and e_3 will be consistent with $CDIQSC_1$, $CDIQSC_2$ and $CDIQSC_3$ respectively. The "choice of equilibrium path" depends on the desirability of the firm with respect to the relative position of K_s and L_s (that is whether $K_s \gtreqless L_s$) 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 *ICSC*. If the firm desires to have $K_s > L_s$ coupled with higher *K*-intensity on the assumption that either the trade union is naïve, or completely unaware of the existing three paths, the firm will choose the equilibrium point e_3, which is consistent with the $CDIQSC_3$ 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_2 corresponding to the $CDIQSC_2$ path, since trade union knows that the $CDIQSC_2$ path involves $L_s > K_s$ coupled with *L*-intensity. The paths $CDIQSC_2$ and $CDIQSC_3$ are considered as the two extreme paths. While $CDIQSC_3$ path is biased against the trade union, the $CDIQSC_2$ path is biased against the firm. But, if neither firm, nor trade union "stoops" before each other, then through the bargaining process, the intermediate path $CDIQSC_1$, which may be looked upon as an "egalitarian path", as along such path $K_s = L_s$ 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 *CDIQSC*, the *HTP* is neutral, as suggested by the received theory. This means that for *CDPF*, the intra-*IQM* or intra-*IQSC* technological progress (*TP*) is neutral in Hicksian sense. But, this neutrality of *HTP* is vitiated owing to divergence of choice of path, *CDIQSC* or e_i. This means that the inter-path, inter-*IQM* or inter- *IQSC-TP* is non-neutral in Hicksian sense. More specifically, owing to divergence of choice of path, if the *CDIQSC* shifts from its initial position $CDIQSC_2$ to the final position $CDIQSC_1$, such shift of *CDIQSC* indicates Hicksian *K*-intensive *TP* (*HKITP*), while the shift of *CDIQSC* from $CDIQSC_3$ to $CDIQSC_1$ indicates Hicksian *L*-intensive *TP* (*HLITP*). Thus, the inter-path, inter-*IQM* or inter-*IQSC-TP* is always non-neutral, which has not been considered by the received theory.

If the *CDPF* is rewritten as $X_i = F_i(L_i, K_i) = A_i L_i^a K_i^b$ or $k_i = B_i m_i$, where the subscript *i* may designate industry, firm within an industry, or the plant within a firm, the movement along any $CDIQSC_i$ (i = 1, 2, 3) must imply intra-industry, intra-firm or intra-plant *HTP*, which is neutral for the *i*th industry, firm or plant. But the shift of $CDIQSC_i$ in either ward (upward or downward) involves inter-industry, inter-firm or inter-plant *HTP*, which is non-neutral. More specifically, if the *CDIQSC* shifts from $CDIQSC_2$ (or $CDIQSC_3$) to the $CDIQSC_1$, 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_s. 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_s 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*.

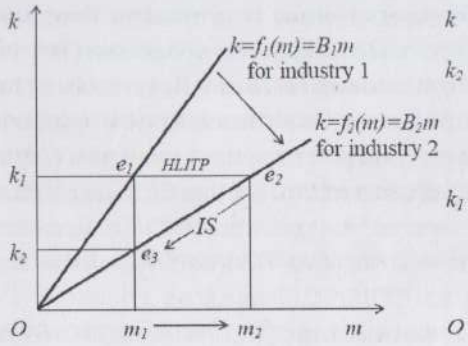


Figure 4: Intra- and Inter-Industry TP(L-Intensive)

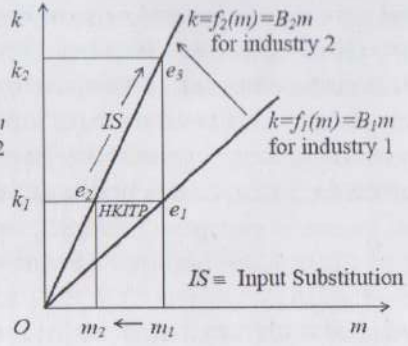


Figure 5: Intra- and Inter-Industry TP (K-Intensive)

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 *HLITP*, the *CDIQSC* shifts to the right from $k = f_1(m)$ to $k = f_2(m)$, for which at the given $k = k_1$, m rises from m_1 to m_2. The movement from the point e_1 to the point e_2 is called "inter-industry *HLITP*", for which the relative share of $K\ (=K_s/L_s)$ 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_2 to the point e_3 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_3 is also called "intra-industry Hicksian neutral *TP*". But, in figure 5, due to inter-industry *HKITP*, 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 $K\ (=K_s/L_s)$ 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 *HKITP* 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 *HKITP*", while the movement from the point e_2 to the point e_3 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 bypassing the repetition of reasoning of the foregoing two subsections, only the nature of *CESIQSC* has been disclosed, as follows.

By analogy of *CDPF*: $X = F(L, K) = A\,L^a\,K^b$, the *CESPF* can be written as:

$X = F(L,K) = A\,[a\,L^{-r} + b\,K^{-r}]^{-v/r}$, (14) where $(a + b) = 1$, v returns to scale parameter 1, A technological change parameter, r substitution parameter, while a and b refer to distributional parameter.

From equation (14) we get two derivative functions such as (15) and (16):

$$F_L = [A^{-r/v}\,a\,v\,X^{(1+r/v)}]/L^{(1+r)} \qquad (15)$$

$$F_K = [A^{-r/v}\,b\,v\,X^{(1+r/v)}]/K^{(1+r)} \qquad (16)$$

From equation (15) and (16) we get:

$$k = B^{\sigma}\,m^{\sigma} \Rightarrow CESIQSC \qquad (17)$$

From equation (17) we get:

$$k/m = B^{\sigma}\,m^{\sigma-1} \Rightarrow CESAIQSC = (K_s/L_s) \qquad (18)$$

$$dk/dm = B^{\sigma}m^{\sigma-1} = (k/m) \Rightarrow CESMIQSC \qquad (19)$$

$$d^2k/dm^2 = \sigma(\sigma\text{-}1)(k/m^2) \Rightarrow \text{slope of } CESMIQSC \qquad (20)$$

$$\partial k/\ B = \sigma B^{\sigma-1}m^{\sigma}, \qquad (21)$$

where $E_{km} = \sigma = CESMIQSC/CESAIQSC = [1/(1+r)] = \sigma(r)$, (22)

$$B = (b/a) = (k/m)\,k^{(1-\sigma)/\sigma} = (K_s/L_s)\,k^r, \qquad (23)$$

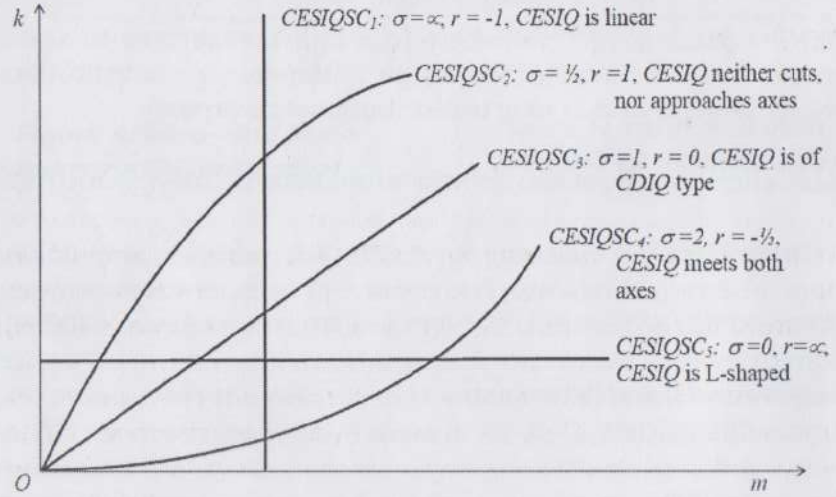
since $r = [(1-\sigma)/\sigma]$ and (24)

$a = (L_s A^{1/\nu} L')/\nu X^{1/\nu}$ (here $L_s \neq a$, while in *CDPF*, $L_s = a$) (25)

$b = (K_s A^{1/\nu} K')/\nu X^{1/\nu}$ (here $K_s \neq b$, while in *CDPF*, $K_s = b$) (26)

The *CESIQSC* assumes various shapes depending upon the nature of *CESIQ*, which in turn depends upon the values of r and σ as shown in figure 6.

Figure 6: Five CESIQSCs Corresponding to Five CESIQs

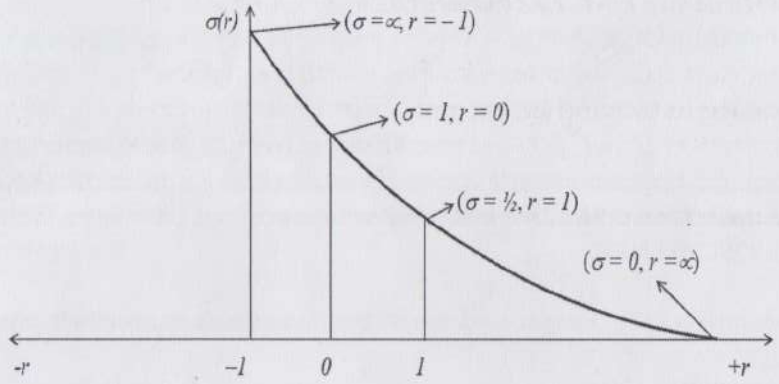


If positively sloping (linear or non-linear) *CESIQSCs* are substituted for *CDIQSCs* in figure 3, figure 4 and figure 5 leaving other things intact, it will be evident that the two problems, indicated by subsection 3.1 and subsection 3.2, are equally applicable to the *CESPF* like *CDPF*.

On the basis of equation (22) or (24), the "*CES*-Curve" can be derived as follows. Since $E_{km} = \sigma = 1/(1+r) = \sigma(r)$, so $\sigma'(r) = -\sigma^2 < 0$ and $\sigma''(r) = 2\sigma^3 > 0$ on the assumption that $\sigma > 0$.

This indicates that the "*CES*-Curve", which shows the relationship between σ 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 (*IQSC*). 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
$X = F(L, K)$, (27)

which can be rewritten as $x = t(k)$, (28)

where $x = AP_L = (X/L)$, $(x/k) = AP_K$ and $k = (K/L)$.
Equation (27) can also be rewritten as $X = L\,t(k)$ (29)

From equation (29), we get two derivative functions such as (30) and (31):

$MP_L = F_L = (t - kt') = AP_L(1 - K_s) = AP_L L_s$ (30)

where $K_s = F_K K/X =$ share of K in X and $L_s = F_L L/X =$ share of L in X.

$MP_K = F_K = t'(k) = AP_K K_s$ (31)

From equations (30) and (31) we get:

$F_L/F_K = m = (t - kt')/t' = f^{-1}(k)$, (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):

$dk/dm = MIQSC = -t'^2/tt''$ (34)

$k/m = AIQSC = K_s/L_s = kt'/(t - kt')$ (35)

Similarly from equation (32), we get two derivative functions such as (36) and (37):

$dm/dk =$ "inverse $MIQSC$" $= -tt''/t'^2$ (36)

$d^2m/dk^2 = (2tt'^2 - t^2t'' - tt't''')/t^3$, (37) which is called "slope of inverse *MIQSC*" of *LHPF*.

From equations (34) and (35), we get:

$E_{km} = = (dk/k)/(dm/m) = (dk/dm)/(k/m) = (m/k)/(dm/dk)$

$= MIQSC/AIQSC = -[t'(t - kt')]/ktt'' = (k)$, (38)

where σ "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:

$d\sigma/dk = d[(m/k)/(dm/dk)]/dk$

$= (m/k)[(1 - \sigma)m/\sigma^2k^2 - (d^2m/dk^2)]/(dm/dk)^2$ (39)

$E_{xk} = (dx/x)/(dk/k) = (dx/dk)/(x/k)$

$= kt'/t = MP_K/AP_K = F_K K/X = K_s$ (40)

where E_{xk} "k elasticity of x" measured along the AP_L curve: $x = t(k)$.

So, the trend in K_s with the change in k can be given by:

$dK_s/dk = dE_{xk}/dk = [t'(t - kt') + ktt'']/t^2 = (t'F_L + ktt'')/t^2 = [(F_L F_K/AP_L^2) + (F_{KK}/AP_K)]$ (41)

3.5.1 Shapes of AP_L Curve Derived from *LHPF*

The AP_L function: $x = t(k)$ assumes various shapes depending upon the value of E_{xk} and t'', on the assumption that $t' > 0$, which will be obvious from figure 8.

Figure 8: Five APL Curves of LHPF

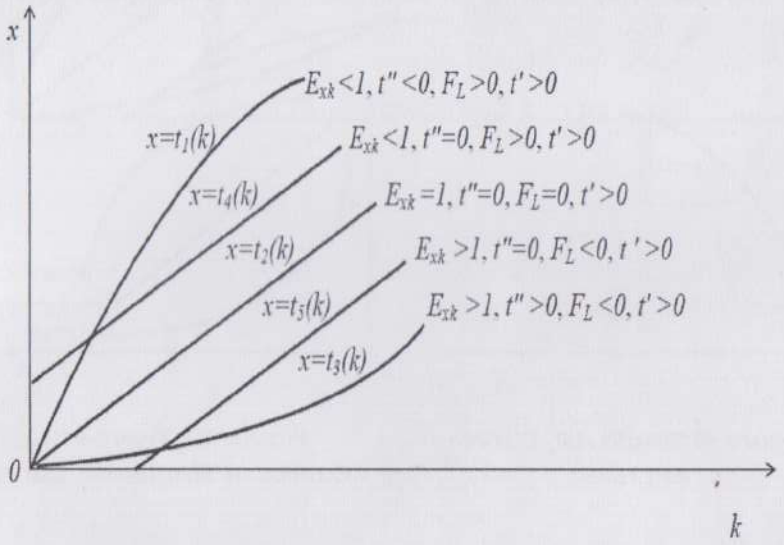


Figure 8 shows that the two AP_L functions $t_1(k)$ and $t_4(k)$ are practically feasible, as $K_s < 1$ and $MP_L > 0$, while the AP_L function $t_2(k)$ is theoretically feasible, as $K_s = 1$ and $MP_L = 0$. But the other two AP_L functions $t_3(k)$ and $t_5(k)$ are quite impossible in reality, as K_s can never be greater than unity and MP_L can never be negative.

So, for practical purpose, the AP_L functions $t_1(k)$ and $t_4(k)$ can be retained, deleting the rest of the AP_L 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 *mk*-space, which will be consistent with the three AP_L functions such as t_2 *(k)*, t_4 *(k)* and t_5 *(k)* in figure 8, irrespective of whether $E_{xk} = K_s$ *1*. Further, in the case of vertical *IQSC*, we find that $= \sigma$ $E_{km} =$ and $d(k/m)/dk = d(K_s/L_s)/dk > 0$.

(ii) But, if the AP_L curve: $x = t(k)$ is concave to the *k*-axis in *kx*-space (see figure 9), which is possible if $t' > 0$, $t'' < 0$ and $E_{xk} = K_s < 1$, 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.

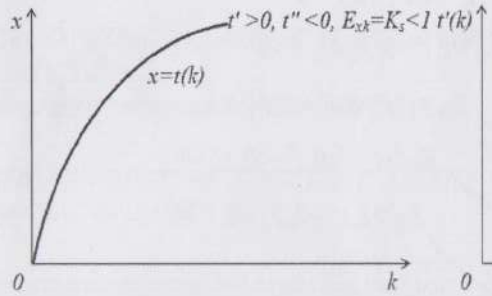


Figure 9:* Single AP_L Curve of *LHPF

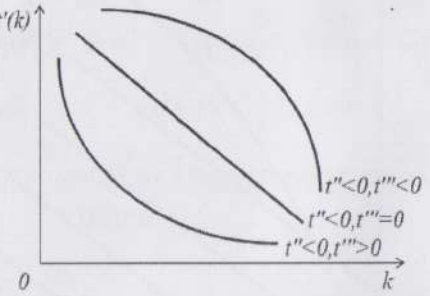


***Figure 10:* Three MP_K Curves of Single AP_L Curve**

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 $k = f_i(m)$ $[i = 1 \text{ to } 7]$ in figure 11 are consistent with the single AP_L 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

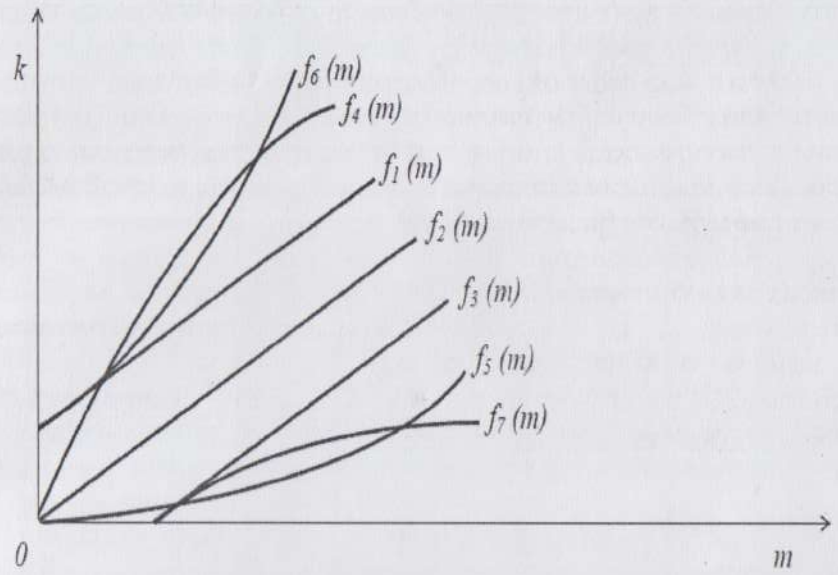


Table 2: Features of Seven *IQSCs* of *LHPF*

IQSC : $k = f_i(m)$ in figure 11	Value of $= E_{km}$	d/dk	$f''(m)$	dm/dk	d^2m/dk^2	$t'(k)$	$t''(k)$	$t'''(k)$	$d(K_s/L_s)/dk$ or $d(k/m)/dk$	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	$\gtreqless 0$	<0	>0	>0	>0	<0	$\gtreqless 0$	<0	CESPF, CDPF, VESPF
$f_5(m)$	>1	$\gtreqless 0$	>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	$\gtreqless 0$	>0	VESPF

Table 3: Features of Five APL Curves of LHPF

AP_L Curve: $x = t_i(k)$ in Figure 8	$AP_L = t(k)$	$MP_L = F_L$	$AP_K = x/k$	$MP_K = F_K = t'(k)$	$F_{KK} = t''(k)$	$E_{xk} = K_s = MP_K/AP_K$	$L_s = MP_L/AP_L$	dK_s/dk	dL_s/dk
$t_1(k)$	>0	>0	>0	>0	<0	<1	<1	$\gtreqless 0$	$\gtreqless 0$
$t_2(k)$	>0	$=0$	>0	>0	$=0$	$=1$	$=0$	$=0$	$=0$
$t_3(k)$	>0	<0	>0	>0	>0	>1	<0	$\gtreqless 0$	$\gtreqless 0$
$t_4(k)$	>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.

3.7. References

- Allais, M. (1997). An outline of my main contributions to economic science: Nobel lecture, December 9, 1988. *American Economic Review*, 87(6), 3-12.
- Arrow, K.J., Chenery, H. B., Minhas, B. S. & Solow, R. M. (1961). Capital-labour substitution and economic efficiency. *Review of Economics and Statistics*, 43(3), 225-250.
- Cobb, C. W. & Douglas, P. H. (1928). A theory of production. *American Economic Review*, 18 (1), 139-165.
- Konar, A. K. (2009). Surrogate substitution curve of Lerner (1933). *Asian Economic Review*, 51(1), 133-146.
- Lu, Yao-Chi & Fletcher, L. B. (1968). A generalization of the CES function. *Review of Economics and Statistics*, 50(4), 449-452.
- Massell, B. F. (1961). A disaggregated view of technical change. *Journal of Political Economy*, 69(6), 547-557.
- Mc Fadden, D. (1963). CES production function. *Review of Economic Studies*, 30 (2), 73-83.
- Uzawa, H. (1962). Production function with CES. *Review of Economic Studies*, 29 (4), 291-299.

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24

शैलेश मटियानी की कहानियों में महानगरीय हाशिये का समाज

गौतम सिंह राणा
सहायक प्राध्यापक
हिंदी विभाग
अछुराम मेमोरियल कॉलेज, झालदा
जिला – पुरुलिया(प. बं.)

हिंदी कहानीकारों में शैलेश मटियानी एक सुपरिचीत नाम है । हिंदी कथा साहित्य में प्रेमचंद की परंपरा को आगे बढ़ानेवाले मुकम्मल कथाकारों में निर्विवाद रुप 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 य़थार्थ 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 चितेरा 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 मूलत: 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 बिमारी 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 कलई खोलकर हमारे सामने रख देता है तो दूसरी ओर गनेसी जैसे गरीब पात्रों की चारित्रिक उज्जवलता 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 उद्धेश्य 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 जरुर 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 गालियों 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 बलाने 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 अद्भुत 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 फुटपाथी 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 जिस्म 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...मैं 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 भोंडा मजाक तो नहीं ही करना चाहिए । मटियानी जी को इस नारकीय स्थति 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 वनने से बचाने के लिए वर्दीधारी हवलदार का गला दबोचते दर्शाया है । यास्तव 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 चमत्कारिक 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 प्रतित होती है ।

निष्कर्षत: 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 उद्भासित होता नजर आता है । कहने का तात्पर्य है कि इनकी कहानियों मे 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

संदर्भ -

1. मनु, प्रकाश, कथापुरुष शैलेश मटियानी : अंतरंग स्मृतियाँ और मुलाकातें, ग्रंथ सदन, शाहदरा, दिल्ली, प्रथम संस्करण : 2004, पृ - 13
2. मटियानी, शैलेश, शैलेश मटियानी की सम्पूर्ण कहानियाँ(भाग-1), राकेश मटियानी (संपा.), प्रकल्प प्रकाशन, मोतीलाल नेहरू नगर, इलाहाबाद, द्वितीय संस्करण : 2008, पृ – 57
3. मनु, प्रकाश, कथापुरुष शैलेश मटियानी : अंतरंग स्मृतियाँ और मुलाकातें, ग्रंथ सदन, शाहदरा, दिल्ली, प्रथम संस्करण : 2004, पृ – 86
4. मटियानी, शैलेश, शैलेश मटियानी की सम्पूर्ण कहानियाँ(भाग-1), राकेश मटियानी (संपा.), प्रकल्प प्रकाशन, मोतीलाल नेहरू नगर, इलाहाबाद, द्वितीय संस्करण : 2008, पृ – 59
5. मटियानी, शैलेश, शैलेश मटियानी की सम्पूर्ण कहानियाँ(भाग-2), राकेश मटियानी (संपा.), प्रकल्प प्रकाशन, मोतीलाल नेहरू नगर, इलाहाबाद, द्वितीय संस्करण: 2008, पृ – 399
6. मनु, प्रकाश, शैलेश मटियानी की सम्पूर्ण कहानियाँ(भाग-5), राकेश मटियानी (संपा.), प्रकल्प प्रकाशन, मोतीलाल नेहरू नगर, इलाहाबाद, द्वितीय संस्करण: 2008, पृ – 36
7. मटियानी, शैलेश, शैलेश मटियानी की सम्पूर्ण कहानियाँ(भाग-1), राकेश मटियानी (संपा.), प्रकल्प प्रकाशन, मोतीलाल नेहरू नगर, इलाहाबाद, द्वितीय संस्करण : 2008, पृ – 154
8. मनु, प्रकाश, कथापुरुष शैलेश मटियानी : अंतरंग स्मृतियाँ और मुलाकातें, ग्रंथ सदन, शाहदरा, दिल्ली, प्रथम संस्करण : 2004, पृ - 25

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Perspectives, Transformation and Prospects

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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 international de la Francophonie
- Koulu.me
- Keep Learning Going
- Global Business Coalition for Education

- European Commission Resources
- EdSurge
- Education Nation
- Brookings Common Sense Education Commonweatlh of Learning

Massive Open Online Course (MOOC) Platforms

- Alison
- Canvas
- Coursera
- European Schoolnet Academy
- EdX
- iCourse
- Future 8. Learn
- Icourses
- TED-Ed Earth Schoo
- 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. UNCESCO 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.

References

1. https://www.scielosp.org/scielo.php?lng=en
2. https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/
3. https://en.unesco.org/covid19/educationresponse/solutions
4 https://nss.gov.in/nss-detail-page
5. http://saber.worldbank.org/index.cfm
6. SABER Systems Approach for Better Education Results – About, Retrieved 2017-07-14.
7. https://openknowledge.worldbank.org/handle/10986/33696 License: CC BY 3.0 IGO."
8 https://thewire.in/rights/covid-19-crisis-will-push-millions-of-vulnerable-children-into-child-labour
9. https://www.educationcannotwait.org/covid-19/
10. Barmola, Kailash and Srivastava, S.K., "Effect of Examination Stress on Adolescents' Health" In book: Edited book on Healthcare Management, Publisher: New Century Publication, New Delhi, pp. 289-303, 2020.

11. Ruchi Singh, Manish Goyal, Sunita Tiwari, Archana Ghildiyal, Shankar M Nattu, Shobha Das, "Effect of Examination Stress on Mood, Performance and Cortisol Levels in Medical Students", *Indian J Physiol Pharmacol.* 56(1): pp. 48-55, 2012.
12. Psychologists Study Impact of Lockdown on Young People, Dr. Liat Levita's report, The University of Sheffield, 22 April 2020
13. http://www.ufh.ac.za/news/News/
14. https://www.firstpost.com/india/coronavirus-lockdown-calcutta-university-begins-free-online-counselling-service-for-students-mental-well-being-8247081.html
15. Global Estimates of Child Labour: Results and Trends, 2012-2016, International Labour Office (ILO), Geneva, 2017 ISBN: 978-92-2-130152-3 (print) ISBN: 978-92-2-130153-0 (web pdf)
16. https://www.indiaspend.com/how-a-kerala-districts-initiative-is-helping-migrant-workers-children-stay-in-school/
17. https://nss.gov.in/covid-19-123

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National Service Scheme in India keeps a well tuned relationship between stake holders of academic institutions and communities from its inceptions. 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, [illegible] and common mass of our beloved country.

Dr. Savita Mishra is a [illegible] 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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আমেরিকান সমাজের উদ্ভব

পৃথিবীর যে-কোনো দেশে সমাজ জন্মায় না, তাকে সৃষ্টি করা হয়। মানব সভ্যতার বিবর্তনের হাত ধরে সমাজের উৎপত্তি ঘটে। আমেরিকা যুক্তরাষ্ট্র এই নিয়মের ব্যতিক্রম নয়। আদিম আমেরিকার অধিবাসীরা বনের পশুশিকার এবং খাদ্য সংগ্রহের মাধ্যমে জীবন-জীবিকা অতিবাহিত করত। আজ থেকে বহু শতাব্দী পূর্বে নেটিভ-আমেরিকানরা এশিয়া মহাদেশ থেকে স্থানান্তরিত হয়ে পশ্চিম গোলার্ধে (Western Hemisphere) বসবাস শুরু করেছিল। এখানে 'Hemisphere' বলতে সমগ্র পৃথিবীর অর্ধেক ভূখণ্ডকে বোঝানো হয়েছে। প্রাচীনকালে সমগ্র আমেরিকা মহাদেশের বিস্তীর্ণ অঞ্চলে বহু আদিম জনজাতির মানুষ বসবাস করত এবং তাদের সমাজব্যবস্থার মধ্যে নানা স্তরবিন্যাস বিদ্যমান ছিল। যেমন 'Kinbased Society' বা 'কুটুম্বভিত্তিক সমাজ' বা 'প্রধান পুরোহিততান্ত্রিক সমাজ' ইত্যাদি। কিন্তু সপ্তদশ শতাব্দীর প্রথম ভাগে ইওরোপ থেকে উত্তর ও দক্ষিণ আমেরিকায় নব্য আগন্তুকদের অভিপ্রয়াণ শুরু হলে আমেরিকার প্রাচীন সমাজব্যবস্থার মধ্যে অতিদ্রুত নানা রকম পরিবর্তনের ধারা লক্ষ করা যায়। এইপর্বে আমেরিকার সমাজব্যবস্থায় শ্বেতকায়দের সঙ্গে কৃষ্ণাঙ্গদের মিলনের ফলে আমেরিকা মহাদেশের অধিবাসীদের জীবন-জীবিকা-অর্থনীতি, সমাজব্যবস্থা ও সংস্কৃতিচর্চায় এক সুদূরপ্রসারী পরিবর্তনের জোয়ার আসে।

বর্তমানে আমেরিকা বলতে মার্কিন যুক্তরাষ্ট্রকে বোঝানো হয়, কিন্তু আজ থেকে ২৪০ বছর পূর্বে আমেরিকা বলতে সমগ্র উত্তর ও দক্ষিণ মহাদেশদ্বয়কে বোঝাত। বর্তমানে এই সমগ্র আমেরিকা মহাদেশে ৩৫টি স্বাধীন সার্বভৌম দেশ এবং অনেকগুলি ভূখণ্ড রয়েছে। তার মধ্যে অন্যতম একটি গুরুত্বপূর্ণ এবং বিশ্বশক্তিধর দেশ হল আমেরিকা যুক্তরাষ্ট্র। এই বিশাল সার্বভৌম মার্কিন যুক্তরাষ্ট্রের বিশেষ বৈশিষ্ট্য হল এই যে, এই দেশের অধিবাসীরা কোনো একটি বিশেষ জনগোষ্ঠী বা দেশ থেকে এখানে আসেনি, তারা এসেছিল বিভিন্ন দেশ থেকে। এই আমেরিকানরা হল বিভিন্ন জাতির একটি মিশ্রিত রূপ। বিভিন্ন জাতির মধ্যে যে ঐক্যবদ্ধ রূপ—আমেরিকান নামক জাতির সৃষ্টি করেছিল তার ঐক্যের বজ্রবেষ্টনীর ক্ষেত্রে ইংরেজি ভাষা প্রধান শক্তি হিসাবে কাজ করেছিল।

আমেরিকার আবিষ্কার ও নামকরণ

ইওরোপিয়ানরা-ই প্রথম আমেরিকার সন্ধান পেয়েছিল ১৪৯৩ খ্রিস্টাব্দে। তার পূর্বে ১৪৯২ খ্রিস্টাব্দে ইতালির নাগরিক ক্রিস্টোফার কলম্বাস পেনিস জাহাজে করে আমেরিকার উদ্দেশ্যে যাত্রা করেছিলেন বলে অনেক ঐতিহাসিকের অভিমত। তিনি ঐ বছরই

প্রাচীন ভারত ইতিহাসের সন্ধানে
প্রাক্ ইতিহাস—৩০০ খ্রিস্টপূর্বাব্দ ১ম খণ্ড
৩০০ খ্রিস্টপূর্বাব্দ—৭৫০ খ্রিস্টাব্দ ২য় খণ্ড
তুষার চক্রবর্তী

ভারতের পুরাণকথা প্রথম ভাগ
প্রাগৈতিহাসিক যুগ—বৈদিক যুগ পর্যন্ত
বুদ্ধ যুগ—গুপ্ত যুগ পর্যন্ত দ্বিতীয় ভাগ
ড. অলোককুমার চক্রবর্তী

মধ্যযুগে ভারত
সুলতানি ও আঞ্চলিক সাম্রাজ্যের উত্থান—পতনের ইতিহাস ১২০৬—১৫২৬ খ্রিস্টাব্দ
তুষার চক্রবর্তী

ভারতের ইতিহাস ঃ আদি মধ্যযুগ
রাজনীতি, সমাজ, অর্থনীতি, ধর্ম ও সংস্কৃতি ৭৫০—১২০৬ খ্রিস্টাব্দ
তুষার চক্রবর্তী

মুঘল যুগের ভারত
সূচনা থেকে সুদৃঢ়করণ ১৫২৬—১৬০৫ খ্রিস্টাব্দ
তুষার চক্রবর্তী

সংগ্রহশালা লেখ্যাগার এবং প্রত্নতত্ত্ব
রঙ্গনকান্তি জানা

ভারত—শিল্পকলা
ঐতিহ্যের রূপরেখা
রঙ্গনকান্তি জানা

বিশ্ব সভ্যতা প্রাচীন যুগ
সিদ্ধার্থ গুহ রায় ও অপরাজিতা ভট্টাচার্য

মানব সভ্যতা ও সংস্কৃতি প্রাচীন বিশ্বের ইতিহাস
টিনা বসু

বিশ্ব সভ্যতার মধ্যযুগ সামাজিক সংগঠন ও সাংস্কৃতিক বিন্যাস
আসিফ জামাল লস্কর

প্রাচীন বিশ্ব ঃ রোমান সভ্যতার ইতিহাস
তাম্র ও ব্রোঞ্জ যুগ থেকে ৪৭৬ খ্রিস্টাব্দ
বিমল চন্দ্র বেতাল

প্রাচীন বিশ্ব ঃ গ্রিক সভ্যতার ইতিহাস
তাম্র—ব্রোঞ্জ যুগ থেকে রোমান বিজয় ১৪৬ খ্রিস্টপূর্বাব্দ
বিমল চন্দ্র বেতাল

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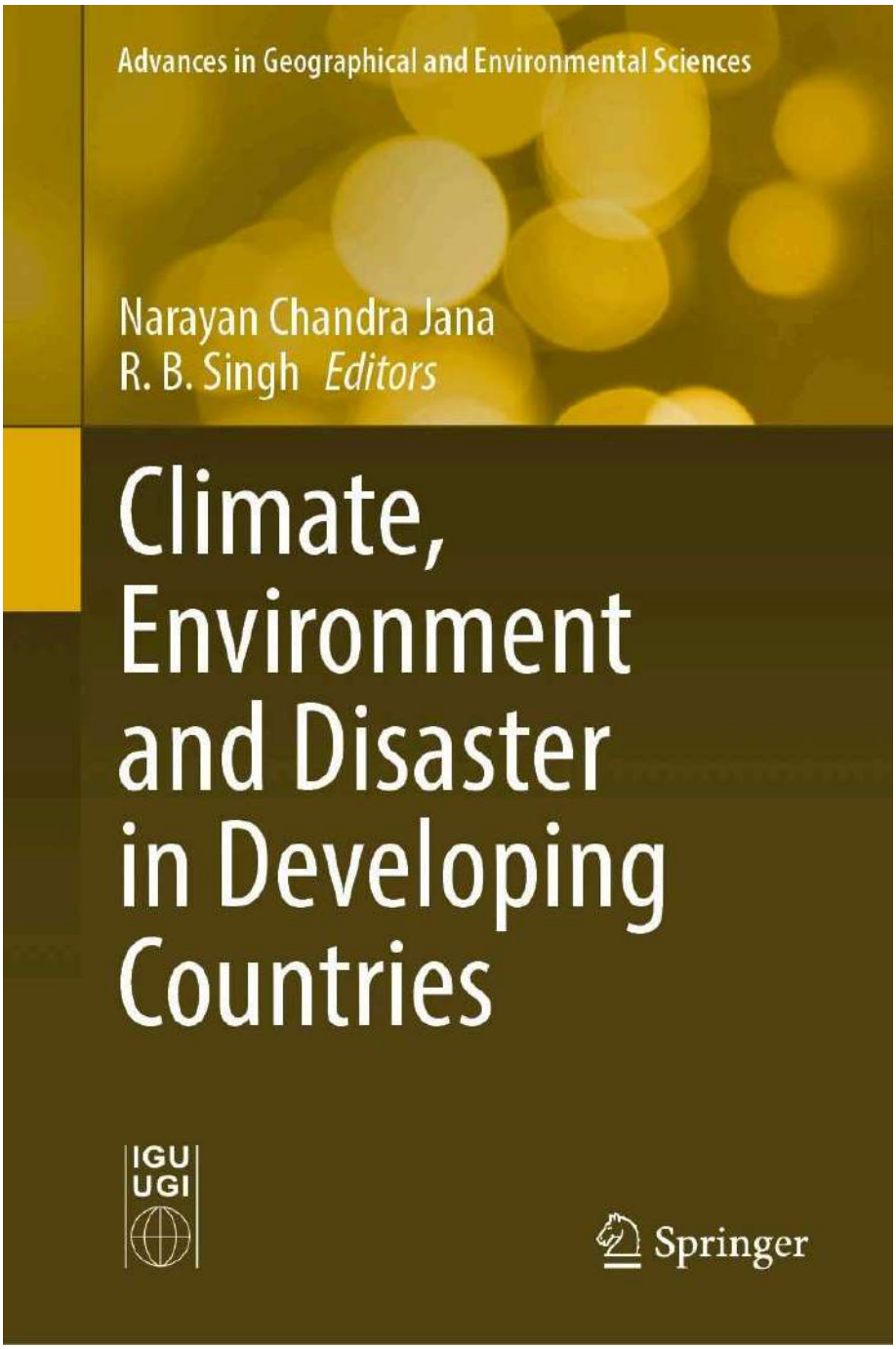
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Chapter 10
Mapping and Reclamation of Wastelands in Drought-Prone Purulia District of West Bengal, India Using Remote Sensing and GIS

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 (NRSA2007; 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^2, of which Purulia alone has 470.19 km^2 (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; Sugumaran 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 Barddhaman, Bankura, and Jharagram of West Bengal, India. Total geographical area of the district is 6,259 km^2.

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

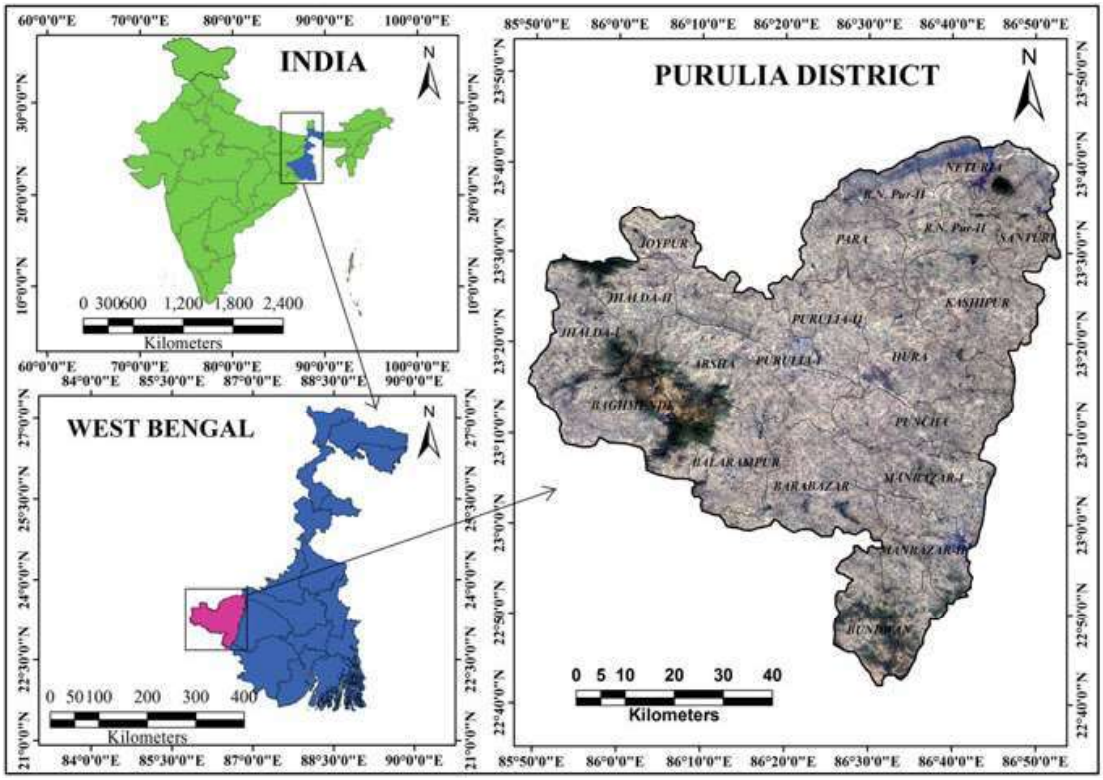

Fig. 10.1 Location of the study area

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

biodte granite gneiss, prophyroblastic granite gneiss, massive granite composite gneiss, augen gneiss, and migmatites (Chatterjee 1946). The Chotonagpur 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

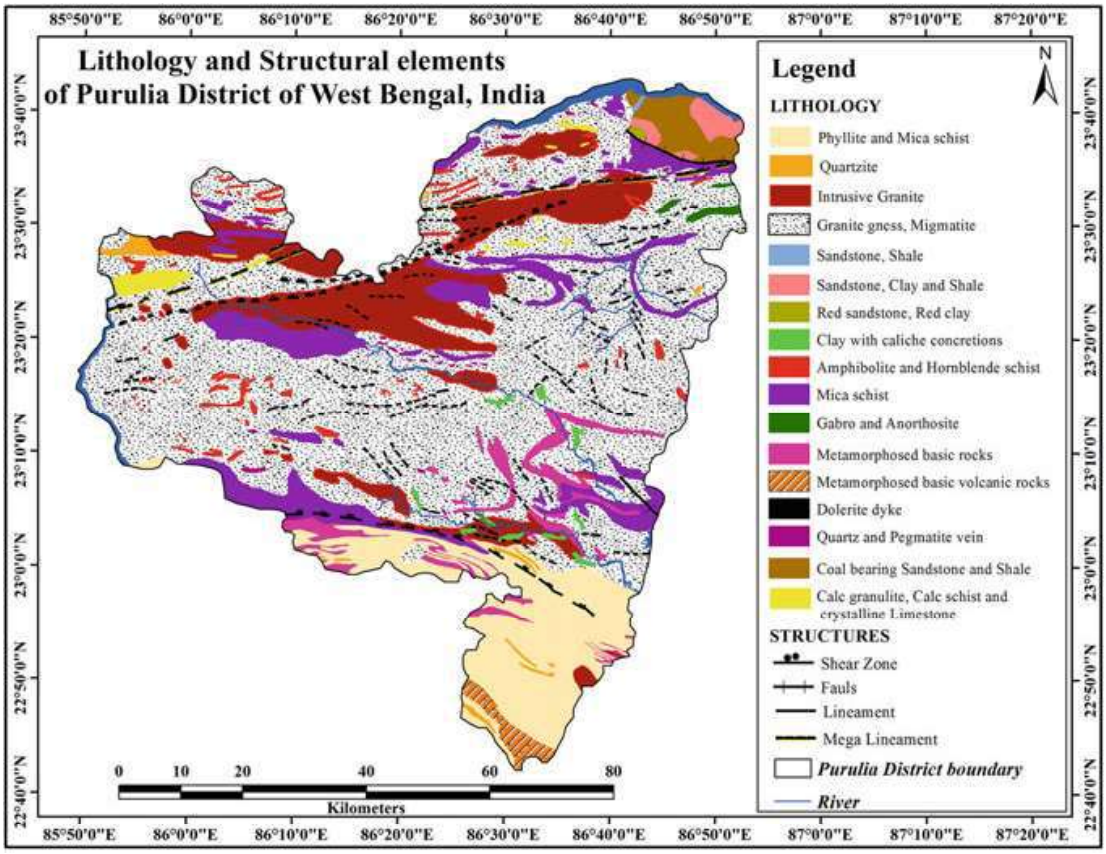

Fig. 10.2 Lithology and structure of Purulia District, West Bengal, India. *Source* Geological Map, published by Geological Survey of India, Kolkata, 2001

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.

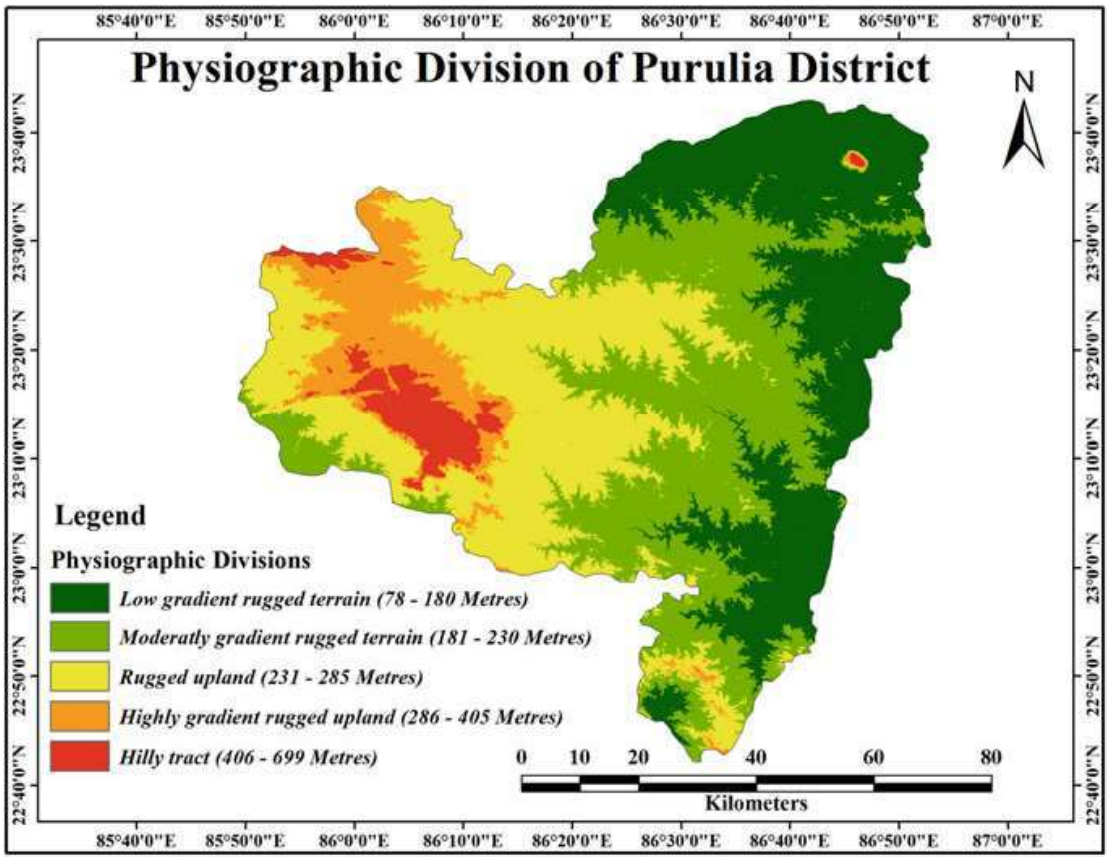

Fig. 10.3 Physiographic division of Purulia District. *Source* ASTER DEM, September 2014

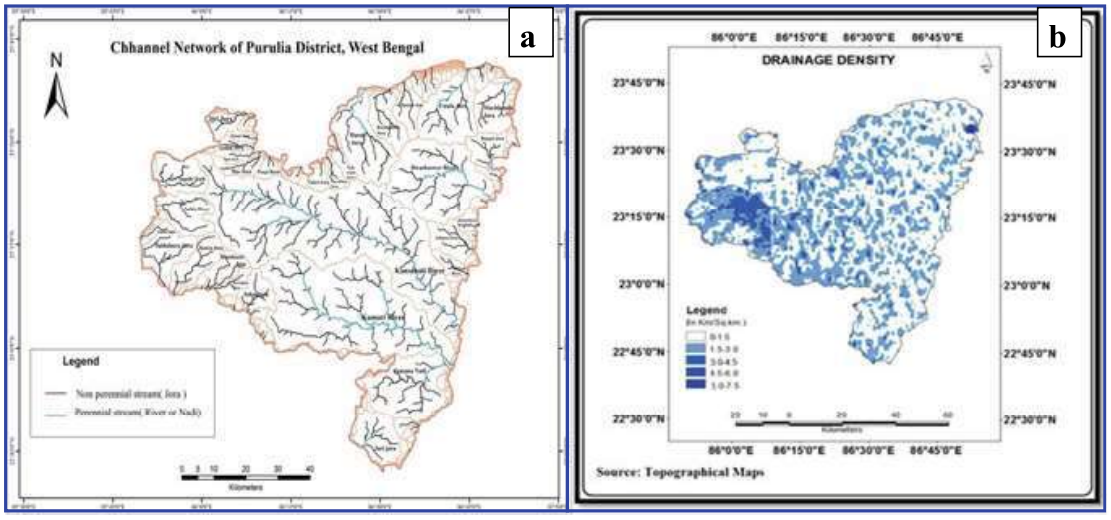

Fig. 10.4 Drainage System of Purulia District, **a** showing the channel network of Purulia District; mainstream of Kangsabati, Kumari, and Dwarakeswar river are perennial. Apart from these mainstreams, all the tributaries of these rivers are non-perennial. **b** is showing the drainage density of the 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 *Drainage length/area in sq.km*
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) www.soinakshe.uk.gov.in	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.

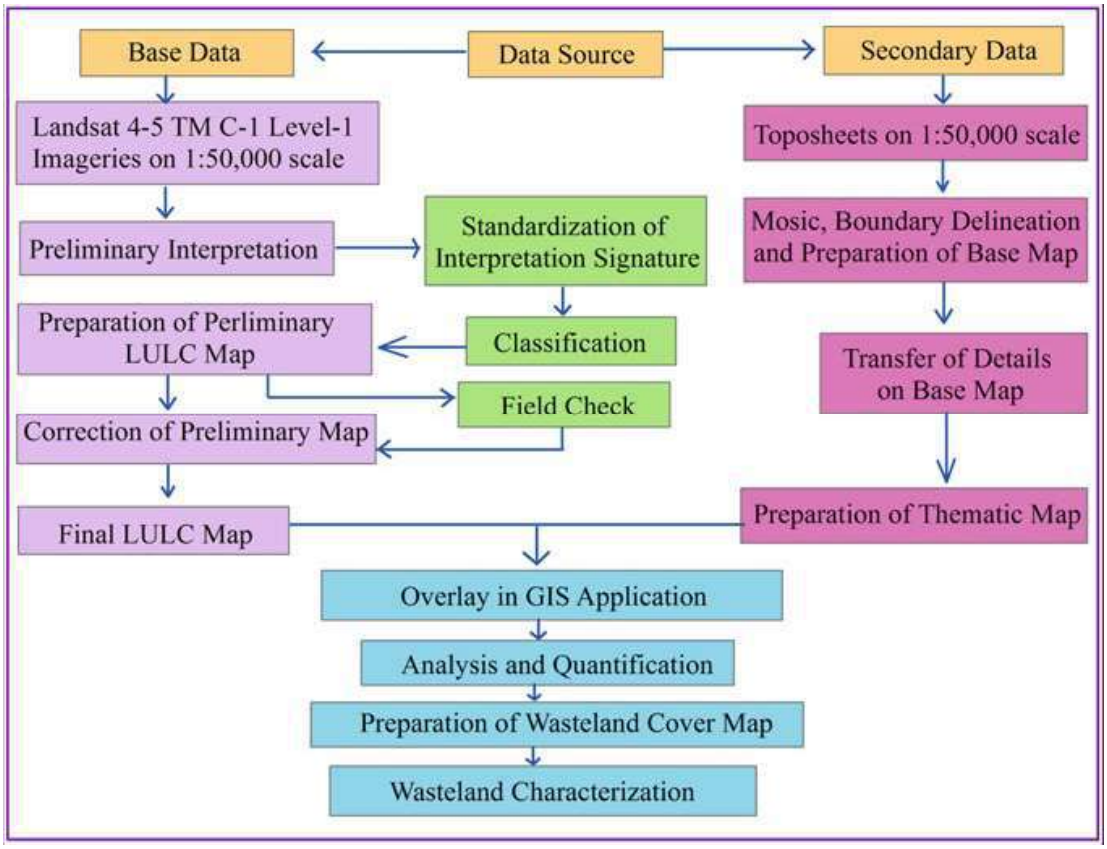

Fig. 10.5 Flow Chart showing an overview of wasteland mapping methodology

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 Tranverse 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 Inamdar 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.

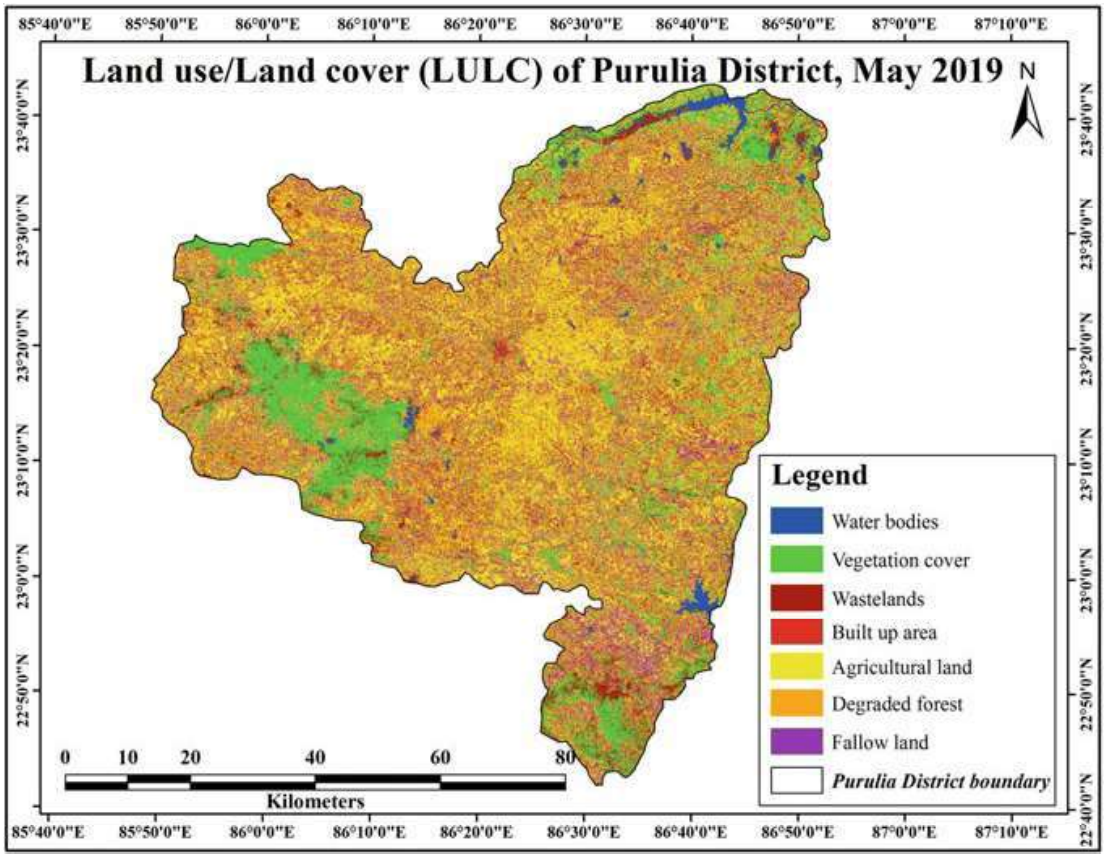

Fig. 10.6 Land use/Land cover (LULC) of Purulia District. *Source* Landsat 8 imagery, May 2019

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^2	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).

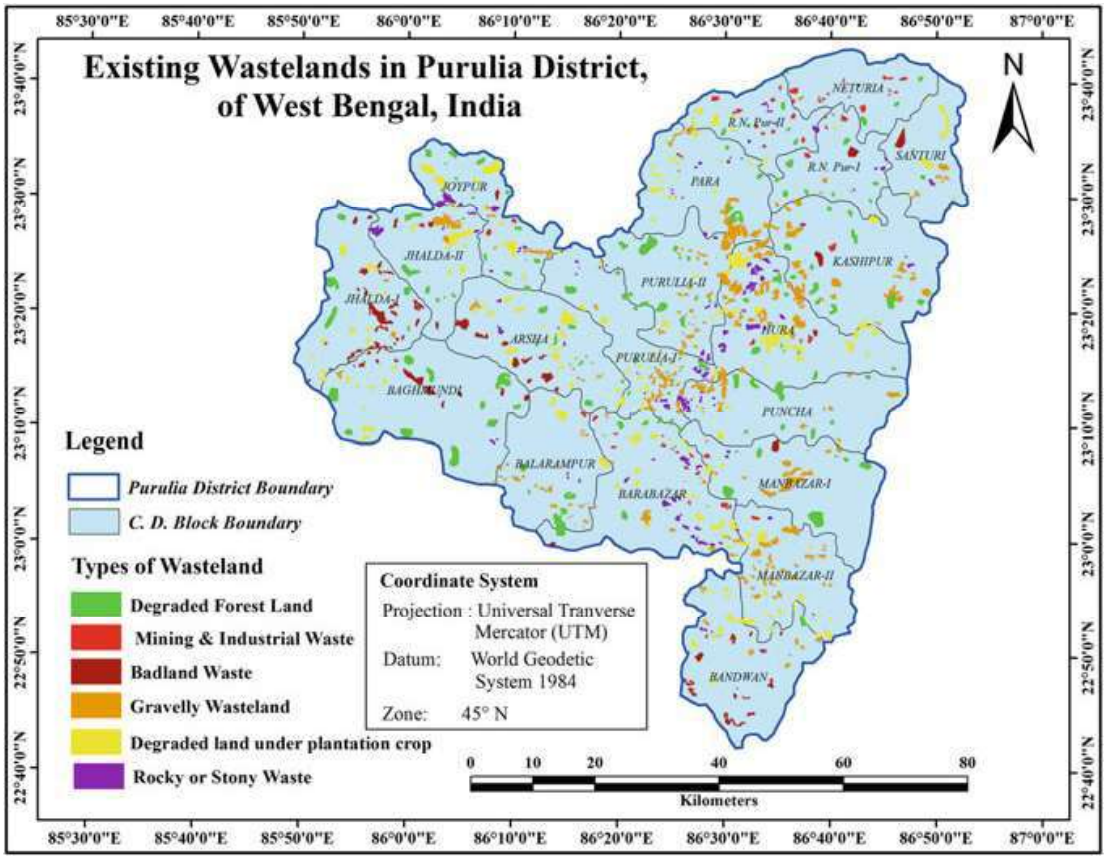

Fig. 10.7 Different categories of existing wastelands of Purulia District. *Source* SOI toposheets, Landsat-8 OLI/TIRS C-1 Level-1 satellite images and field survey

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^2. (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 × 100; C. D. Block wise share in % = Total Wastelands Area of specific C. D. Block/grand total wasteland area (47,193.00) × 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

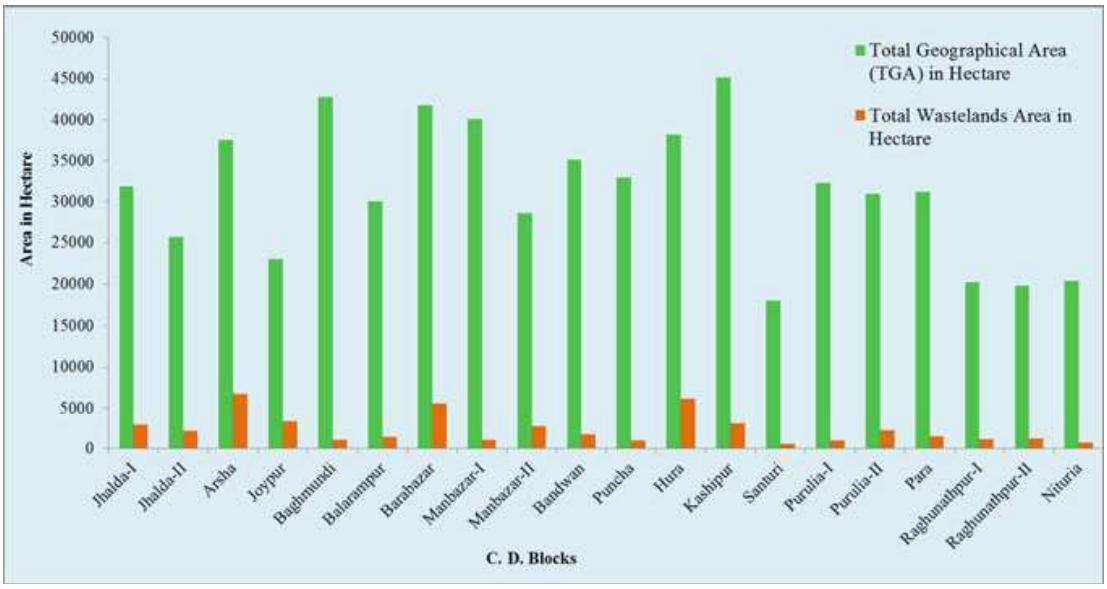

Fig. 10.8 Amount of wasteland to the total geographical area of the Purulia District. *Source* Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

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.

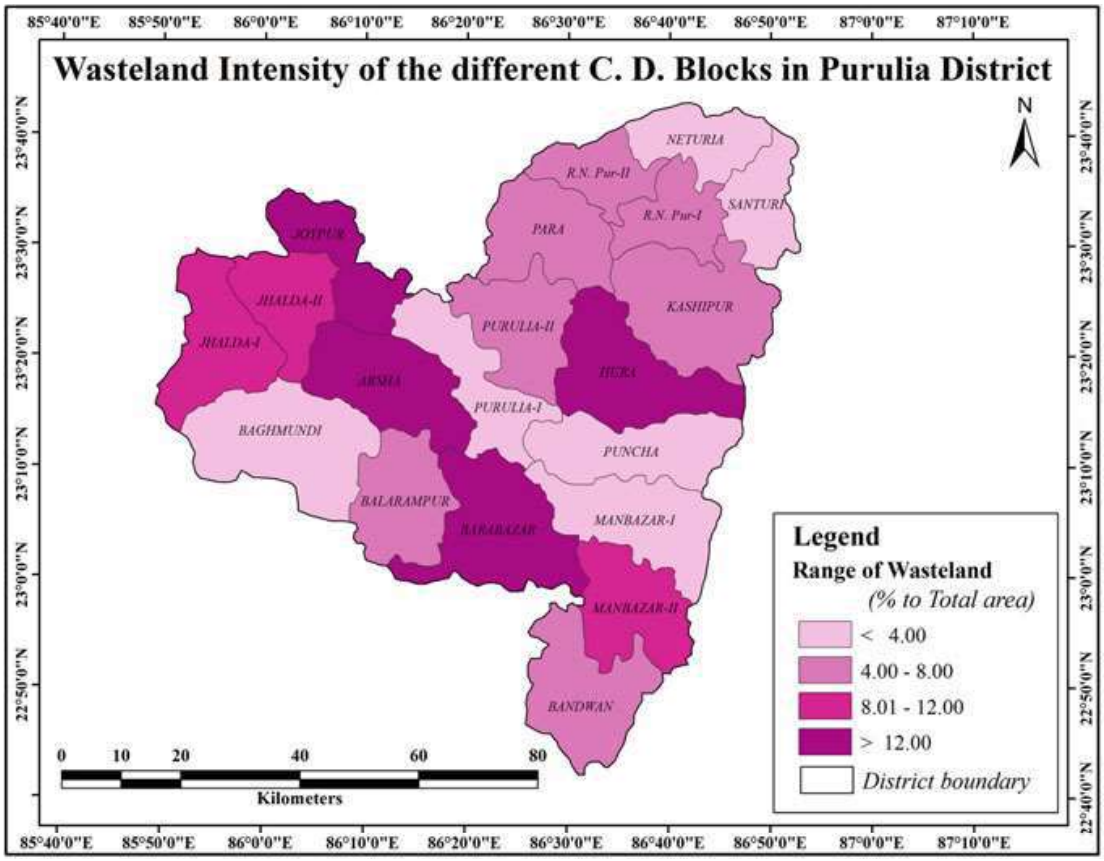

Fig. 10.9 Intensity of wasteland of the different C. D. Blocks in Purulia District. *Source* Landsat-8 OLI/TIRS C-1 Level-1 satellite imageries, SOI toposheets and field survey

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.

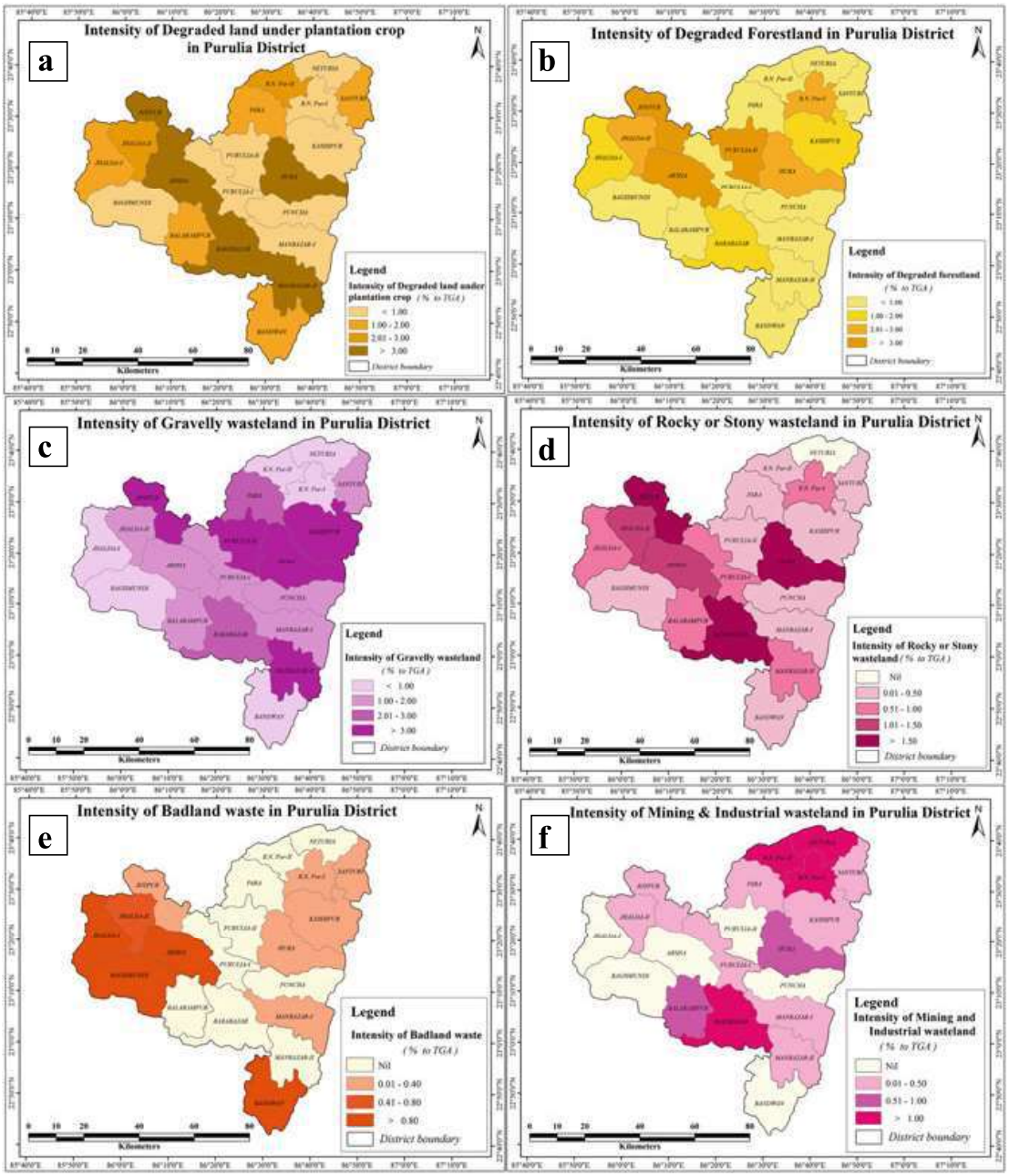

Fig. 10.10 Distribution of categories of wasteland; **a** distribution of degraded land under plantation crop among the C. D. Blocks, **b** distribution of degraded forestland among the C. D. Blocks, **c** distribution of gravelly wasteland among the C. D. Blocks, **d** distribution of rocky or stony 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. ***Sanaijhuri*** 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 Latpoda 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** ***Panjania 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 imaginary 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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References

Anderson JR, Hardy EE, Reach JT, Witmer RE (1976) A land use and land cover classification system for use with Remote Sensor data. US Geological Survey Professional Paper, 964. https://www.researchgate.net/publication/287997665

Baidya TK, Chakrabarty PS, Orubetskoy E, Kiltova VJ (1987) New geochronologic data on some granitie phases of the chhotonagpur granite gneiss complex in the northwestern Purulia district, West, Bengal. Ind Jr Earth Sci XIV(2):136–141. https://www.osti.gov/etdeweb/biblio/5121618

Ball V (1881) Geology of Manbhum and Singhbhum. Mem Geol Surv Ind 18:61–90

Barchyn TE, Martin RL, Kok JF, Hugenholtz CH (2014) Fundamental mismatches between measurements and models in aeolian sediment transport prediction: the role of small-scale variability. Aeol Res 15:245–251. https://doi.org/10.1016/j.aeolia.2014.07.002

Basavarajappa HT, Manjunatha MC (2014) Geoinformatic techniques on mapping and reclamation of wastelands in Chitradurga District, Karnataka, India. Int J Comput Eng Technol (IJCET) 5(7):99–110. https://www.researchgate.net/publication/281319668

Basavarajappa HT, Manjunatha MC, Pushpavathi KN (2015) Mapping and Reclamation of Wastelands through geomatics technique in precambrian Terrain of Mysuru District, Karnataka, India. Int J Civil Struct Eng 5(4):379–391. https://doi.org/10.6088/ijcser.2014050035

Basavarajappa HT, Pushpavathi KN, Manjunatha MC (2016) Mapping and reclamation of Wastelands in Yelanduru Taluk of Chamarajanagara District, Karnataka, India Using Geo-Informatics Technique. Int J Sci Res Sci Technol 2(3):91–98. https://www.researchgate.net/publication/303751359

Basavarajappa HT, Dinakar S (2005) Land use/land cover studies around Kollegal, Chamarajanagar district, using Remote Sensing and GIS techniques. J Indian Mineral 1:89–94. https://www.researchgate.net/publication/280066552

Bhattacharya BK, Ray P, Chakraborty BR, Sengupta S, Sen NN, Sengupta KS, Mukherji S, Maity T (1985, 2005) West Bengal District Gazetteers, Purulia, Government of West Bengal. Published by Narendra Nath Sen, State Editor, West Bengal District Gazetteers, Calcutta. www.wbpublibnet.gov.in

Breunig FM, Galvao LS, Formaggio AR (2008) Detection of sandy soil surfaces using ASTER-derived reflectance, emissivity and elevation data: Potential for the identification of land degradation. Int J Remote Sens 29(6):1833–1840. https://doi.org/10.1080/01431160701851791

Chandramohan T, Durbude DG (2002) Estimation of soil erosion potential using universal soil loss equation. J Indian Soc Remote Sens 30(4):181–190. https://link.springer.com/article/10.1007/BF03000361

Chatteijee SC (1946) Physiographic evolution of Chotonagpur. Geogr Rev (Calcutta) VIII 3–4:31–35

Chaturvedi OP, Kaushal R, Tomar JMS, Prandiyal AK, Panwar P (2014) Agroforestry for wasteland rehabilitation: mined, ravine, and degraded watershed areas. Adv Agrofor 10:233–271. https://doi.org/10.1007/978-81-322-1662-9_8

Contador JFL, Schnabel S, Gutierrez AG, Fernandez MP (2008) Mapping sensitivity to land degradation in Extremadura, SW Spain. Bolet´ın de la Asociaci´on de Ge´ografos Espa˜noles 53:387–390. https://doi.org/10.1002/ldr.884

Crosbishley, Pearce D (2007) Growing trees on salt-affected land, ACIAR impact Assessment series Report No. 51. www.aciar.gov.au

Datta SK, Chakraborty T (2017) District statistical handbook, Purulia, Bureau of applied economics & statistics, department of planning, statistics & programme monitoring. Government of West Bengal. http://www.purulia.gov.in/distAdmin/departments/baes/baes.html

De NK, Jana NC (1996) The land: multifaceted appraisal and management. Sri Bhumi publishing co., Calcutta

Dunn JA (1929) The Geology of North Singhbhum including parts of Ranchi and Manbhum district. Mem Geol Surv Ind vol LIV:1–66

Dunn JA (1935) Late Tertiary uplift in Singhbhum. Proc As Soc Bengal XXIX:285–288

Dunn JA, Dey AK (1942) The geology and petrology of eastern Singhbhum and surrounding areas. Mem Geol Surv India LXIX(2):281–456. https://books.google.co.in/books/about/The_Geology_and_Petrology_of_Eastern_Sin.html?id=EE1RAQAAIAAJ&redir_esc=y

Dwivedi RS, Sankar TR, Venkataratnam L (1997) The inventory and monitoring of eroded lands using remote sensing data. Int J Remote Sens 18(1):107–119. https://doi.org/10.1080/014311697219303

Ghosh S (2012) Geomorphic Land Evaluation for Sustainable Use of Land Resources in Puruliya District, West Bengal. J Lands Syst Ecol Stud 35(1):263–274

Government of India (2016) Ministry of agricuture and farmers welfare: Deparment of Agriculture, C. and W, India Annual Report 2016–17, 194. http://agriculture.gov.in/

Grunwald S (2013) The current state of digital soil mapping and what is next. Boetinger JL, Howell DW, Moore AC, Hartemink AE, Kienst-Brown S (eds) Digital soil mapping: bridging research, production and environmental applications. Springer, Heidelberg, Germany, pp 3–12. https://www.springer.com/gp/book/9789048188628

HARSAC (2006) Haryana Space Applications Centre, Wastelands Atlas of Haryana, Haryana State Remote Sensing Application Centre, Department of Science and Technology, Government of Haryana

Jain AK, Hooda RS, Nath J, Manchanda ML (1991) Mapping and monitoring of urban land use of Hisar Town, Haryana using remote sensing techniques. J Indian Soc Remote Sens 19(2):125–134. https://link.springer.com/article/10.1007/BF03008127

Jha VC (1987) Wasteland types and their effective utilization in Birbhum District. The Deccan Geographer. Secunderabad 15(2 & 3):231–242

Khatun S, Debnath GC (2014) Identification and mapping of wasteland in Birbhum District, West Bengal. Int J Adv Remote Sens GIS 3(1):713–722. http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-313

Kohli RK, Garg VK, Dhawan A, Pandey P, Choudhary BK (2018) Applications of remote sensing and GIS in wasteland mapping. Environ Sci 6:5–31. https://www.researchgate.net/publication/323411930

Luna RK (2006) Plantation forestry in India. Offset Printers and Publishers, Dehradun, pp 361–386

Metternicht IG, Zinck AJ (2008) Remote sensing of soil salinization: impact on land management. CRC Press, Taylor & Francis Group, Boca Raton, Fla, USA, pp 257–272. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.523.5717&rep=rep1&type=pdf

Mishra CSK, Rath M (2013) Wasteland reclamation: novel approaches. Ecoscan 3:99–105. http://theecoscan.in/JournalPDF/Spl2013_v3-15%20C.%20S.%20K.%20Mishra.pdf

Mulder VL, de Bruin S, Schaepman ME (2013) Representing major soil variability at regional scale by constrained Latin Hypercube Sampling of remote sensing data. Int J Appl Earth Obs Geoinf 21(1):301–310. https://doi.org/10.1016/j.jag.2012.07.004

Mustak S, Baghmar NK, Singh SK (2015) Prediction of industrial land use using linear regression and MOLA techniques: a case study of Siltara industrial belt. Lands Environ 9(2):59–70. https://doi.org/10.21120/LE/9/2/2

National Atlas & Thematic Mapping Organisation (2010) Annual Report 2009–10. Government of India, Kolkata, (Deptt. of Science & Technology), pp 7–8

National Commission on Agriculture (1976). Report of the national commission on agriculture, ministry of agriculture and irrigation. Government of India, New Delhi, India. http://krishikosh.egranth.ac.in/handle/1/2041447

National Council of Educational Research and Training (2016) Land resources and agriculture. India: People and Economy, XII Level book chapter, 5, pp 40–44. http://ncert.nic.in/ncerts/l/legy205.pdf

Nawar S, Buddenbaum H, Hill J (2015) Digital mapping of soil properties using multivariate statistical analysis and ASTER data in an Arid region. Remote Sens 7(2):1181–1205. https://doi.org/10.3390/rs70201181

NBSS & LUP (2010) Forest Soils of Puruliya district, West Bengal, Report No. 794, 10. https://www.nbsslup.in/kolkata.html

NRSA (1987) Manual of procedure for wasteland mapping using remote sensing techniques. National Remote Sensing Agency, Hyderabad.

NRSA (2007) Manual of national wastelands monitoring using multi-temporal satellite data, National Remote Sensing Agency, Hyderabad. https://economictimes-indiatimes.com/topic/National-Remote-Sensing-Agency-in-Hyderabad

NRSC (2005) Wastelands Atlas of India. National Remote Sensing Centre, ISRO (DOS) Govt. of India, Hyderabad, India. https://dolr.gov.in/sites/default/files/West_Bengal.pdf

NRSC (2011) Wastelands Atlas of India 2011 (Change analysis based on temporal satellite data of 2005–06 and 2008–09. National Remote Sensing Centre, ISRO (DOS) Govt. of India, Hyderabad, India. https://dolr.gov.in/sites/default/files/Wastelands_Atlas_2011.pdf

NRSC (2019) Wastelands Atlas of India 2019. National Remote Sensing Centre, ISRO (DOS) Govt. of India, Hyderabad, India. https://dolr.gov.in/sites/default/files/West%20Bengal_0.pdf

NRSC/ISRO (2010) Wastelands Atlas of India, change analysis based on multi-temporal satellite data. Version 1, pp 1–16. https://dolr.gov.in/sites/default/files/west%20Bengal.pdf

NWDB (1987) National Wasteland Development Board, Description, classification, identification and mapping of wastelands. Ministry of Environment and Forests, Government of India, New Delhi

Paudel D, Thakur JK, Singh SK, Srivastava PK (2015) Soil characterization based on land cover heterogeneity over a tropical landscape: an integrated approach using earth observation data sets. Geocarto Int 30(2):218–241. https://doi.org/10.1080/10106049.2014.905639

Pramila R (1994) Assessment of soil degradation Hazards in Jalor and Ahor Tehsil of Jalor district (Western Rajasthan) by remote sensing. J Indian Soc Remote Sens 22(3):169–181. https://link.springer.com/article/0.1007/BF03024778

Ramachandra TV (2007) Comparative assessment of techniques for bio-resource monitoring using GIS and remote sensing. ICFAI J Environ Sci 1(2):2–8. https://www.researchgate.net/publication/256453918_Comparative_assessment_of_techniques_for_bioresource_monitoring_using_GIS_and_Remote_sensing/link/00b49522afb183a525000000/download

Rao DP (1999) Remote sensing application for land use and urban planning: retrospective and perspective. In: Proceedings of the ISRS national symposium on remote sensing application for natural resources retrospective and perspective, Bangalore, India, pp 287–297

Rao DP, Gautam NC, Sahai B (1991) IRS-1A application for Wasteland mapping. Current Sci 61(25):3–4. https://www.researchgate.net/publication/323411930_Applications_of_Remote_Sensing_and_GIS_in_Wasteland_mapping

Rawat KS, Mishra SV, Singh SK (2018) Integration of earth observation data and spatial approach to delineate and manage Aeolian Sand-affected Wasteland in highly productive lands of Haryana, India. Int J Geophys 2847504:1–7. https://doi.org/10.1155/2018/2847504

Ray S (1982) Some aspects of geoecological adjustment in the upper Kangsabati basin‖, West Bengal. Ind Jr Lands Syst, Calcutta, 5(1–2):25–27. https://shodhganga.inflibnet.ac.in

Roy A, Inamdar AB (2018) Multi-temporal Land Use Land Cover (LULC) change analysis of a dry semi-arid river basin in western India following a robust multi-sensor satellite image calibration strategy. Heliyon 5:e01478. https://doi.org/10.1016/j.heliyon.2019.e01478

Saha SK, Kudrat M, Bhan SK (1990) Digital processing of Landsat TM data for wasteland mapping in parts of Aligarh District (Uttar Pradesh), India. Int J Remote Sens 11(3):485–492. https://doi.org/10.1080/01431169008955034

Sharma A, Moorti T, Chauhan SK (2007) A study on the estimation of wasteland and proposed strategy for their regeneration in Western Himalayas; agricultural situation in India 47 CSSRI–2007. Annual Report 2006–07

Singh AN (2006) Geospatial database for sustainable reclamation of degraded lands. In: Proceedings of the abstracts of the ISPRS TC-IV international symposium on geo spatial databases for sustainable development, Goa, India, 151–152

Singh RP (1969) Geomorphological evolution of Chotanagpur highlands. Nat Geog Soc Ind Varabasi 5:4–29. https://search.library.wisc.edu/catalog/999615257002121

Singh S (1978) Physiographic regions, landforms and erosion surfaces of the Ranchi Plateau. Nat Geograph 12 (l):43–65

Singh S (2012) Common lands made 'Wastelands' making of the 'Wastelands' into Common Lands. Ecol Secur 7(5):14–33. https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/9074/SINGH_0217.doc.pdf?sequence=1&isAllowed=y#:~:text=In%20the%20Panjab%2C%20the%20areas,for%20the%20extension%20of%20cultivation

Singh SK, Kewat SK, Aier B, Kanduri VP, Ahirwar S (2012) Plant community characteristics and soil status in different land use systems at Dimapur, Nagaland, India. Forest Res Papers 73(4):305–312. https://doi.org/10.2478/v10111-012-0029-x

Singh SK, Mustak S, Srivastava PK, Szab´o S, Islam T (2015) Predicting spatial and decadal LULC changes through cellular automata markov chain models using earth observation datasets and geo-information. Environ Process 2(1): 61–78. https://link.springer.com/article/ https://doi.org/10.1007/s40710-015-0062-x

Singh SK, Pandey AC, Singh D (2014) Land use fragmentation analysis using remote sensing and Fragstats. In: Srivastava PK, Mukherjee S, Islam T, Gupta M (eds) Remote sensing applications in environmental research. Springer International Publishing, Cham, Switzerland, 9, pp 151–176. https://link.springer.com/chapter/10.1007/978-3-319-05906-8_9

Singh SK, Singh CK, Mukherjee S (2010) Impact of land use and land-cover change on groundwater quality in the Lower Shiwalik hills: a remote sensing and GIS based approach. Cent Eur J Geosci 2(2):124–131. https://link.springer.com/article/10.2478/v10085-010-0003-x

Singh SK, Srivastava PK, Szabo SG, Petropoulos P, Gupta M, Islam T (2017) Landscape transform and spatial metrics for mapping spatiotemporal land cover dynamics using Earth Observation data sets. Geocarto Int 32(2):113–127. https://doi.org/10.1080/10106049.2015.1130084

Sreekala S, Neelakantan R (2015) Mapping of wasteland and change detection using geospatial data - a case study from Annavasal block of Pudukkottai District, Tamilnadu, India. Int J Innov Sci Eng Technol 2(12):707–714. http://ijiset.com/vol2/v2s12/IJISET_V2_I12_77.pdf

Srivastava PK, Singh SK, Gupta M, Thakur JK, Mukherjee S (2014) Appraisal of land use/land cover of mangrove forest ecosystem musing support vector machine. Environ Earth Sci 71(5):2245–2255. https://doi.org/10.1007/s12665-013-2628-0

Sugumaran R, Sandhya G, Rao KS, Jadhav RN, Kimothi MM (1994) Potential of satellite data in delineation of wastelands and correlation with ground information. J Indian Soc Remote Sens 22(2):113–118. https://link.springer.com/article/10.1007%2FBF03023881

Szabo G, Singh SK, Szabo S (2015) Slope angle and aspect as influencing factors on the accuracy of the SRTM and the ASTER GDEM databases. Phys Chem Earth 83(84):137–145. https://doi.org/10.1016/j.pce.2015.06.003

Thakur JK, Srivastava PK, Pratihast AK, Singh SK (2012). Estimation of evapotranspiration from wetlands using geospatial and hydro-meteorological data in Geospatial Techniques for Managing

Natural Resources. Thakur JK, Singh SK, Ramanathan AM, Prasad BK, Gossel W (eds). Springer and Capital, pp 53–67. https://www.researchgate.net/_publication/271905531

Thakur JK, Srivastava PK, Singh SK (2012) Ecological monitoring of wetlands in semi-arid Konya closed basin, Turkey. Reg Environ Change 12(1):133–144. https://link.springer.com/article/10.1007/s10113-011-0241-x

Xiaoyan L, Wang Z, Kaishan S, Bai Z, Dianwei L, Zhixing G (2007) Assessment for salinized wasteland expansion and land use change using GIS and remote sensing in the west part of Northeast China. Environ Model Assess 131(1–3):421–437. https://doi.org/10.1007/s10661-006-9487-z

Yadav SK, Singh SK, Gupta M, Srivastava PK (2014) Morphometric analysis of Upper Tons basin from Northern Foreland of Peninsular India using CARTOSAT satellite and GIS. Geocarto Int 29(8):895–914. https://doi.org/10.1080/10106049.2013.868043