ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 3, Issue, 7, pp.296-301, July, 2011

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

TERRAIN EVALUATION - A REVIEW

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ARTICLE INFO

Article History:
Received 17th April, 2011
Received in revised form
24th May, 2011
Accepted 15th June, 2011
Published online 16th July 2011

Key words:
Upland, Terrain,
Terrain Evaluation,
Land use model.

ABSTRACT

The main objective of this paper is to identify and fill up the voids in terms of concepts and methods of research work on 'Terrain Evaluation for Agricultural Land use And Planning in the Burdwan Upland, West Bengal'. This work will make suggestion relating to the research work to be conducted by research scholars on almost similar type of problems and methods. For achieving the target, the author has reviewed the literature previously presented. The whole literature survey has been attempted on almost all the main parts of the research topic. The previous works related to terrain evaluation, agricultural land use, land use model, statistical techniques, regional development disparity and Remote Sensing and Geographical Information System (GIS) etc. have enriched the present study.

INTRODUCTION

Terrain and its evaluation for particular purpose come under the sub-branch of geomorphology i.e. Applied Geomorphology. Terrain evaluation is very important for land use planning as it depicts the land suitability, e.g. while agriculture tends to favors flat fertile areas of little aesthetic charm, recreational and residential developments prefer the proximity of hilly or rocky areas. Land use of an area is directly influenced by the terrain characteristics. In the present work, discussion is categorized into three parts. The first part deals with the conceptual aspects, the second part with previous literature on different momentous aspects and third or the final part sums up the research gap and tries to give probable solution technique.

Conceptual Aspects

Conceptual aspects related to the topic like Upland, Terrain, Terrain Evaluation, Landuse, Agricultural Landuse, Landuse Planning etc. have been discussed briefly. Upland means the higher ground of a region contrasted with the valleys and plains or to lowland (Stamp, 1966). The term is also 'applied to higher ground, in contrast to lowland or lowlands' (Clark, 1985). So, upland is a land surface relatively with higher elevation than its surrounding areas generally characterized by undulating surfaces alternated with valleys and spurs of low magnitude. Terrain, the term is a derivative from terra, a Latin word meaning thereby 'earth'. In the Oxford Dictionary this term means 'standing ground' or 'position'. It also refers to 'any tract or region of earth's surface, considered, as a purely physical feature, an ecologic environment, a geologic setting or as a site of some applied activity of man- an engineering location, an architectural setting or a landscape analysed in terms of military science' (Fairbridge, 1968). Terrain is thus a facet of land with more or less homogeneous or uniform properties, uniformity not only in relief, but also in slope morphology, soil characteristics, drainage condition, vegetation cover and other natural features (Prasad and Mahto, 2009). In one sense the term is used to denote a 'region' with uniform properties of natural features and configuration. Terrain is, therefore 'the expression of the geological character, the soil and the surface geometry of the earth's crust' (Mitchell, 1973) and 'terrain studies are natural studies usually with an emphasis on relief – soil, vegetation, and drainage' (Stamp, 1968).

Terrain Evaluation, 'involves first analysis: the simplification of the complex phenomenon which is the natural geographic environment; secondly classification: the organization of data distinguishing one area from other and characterizing each; and the thirdly appraisal: the manipulation, interpretation, and assessment of data for practical ends' (Mitchell, 1973). The objective of terrain evaluation is to judge the value of an area for defined purpose. Various methods of terrain evaluation have been introduced by the American or the USDA (United States Department of Agriculture), the Canadian, the British, the USSR, the CSIRO (The Commonwealth Scientific and

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Industrial Research Organisation in Austraila), the Oxford MEXE (Military Engineering Experimental Establishment), the FAO (Food and Agriculture Organisation), Framework for Land Evaluation, the Parametric, the Land System method and many others (Mitchell, 1973; Ollier, 1978; Davidson, 1980; Prasad and Mahto, 2009). All the methods of terrain evaluation noted above are coming under two groups, the landscape method and the parametric method. The landscape method describes a land unit as an area or group of areas throughout which a recurring pattern of topography, soils and the vegetation can be recognized. In this method Aerial photographs and Satellite images can be used for interpretation. The parametric method, on the other hand, is defined as the classification and subdivisions of land on the basis of selected attribute values. The first one deals with more subjectivity and the second one with more objectivity but both are complimentary rather than conflicting.

Land use is the purpose to which the land cover is committed. Land-use change refers to any change in the use or management of land by humans, which may lead to a change in land cover. Land cover is the physical surface of the earth including various combinations of vegetation types, soils, exposed rocks and water bodies as well as anthropogenic elements such as agriculture and built environment. Land cover conversion means the complete replacement of one cover type by another. Land cover modification refers to subtle change which affects the character of the land cover without changing its overall classification (Lambin *et al.,* 2006). There are two types of causes responsible for landuse land cover change. One is the proximate cause (direct) related to direct human activity, which immediately affects the land cover. Another is the underlying (indirect) or root cause which acts from a distance and related with social, political, economic, demographic, technological, cultural, biophysical elements. It also alters the proximate cause (Lambin *et al.,* 2006). Actually land use land cover change is always caused by multiple factors rather than single factor. Different perspectives are there for the modeling and explanation of landuse change. Agent-based perspective is concerned with individual motivations behind decision making. It depends on individual understanding man-environment relation and affects the local/micro scale land use change. Systems perspective is concerned with the organization (Govt. or NGOs) and institutions (Governments, communities or market) of the society. System perspective tends to focus on gradual and progressive process of LUCC at large scale entities. Narrative perspective covers the historical details, interpretation and takes a large time horizon to solve the present problem. Historical record of LUCC is very significant for future projection.

Agricultural Land use – The term culture (derived from the Latin/ French cultural stemming from colere, meaning thereby 'to cultivate') has various meaning depending upon the contextual and historical perspectives (WCD, 1982). Agricultural, the primary economic activity includes not merely food grain production but also animal husbandry, forestry, mining, irrigation, pisciculture, dairy etc. (Zimmermann, 1933; Roy, 1992). Land is the most valuable aspect for agriculture. Therefore, land evaluation for agriculture is also essential. Land use Planning is necessitated for better use of land. The main objective of the land use planning is to get maximum output from every bit of land with a sustainable approach. 'It must be dynamic and flexible' (De, 1997).

Past Studies

Virtually no work on this particular topic has been made previously. However, the author has been benefited by getting various details published in books, reports, journals etc. related to her study area. The total work has been divided into some major parts like terrain evaluation and assessment, agricultural landuse, models of landuse and land cover change, application of Remote Sensing and Geographical Information System (RS & GIS), regional development disparity, statistical methods etc. terrain evaluation and landuse study. Geology is very momentous aspect of the Burdwan Upland because soil character depends mainly on geology and climate. The geological details of the study area are available in the books and reports written by Wadia (1970), Pasco (1963), Biswas (1994), Mukherjee (2008), Sarbadhikari (1974) and a host of others. These geological documents are carrying a mystical meaning with lot of information those are very fundamental one. The author has been acquainted with some of these great books. Wadia (1970) and Pasco (1963) have done a good work on geology. They have provided a lot of details about the geology of India. The author has got almost all the geological details of the Upland from their books. In 1974, Sarbadhikari gave his idea in a book written in Bengali which helped the author very much. Surface geology map has been prepared count on the basis maps of Raniganj Coalfield published by Geological Survey of India, Kolkata. Other geological details were obtained from the Burdwan District Resource Map, Kolkata.

Terrain Evaluation has been made with reference to a number of purposes particularly for landuse in general, agricultural landuse, urban landuse, settlement rationalization, transport and communication etc. by a host of scholars from India and abroad. The author has gone through all such studies related to her study area for getting conceptual ideas, methods and tools, important among them are the work of Way (1973), Mitcheel (1973), Ollier (1978), Mahto (1985), Patnaik (1993), Basu (1998), Prasad (2000, 2009), Khadse (2003), Bhattacharjee (2004). Some of these are giving the fundamental aspects. The books by like Mitcheel (1973), Ollier (1978), Hart (1986), Crais and Craft (1982), Prasad and Mahto (2009) are noteworthy. Some of the works made on some pockets of India have been very much beneficial to the author her work comfortably. Most of them are in the form of articles published in journals and edited books. Some of the works are in the form of doctoral theses submitted for doctoral degrees, most of them are unpublished, but are worth mentioning. The terrain of the Chhatrapur Subdivision in the Ganjam District of Orissa is evaluated by Patnaik (1993) for agricultural landuse. The author has deducted some major findings from the thesis, e.g. (a) tropical weathering formed laterite over a wide area of the study area, (b) land forms are ranging from high hills, valleys, residual hills, spurs, elongated and disjointed ridges, subdued uplands, scarp faces, tors, subdued plateaus, narrow upland plantation surfaces, interfluvial ridges, water divides, bare rocky exposures, weathered overburdens, laterite springs etc., (c) the shallow soil depth with saline character due to water-logging are evidenced in the low productivity of the

agricultural tracts, (d) the terrain has been divided into 5 first order units, 15 second order units and 43 third order units. There are 90 units of various units all over, (e) around 70% of the total area is under agricultural landuse. Proposal has been given to manage the under-utilised and non-utilised potential terrain for agricultural purpose. Manjari Basu (1998) has evaluated the terrains of the Madhupur Erosion Surface, a small geomorphic unit in the highlands of Chotanagpur of the Bihar Province for the development of agricultural landuse by parametric method. Some major findings are (a) the Archean granite and gneissic base of the area restrict the agriculture in this erosion surface. Conservation of over-land flow along the impervious rocks is suggested to fulfill the water requirement, (b) afforestation is suggested through administrative and social endeavours to improve the land capability, potentiality and economic condition also, (c) agriculture is less intense in high slope areas with poor soil status like texture, permeability, depth, erosion etc., (d) additional irrigation water is required though non-perennial streams are not able to supply sufficient water for agriculture, (e) good agricultural lands are owned by business man and service holders who are not worried about maximum return from the land rather satisfied with low production without any extra efforts, (f) measurable number of agricultural lands are shifted into market gardening land, (g) soil management is required to restrict the soil erosion as the area is highly suffered by soil erosion, (h) intensifying the existing cultivated area is suggested to further development of agriculture, (i) human efforts with proper planning can improve the Madhupur erosion surface.

Bhattacharjee (2002) in her thesis on 'Geomorphology and Agricultural Landuse in the Jayanti River Basin, Jharkhand, India' under The University of Burdwan has identified some problems related to agriculture like (a) excessive gully erosion in agricultural field due to seasonal steams, (b) granite and gneiss base steep sloped undulating surface, (c) uncertainty of ground water, (d) lack of modern technology etc. she gave some valuable planning proposals to improve the agriculture. Terrain and human resource of the Akola District in the north-central part of Maharashtra State have been evaluated by N. H. Khadse (2003) for the development of agriculture. Parametric and landscape both methods have been used for terrain classification. The author has drawn some major findings from the thesis e.g. (a) identified favorable zone for irrigation in the study area, (b) made plan for ground water development in the plateau through dug well, (c) terrain capability classes emerged mainly on the basis of slope properties, (d) optimum utilization and efficient management of land, water and human power can lead the prosperous future of Akola District. A. K. Bhattacharjee (2004) has evaluated the terrain, of one portion of the Chotanagpur Highland in the Deoghar subdivision of Deoghar District in the State of Jharkhand for agricultural land utilization following parametric method. The author has major findings of the thesis e.g. (a) the impermeable granite-gneiss rock base has the ability to conserve the seasonal over-land flow which can supply the required water for productive space, (b) the work has explored the diverse topographic characteristics which lead the regional variation in distribution , intensity and diversity of crops, (c) fine drainage texture in the rolling and rugged terrain initiates gullies in the agricultural land and, (d) soils are not poor here but require some treatments according to the need and crop to be grown, (e) maximum good agricultural lands are owned by business castes and service holders who don't have ambition of maximum return from the land, (f) maximum cultivated areas are under-utilised mainly due to social and economic factors, (g) soil conservation through check dams, silt detension dams, gully plugging, contour bounding, and afforestation are suggested. Oraon dominated Boreya is relatively a large village, situated in Kanke Block of Ranchi District in the State of former Bihar and presently Jharkhand. A. Mahto (2006) has evaluated the terrains of Boreya village. A detailed work is done on the village. Some major findings are (a) Boreya, the Rurban Centre in Chotanagpur has shown a significant quantitative-cum- qualitative growth and changes in terms of agriculture, irrigation, industries, linkages, transport system, mobility, media exposure, settlement rationalization, education and normative patterns, (b) Boreya has been classified into 5 terrain units of first order, 15 units of second order and 49 units of third order, (c) Boreya is furnished by residual hills, river valleys, terraced terrains, and undulating surfaces of dons and tanrs, (a) soils are rich in potash and quickly responsive to manures, (b) a detailed socio-economic study has been done. A good percentage of literacy has developed multi-occupational society and a remarkable feature is the shift of workers from primary to secondary and tertiary occupations, (c) integrated development is suggested for the overall development of Boreya village. The author has suggested three-tier simultaneous approach. These are (1) education and health, (2) agriculture and (3) employment opportunities for weaker section.

The survey reveals that in most of the theses, terrains have been evaluated mainly based on parametric method. Satellite image and aerial photographs have not been used. Therefore, the author's work is an attempt to evaluate the Burdwan Upland terrain by using both parametric method and satellite image. Previous works are very helpful to the author because the author has made her research design based on these valuable works. Agriculture has been given importance in India from the time immemorial. Agriculture constitutes 15.7 % (2008-2009) of the Gross Demestic Product in India. Therefore, agriculture has always been given priority in our country. Agriculture related work like agricultural marketing, changing pattern of agricultural landuse, agriculture with agro-industrial development, changing landuse and its impact on agriculture etc. already has been done in many pockets of India on the basis of different methods and perspectives (Aherwadkar, 1967; More, 1980; Mishra, 1987; Rajasekharan, 2000). A number of techniques like cropping intensity (single or double cropped), cropping pattern, crop combination, relative yield index, relative spread index, agriculture efficiency etc. have been mentioned by Singh and Dhillon (1984), Huasin (1996) to analyse the characteristics of agriculture in an area. Although, the Asansol Subdivision is one of the most industrialized urban areas not only of the Burdwan district but also in India there, there is need also for some planning for sustainable landuse. The chief colliery areas of Burdwan Upland are Dishergarh, Barakar, Salanpur, Kulti, Asansol, Kalipahari etc. where almost 31 % of rural people was engaged in mining related activity in 1971. Mining industries provided good number of employment and supported the economy and made the Upland one of the developing urban corridors of the district. Mining has created a number of problems also like land subsidence, ground water instability, firing in underground coal (Dutt, 2000). Lot of coal

mines were shut down due to crisis of coal. Therefore, alternative sustainable landuse planning is required now. Agriculture may solve the problem of uncertainty of getting work and may reduce the regional development disparity. So, agricultural landuse planning for a coal belt subsidence prone area is a new approach.

The author has selected some new and modified techniques to evaluate the terrain and for agricultural landuse planning which is differing from the previous work and may give better result. For landuse planning the author has classified (parametric and landscape method) and evaluated the terrain, calculated the village wise Human Development Index to identify the developed and underdeveloped villages, gone through the landuse models to identify the agents of landuse change and selected landuse model to establish the relation between landuse change and their causes. Finally, the author has given planning proposal to improve the economic base and for sustainable landuse on a subsidence prone coal mining dominated Upland. Model represents the artificial interactions between the landuse change and the causes behind it. Landuse models can explore the land dynamics. Model can help the decision makers as it formalizes the knowledge to develop scenario for future. Agarwal et al. reviewed 19 approaches or model of landuse change (Lambin *et al.,* 2006). Lambin et al. (2006) has mentioned some major approaches for landuse modeling like (a) Space based (Spatial model- deals with the spatial variation in landuse change and Non-spatial model- gives emphasis on rate and magnitude of landuse change but not on spatial distribution), (b) Time based (Dynamic model- deals with temporal changes in landuse, multi time point based analysis, very useful for future forecasting and Static model- single time point based analysis, trying to explore the relation between the driving force and landuse pattern), (c) Object based (Descriptive model- simulates future landuse, concerned with actual landuse system, dominant processes and suitable for making projection and Prescriptive/ Optimization based- finds the way of optimal landuse, includes present landuse system as a constraint for more optimal landuse, very useful for policy analysis), (d) Theory based (Deductive approach- explores the reason of landuse change, identify human environment relation and Inductive approach- gives emphasis on statistical techniques like multivariate analysis, probability test, calibration etc. to establish the relation between landuse change and exploratory variable) and (e) Simulated object based (Agent based model- gives emphasis on the decision making process of the agents and the social organization and landscape in which agents are embedded, agent may be physical, cultural, individual, group or organization and Pixel based model- pixel is considered as the smallest spatial unit, here the unit of analysis coincides with the level of decision making). A considerable work on landuse model has been made by host of scholars based on the basic concepts already mentioned above. The author has gone through some of these models like Statistical Models (project the future and explain the causes of landuse change by using mathematical techniques to solve the social or demographic problems), Evolutionary Model (based on the concept of Darwinian evolution, can solve the social and ecological both types of data by using artificial intelligence), Expert Model (represents qualitative knowledge as quantitative way where the basic idea is based on the probability techniques like Bayesian probability or Dempster-Schaefer theory), Multi Agent System Land-use land-cover Model or MAS/LUCC (consists two components, Cellular Model/CM- represents 'biogeophisical and ecological aspects' and Agent-based Model/ ABM represents the 'decision making' system, a spatially explicit model can explore the social factors behind landuse change and can establish relation between land and agents and also helps to policy-makers to deal sustainable landuse plan) (Millington *et al.,* 2007; Pontius, 2002; Xiao et al, 2007; Parker, 2003; Irwin and Geoghegan, 2001; Farrow and Winogard, 2001; Engelsman, 2002, Chong, 2004). CM includes cellular automata (CA) and Markov model, can predict the future state of a cell based on the transition rules. Agents are multiple interacting actors who make decisions. Their actions affect the land use patterns and processes. Factors which affect the agents' decision are very important to understand. Models can have 'predictive accuracy' or 'process accuracy' and ABM can balance between these two 'potentially conflicting motivations' (Brown, *et al.,* 2005). Therefore, MAS/LUCC model which includes CM and ABM has wide acceptance in landuse change study. A number of models are using for landuse land cover study. Some of models have been reviewed. All of these models have some advantages and disadvantages. Each model is suitable to solve specific problem. The author has selected agent based model to find out the reasons of landuse land cover change and to explore the agents responsible for the change.

Remote Sensing and GIS Techniques

RS & GIS techniques have been applied in terrain analysis as well as in landuse study. Digital Elevation Model (DEM) is a data file, contains surface elevation data over an area and also gives relief detail, drainage characteristics and three dimensional views, has wide acceptance for terrain evaluation (Chatterjee and Sarkar, 1982; Prakasam and Biswas 2010; Suresh Babu *et al.,* 1999; Xinjian *et al.,* 2002). But application of DEM has some problem like base level selection (Xinjian *et al.,* 2002). Only from stereo pare image we can get DEM. In landuse change detection (urban expansion, deforestation, flood etc.), geomorphic feature identification (landforms, relief, slope, drainage pattern etc.), surface water potential zone identification etc. satellite image has wide acceptance and already has been used (Jha *et al.,* 2000; Engelsman, 2002; Torres-Vera *et al.,* 2009; Chatterjee and Sarkar, 1982). The author has taken topographical sheets as well as satellite image for terrain evaluation and landuse mapping. The Burdwan Upland has been showing Regional Development Disparity at village level. A good deal of works has been done to investigate the level of regional disparity in agricultural development (Jain, 1993; Karlekar, 1993), socio-economic development (Purohit, 1993, Sharma and Kumar, 1993; Basu, 1993; Sharma and Sharma, 1993; Tripathi and Tiwari, 1993; Phanse and Dubey, 1993), industrial development (S.K. Sharma, 1993), literacy (Tripathi and Tiwari, 1993.) in an edited book Regional Disparities and Development in India (Tripathi and Tiwari, 1993). A number of Statistical Techniques like Z-score, composite index, Kendall's co-efficient technique etc. have been used in previous works to measure regional disparity but the author has selected PCA to calculate Village Development Index (VDI). Factor analysis very often is used in multivariate technique (Kothari, 2004). Principal component analysis was first developed by Karl Pearson in 1901 and later Hotelling gave the description of

computing technique of PCA (Manly, 1986). The Principal Component Analysis (PCA) has been used traditionally to transform a large set of correlated variables into a smaller set of uncorrelated variables, called Principal Component (PC). It can solve the problem of arbitrary choice of weighting scheme. Though, a considerable work has been done on regional unequal development but at village level no such work is done still on disparity in human development.

Research Voids

The literature review has been done on terrain classification method, regional planning method; statistical method, landuse model and national and international level work on spatial context. Each of these parts has its own importance and weight age which may improve the total research work and can give proper idea to develop the method of study. The main objective of literature survey is to identify the research void and to make the research framework. The author has identified some methodological, technical as well as spatial gap of analysis. Some of these major gaps which the author wants to incorporate in her thesis are mentioned as follow:

1. There are two methods of terrain classification i.e. parametric and landscape method. Parametric method considers physical parameters which can be analysed quantitatively where landscape method requires aerial photographs and satellite images. Therefore, landscape method needs the aesthetic or landscape view of an area to classify the terrain. Parametric method has been used by most of the Indian researchers whereas most of the foreign scholars are applying DEM i.e. they are taking only the satellites image for terrain classification. Therefore, one gap has developed in classification method because the author has already mentioned that parametric method and landscape method both are complimentary to each other. Application of both the methods can give the better result rather than one method. In most of the theses, these two methods are not used parallels. So the author wants to make an attempt to get the terrain classification method more concrete and error-free by taking parametric and landscape methods together.
2. Regional development disparity at village level has not yet been attempted. The author wants to calculate VDI by using PCA for each village of the Burdwan Upland. On the basis of socio-economic variables, PCA can be done. This technique can give satisfactory result as it is able to identify which factor is lagging behind within a group of factors. For planning, we must know which sector of society is suffering due to lack of social amenities; only then we can develop that particular sector. Therefore combination of VDI and terrain unit's characteristics can help the author to give the planning proposal in a better way.
3. Land use change study and its cause-effect relations are very much important in recent time. Landuse model represents the cause-effect relations in a single frame. In India no such work has been done on landuse model. Therefore the author wants to develop landuse model for her study area which also can help to make the planning proposals.
4. Burdwan Upland is a part of Raniganj coal belt. Coal mine and environment and land subsidence related works have been done on Raniganj coal belt area. But the terrain of the Upland has not yet been classified and judged for agriculture purpose. Coal is a non-renewable natural resource which cannot support the local economy long time. So agriculture can give the local people safe and long term engagement in cultivation and marketing work through sustainable land use.

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