CHAPTER 26

LAND RESOURCE INVENTORY TOWARDS VILLAGE LEVEL AGRICULTURAL LAND USE PLANNING

V. RAMAMURTHY,[1] S. K. SINGH,[2] S. CHATTARAJ,[3]
G. P. OBI REDDY,[4] and S. C. RAMESH KUMAR[1]

[1]Principal Scientist, ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore-560 024, India

[2]Director, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur – 440 033, India

[3]Scientist, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur – 440 033, India

[4]Principal Scientist, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur – 440 033, India

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ABSTRACT

Land resource is finite and competing demands for land are infinite. Arable land is shrinking because of diversion of agricultural lands to other non-agricultural uses and agriculture related activities are being taken up on marginal lands. This has resulted in land degradation and land resource management is considered as one of the priority areas for achieving sustainable food security by raising land productivity. The concept of using the land for suitable utilization lies within the land use planning (LUP) process, which aims at optimizing the use of land while sustaining its potential by avoiding resource degradation. It has been recognized that the land assessment and its reliability for land use decisions depend largely on the quality of soil information. Efforts were made to develop regional level land use plans by using land resource information generated at small scale (1:250,000 and 1:50,000). However, the efforts could not yield desired results at village level due to unavailability of large scale land resources database. Stakeholders seldom adopted these land use plans due to lack of site-specific information. Land Resource Inventory (LRI) at large scale (1:10,000) provides required information to prepare sustainable land use plan at village level, which sets the path for using right land use and right agro-techniques on each parcel of land. In India, LUP at local level are governed by farmers own requirement and market prices rather than land suitability criteria alone. LUP aims to encourage and assist land users in selecting options that increase their productivity, are sustainable and meet the needs of society. The systematic evaluation and planning of land resources requires basic data and information about the land, the people and the organization of administration and service. Participatory land use planning (PLUP) approach helps greatly in developing site-specific land resource management options to improve the land productivity and to minimize land degradation.

26.1 INTRODUCTION

In recent years, village level LUP has become widely accepted felt need as a means to resolve land use conflicts and enhance sustainable utilization and management of natural resources. Important natural resources at the village include soils, plants, water, minerals and sunshine. In a predominantly rural society of India, people who own productive lands are considered relatively rich and wealthy; landless people are poor, underfed, and often remain dependent on others for their livelihood. Land is scarce resource in India, even though the country has a land area of about 328 m ha, which is the seventh largest land area in the world. India is burdened with a population of 1210 million as per the 2011 census, which grew from 345 million in 1947 with a growth rate of 1.76 in the last decade. Population density has increased from 117 per sq.km in 1951 to 368 in 2011.

The rapid population increase currently experienced in the country has put land resources under enormous pressure. Competition for land among the different uses is becoming acute and conflicts arising out of this competition are more frequent and more complex. Land is crucial for all developmental activities, for natural resources, ecosystem services and for food security. As a consequence of various developmental endeavors like intensive farming, tourism, development of infrastructural facilities, etc., present arable land is shrinking because of diversion of prime agricultural lands to other non-agricultural uses and agriculture related activities are being taken up on marginal lands. Due to these activities ecological balances is being impaired by soil erosion, siltation of dams, shortage of ground water, land and water pollution, water logging, etc.

During the last two decades Indian agriculture has been facing major challenges like deceleration in growth rate, inter-sectoral and inter-regional inequality, declining input use efficiency, degradation of natural resources, etc., with consequent adverse effects on food and nutritional security and food inflation. Over the past few decades, agriculture has changed from a traditional low-tech and ecologically-benign sector into a modern high-tech industrial sector. In the past, agricultural land use served mainly a monosectoral purpose, *viz.* the production of foodstuffs in order to meet the multifaceted demand for nutrients in various forms. Agriculture contributes around 14% to India's Gross Domestic Product, but absorbs nearly 60% of the country's working population. About three-fourth of the total population draw their livelihood from agriculture. In recent decades, the industrial development and urbanization are major drivers of economic growth in India. The XII Five Year Plan provides that the country needs to reach an economic growth rate of at least 8% in the next five years in order to significantly increase the quality of life for its citizens, reducing poverty and fostering environmentally sustainable development. The sustainability movement has emphasized the need for environmentally-benign modes of agricultural production, so that the agricultural sector – the biggest land use consumer – would also serve the broadly accepted policy objective of sustainable land use in an ecologically vulnerable world. Consequently, agriculture is becoming a center piece in the worldwide sustainability debate, as food, energy, ecology and land use are concentrated here in one sector.

Therefore, better-directed efforts are needed to preserve our resource *viz.,* land, water and soil biota. In view of these, the LUP process forms an important exercise in this direction (Bauer, 1973). Proper planning of land and its resources allows for rational and sustainable use of land catering to various needs, including social, economic, developmental and environmental needs. Proper LUP based on sound scientific, and technical procedures, and land utilization strategies, supported by participatory approaches empowers people to make decisions on how to appropriately allocate and utilize land and its resources comprehensively and consistently catering to the present and future demands. These decisions depend largely on the quality of land resource information (Bogaert and D'Or, 2002; FAO, 1976; Salehi et al., 2003). Land resource information at large scale provides site-specific information, which is need of the hour to improve the productivity of crops and efficiency of inputs besides conserving precious natural resources.

26.2 STATUS OF LAND RESOURCES IN INDIA

The area available for agriculture, forestry, pasture and other bio mass production in India is 262 m ha and the net sown area is 140 m ha (Table 26.1). The remaining area is not suitable for agriculture due to inaccessibility of the terrain or harsh nature of the climate.

The degradation of land resources is taking place at an alarming rate and not all the cultivated lands at present are highly productive. A number of surveys and assessments have been carried out by different agencies over the past several decades on the extent and type of land degradation occurring in the country. The major surveys/estimates are summarized in Table 26.2. Estimates prepared by different agencies vary considerably from 53 m ha to 239 m ha. (Planning Commission, Tenth Five-Year Plan documents). Sehgal and Abrol (1994) reported that about 57% (187.8 m ha) of the land resources in the country are subjected to different types of degradation and threatening the sustainability of the resource base (Table 26.2).

TABLE 26.1 Land Utilization Pattern in India During 2012–13

S.No.	Land use	Area (m ha)	Area (% to TGA)
1	Total geographical area (TGA)	328.73	-
2	Forest	70.00	22.89
3	Area under non agricultural uses	26.45	8.6
4	Barren and un-cultural land	17.28	5.6
5	Permanent pastures and grazing lands	10.24	3.35
6	Miscellaneous tree crops and groves	3.16	1.03
7	Culturable wasteland	12.58	4.11
8	Old Fallow lands	11.00	3.6
9	Current fallows	15.28	5.0
10	Net sown area	139.93	45.76

Source: Directorate of Economics and Statistics, Ministry of Agriculture (2012–13).

However, recently ICAR and NAAS (2010) reported harmonized estimates on land degradation to be about 120.72 m ha (Table 26.3), which was worked out through reconciliation of datasets from various sources *viz.,* NBSS & LUP, CSWCR&TI, CAZRI, CSSRI, NRSC, FSI, NAAS).

A close look at the present health of the soil and water resources of India reveals a failure of the land use policy. About 120 m ha are threatened by

TABLE 26.2 Estimates of Soil Degradation in India by Various Agencies (area in m ha)

Agency	Estimated area (m ha)	Criteria for delineation
National Commission on Agriculture (1976)	148.09	Based on secondary data
Ministry of Agriculture (1978)	175.00	Based on NCA estimates
Society for Promotion of Wastelands Development (1984)	129.58	Based on secondary collected data
National Remote Sensing Agency (1985)	153.28	Mapping on 1:1 million scale based RS techniques
Ministry of Agriculture (1985)	173.64	Land degradation statistics of the states
Ministry of Agriculture (1994)	107.43	Elimination of duplication of data
NBSS & LUP (ICAR) (1994)	187.70	Mapping of 1:4.4 million scale based on GLASOD guidelines

Source: Gajbhiye and Sohanlal (2006).

TABLE 26.3 Extent of Degraded and Wastelands in India

Degradation type	Area (in m ha)	Open forest (<40% canopy) (mha)
Water erosion	73.27	9.30
Wind erosion	12.40	-
Chemical degradation soils		
Exclusively Salt affected soils	5.44	
Salt affected and water eroded soils	1.20	0.10
Exclusively acidic soils (pH<5.5)	5.09	-
Acidic and water eroded soils	5.72	7.13
Physical degradation		
Mining and industrial waste	0.19	
Water logging	0.88	
Total	104.19	16.53
Grand Total area (Arable land and open forest)	120.72	

Source: ICAR and NAAS (2010).

various types of degradations like salinity, alkalinity, ravine and gully erosion areas, areas under ravages of shifting cultivation, and desertification. The highest proportion of degradation is caused by soil erosion (9.86%). There are also specific problems of land degradation due to open-cast mining operations.

Currently, India produces about 257 m tons of food grains (2014–15), whereas by the end of the decade, it is estimated that the demand for food shall rise to 307 m tons. Further, LUP in the country has so far not been comprehensive and adequate, particularly to deal the competitive demands by various sectors. Thus, there is a need to protect agricultural areas that are essential for food security including the prime agricultural lands, command areas, double cropped land and other lands that are essential for livelihood of rural population. Thus, conserving prime agricultural lands by proper LUP at different levels assumes mammoth importance.

26.3 NEED OF LRI AT LARGE SCALE

LRI plays a vital role in resource management. It assists in the planning for future land use, particularly agriculture, because it assesses the land resource and its potential for sustainable agricultural production.

The LRI provides two sets of data:

i) LRI – inventory of five physical factors (rock, soil, slope, erosion type and severity, and vegetation) which is the basis of assessing land resources.
ii) Land Use Capability classification (LUC) – evaluation of the potential for sustained agriculture production (land use) in the long term.

In the early years the use of the soil information was mainly focused at national and regional level but in recent years this has expanded to be increasingly at district, block and village. Information about the land resources and its contribution to food production for an ever-growing population, biodiversity, urban and rural infrastructures, is now required at village level. To achieve a quantum jump in agricultural productivity at reduced cost on a sustainable basis and to usher second green revolution in India, natural resources like soil and water need to be efficiently utilized by developing site specific soil management strategies. Soil specific management provides the required input on each soil type and prevents over and under application of inputs resulting from blanket field applications, which are currently followed.

Spatial variation of soil properties causes uneven patterns in soil fertility and crop growth, and decreases the use efficiency of inputs applied uniformly at the field scale (Bhatti et al., 1991; Larson and Robert, 1991; Miller et al., 1988). Application of variable rather than uniform rates of N has been proposed to avoid application of excessive N where it will not be utilized by crops (Carr et al., 1991; Mulla et al., 1992). In order to apply fertilizer at variable rate or management of application, a methodology needs to be developed to divide farmlands into management zones/units that have similar soil characteristics, management responses and climate.

Delineation of spatial variability and mapping at village level is possible at larger scale, i.e., 1:5000 or 1:10,000. Soil series, the lowest category in soil taxonomy, which is considered the most homogeneous unit for management interpretations (Soil Survey Staff 2000). It is the basic units of soil classification as well as mapping at large scale. The pedon represents the sampling unit for soil series. The soils within a series may have similar properties but these may not be identical. Differences in characteristics like slope, texture, stoniness, degree of erosion and other features known as soil phases separate them each other. These have developed on similar parent material and comparable climatic and geo-morphic environments. Since soil series represents comparatively uniform edaphic characteristics of an area occupying larger extent helps in formulating land use plans and for natural resource conservation and management. In this direction, NBSS & LUP and ICRISAT in collaboration tried to identify suitability of Vertisols and associated soils for improved cropping systems in Central India based on 10 benchmark soil series (NBSS & LUP-ICRISAT, 1991). The study suggested possible cropping systems for different benchmark soil series of Vertisols based on soil resource inventory, farmers interviews and with limited field testing. Similarly, Gaikwad et al. (1986) and Yadav et al. (1985) suggested soil-site characters in relation to crop productivity as case studies based at soil order level, i.e., Vertisols. Management strategies suggested at soil order level may not applicable to soil series and within series. Naidu et al. (1986) assessed productivity and potentiality of eight extensively occurring soil series of Delhi. The soil series are grouped into three productivity classes namely good, average and poor on the basis of morphological, physico-chemical and soil environmental factors. Among the parameters considered for productivity and potentiality assessment, texture and soil moisture were found to be pre-dominant factors governing the rating indices. Hence, management strategies need to be developed at phase level by considering site characteristics.

The soil series are useful in developing inter relationship among properties to predict soil qualities and crop management strategies including leaching, run-off potential, drainage, terraces and diversions, grassed water ways, capability classes and sub-classes, crop yield, wind break and rangeland suitability.

Khakural et al. (1992) reported that when soil series are most distinct, then individual tillage system could be developed for specific soil series. Several articles in the literature indicate an increase in profits from applying plant nutrients to soil as compared to general application in the larger area (Bechman, 1992; Richter, 1991). Munson and Runge (1990) suggested that the site specific testing would help in identification of soil sensitivity to nutrient leaching or erosion and run-off.

At North Dakota, a study was carried out to know the response of barley and wheat to fertilizer management and nutrient grid method based on soil series (at phase level). Although grid sampling produced significantly higher yields, the extra cost of soil sampling and management caused it to have the lowest net returns (Wibawa, 1991).

Although India has made much advances in agricultural research, but still the blanket recommendations are very much in practice for adoption over large area. These blanket recommendations are no more useful to enhance productivity gains, which were witnessed between 1965 and 1985. Now, to enhance growth rate in productivity, precision agriculture technologies have to be developed. To realize the agronomic potential of existing soil type without soil degradation or to improve the potential of soils on sustainable basis. For assessing the productivity of soils in an area, one needs to have knowledge on the different soil types and their properties. The research results and predictions can be enhanced using the site-specific information. Land resource information at phase/series level is more important for prioritizing integrated soil management strategies to develop farm/village level LUP for optimizing natural resource, conservation and management.

The concept of using the land for suitable utilization lies within the LUP process, which aims at optimizing the use of land while sustaining its potential by avoiding resource degradation. It has been recognized that the land assessment and its reliability for land use decisions depend largely on the quality of soil information. Efforts were made to develop regional level land use plans by using land resource information generated at small scale (1:250,000 and 1:50,000). However, the efforts could not yield desired results at village level due to unavailability of large-scale (site-specific) land resources database. Stakeholders seldom adopted these land use plans due to lack of site-specific information. LRI at large scale (1:10,000) provides required information to prepare sustainable land use plan at village level, which sets the path for using right land use and right agro-techniques on each parcel of land. Also LRI information could be utilized by government departments to implement various developmental programs in the country (*viz.* IWMP, RKVY, NHM, MGNREG, etc.).

26.3.1 APPROACH

Soils are normally mapped based on physiography/landform-soil relation. The accuracy of soil map largely depends on how precisely and accurately the physiography/landform units are delineated. Soil maps are prepared at different scale *viz.* small scale (1:250,000, 1:1M, or smaller), medium scale (1:100,000, 1:63,360, 1:50,000) and large scale (1:25,000, 1:10,000, or larger), depending upon the purpose and requirement of user agencies.

The application of satellite remote sensing data products for small and medium scale of soil mapping are widely accepted (Soil Survey Staff, 1995) but the same have not been used in large-scale soil mapping frequently due to their coarse resolution. Large-scale soil mapping done so far following conventional methods that are time consuming, expensive and have low repetitive value especially in difficult and inaccessible terrain. However, with the availability of high resolution LISS-IV data (better than 6 m) from IRS-P6 satellite and panchromatic mode (2.5 m resolution) from Cartosat-1 IRS satellite, it is now possible to utilize these data for quick and precise LRI on 1: 10,000 scale.

26.3.2 METHODOLOGY

The methodology proposed for LRI on 1:10,000 scale is essentially a six tier approach comprising: (i) generation of orthorectified Cartosat merged LISS-IV using digital terrain database, (ii) landform/physiography analysis based on interpretation of high resolution satellite data, (iii) field characterization of soils for landform-soil relationship and mapping, (iv) laboratory characterization of soil, (v) development of land resource information system, and (vi) Decision Support System (DSS) for LUP (Figure 26.1).

26.3.3 DATASETS REQUIRED

Stereo pair of Cartosat-1 data (2.5 m resolution) provides the opportunity for precise and accurate delineation of landform units as it can be used to generate digital elevation model (DEM), generation of contours (10 m) and deriving information on slope and other terrain features of land. The high resolution IRS LISS-IV data (5.8 m) provides multispectral information about the object which helps in better delineation of land use/land cover, vegetation condition, etc., that may provide indirect inferences about the soils. Keeping this in view the datasets like Stereo pair Cartosat-1 digital data, IRS-P6 LISS IV digital data, Survey of India (SOI) toposheets (1:50,000 scale or larger), cadastral maps, other collateral data *viz.* global spatial datasets, SRM reports, district reports, geology maps, available LULC maps, etc., are proposed.

26.3.4 SATELLITE DATA PROCESSING

***Geo-referencing*:** As the SOI topomaps on 1: 10,000 scales are not available, it is proposed that all the spatial datasets *viz.* Cartosat-1 data, LISS-IV

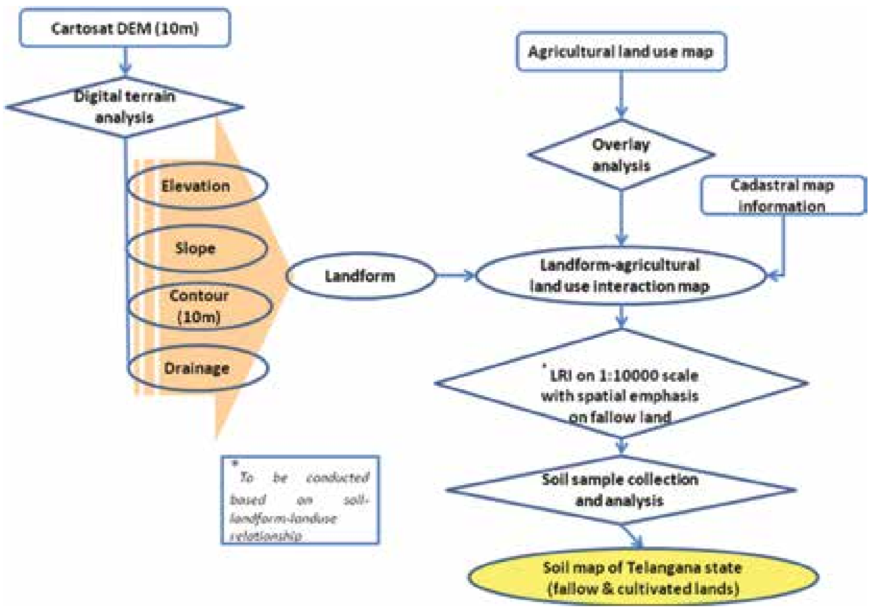

FIGURE 26.1 Land Resource Inventory methodology at 1:10000 scale.

data, Cadastral maps, etc., will be georeferenced with the Global datasets using Global coordinate system (GCS) and WGS-84 datum.

Generation of DEM (10 m): It is proposed to use digital elevation model (DEM) of 10 m resolution as it provides better visualization features for precise delineation of landform units on 1:10,000 scale. As the DEM (10m) is not readily available, the same need to be generated from the stereo pair Cartosat-1 data.

***Generation of ortho-rectified Cartosat merged LISS-IV data*:** IRS LISS-IV data (5.8 m resolution) will be fused with high resolution Cartosat-1 data (2.5) to generate ortho-rectified cartosat merged LISS-IV data which will be used for on-screen digitization of different landform units.

26.3.5 Satellite Data Interpretation

26.3.5.1 Land Use/Land Cover (LULC) Mapping

LULC map of the area was generated based on digital classification of ortho-rectified IRS-P6 LISS-IV data. Normalized difference vegetation index (NDVI) map will also be generated to account for the variation, if any, within same land use/land cover classes.

26.3.5.2 Generation of Digital Terrain Attributes

Cartosat DEM (10 m resolution) was used to generate spatial maps of different terrain attributes *viz.* slope, aspect, hill shade, terrain wetness index, topographic position index, etc.

26.3.5.3 Landform Mapping

Hybrid approach (involving both visual and digital techniques) was adopted to generate landform maps using orthorectified Cartosat merged LISS-IV data and terrain features derived through Cartosat DEM.

26.3.5.4 Pre-Filed Physiography Map

The pre-field physiography map was prepared by integrating spatial maps of landform, slope, land use/land cover, NDVI, and other relevant maps (e.g., physiographic regions, geology, AESR, etc.). Proposed tentative legend for physiography map is shown in Figure 26.2.

26.3.6 FIELD WORK FOR GROUND-TRUTHING

Intensive traversing will be done in the area to verify the pre-field physiographic units and make any correction, if needed. Transects (approx. 8–10) will be drawn in such a way that all major physiographic units occurring in the block/tehsil are covered. Intensive observations (profiles/mini-pits/augur bores) will be taken in each physiographic unit to establish the soil

FIGURE 26.2 Interpretation legend for physiographic unit.

series and develop physiography-soil relationship in the area. Horizon-wise soil samples will be collected from the representative soil series for laboratory analysis.

After establishing the physiography-soil relationship, detailed fieldwork will be undertaken in each village of the block/tehsil. Soil profiles (approx. 8–10) will be studied on all dominant physiographic units of the village and horizon-wise soil samples will be collected for detailed laboratory characterization.

26.3.6.1 Soil Mapping

The process of soil mapping begins with the checking of physiographic map units in the field. Simultaneously, soils are also studied in different physiographic units for developing correlation between physiographic units and soil composition to ensure correct stipulation of soil of the map units. Soil mapping unit will be essentially phases of soil series or soil complexes. Soil map generated at village level for Kokarda village, Kalmeshwar thesil of Nagpur, Maharashtra is shown in Figure 26.3. Dominant phases of soil series (e.g., surface texture, slope, erosion, salinity/sodicity, stoniness, flooding, etc.), influencing land use (agricultural productivity) and soil management will be shown in each soil mapping unit. Necessary guidelines need to be framed to maintain the quality and accuracy of datasets developed.

26.4 VILLAGE LEVEL LAND USE PLANNING (VLUP)

Village land-use planning is the process of evaluating and proposing alternative uses of natural resources in order to improve the socio-economic

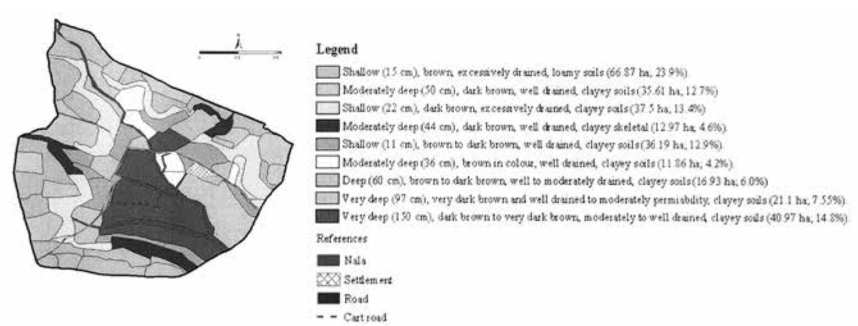

FIGURE 26.3 Soil map of Kokarda Village.

conditions of villagers. It is believed that this process only becomes effective when it is carried out in a participatory way, which means that the principal users of land, the villagers, are fully involved. To ensure full participation it is important to consider the different socio-economic groups in a village (including gender) which have different interests and expectations. The optimal use of these natural resources depends mainly on: the potential of people to utilize and manage them; their priorities; the socio-economic conditions and; the carrying capacity of the natural resources.

Objective of LUP is "Land use planning creates the preconditions required to achieve a type of land use that is environmentally sustainable, socially desirable and economically sound. It thereby activates social processes of decision making and consensus building concerning the utilization and protection of private, communal or public areas" (GTZ, 1995).

LUP is an iterative process based on the dialog amongst all stakeholders aiming at the negotiation and decision for a sustainable form of land use in rural areas as well as initiating and monitoring its implementation (GTZ, 1999).

In India, LUP at local level are governed by farmers own requirement and market prices (Velayutham et al., 2001) rather than land suitability criteria (Ramamurthy et al., 2000) which is followed in developed countries. The land use plans suggested by national and state land use boards and research institutes are seldom adopted by local communities/stakeholders. The reasons for non-adaption are the initiatives usually come from government officials or others outside the local community and the techniques, resources and skills suggested rely heavily upon innovations developed at research stations. Moreover suggested plans developed from soil survey and land capability assessments (Dhanorkar et al., 2013; Patil et al., 2011), focuses upon the relationship between land use and its environmental compliance alone. The socio-economic and political factors at the household, community and national levels, which influence land use, are often neglected. Also, there is a tendency to focus on land use per se and to neglect the details of land management and husbandry. Such land use plans have limited replicability because it involves considerable manpower and technical resources like maps and field staff and farmers do not easily comprehend the technicalities in this top down approach. As a result the implementation of LUP is often difficult.

It has now been endorsed that successful LUP depends on the participation of farmers. Thus, PLUP is considered as an important tool for sustainable resource management by local communities (Amler et al., 1999; Fagerstrom et al., 2003; Oltheten, 1999; Sawathvong, 2003). The aim of PLUP is to strike a balance between technical approach and farmer's requirements to maintain natural resources in sustainable manner. The plan should blend with bio-physical, socio-economic, gender, policy, equity, community participation and institutionalized management of common property resources on a village basis.

26.4.1 PRINCIPLES OF LUP

There are eleven principles of LUP, they are:

1. LUP is orientated to local conditions in terms of both method and content
2. LUP considers cultural viewpoints and builds up on local environmental knowledge
3. Land use planning takes into account traditional strategies for solving problems and conflicts
4. LUP assumes a concept which understands rural development to be a "bottom-up" process based on self-help and self-responsibility.
5. LUP is a dialog, creating the prerequisites for the successful negotiation and cooperation among stakeholders.
6. LUP is a process leading to an improvement in the capacity of the participants to plan and take actions.
7. LUP requires transparency. Therefore, free access to information for all participants is a prerequisite.
8. The differentiation of stakeholders and the gender approach are core principles in land use planning.
9. LUP is based on interdisciplinary cooperation.
10. LUP is an iterative process; it is the flexible and open reaction based on new findings and changing conditions.
11. LUP is implementation-orientated.

26.4.2 PARTICIPATORY LAND USE PLANNING (VILLAGE/ WATERSHED/FARM LEVEL)

After several failures of top-down approach, 'bottom-up approach' has become the jargon of implementation of developmental plans in recent days, where farmer is the main player in the development or identification of problem, planning, implementation of interventions and evaluation. The other agencies act as facilitators in the program implementation (Figure 26.4). For the success of such a planning process, the need for changes in land use or action to prevent some unwanted change must be desired and accepted by all the stakeholders and there must be a political will.

PLUP is "an iterative process based on dialog among all participants involved, and aiming to reach decisions on a sustainable form of land use in rural areas. It also includes the initiation of and support to appropriate implementation measures" (GTZ, 1995). In the Indian context, it is essentially a collective consensus on the use of resources.

PLUP should be methodologically and contextually oriented to local conditions and should be built on local environment using indigenous knowledge for problem and conflict management. It is based on the assumption that development is a process brought about 'from bottom' and based on self-help and collective responsibility. It is an interdisciplinary task and is intended to improve the participant's capacity to prioritize, plan, implement and evaluate. This requires transparency of information. The focus should be planning for and by the people.

Three types of land use options are possible through PLUP:

(1) Scientifically optimal, socio-economically tenable and accepted by partners/stake holders;
(2) Socio-economically desirable, scientifically permissible and accepted by partners;
(3) Socio-economically acceptable, scientifically feasible and desired by partners.

FIGURE 26.4 Players in Participatory Land Use Planning and their roles (in parentheses).

Using the above options, PLUP aims to achieve the following objectives:

- Optimization of production from different farming systems to improve farm income;
- Controlling of soil and water erosion/degradation;
- Restoration of degraded lands to their primary production potential;
- Utilization of wastelands;
- Optimization of use of surface/ground water resources;
- Provision for food, fodder, fiber and fuel security;
- Environment security.

An important aspect of the PLUP process is the participation of villagers in managing and protecting natural resources, participation is key to sustainable development.

26.4.3 INFORMATION REQUIRED FOR VILLAGE LEVEL LAND USE PLANNING

The local planning unit may be the village/Panchayat/Watershed. At this level, it is easiest to fit the plan to the people, making use of local people's knowledge and contributions. Where planning is initiated at the district level, the program of work to implement changes in land use or management has to be carried out locally. Alternatively, this may be the first level of planning, with its priorities drawn up by the local people. Local-level planning is about getting things done on particular areas of land – what shall be done where and when, and who will be responsible. At local level, the plan is very detailed, and it is possible for all participants to take part directly in the decision-making process. The data sets required for local planning is presented in Table 26.4.

The information to be collected for LUP can be broadly categorized as:

1) Bio-physical information
    - Land use/cover
    - Soil variability
    - Soil fertility status
    - Soil constraints and potential
    - Soil degradation
    - Climatic information
2) Socio-economic information
    - Socio-economic constraints and potential
    - Adoption and yield gap of crops

TABLE 26.4 Data Set for Village/Village Panchayat/Watershed Level Land Use Plan

Management units	Base data needed				Quality of Plan	Implementing Agency	Goals
	Soil	Climate	Land Use	Social and Economic			
• Iso grow area maps	• Soil series-phases (1:10,000)	Weekly data • Rainfall • PET • Temp	Major LUTS • Rainfed • Irrigated • Forestry • Barren • Flood area • Habitation • Specific crop information like varieties, management, etc.	Farm family wise • Capital availability • Socio-Economic status • Needs	Quantitative (management unit wise crop, variety & management details)	• Dept of Agri./ horticulture • Dept. of Forestry • Village Panchayats • Village level workers • Farming Community	Village/ Farm/ Watershed development

- Economics of land use types
- Farming constraints and potentials
- Stakeholders priorities

3) Environmental information

The required information and data can be sub categorized as:

- Population, demographic trends, migration;
- Actors and institutions;
- Land and other resources, including information on biodiversity, conservation values, ecosystem services, etc.;
- Environment, e.g., availability of water, climate trends, natural hazards;
- Past, present and future land use;
- Production and trends; Infrastructure;
- Social services;
- Topographic references; administrative boundaries.

26.4.4 HOW TO GET THE INFORMATION?

It is assumed that PLUP begins with LRI.

- Information on current land use, water resources, forest resource and soil resources and land degradation could be documented during LRI.
- Information documented during LRI could be cross checked from secondary sources and information on population of the village and other means of livelihood could be either collected from secondary sources such as Panchayat records or line departments.
- Socio-economic information may be collected by visiting the households and conducting structured interview. Data sources could be formal or informal, physical or digital. Questions related to socio-economic information should not be fixed, use Participatory Rural Appraisal (PRA) tools for collecting maximum information.

26.4.5 PROCESS OF VILLAGE LEVEL LAND USE PLANNING

Understanding the sequence of steps (or the process) in PLUP before attempting the fieldwork is most important. In the PLUP process there are procedures to follow, methods to apply and practices or tasks to undertake. PLUP involves different stages in planning and implementation. The process of PLUP is outlined in Figure 26.5 and stages are described below.

***Stage 1: Preparation for Implementing LUP*:** Prepare implementation teams at local level and conduct training for team members in Participatory Land Use and Management approaches. This will include preparation of survey and mapping equipment and materials. Villagers also need to be well informed, and must have the implementation activities and methods of the LUP process and policies, regulations and objectives explained to them properly.

***Stage 2: Survey and mapping of village boundary and forest and agricultural land use zones/units*:** This necessitates the determination of village boundaries and the preparation of boundary agreements, followed by the drawing of a village base map. Study the land resources of the village and document village landmarks and topographic features to establish village reference points and to identify and map village land-use zones/units.

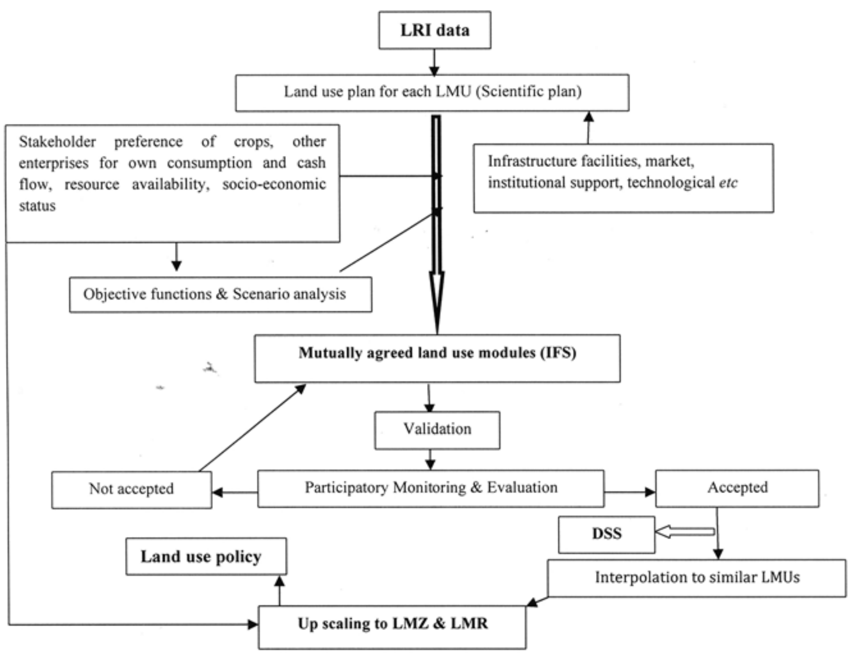

FIGURE 26.5 Conceptual model for village level land use planning.

***Stage 3: Data collection and analysis*: Information on village land tenure, land use and land claims including traditional village agreements and farming systems need to be collected. In addition, information on socio-economic conditions and villagers' perceived problems and needs are to be documented by employing PRA tools and techniques. This information should then be summarized and analyzed to determine agricultural land allocation criteria.

***Stage 4: Village land-use plans*: Conduct staff and villager awareness training on the definition, objectives and activities in agricultural land use planning. Evaluate land resources of each farmer, match with farmers needs and prepare mutually agreed land use plans considering resources available locally. Select and demonstrate with participating families suitable land use options based on the above (Figure 26.6). Year-end monitoring should be undertaken in order to facilitate planning and expansion of demonstration activities prior to adopting ongoing land use plans.

***Stage 5: Land use and management plan*: Use the land-use zoning/unit map prepared in stage 2 to discuss land use management with villagers. It is important to reach agreement on appropriate land uses for each of the land-use zones/unit. It is then necessary to conduct a village meeting to discuss about land management options.

***Stage 6: Agricultural land allocation records*: When land allocation is completed in each village, a temporary land-use certificate (TLUC) record book needs to be established at the Village panchyat. The book should include all TLUCs cross-referenced, coded and checked against the village land use map.

***Stage 7: Monitoring and evaluation*: Conduct field monitoring of land-use practices with the village LUP/LA committee and villagers. Make a

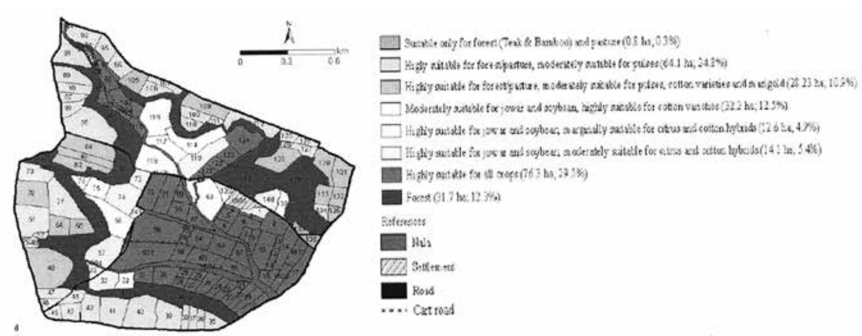

FIGURE 26.6 Land use plan map of Kokarda village.

report and feedback monitoring results to villagers and the LUP/LA committee. Use the results to prepare a follow up activity plan to address issues and problems identified during monitoring work and to improve the whole LUP procedure.

26.4.6 ADVANTAGES OF VILLAGE LEVEL LUP

- Local targets, local management and local benefits. People will be more enthusiastic about a plan seen as their own, and they will be more willing to participate in its implementation and monitoring;
- More popular awareness of land-use problems and opportunities;
- Plans can pay close attention to local constraints, whether these are related to natural resources or socio-economic problems;
- Better information is fed upwards for higher levels of planning

28.4.7 DISADVANTAGES OF VILLAGE LEVEL LUP

- Local interests are not always the same as regional or national interests;
- Difficulties occur in integrating local plans within a wider framework;
- Limited technical knowledge at the local level means technical agencies need to make a big investment in time and labor in widely scattered places;
- Local efforts may collapse because of a lack of higher-level support or even obstruction.

26.5 IMPACT OF VILLAGE LEVEL LAND USE PLANNING ON LAND USE AND LIVELIHOOD SECURITY

LRI based LUP was implemented in Kokarda and Kaniyadol villages of Kalmeshwar thesil of Nagpur from 2000–2005 under Institute-Village linkage program (Figure 26.6). The mean annual rainfall of the area is 976 mm received mostly from south-west monsoon, from second fortnight of June to October. About 96% of the total rainfall occurred during June to September in 67 rainy days with length of growing period workout to be about 150–170 days. Delayed onset, early withdrawal and prolonged dry spells, are the common characteristics of the monsoon. These aberrations have a severe impact on the crop production and productivity.

The soils are shallow to moderately deep and deep, well drained/moderately well drained, with gravely clay loam/sandy clay loam soils (Figure 26.3). Shallow soils occur on hill slopes and deep soils in valley bottom. Shallow soils, are under *kharif* monocrops. Deep soils are cultivated to *kharif* and *rabi* crops.

Before implementation of soil based land use plans, about 26% of the area was under sorghum, 22% under cotton, 17% under soybean and 13% of the area was under orange orchards. The small and marginal farmers were mostly the wage earners. The cattle and goat rearing formed an integral part of their livelihood. Dairying was supplementary enterprise to most of the farmers.

After LRI, methodology outlined in Figure 26.5 was followed to prepare and implement LUP of the village. At the end of the project impact assessment was carried out and it was found that socially acceptable, technically feasible and economically viable technologies were by and large, considered sustainable.

- Due to VLUP, area under cultivation increased in the village. The uncultivable land (12%) and current fallows (34%) were brought under cultivation by way of fodder production, afforestation and agro forestry. There was 5% increase in net sown area.
- Changes in land use and cropping pattern were significant due to VLUP. Before the implementation of the VLUP, maximum area was under cotton hybrids and sorghum. After five years, cotton hybrids have shifted to deep soils and varieties to shallow soils. Similarly, sorghum and citrus has been shifted to soybean. This indicates that productivity level and market forces influence the land use rather than soil suitability alone.
- The productivity of dryland and irrigated crops has increased in the range of 14 to 48% in grain crops and 400% in fodder crops.
- The Crop Productivity Index (CPI) of rainfed crops is higher than irrigated crops.
- The income of farmers was increased by about 32% after implementation of the VLUP.
- In a short period, VLUP has been able to motivate large number of farmers to adopt modern farm technology and help them in raising farm production and consequently income.

- The VLUP helped in generating knowledge and providing skills about new production technology among adopted and also other farmers of the area.
- The VLUP provided an excellent mechanism for feedback information for generation of refined, low cost and effective technology and develop interpretive base for soil units mapped.
- The VLUP has generated demand for better services and supplies of inputs and creation of physical facilities essential for raising production and livelihood.

26.6 CONCLUSIONS

Land resource is finite and competing demands for land are infinite. Present arable land is shrinking because of diversion of prime agricultural lands to other non-agricultural uses and agriculture related activities. The concept of using the land for suitable utilization lies within the LUP process, which aims at optimizing the use of land while sustaining its potential by avoiding resource degradation. It has been recognized that the land assessment and its reliability for land use decisions depend largely on the quality of soil information. Efforts were made to develop regional level land use plans by using land resource information generated at small scale (1:250,000 and 1:50,000). However, the efforts could not yield desired results at village level due to unavailability of large-scale land resources database. Stakeholders seldom adopted these land use plans due to lack of site-specific information. LUP at local level are governed by farmers own requirement and market prices rather than land suitability criteria alone. LUP aims to encourage and assist land users in selecting options that increase their productivity, are sustainable and meet the needs of society. The systematic evaluation and planning of land resources requires basic data and information about the land, *viz.,* land use/cover, soil variability, soil fertility status, soil constraints and potential, soil degradation, climatic information, socio-economic constraints and potential, adoption and yield gap of crops, economics of land use types and stakeholders priorities. Proper implementation of VLUPs based on LRI, showed significant change in land use, productivity improvement of crops besides improving economic capability of farmers. LRI at large scale (1:10,000) provides required information to prepare sustainable land use plan at village level, which sets the path for using right land use and right agro-techniques on each parcel of land.

KEYWORDS

- **Integrated Land Use Plan**
- **Land Evaluation**
- **Land Use**
- **Livelihood**
- **Mutually Agreed Plan**
- **Participatory Land Use Planning**
- **Stakeholders**

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