Chapter One

INTRODUCTION

Land Use and Land Cover are critical ingredients of human livelihood from the perspective of socioeconomic conditions, climatic changes and sustainability, and changes in the patterns of land use and land cover are emerging as critical components of global social, economic and climatic changes. It precipitates changes in socioeconomic condition of people associated with different kind of land cover, and as the usage of land changes, so does the social production relations. This has far reaching consequences on the economy and polity of a region. In addition, land cover changes may significantly interact with global biogeochemistry to alter future climate. Understanding the global implications of current trends necessitates interdisciplinary studies of regional patterns and processes of Land Use and Land Cover (LULC) changes (Graumlich, 1996).

UNDERSTANDING CHANGES IN LAND USE/LAND COVER

1. Defining Land Use and Land Cover

"Land cover is the biophysical state of the earth's surface and immediate subsurface" (Turner et al. 1995). In other words, land cover "describes the physical state of the land surface: as in cropland, mountains, or forests" (Meyer 1995, Moser 1996). Meyer and Turner (1994) add: “it embraces, for example, the quantity and type of surface vegetation, water, and earth materials. Moser (1996) notes that: “The term originally referred to the type of vegetation that covered the land surface, but has broadened subsequently to include human structures, such as buildings or pavement, and other aspects of the physical environment, such as soils, biodiversity, and surfaces and groundwater".
"Land use involves both the manner in which the biophysical attributes of the land are manipulated and the intent underlying that manipulation – the purpose for which the land is used" (Turner et al. 1995). In a similar vein, Meyer (1995) states that "land use is the way in which, and the purpose for which, human beings employ the land and its resources (Meyer 1995 cited in Moser 1996). Briefly, land use "denotes the human employment of land" (Turner and Meyer 1994). Skole (1994) expands further and states that "Land use itself is the human employment of a land-cover type, the means by which human activity appropriates the results of net primary production (NPP) as determined by a complex of socio-economic factors" (Skole 1994). Finally, FAO (1995) states "land use concerns the function or purpose for which the land is used by the local human population and can be defined as the human activities which are directly related to land, making use of its resources or having an impact on them".

In the words of Chapin and Kaiser (1979): "At territorial scales involving large land areas, there is a strong predisposition to think of land in terms of yields of raw materials required to sustain people and their activities. At these scales, 'land' is a resource and 'land use' means 'resource use'. In contrast, at the urban scale, instead of characterizing land in terms of the production potential of its soils and its submineral content, the emphasis is more on the use potential of the land's surface for the location of various activities". This connotation of the term "land use" is implicit in several other texts dealing with land use in the context of urban and regional analysis and planning (Hoover and Giarratani 1984, 1999).

The description of land use, at a given spatial level and for a given area, usually involves specifying the mix of land use types, the particular pattern of these land use types, the areal extent and intensity of use associated with each type, and some times also the land tenure status (Bourne 1982, Skole 1994).

It will have become apparent by now from the above discussion that land use and land cover are not equivalent, although they may overlap. Meyer and Turner (1994) state that "By land cover is meant the physical, chemical, or biological categorization of the terrestrial surface, e.g. grassland, forest, or concrete, whereas land use refers to the human purposes that are associated with that cover, e.g. raising cattle, recreation, or urban living". Land use relates to land cover in various ways and affects it with various implications. As Turner and Meyer (1994) state: "A single land use may correspond fairly well to a single land cover: pastoralism to unimproved grassland, for example. On the other hand, a single class of cover may support multiple uses (forest used for combinations of timbering, slash-and-burn agriculture, hunting/gathering, fuelwood collection, recreation, wildlife preserve, and watershed and soil protection), and a single system of use may involve the maintenance of several distinct covers (as certain farming systems combine cultivate
land, woodlots, improved pasture, and settlements). Land use change is likely to cause land cover change, but land cover may change even if the land use remains unaltered. Meyer (1995) adds the important point that “changes in land cover by land use do not necessarily imply a degradation of the land”.

Land use cannot be directly related to global change because it is a qualitative descriptor. Land use categories are abstract typologies that, although useful, cannot be meaningfully included in process models seeking to forecast the time and space patterns of global change. It is land cover, rather than land use, that has the mechanistic meaning in the processes of global environmental change (Graetz 1994).

However, the distinction between land use and land cover, although relatively easy to make at a conceptual level, is not so straightforward in practice as available data do not make this distinction clear all the time, a fact that complicates the analysis of either one of them. At the global level, “key sources of global data do not distinguish clearly between cover and use” (Meyer and Turner 1994). Skole (1994) provides more insights into these data problems. The links between land use and land cover are elaborated further in the next section.

2. Understanding Land Use and Land Cover Changes

In the analysis of land use and land cover change, it is first necessary to conceptualize the meaning of change to detect it in real world situations. At a very elementary level, land use and land cover change means (quantitative) changes in the spatial extent (increases or decreases) of a given type of land use or land cover, respectively. It is important to note that, even at this level, the detection and measurement of change depends on the spatial scale; the higher the spatial level of detail, the larger the changes in the areal extent of land use and land cover which can be detected and recorded.

However, both in the case of land cover as well as of land use, the meaning and conceptualization of change is much broader. In the case of land cover change, the relevant literature distinguishes between two types of change: conversion and modification (Turner et al. 1995; Skole 1994). Land cover conversion involves a change from one cover type to another. Land cover modification involves alterations of structure or function without a wholesale change from one type to another; it could involve changes in productivity, biomass, or penology (Skole 1994). Land cover changes are the results of natural processes such as climatic variations, volcanic eruptions, changes in river channels or the sea level, etc. However, most of the land cover changes of the present and the recent past are due to human actions – i.e. due to changes in uses of land for production or settlement (Turner et al. 1995). More specifically, Meyer and Turner (1996) suggest that “Land use alters land cover in
three ways: converting the land cover, or changing it to a qualitatively different state; modifying it, or quantitatively changing its condition without full conversion; and maintaining it in its condition against natural agents of change.

Similarly, land use change may involve either

(a) Conversion from one type of use to another – i.e. changes in the mix and pattern of land uses in an area, or

(b) Modification of a certain type of land use involving changes in the intensity of use as well as alterations of its characteristic qualities/attributes – such as changes from low-income to high-income residential areas (the buildings remaining physically and quantitatively unaltered), changes of suburban forests from their natural state to recreation uses (the area of land staying unchanged), and so on (Jones and Clark 1997).

As regards the spatio-temporal frame, the point is that local level land use changes may not produce significant local land cover change (and, consequently, significant environmental impacts). However, they may accumulate across space and/or over space and produce significant land cover changes at higher (e.g. regional or national) levels. This is the case, for example, of agricultural land conversion to urban use that result from the decision of the individual land owners to convert their farmland to non-farm uses. Similarly, land use changes may be more qualitative rather than quantitative at lower levels of spatial and temporal detail but they show up as quantitative changes at higher levels and in the longer run. For example, gradual and incremental changes in the types of crops grown at the farm scale or in the quality of land management may result in the long run in abandoned agricultural land or seriously degraded farmland (in other words a change in category from productive to non-productive land).

By definition, LULC changes are of two types – Land Cover changes and Land Use changes. While the former is the alteration of the physical or biotic nature of a site, for example, the transformation of forest to grassland; the later involves alterations in the human management of land, including settlement, cultivation, pasture, rangeland and recreation (Meyer and Turner, 1994). Both, land use and land cover changes are arguably most important factor of the many interacting components of global change that affect ecological systems and human livelihoods (Vitousek 1997). Human activities have played increasingly predominant role in changing the nature of a large percentage of the Earth's land surface, and this pace is accelerating in recent years. In terms of land transformation, agricultural expansion and depletion of forests and grasslands was greater in absolute terms over the 30 years between 1950 and 1980 than in the 150 years between 1700 and 1850 (Richards, 1990). Different types of human activities over the past three hundred years have resulted in vast changes in natural cover - a net loss of
approximately 6 million km² of forest, a net gain of about 12 million km² of cropland, and a net loss of approximately 1.6 million km² in wetlands (Turner et al. 1993).

The direct effects, the mechanism of which has not yet been understood fully, of this human induced land-cover change on global biogeochemistry, and therefore climate, are recognized as having substantial impact. The conversion of natural to human-managed systems over the past 150 years has resulted in a net flux of CO₂ to the atmosphere about the same to that released over the same period due to fossil fuel burning; the current release of CO₂ from land-cover change is about 30 per cent of that from fossil fuel combustion. Land use and land cover change represents the largest human source of N₂O emissions (Turner et al. 1993). It is clear that credible projections of the trajectory of trace-gas induced changes in climate necessitate an ability to forecast trends in LULC changes, and their likely impacts.

Moreover, while these changes are likely to alter climate on time scales of decades or more, there are more immediate implications of accelerating rates and patterns of LULC change on local ecological systems. Land-use changes deeply affect structure, function, and complexity of local ecology with critical implications for maintenance of biodiversity at genetic, species, and landscape scales (NCR, 1993, Vitousek 1994). From an economic standpoint, on the other hand, accelerating rates of LULC changes are likely to strain our capacity to meet basic natural resource needs of many of the indigenous groups of people (Kates and Haarmann 1992). These issues of adverse impact on the sustainability of our environmental and our livelihood are major areas of concern for global opinion makers.

**IMPORTANCE OF ANALYSING LAND USE CHANGE**

Spurred by these concerns, global academic community is revisiting the long-standing inquiry into the patterns and processes of land transformation (Marsh 1965, Thomas 1956, Turner et. al 1990, Vernadsky 1929). An internationally coordinated effort has been launched with the aim “to improve the understanding of the dynamics of land use and land cover change globally, with focus on improving the ability to project such change” (Turner et al. 1995). To facilitate a high degree of international and interdisciplinary co-ordination in this effort, IGBP and IHDP have developed a Science Plan for Land Use and Land Cover Change (LUCC) to guide
The general objectives of the LUCC Plans are:

i) To obtain a better understanding of global LULC driving forces;

ii) To investigate and document temporal and geographical dynamics of LULC;

iii) To define the links between sustainability and various land uses; and,

iv) To understand the inter-relationship between LULC, biogeochemistry and climate.

This will lead to an improvement in the development of regional and global models and projections of land use and land cover change. To formalize such knowledge, we need to produce, compile and integrate suitable data; analyze these data to bring out the local factors determining LULC changes and the impact of such changes on geography, economy, society and sustainability.

However, only a few historical datasets on LULC exist which are spatially comprehensive and accurate and readily adaptable for LUCC research. Even when datasets are present, there is a general dearth of analyzing those data and correlating them with the broader socio-economic characteristics of the region. The areas that need much better documentation and analysis include:

a) The state and distribution of existing land cover,

b) The rate & distribution of land cover conversion, both historical and current,

c) The underlying factors which determine land use and land management practices, and,

d) The likely changes in LULC given the current & historical trends and their impact.

Clearly, some combination of historical reconstruction and remote sensing is needed to refine the first two areas. The third area of uncertainty will require closer linkages of physical and social analysis.

Description of land use change documents changes from one type of land use to another over a given time period and within a given spatial entity. Changes in both the qualitative as well as the quantitative characteristics of land use are described, the level of detail conditioned by the spatial level of analysis and the availability of requisite data. Descriptive studies of land use change have provided the impetus for more thorough investigations of the “why” of these changes as well as for taking actions (policies) to counteract the negative impacts of the changes identified.

Explanation attempts to address the question of “why” these changes have occurred (or, are occurring) and to uncover the factors or forces that bring about these changes directly or indirectly, in the short or the longer run. The level of

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1 IGBP: International Geosphere Biosphere Programme; IHDP - International Human Dimensions Programme on Global Environmental Change.
explanation offered by any study is a matter of the chosen spatial and temporal level of analysis. Macro-analyses necessarily refer to global changes and take into account global explanatory factors or determinants of land use change. As the analysis moves towards lower spatial levels, explanation moves deeper into the social and psychological dynamics that underlie observed human behaviour and, consequently, land use change. Similarly, explanatory analyses over long time periods attempt to reveal the macro-forces that induce land use changes such as social, cultural and technological change. On the contrary, short-term explanatory analyses necessarily seek for more immediate factors affecting human behaviour that leads to land use change, although the influence of the larger macro-forces can be taken into account as conditioning the shorter-term phenomena. Explanatory studies employ more or less specific theoretical schemata that account for the main determinants of land use change and their intricate interrelationships.

In addition to describing and explaining land use change, an important purpose for conducting such analyses is to predict future changes in land use. Predictions may be unconditional or conditional. Unconditional predictions, also called trend extrapolations, provide future images of the land use patterns in an area that will exist if past trends continue into the future. Unconditional predictions may be mechanistic extrapolations of past land use change or, if they are informed by theory, they may be more thorough projections of past trends in the determinants and the resulting land use change into the future. Conditional predictions of land use change produce alternative land use futures of an area under hypothetical conditions or scenarios. Some analyses are conducted with the purpose of predicting land use changes caused by climatic change or by changes in future population, food and other habits and so on. Conditional predictions, based usually on scenario analysis, are frequently used in the context of policy making on issues of global change (e.g. climate change, biodiversity loss, and desertification). In both unconditional and conditional predictions, the critical issues are again the spatial and temporal level of analysis.

Another important purpose of the analysis of land use change is impact assessment. The contemporary interest is not so much on land use change itself as is on its various environmental and socio-economic impacts at all spatial levels. In addition, as policies are designed to address several of the environmental and socio-economic problems in which land use change contributes in one way or another, policy impact assessment has emerged as a significant scientific activity. The recent policy interest, specifically, is on the broader issue of sustainability of development as it is impacted by land use change triggered by proposed or implemented policies. Land use changes with adverse impacts - such as land degradation, desertification, depopulation, etc. - contribute negatively to the achievement of long term
sustainability as they reduce the natural, economic, human, and social capital available to future generations.

In the present study we seek to study the pattern of changing land use, land cover and development in the Damodar Delta of West Bengal. This region, as will be discussed later, has seen extensive expansion of agricultural and industrial activities in the last century, especially in the last quarter of it. This has been accompanied by increased human settlements. As a result, LULC changes have been prominent in the region. This calls in for exploring the trends, patterns, magnitude of such changes and the impact of them on the region. The study will make extensive use of Geographical Information System and Remote Sensing on one hand, and socioeconomic correlates on the other to explore these issues.