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Land resource utilization

by different crops in India : Need for effective land use planning

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Access to land is becoming increasingly difficult with competing demands by various stockholders including urban housing. Changes in land use in India have intensified in the recent years under pressure of population, economic forces, livestock pressure and weakening of various types of institutions that regulate land use formally or informally. Natural factors have also caused some change in the land use pattern. In the absence of any well thought out plan and policy, indiscriminate change in land use has several implications that impinge upon sustainable and optimum use and result in a haphazard development devoid of economic, social, environmental and aesthetic sense.

Keywords: Arid zone, Crop, Land form, Land use pattern

LAND has become a scarce property with increasing demands from housing, industrial and agricultural purpose. Despite all odds, food production growth will have to keep pace with population growth while agriculture sector's growth has to reach 4% per annum matching with the targeted economic growth of 8% during India's plan period. India is facing the daunting task of increasing food production by over 50% in the next two decades. There is need for a strong monitoring of the ongoing land use changes either driven by market or policy, or both. Special efforts should be made to utilize the information technology and remote sensing inputs in monitoring.

Land use pattern

Out of the 328.73 million ha total land mass of the country, the reported area for land utilization has been 307.75 million ha. During the past several years (1951-52 to 2015-16) the net sown area has remained, by and large, constant at 140 million ha (Fig. 1). Area under non-agricultural uses has increased from 17 million ha to 27 million ha, while the area under barren and unculturable land has come down from 28 million ha in 1971-72 to 17 million ha in 2015-16. However, the gross cropped area has increased from 166 million ha in 1971-72 to 197 million ha in 2015-16. As a normal process of urbanization and development, the area under non-agricultural uses is increasing, but due to efforts of the government, land has been reclaimed for cultivation from barren and culturable waste land category. The cropping intensity has increased from 118-140% during the same period. Owing to a burgeoning population, it is estimated that per capita total land availability which was 0.32 ha in 2001 against the world average of 2.19 ha will decrease to 0.23 ha in 2025 and 0.19 ha in 2050. Further, it is reported that about 120 million ha land is degraded

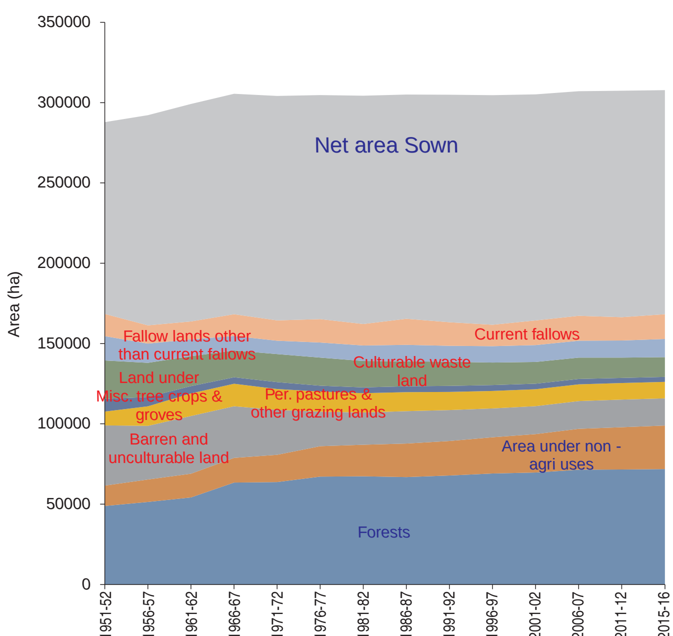

Fig. 1. Spatial variation in land utilization pattern in India over the period from 1951-52 to 2015-16.
Source: Land Use Statistics, 2015-16, Directorate of Economics & Statistics

in India, and about 5334 million tonnes of soil is lost annually through soil erosion. Out of 120 million ha degraded area, water erosion accounts for 68%, chemical degradation 21%, wind erosion 10% and the rest physical degradation. Effective land management policies are required to address these issues in addition to other concerns such as small size and fragmented holdings, tenancy, ceiling limits, acquisition and diversion of productive land, land records and inventories, climate change and land use change. Land-use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options.

Agricultural Land use pattern

Analysis of agricultural land use changes over the past 70 years of independence Indicated that cereals are the major food crops of India, both in terms of the coverage and volume of production (Fig. 2). Among the cereals, land use under rice crop has shown polynomial growth (R^2 = 0.96) and increased by 1.5 times since independence because of additional increase in irrigated area (from 9.8 to 26.3 million ha) put under rice cultivation mainly in Uttar Pradesh, Punjab, West Bengal and Haryana. Land use under wheat crop has increased more than 3 times (29.8% CV) since independence, which has not only completely replaced the barley crop but also affected the other land uses (Table 1). It was evident by the fact that the new irrigation facility developed was assigned to wheat cultivation during *rabi* season and as a result, irrigated area under wheat increased from 3.3 to 28.5 million ha in Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and Rajasthan. Among the coarse cereals, land use under maize crop showed a polynomial growth but the land use under sorghum and pearl millet had shown drastic reduction over the same period. Land use occupied under ragi and barley has also shown declining trend. Thus, it is clearly evident that the additional land use under rice, wheat and maize crop has come from land use previously occupied by other cereals.

Land use under total pulses remains stationary since independence at around 22 million ha (Fig. 3). This situation has arise because land use under principal pulse crop i.e. chickpea remain stagnant at around 7-8 million ha over the years with 14.6% CV. However, land use under tur/ arhar has shown a content exponential growth (Table 2). Among the oilseed crops, soybean introduced late in India as an oilseed crop in early seventies, has got momentum in mid-eighties and showed a perfect polynomial trend (R^2=0.99), which presently occupying maximum area under oilseed crops (< 11 million ha). Similarly, rapeseed and mustard crop has also showed an exponential growth. However, the land use under groundnut crop which initially showed increasing trend, after the introduction of soybean crop, that finally showing negative polynomial growth. Land use under the sesame crop is by and large constant since independence. The land use under sugarcane and cotton has increased from 2.41 and 8.38 m ha in 1971-72 to 4.74 and 12.59 m ha in 2017-18 due to systematic increase in irrigation facilities.

Emerging Demand—Supply Imbalances

Most land use decisions are still based primarily on economic considerations or short term needs, rather than on unique analysis of the landscape. Once land has been converted into intensive human use, it is generally unavailable for other uses. The type of land use changes in cereals vis-à-vis productivity constraints in oilseed and pulses has caused demand and supply imbalances and there is an increasing pressure on the prices of such short supply commodities. The per capita monthly consumption of cereals has declined from 14.80 kg in 1983-84 to 11.35 kg in 2009-10 in the rural areas. In the urban areas, it has declined from 11.30 kg in 1983-84 to 9.37kg in 2009-10. In 1993-94, only 3% of oil consumed in India was imported. The figure today is nearly 70% and India spends around ₹ 70,000 Crore annually on its import. India today imports 25% of its pulses, spending around ₹ 20,000 Crore annually. The import of pulses has also risen threefold in the last decade. While India's net export from basmati rice, non basmati rice, wheat, maize, other cereals, groundnuts, guargum, jaggery & confectionery and cereal preparations is only ₹ 60,000 cr.

The agricultural production basket is still not fully aligned to the emerging demand patterns. As land resources are stagnant, an increase in food production has to come from increase in productivity. The quality of Indian soils is gradually deteriorating at the farm and eco-system level. The major threats to soil quality come from a loss of organic carbon, erosion, nutrient imbalance, compaction, salinization, water-logging, decline in soil bio- diversity, urbanization, contamination with heavy metals and pesticides and from an adverse impact of climate change.

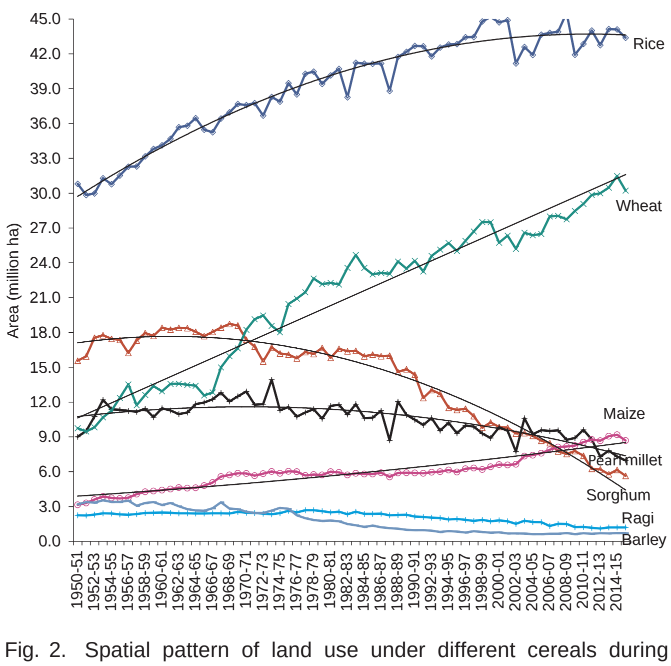

Fig. 2. Spatial pattern of land use under different cereals during 1950-51 to 2015-16

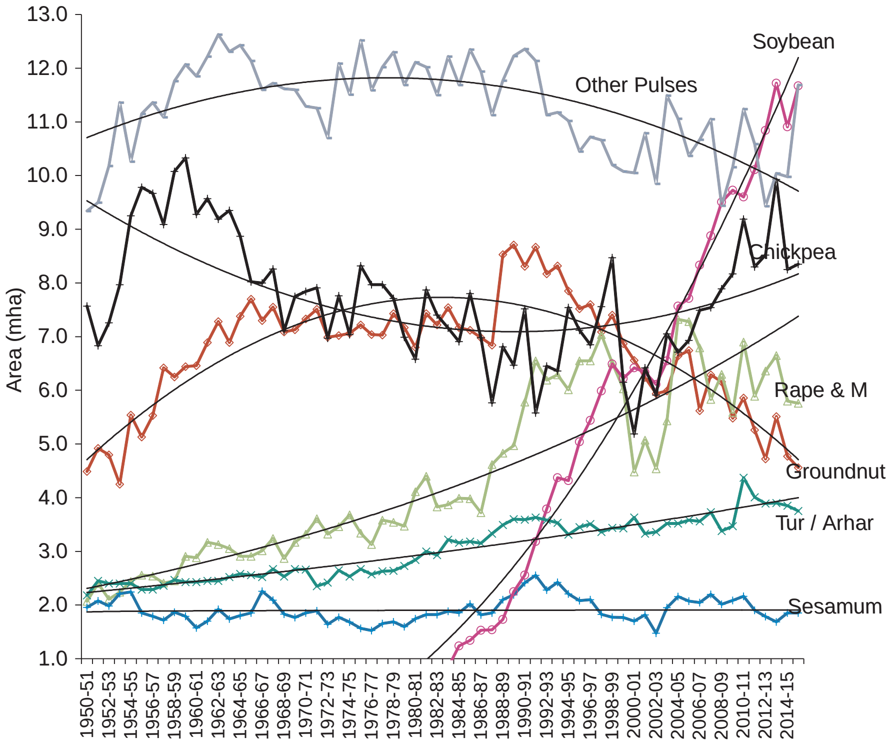

Fig. 3. Spatial pattern of land use under different oilseeds and pulses during 1950-51 to 2015-16

Table 1. Polynomial equations of land use changes under different cereal crops during the last 70 years

Crop	Equation	R-Squar	CV (%)
Rice	$Y = -0.003x^2 + 0.469x + 29.25$	0.956**	11.08
Wheat	$Y = -0.002x^2 + 0.493x + 8.386$	0.968**	29.82
Maize	$Y = 0.000x^2 + 0.046x + 3.856$	0.882**	24.29
Pearl millet	$Y = -0.002x^2 + 0.087x + 10.67$	0.703*	13.63
Sorghum	$Y = -0.004x^2 + 0.109x + 17.00$	0.963**	29.27
Ragi	$Y = -0.000x^2 + 0.028x + 2.219$	0.947**	21.20
Barley	$Y = 0.000x^2 - 0.085x + 3.959$	0.934**	58.47

Way Forward

Plan and manage all resources including land in an integrated manner for maximization of environmental, social and economic factors apart from ensuring livelihood and equity. The soil resource mapping and classification provides basic data, which can be used for planning and implementing land use strategies. Prepare comprehensive land inventories; Prepare a perspective plan for treating degraded lands; Develop infrastructural facilities and strengthen the technology support system; Develop proper computerized, updated, on-line information system on land records; Develop and use advanced methodologies for land use planning. To effectively ensure all these, site specific data, particularly on soils and situation specific recommendation (LRI) are pre-requisite.

Table 2. Polynomial equations of land use changes under different oilseeds and pulses during the last 70 years

Crop	Equation	R-Squar	CV (%)
Soybean	$Y = 0.004x^2 - 0.093x - 0.454$	$R^2 = 0.985$**	86.27
Groundnut	$Y = -0.002x^2 + 0.191x + 4.520$	$R^2 = 0.766$*	15.84
Mustard	$Y = 2.268e^{0.017x}$	$R^2 = 0.872$**	35.54
Chickpea	$Y = 0.001x^2 - 0.128x + 9.657$	$R^2 = 0.334$	14.62
Tur/Arhar	$Y = 2.213e^{0.009x}$	$R^2 = 0.893$**	18.05
Other Pulses	$Y= -0.001x^2 + 0.084x + 10.62$	$R^2 = 0.427$	7.69

Objectives of Land Use Planning

- To quantify the agro-ecology factors that defines the categories of land use and optimal cropping patterns
- To integrate the economic/ market relationships of the input - output matrix that governs the acreage and production relations under the particular crop regime
- To arrive at the mechanism to improve and strengthen planning, management and evaluation systems for land and land resources.
- To explore the use of innovative technologies in planning and management of land resources.

Land Resource Information (LRI)

The classification and mapping of agricultural land according to the capacity and utility become important goals for better management. It provides a suitable context for resource management, conflict resolution and decision making at the local and regional levels, consistent with national policies and priorities. However, the existing database on land use is highly inadequate. Therefore, strengthening of the database, using geo-spatial techniques, GPS, GIS and computerization of land records would be necessary.

Site specific data can be obtained by detail characterization and mapping of all the existing land resources like soil, climate, ground water, vegetation, land use pattern through systematic soil survey. The advent of high resolution remote sensing data and digital terrain model (DTM) has added a new dimension in LRI. The land use and land cover maps (IRS LISS-IV data) are superimposed on landform map to develop landscape ecological unit (LEUs) map. LEU is the assemblage of landforms, slope and land use. These LEU map units are attached with physiography, sub-physiography and broad landforms. The extensive traversing and ground truth collection through minipits and soil profile investigation in well defined strips representing assemblage of LEU is done. Thus, developed soil map is basically meant for developing

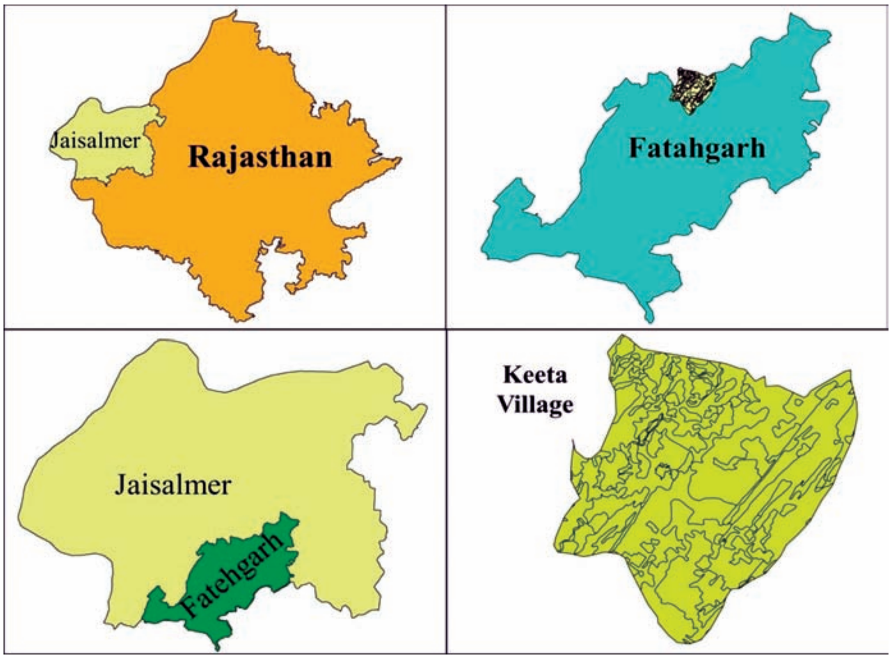

Fig. 4. Location map of Keeta village in Fatehgarh tehsil of Jaisalmer

sustainable land use planning.

Land-use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Land-use planning can be applied at three broad levels: national, district and local. These are not necessarily sequential but correspond to the levels of government at which decisions about land use are taken. Different kinds of decision are taken at each level, where the methods of planning and kinds of plan also differ. However, at each level there is need for a land-use strategy, policies that indicate planning priorities, projects that tackle these priorities and operational planning to get the work done. The flow of information should be in both directions and direct participation of the local people should be there.

A case study of Keeta village of Fatehgarh Tehsil in Jaisalmer district of Rajasthan

Keeta is a village of Fatehgarh Tehsil (Fig 4). This is one the most desiccated tehsil of Indian arid zone. It experiences low, erratic and sporty rainfall, high temperature with large diurnal variations, annals of drought, high wind speed and low biological productivity. It belongs to Agro-Ecological Sub-Region 2.1 (M9Eh1) having < 45 days length of growing period with average rainfall of 183.3mm and 9.4 rainy days with high aridity index and extreme temperature fluctuations.

A new geospatial technique was used to analyze present land use in Keeta village. Land Resource Inventory (LRI) on 1:10, 000 scale is conducted in village area using high resolution remote sensing data and digital elevation model. The digital terrain model (DTM) data was obtained from Cartosat-1 (2.5-meter resolution) namely, the contour, drainage, hill shades and slope, which are used for developing precise and quantified data on landforms. Land use and land cover (LULC) map is derived from the interpretation of IRS LISS-IV data of (5.8-meter resolution) and other data available in public domain was used to develop landscape ecological unit (LEUs) map. LEU is the assemblage of landforms, slope and land use. The site specific data were obtained by detail characterization and mapping of all the existing land resources through systematic soil survey involving extensive traversing and ground truth collection and soil profile investigation, in well defined strips representing assemblage of LEU is done. Extensive field work is done to verify the boundaries and record the soil properties closely. The landscape ecological units consisting physiography, sub-physiography, broad landforms, landforms, slope and land use are delineated. Studies on the evolution of landforms through

Table 3. Landform and land use analysis of Keeta village

Land form/ Land Uses	Total Area	Agriculture	Sparse use	Barren Vegetation	Mining Area
Aeolian pediment	4371			3530	841
Aeolian plain	3148	**2755**		**394**	
Denudational Ridges	754			754	
Denudational Foot Slope	1121			1121	
Interdunal Plain	508	**68**	**298**	**142**	
Sand Dunes	1768			**1768**	
Total	11, 717	2822	298	7708	841

Table 4. Land use planning for Keeta village

Present land use	Spares Vegetation	Agriculture	Barren
Size /area	298 ha	2,823 ha	2,304 ha
Intended land use	Silvipasture	Intensive cropping	Afforestation
Rough description of intervention	Planting of fodder plants xy in rows 5 m apart; sowing of grass seed (*C. setigerous*) 6 kg per hectare; local Fencing	*In-situ* SWC measures; BBF, Ridge & furrow, Reduce tillage, Ex-situ: gully control, water tank, GWW, short duration pulses, IWM, INM	Planting of forest plants
Labour Requirement	1.0 man month/ha	0.5 man month/ha	0.5 man month/ha
Employment Generation for MNREGA	298 man months	1412 man months	2,304 man months

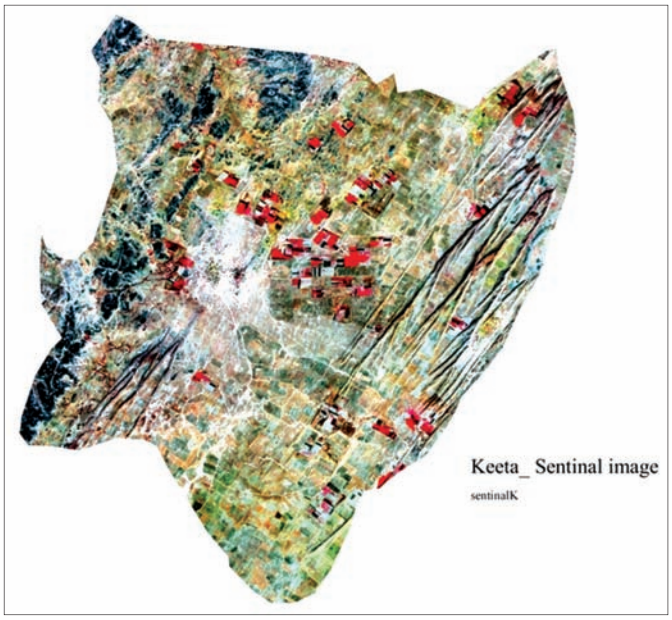

Fig. 5. Sentinel image of the Keeta Village in Fatehgarh tehsil of Jaisalmer

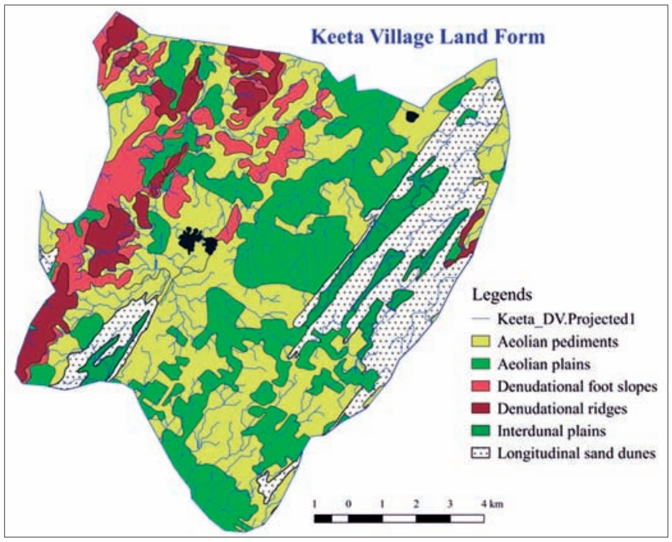

Fig. 6. Major landform of the Keeta Village in Fatehgarh tehsil of Jaisalmer

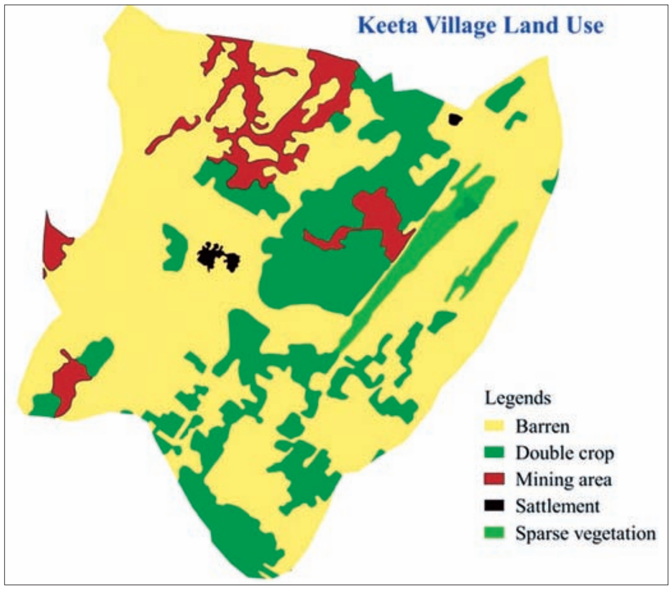

Fig 7 Land use map of Keeta village in Fatehgarh tehsil of Jaisalmer

geomorphological processes, their geomorphological characteristics and the mapping of their distribution help to assess and evaluate the physical potential of the land for development and rational land-use planning of the village. Based on the origin, erosional and depositional processes, six land forms have been identified in the Keeta village having 11,717 ha area (Fig. 4). The major land use (Fig. 6) comprises agriculture, sparse vegetation, mining and barren land. Land use analysis (Table 3) indicate that area under agriculture (2,822 ha), sparse vegetation (298 ha) and barren land (2,304 ha) have the potential for higher category of land use (Table 4) with some soil work and contribute for increasing farmers income.

SUMMARY

Access to land is becoming increasingly difficult by competing demands of various stockholders including urban housing. Changes in land use in India have intensified in the recent years under pressure of population, economic forces, livestock pressure and weakening of various types of institutions that regulate land use formally or informally. Out of the 328.73 million ha total land mass of the country, the reported area for land utilization has been 307.75 million ha. During the past several years the net sown area has remained, by and large, constant at 140 million ha. Among the cereals, land use under rice crop has shown polynomial growth ($R^2 = 0.96$) and increased by 1.5 times since independence because of additional increase in irrigated area (from 9.8 to 26.3 mha) put under rice cultivation mainly in Uttar Pradesh Punjab, West Bengal and Haryana. Land use under wheat crop has increased more than three times (29.8% CV) since independence, which has not only completely replaced the barley crop but also affected the other land uses. Most land use decisions are still based primarily on economic considerations or short term needs, rather than on unique analysis of the landscape. The soil resource mapping and classification provides basic data, which can be used, for planning and implementing land use strategies. In Keeta village, the major land use comprises agriculture, sparse vegetation, mining and barren land. Land use analysis indicate that area under agriculture (2,822 ha), sparse vegetation (298 ha) and barren land (2,304 ha) have the potential for higher category of land use with some soil work and can contribute for increasing farmers income and employment.

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