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LAND USE AND LAND COVER CHANGE -- *An Empirical approach of assessment to Man-Environment Relationship*

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Abstract:

Since pre-historic times marked environmental changes are going on in association with changing pattern of economy, society, culture and civilization. Multifaceted changes, transformation and conversions are the results of multi level pressures on ecosystems and the human dimensions of global environmental changes happen through a sub-set of multi-level driving forces which directly or indirectly alter aspects of the physical, economic, social and cultural environment in ways that have global as well as regional effects. The triggering forces for land use and cover changes may be bio-physical, technological, organizational and economical in nature. Land use and land cover change offers significant association with the functioning of socio-economic and environmental systems with important tradeoffs for sustainability, food security, biodiversity and the vulnerability of people and ecosystems to global change impacts. In terms of human dimension of land use change it has been ascertained that the globe is underlying a transformation from predominantly rural centric to urban society. In the last part of the 20th century the land has been mostly degraded with the increment of irrigated area around the world especially for meeting the demand of the huge population. The driving forces and crux of land use change may be sub-divided into two categories. - i) Direct or Proximate causes; ii) Indirect and root (inherent) causes. Proximate causes of land use change are primarily local and constitute instant human activities or immediate actions that originate from intended land use and physical actions that directly affect land cover; In contrast, underlying or root causes are fundamental forces, may originate from the regional or even global. However, most of those basic drivers leading to land use modification are usually endogenous, although they may also be influenced by exogenous factors as well. However, it is to be concluded that the whole biosphere, ecosphere and global system mechanism are directly affected by land use and land cover changes through bio-geo-physical, bio-geo-chemical and energy transformation processes.

INTRODUCTION

Landscape changes, transformation and conversions are the results of multi level pressures on ecosystems and all the human dimensions of global environmental changes happen through a sub-set of multi-level driving forces which directly or indirectly alter aspects of the physical, economic, social and cultural environment in ways that have global as well as national effects. Almost all natural cover including virgin forests, grasslands, wetlands and coastal areas around the globe often undergo diverse transformation and conversion in varying degrees. The triggering forces for land use and cover changes may be bio-physical, technological, organizational and economical in nature. Land use and land cover change is no doubt a long debated issue in relation to the human influence on global surface. The pace,

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magnitude and spatial reach of human intervention on the earth's land surface are unprecedented in connection with global environmental changes particularly in ecosystems and geo-environmental processes. Land use and land cover change not only affect the total ecosystem, affects the ability to biological system to support human needs also. However, the concept, nature, consequences and possible impacts of land cover and land use change on eco-spherical system is long range issue especially in relation to 'human dimension and environmental changes'. Concerns about the changes of land cover and land use change emerged in the purview of research regarding global environmental issues a few decades ago especially with the initiation of the problem of global warming and with the realization that the land cover change modifies surface albedo and thus surface-atmosphere energy exchanges, which have significant impact on regional climate. A wide range of fusion of land use and cover change on ecosystem goods and services were identified with primary concern on - i) biotic diversity worldwide; ii) Land degradation; iii) the ability of biological systems to support human needs. It may also determine the vulnerability of places and people to climate, economic or sociopolitical perturbations. In global effect LULCCs significantly affect the core system of the earth-system functioning.

Land use and land cover change offers significant association with the functioning of socio-economic and environmental systems with important tradeoffs for sustainability, food security, biodiversity and the vulnerability of people and ecosystems to global change impacts. Land cover change denotes the modification of land types by any means e.g. deforestation, desertification, gully formation, building and construction, urbanization etc. Whereas, land use change includes the modification of land cover types, e.g. intensification of agricultural management or any other changes in the farming system. Therefore LULCCs are the complex interactions among the socio-economic, organizational and environmental variables and much efforts on research should be devoted to the analysis of relations between land use and the socio-economic and the bio-physical variables that act as the 'driving forces' of land use change. In terms of human dimension of land use change it has been ascertained that the globe is underlying a transformation from predominantly rural centric to urban society. It has been observed that--

- a) Presently, North America, Europe and Latin America nearly 70% of total population has become urban and in Asia and Africa this figure is around 40% (Population Reference Bureau, 2007).
- b) By 2030 more than 60% of the world's population will be transformed to urban;
- c) During the last three centuries in the world nearly 1.2 million sq. km. of forests and woodlands, 5.6 million sq. km. of grass lands and pastures have been converted into other types of land use,
- d) The cropland has increased remarkably to 12 million sq. km. during the same span.
- e) Development and welfare have remained alien to the major section of human population of world over largely due to disparities in distribution and access to resources.

Inter and Intra National Trend of LULCCs -- Pre-historic to Recent:

The surface of the earth has got its present layout since historical times especially to meet the human needs and all the anthropogenic causes of global environmental changes happen through a subset of proximate causes. Since humans have controlled fire and domesticated plants and animals, they started to cleared forest to wring higher value from the land. A number of studies have estimated the status of LULCCs since pre-historic time to recent and it has been revealed that virgin areas represent 46% of the earth's land surface and forest covered about 50% of the earth's total area 8000 year ago, as opposed to 30% today. Croplands have expanded into forests, savannas, and steppes in all parts of the world to meet the demand for food and fodder. Conversion from virgin land to crop land since historical times has been estimated at a global scale during last 250 - 350 years by cropland inventory data based on a global land cover classification extracted from the compilation of maps and Remote Sensing images. It has been observed that the cropland area has increased globally from a 4.5 to 5 fold during three centuries and a 50% net increase just in 20th century. The area pasture increased to more than 6 times from 1700 to 1990; whereas, forest area has been decreased from 5000 - 6200 m ha in 1700 to 1800 - 2700 m ha in 1990. Europe, the indo-Gangetic plain and eastern China experienced first the most rapid expansion of crop land during the 18th century.

Year	Woodlands(10 ⁶ ha)	Tropical and Temperate Grasslands (10 ⁶ ha)	Cropland (10 ⁶ ha)	Pasture (10 ⁶ ha)
1700	5000 - 6200	3200	300 - 400	400 - 500
1990	4300 - 5300	1800 - 2700	1500 - 1800	3100 - 3300

Source: global LUCC, IGBP and IHDP

From the observation and analysis the significant message about most rapid land cover and land use changes in the past decades are:

- i) The net global decrease in forest area was 9.4 m.ha per year from 1990 - 2000. The total net forest change for the temperate regions was positive, but it was negative for the tropical regions.
- ii) South East Asia has experienced the highest rate of net land cover change (0.71% per year)
- iii) Forest degradation was most extensive in S.E. Asia (0.42% per year), lowest in Latin America (0.13% per year) and moderate in Africa (0.21% per year).
- iv) Historically, men always tried to increase agricultural output primarily involving more land into production. The highest concentration of farmland is found in Europe.
- v) After 1960, a decoupling between food production increase and cropland expansion has been recorded.
- vi) In the last part of the 20th century the land has been mostly degraded with the marked increase of irrigated area around the world, especially for meeting the demand of the huge population.
- vii) Forest cover on the globe has not only transformed to cropland but several other uses also. During last decade, pastures and unfertile cover have increased considerably in non-tropical Asia.
- viii) Urban population has been growing more rapidly than rural population worldwide, especially in developing countries. According to the UNO, the number of Class -I cities, Million cities, Megacities, Megalopolis and New towns have been developed at very faster rate worldwide due to rapid growing rate of urban population than rural population.

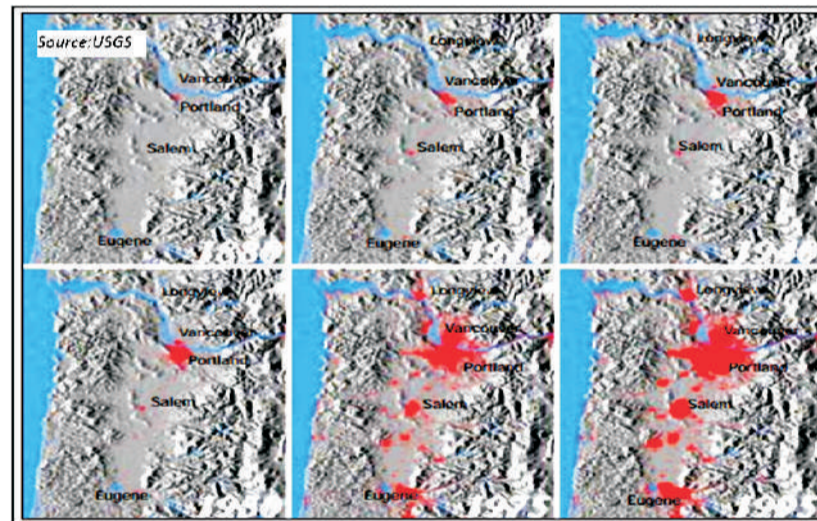


Fig. - 1-Sequential (Temporal) Land-cover change shown by Night-Time Image (Relief Shaded) detected by satellite lustrate.(Vancouver-Portland area, USA)

- ix) Another interesting fact has been highlighted from Night Time Image which is now used for enhancing the scene of real expansion of the urban areas. Temporal Images of globe of night time lights detected by satellite lustrate the rapid changes in both urban extent and electrification of the cities and their surroundings. The more expanded diameter of the electrified areas, the more will be the urban expansion or encroached by population.

Nature and Causes of land use and Land Cover changes - Empirical evidences

Conceptually, land cover is meant for the bio-physical attributes of the earth's land surface and immediate sub-surface including biota, soil, topography, landscapes, surface and ground water, and anthropogenic structures; whereas land use is more complicated in terms, than land cover. Land managers, today, define land use in relation to syndromes of human activities like agriculture, forestry and building and construction that alter land surface processes including biogeochemistry, hydrology and biodiversity. Economists and social scientists established land use more broadly to include the social and economic purposes and contexts for and within which lands are managed, such as subsistence Vs commercial agriculture, rented Vs owned or change is the transformation and re-orientation of earth's surface which is the direct and indirect consequence of human action to secure essential resources. Land cover transformations are measured by a shift one land cover to another category in the form of agricultural expansion, deforestation, or urban expansion. Land cover modifications are more subtle changes that affect the character of the land cover without changing its overall classification. More recently there has been increased recognition of the importance of the processes of modification of land attributes.

Purposefully, land use is the human exploitation of the land cover and practically exploited for human needs. High spatio-temporal variability in bio-physical environment, socio-cultural make up, economic and technological activities and cultural swings that are associated with the lands use modifications. The major aspects of land use change settled on the understanding of how the people prepare plan for land use and how several factors interact in specific contexts to influence decision making on land use which is furthermore influenced by factors within local, regional, or global scale. Land cover and land use change, since historic time, is the burning issue of environmental changes and accelerated dramatically, resulting from unscientific clearing and management of earth's terrestrial surface that continuing till today. More recently industrialization and intensification of tertiary economy encouraged the high concentration of human populations within urban areas which resulting the depopulation in rural areas.

The driving forces and crux of land use change may be sub-divided into two categories. -

i) Direct or Proximate causes; ii) Indirect and root (underlying) causes. Proximate causes of land use change are primarily local and constitute instant human activities or immediate actions that originate from intended land use and physical actions that directly affect land cover; In contrast, underlying or root causes are fundamental forces, may originate from the regional or even global levels with complex interplays between levels of organization, that underpin the proximate causes of land cover change. They enable their function from a distance, often altering one or more proximate causes which include political, social, economic, demographic, technological, cultural, institutional and biophysical variables that constitute initial conditions in the man-environment relations and are structural in nature. Underlying causes are often exogenous to the local communities managing land and are thus uncontrollable by these communities. Only some local factors are endogenous to decision makers. Changes in land use and land cover are the interplay between multiple factors originating from different levels of organization of the coupled human-environment systems. The co-action of driving forces of land use change varies in time and space, according to specific human-environment conditions. Driving forces can be slow variables, with long turnover times, which determine the boundaries of sustainability and collectively govern the land use trajectory, or fast variables, with short turnover times. Biophysical drivers may be as important as human drivers. Trigger events, whether these are biophysical or socioeconomic, also drive land-use changes. Such changes are usually driven by a combination of factors that work gradually and factors that happen intermittently.

i) Natural environmental change and variability interact with human causes of land-use change. Highly variable ecosystem conditions driven by climatic variations amplify the pressures arising from high demands on land resources, especially under dry to sub-humid climatic conditions. Natural and socioeconomic changes may operate as synchronous but independent events. Land use change, such as cropland expansion in dry lands, may also increase the vulnerability of human-environment systems to climatic fluctuations and thereby trigger land degradations.

ii) Economic and Technological variables are factors and policies which are related to individual and social responses to changing economic conditions, which are mediated by institutional factors. Economic conditions and policies offer a range of variables that create a direct impact on the decision making by land managers. The variables which act as catalyst are - production and transport costs, input and output prices, taxes, subsidies, capital flows and investments, credit access, trade, and technology. The unequal flow of resources among households, states, regions and countries highlight geographic

differences in economic opportunities and constraints. Thus, such unequal access of local wealth can directly change the land cover and quality,

iii) Demographic as well as non-demographic Variables like pattern of population distribution, density, growth pattern, fertility-mortality status, household structure and dynamics, migration etc. largely impact on land use modification. Thus, development of household and their life cycle (pastoral and nomadic) features, labour availability and breakdown of extended families into several nuclear families are evolved and consequently fuel wood demands, increase of croplands and forest degradation, especially in peri-urban units deserve special mention in this regard which can shape the trajectory of land use change. Among non-demographic factors migration commands a decisive role for land use change in various forms at timescales of a couple of decades. Migration, in this regard, treated as a significant driver with other non-demographic factors like government policies, changes in consumption patterns, economic integration and globalization which may provoke or intricately linked with accelerated migration.

iv) Institutional impact on land use change and their interactions with individual decision making is also significant in relation to political, legal, economic and traditional perspectives. Local, regional and national policies may change the land orientation. It is observed that distorted land use planning, ill-defined policies and weak institutional enforcement influence land use changes.

v) Individual thought and perceptions of land managers, beliefs, attitudes, values, individual histories, collective memories, intellects, motivations and several other cultural variables may influence land use planning and decision, sometimes intensively. Due to such internal behavior and attitude of land manager resource access and proper land use affected intensively. Globalisation and its multi-tire impacts can also amplify existing driving forces for land use change and from the recent findings from the research highlight that the process of globalization cannot directly drive the changing factors of land use, rather it is a process which may control the aforesaid driving forces, thus it actually acts as a 'buffer impact' of all those drivers of land use.

Access, Routes and Pathways of Land use changes:

Processes of land use and land cover change on the earth's surface are going on uninterruptedly and have dynamic effect on land use and land cover modifications. The explained drivers of land use change are closely linked within and between levels of organization of man-environment systems. Moreover, a number of human, economic and organizational syndromes of land use change processes are observed repeatedly around the world. Such Syndromes of land system changes include the following:

- i) Loss of productivity and subsequent transitional effects in sensitive areas following unscientific, inappropriate and unplanned land use planning;
- ii) Illegal and unscientific felling of trees and subsequent loss of forests on frontiers (forest) by weak state economies, especially for geopolitical reasons.
- iii) The transitional impact from communal to private land ownership in developing and under developed regions.
- iv) Ecological marginalization of the poor by land exploitation for large scale agriculture, construction of dams, forestry projects, tourism and wild life protection and conservation etc.
- v) Intensification of land use, especially, in the peri-urban and market accessible areas of developing areas.
- vi) Continuous transformation of rural to urban centers through urbanisation process and consequent changes in regional consumption patterns and income distribution with possible impacts on rural land use.
- vii) New economic opportunities linked to new market outlets, changes in economic policies or capital investments.
- viii) Policy intervention and planning strategies that drive modifications of landscapes and ecosystems.
- ix) The segregation of traditional nuclear families and its impacts on resource use efficiency.

However, despite the diversity of causes of land use change, there are some generalized patterns of change that result from recurrent interactions between driving forces.

Co-action, Association and Interactions of Land Use Change:

A number of studies have been carried forward in international and national perspective and from their inferences it has been ascertained that land use modification is primarily accelerated by a combination of basic high level forces:

- i) Resource scarcity to an increase in the pressure of production on resources due to natural growth of population, division of land parcels, domestic life cycles, loss of productivity etc. Moreover, encroachment by spontaneous migration exerting excessive pressure on land.
- ii) Changing scenario of infrastructure and amenities by increase in commercialization and agro-industrialization, improvement of accessibility offer new avenues to the land holders and land managers which is accelerated by new technologies and intensification of resources and capital investment.
- iii) Intervention of outside policies through economic development programs, Frontier development, Poor governance and corruption, insecurity in land tenure extensively accelerate the modification of land parcels.
- iv) Weak buffering capacity, no access to credit, lack of alternative income source, dependency on external resources resulting social discrimination in association with disease, crop failure, loss of resources and natural and quasi-natural hazards may accelerate the chances of land degradation and subsequent modification.
- v) Growth of urbanization, shift from communal to private right, segregation of nuclear families growth of individualism and materialism and poor flow of environmental information are also intricately responsible for land parcel re-designation and modification.

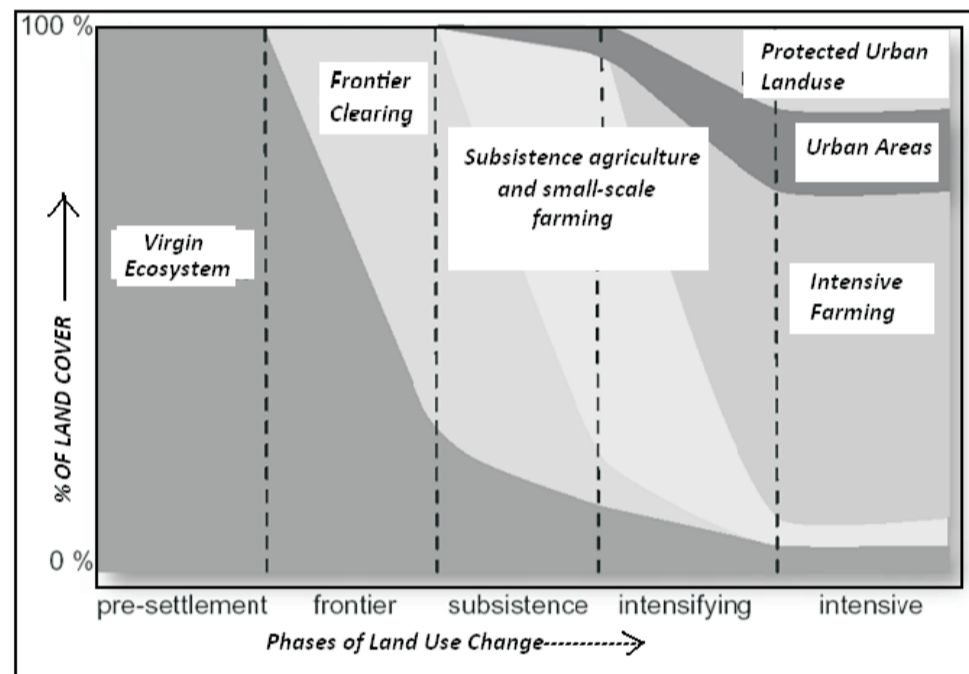


Fig. - 2- Land Use Change--Transitional Phases

Land Use Change - Transitional and Complex Adaptive System

Land use is never static; rather it is constantly changing in response to dynamic interaction between drivers and feedback from land use change to these drivers. Empirically, Land use can be connoted in the following clauses and adaptive elements and sub-elements:

Land use (P, O, PL, V, So.....); Where, P- Pressures; O- Opportunities; PL - Policies; V- Vulnerability and So - Social Organisation

Sub-elements of each respective element are also differentiated into various following sub-elements; these are:

- Pressures (population, labour supply, quality and quantity of resources)
- Opportunities (Market prices, production costs, Transportation costs, and Technology)

- Policies (Subsidies, Taxes, property rights, Infrastructure, and Governance ;)
- Vulnerability (Exposure to external perturbations, sensitivity and coping capacity)
- Social Organisation (resource access, Income variation, Household status, and Rural-urban interaction.)

In relation to LCLUCs human-environment relation is treated as complex adaptive systems in which properties of the entire systems influence the subsequent development of those interactions. Land use is a spatial property observed at the scale of a landscape. It is the aggregate of a number of small, local-scale changes which are the product of multiple decisions resulting from interactions between diverse agents. Land use change is thus a complex large scale spatial behavior that emerges from the aggregate interactions of less complex agents. LULCC is also associated with other societal and bio-physical changes through a series of transition. It results from a set of connected changes, which reinforce each other but take place in several different components of the system. Transitions in land use must be viewed as multiple and reversible dynamics. The specific concept of transition has been applied in land use change studies at different spatial and temporal scales from pre settlement to intensive and modern adaptive system..

Impacts and Consequences of Land use and Land Cover Change:

Historical evidences show that changes in land cover and land use are the direct and indirect consequence of human actions to secure essential resources. Essentially, a number of adverse consequences are noticed and recorded through different experimental observation.

By the significant as well as extensive changes of land use and land cover the first and foremost consequence is the bio-diversity loss. When land is transferred from natural forest to a farm, the loss of forest species in the deforested areas is the obvious and immediate result. Extensive research also revealed that species invasion by non-native plants, animals and diseases may occur more readily in areas exposed by LULCC, especially in proximity to human settlements.

Dramatic changes of land use and land cover also play a major role in climate change at global, regional and local scales. At global scale, LULCC is primarily responsible for releasing green house gases and so, also a major driving force for worldwide global warming. Moreover, it also the primary cause for the disturbance of soil and vegetation, deforestation, desertification, release of soil carbon and methane; and it also acts as a driver to alter the surface hydrology, land orientation, wetland drainage etc.

Notwithstanding that, land cover changes can alter the reflection of sunlight from land surface which is other prime driver of global climate change. Especially changes in cover by deforestation or dense vegetation and increase of concrete structure may alter the heat balance pattern and heat transfer processes. It has been ascertained that comparatively warmer temperature is observed in the urban areas in comparison to rural areas; so, the concept of heat island has been emerged.

Marked changes in LULCCs are also significant driver of different types of environmental pollution. Probably, the clearing of land due to removal of vegetation enhance the soil vulnerable to massive increase in soil erosion by natural agents; and make soil unfertile, reduce the suitability of land for agriculture including a variety of negative impacts.

Several other negative and destructive impacts are observed as environmental impact of LCLUCs. Destruction of stratospheric ozone layer by NO_x released from agricultural field, mines and alteration of local and regional hydrological pattern through dam construction, wetland drainage, irrigation projects, and increasing impervious surfaces in urban areas deserve special mention. Moreover, accelerating rate of growth of human population itself a great and long standing threat to land essentially by transforming productive and virgin forest lands to non-productive uses especially due to unnatural expansion of urbanization.

However, it is ascertained that the whole biosphere, ecosphere and global system mechanism are directly affected by land use and land cover changes through bio-geo-physical, bio-geo-chemical and energy transformation processes.

a)Recent incidents like Global warming, intensive flood, uneven fluctuation of temperature, recession of glaciers, gradual intensification of Paraglacial activities are distinct signals of climatic change at local, regional and global scale and all these are directly or indirectly affected by LULCCs. Key role played by the processes of uptake and release of greenhouse gases by the land cover of the terrestrial bio-sphere to and from the atmosphere through vital role played by plants. Variations in reflectance and absorbance of radiation as land-cover changes affect the surface albedo; and surface roughness effects on atmospheric

momentum that are land cover dependent.

b) Observation and studies of LULCCs also add indispensable information for long range vegetation biomass and vegetation cover assessments that are key components of the carbon cycle in the atmosphere and lithosphere..

c) Future assessment of LULCC and its ultimate goals include - i) estimation of accurate biomass, thus help to refinement of knowledge of carbon storage in vegetation; ii) the estimation of regional land use changes that affect biomass; iii) quantifying linkages and feedbacks between LULCC, climate change, and other related human and environmental components.

d) Different types of spatial data are used in spatial analysis of LULCC. In terms of spatial analysis absolute and relative scale, extent, resolution, hierarchy and levels are most important. Many high resolution satellite data sets are used to define and represent the forest extent, habitat fragmentation, enforce conservation laws, and thus possible to minimize greenhouse gas emissions from deforestation land use changes.

e) Each land cover type has different spectral characteristics, absorbing some frequencies of light and reflecting others. With an understanding of the reflectance characteristics and some ground observations it is possible to use remotely sensed data to make inferences about the type of land cover.

f) However, the Normalised Difference Vegetation Index (NDVI) uses multispectral scanner (Bands 2 and 4) to measure the absorption and reflectance of solar radiation. Usually, NDVI is correlated with Photosynthesis which occurs in the green parts of plant material the NDVI is normally used to estimate green vegetation, so related to estimation of land cover and land use changes.

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