Geospatial Land Governance and Management through Digitalisation: A Study in Perspective to Real World's Land Developments in India

Madan MOHAN, India

Key words: Access to land, Geoinformation/GI, Land management, Remote sensing, Spatial planning.

SUMMARY

Geospatial information is forever related to geographic space into the immediate geographic world. Geographic space takes into account to landscape features of geographic world. The geoinformation process involves different data acquisition methods, digital processing of remotely sensed images which are themselves competing each other in term of the excellence and expenses. Besides this, 'to own the land is the highest mark of esteem; to perform manual labour, the lowest'. There is an ever-changing relationship between land, power and people. The ancient records evidenced that among the Indo-Aryans, arable land was held by the individuals or family ownership. The Britishers governed over land for long time, for over the centuries 1750 AD–1947 AD, over the country, India. The present study take into account the many noteworthy issues dealing with the natural resource, and its management by digitalisation in context to the national land policy, land use land cover and its management by Village Resource Centres, agricultural development and land governance for the country, India. Gini's Coefficient is used to measure the extent of concentration. Due to recent technological development there are found number of geospatial techniques which are adopted and used for land governance at the spatio-temporal levels as the Earth Observation (EO) from space platforms. So, the lessons learned from the experiences of India will also help other developing countries as well as in the global fight against hunger and poverty, at large. Consequently, the geospatial information digitalization for land resources mapping and management is the real world problems solutions as land governance for betterment of humanity on this planet earth.

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1. GEOSPATIAL DIGITALISATION

Geospatial information is forever related to geographic space. It signifies to the immediate geographic world. Geographic space is the space of topography, land use land cover, cadastral, and other landscape features of geographic world. Geographic information systems technology is applied to manipulate objects in geographic space, and to obtain information from spatial facts (Goodchild, 1992). In order to share the geospatial information, the Global Spatial Data Infrastructure (GSDI) facility was set-up for international information cooperation which came into existence in July 2003. The fundamental objective of the GSDI organization is to encourage international cooperation and collaboration in support of local, national, and international spatial data infrastructure developments which will allow all the nations to better address their social, economic, and environmental issues at large. So, the geospatial information is a good definition of the space which is measured, described, and represented in its three dimensions and to be made available over and over again (Burrough and McDonnell, 1998).

Earlier, the geoinformation process could be separated into individual disciplines, such as surveying, geodesy, photogrammetry, remote sensing, and cartography during the analogue mapping era. Presently, there are different data acquisition methods such as terrestrial GPS-surveys, aerial photogrammetry, satellite photogrammetry, laser scanning, photo interpretation, digital processing of remotely sensed images which are themselves competing each other in term of the excellence and expenses (Avery, 1992). In this context, these disciplines and technologies application must have been geared corresponding to the global, regional or local levels geospatial information digitalization for land resources mapping and management for solutions to the real world problems as land governance for betterment of humanity on this planet earth.

2. LAND GOVERNANCE AND MANAGEMENT

Land governance and management are noteworthy matters of concern in the emerging economies and developing countries of the world like India. In agrarian economies, the land is most important assets of the people as 'to own the land is the highest mark of esteem; to perform manual labour, the lowest' (Myrdal, 1968). There has been recorded continuous decline in the share of agriculture and allied sectors in its gross domestic product (GDP), from 14.60 per cent in 2009–2010 to 13.90 per cent in 2013–2014, which is an expected outcome for a fast growing and structurally changing economy. So, the falling share of agriculture and allied sectors in GDP is an expected outcome in a fast growing and structurally changing

economy. In order to keep up the momentum gained during the 11th Plan and achieve the targeted growth rate of 4.00 per cent during the 12th Five Year Plan have focused approaches and schemes.

There is an ever-changing relationship between land, power and people over the centuries in India. Land provides basic necessities like food, clothing and shelter to man. There have been found conflicts over land and resources which are at present a marked feature of the economic growth and development. The Land Acquisition Rehabilitation and Resettlement Bill 2012's compensation provisions, at four times the market rate in rural areas and twice in urban areas (Chakraborty, 2013). This will raise land prices exponentially and will fundamentally impede economic growth.

2.1 Land Governance in Indo-Aryan Era

Ancient records as the RigVeda shows that among the Indo-Aryans, arable land was held in individual ownership or family ownership (Muller, 1849). The Land belonged to the person who cleared the forest and woodland and brought the land under cultivation. So, it appears that the principle of private property and private ownership of land has been recognised from ancient times, in India. Throughout the history, during the ancient period 1200 BC– 200 AD as well as during the recent period 1540 AD–1750 AD, the principal unit of land belong to village settlement, in India (United Nations, 1973). Since land returns was the main source of state revenue, the village became the agency for collection and unit of revenue assessment.

2.2 Land Governance in British India

The Britisher's governed over land for long time, which is known as the colonial era, for over the centuries 1750 AD–1947 AD over the country, India. The Permanent Settlement Regulation (PSR) in 1793 was introduced to record all rights in respect of land and to maintain an up-to-date record of land rights, which was completely failed to implement in the country. At the time of independence, in the country, India, the land tenure systems preserved in three main categories, namely, the Zamindari, the Ryotwari, and the Mahalwari tenures (Mukherjee and Frykenberg, 1979). Each one of these were accounting for about 57.03 per cent, 38.14 per cent and 5.02 per cent of the total privately owned agricultural land.

2.3 Land Governance in Independent India

The India became independent country on the 15th August 1947 of the world and adopted their own constitution which came into effect on 26th January 1950 (GoI, 2007). For all round development of the country, the Planning Commission was set up by a resolution of the Government of India in March 1950. The First Five Year Plan was designed and launched for 1951–56 and thereafter the two subsequent five-year plans were formulated till to present, the Twelfth Five Year Plan, 2012–2017. While keeping this in view, it was assumed that the planning in the country, in general, is that it should increasingly be of an indicative nature. So, since the independence the main emphasis has been on industrialisation of the country, India.

Because the agriculture has been treated as a symbol of economic backwardness. Along with the independence, however, the land reforms and agriculture development were paid more attention though the main focus during the plans was on the industrial sector development.

3. OBJECTIVES OF THE STUDY

The Geospatial land governance and management is a complex matter of discussion and it has been paid a lots of attention since long world widely for the betterment of society. The present research discover the people's role in land governance and management, and also to see the historical background of land governance in the country, India. In view of this, the main objectives of the present study are mentioned as follows:

i. to perceive historical background of land governance, management and digitalisation;
ii. to evaluate geospatial trends of natural resources utilization as land use land cover;
iii. to explore geospatial trends and patterns of agricultural land development;
iv. to examine geospatial trends and patterns of land governance by digitalisation;
v. to suggest suitable lessons learned from land governance and its management.

So, the present research take into account the details of the issues and features of the land governance and management practiced over the periods since the beginning of the ancient time to the present in context to the national land development strategies while dealing with the latest plans and policies of the country, India.

4. DATABASE OF THE STUDY

The present study is based on the secondary data available from the different sources as the Agricultural Census, Agricultural Statistics, and Annual Reports etc. which are annually published by the Department of Agricultural and Cooperation, Ministry of agriculture, Government of India, Krishi Bhavan, New Delhi. In addition to this, the present study is also supported by ancillary data available from the Annual Reports published by the Ministry of Rural Development, Government of India, New Delhi. And, the number of volumes have also been taken into consideration of the Five Year Plans published by the Planning Commission, Government of India, Yojana Bhavan, New Delhi. However, the big data have been used in digitalization for real world problems solutions for land governance and its management for the country, India.

Besides this, the National-level Land Use and Land Cover (LULC) mapping at 1: 2,50,000 scale using multi-temporal Resourcesat-1 AWiFS data have also been taken up and analysed using hierarchical decision tree and maximum likelihood algorithm, and interactive classification techniques. Additionally, surface water bodies and snow and glaciers layers for entire country have also been generated for LULC classification and mapping (NRSC, 2006b). While keeping in view for the wider applicability of remote sensing for the land use

land cover, a classification scheme has been devised using of 1: 50,000 scale map which consists of Level-I: 9 classes, Level-II: 29 classes and Level-III: 79 classes (NRSC, 2006c and NRSC, 2007).

Likewise, the LULC Atlas for India was prepared and released for the use of various departments, central, state and others organisations (NRSC, 2011). Land Cover is defined as observed physical features on the Earth's Surface as forest cover, water body and so on. As soon as an economic function is added into this, it becomes Land Use. The multi-temporal Resourcesat-1, LISS III data for the period of 2005-06 acquired to derive information on the spatial and temporal variability of different land use land cover categories. Such kinds of the multi-temporal datasets were georeferenced with Land Cover Classification (LCC) using the Traverse Mercator (TM) Projection and WGS 84 datum (NRSC, 2007). Besides, the ancillary data consisted of base details namely: the administrative boundaries as international, state, district, tehsil, village and forest boundary, as well as the major roads, railway, drainage, settlements, etc. were taken from available sources. Correspondingly, available ancillary information on wastelands and forests generated was also quantified during digitalisation of land use land cover mapping for the country, India as a whole.

5. RESEARCH METHODOLOGY

Geospatial technologies are playing an important role in natural resources mapping, land governance and its management through big data digitalisation for sustainable development, at large. With the advancement of Indian Remote Sensing (IRS) satellite programs over the periods, a variety of remote sensing-based solutions have been provided for all round development of the country as well as to the world. In other words, due to recent remote sensing technological development as the Earth Observation (EO) from space platforms have been largely used in geospatial information digitalisation at spatio-temporal levels. The EO Satellites play an essential role in generation and dissemination of digital information on land use land cover patterns in a timely and dependable manner providing vital inputs required for optimum land use and planning for sustainable development. The Digital Image Processing (DIP) methodology adopted consists of satellite data preparation, onscreen visual interpretation, ground truth data collection, map finalization, quality checking of final maps and databases organization based on recommended standards (NNRMS, 2009).

The Big Data computation requires statistical tools and techniques for summarization in form of final results. The empirical studies shows that there are statistical techniques used for land governance as Gini's Coefficient (GC) is used to measure the extent of concentration. This method measure of inequalities which is commonly used to gain an over-all view of the prevailing geospatial inequalities. In spite of the limitations of this measuring method, it has been used in the number of studies to compute the geospatial concentration of inequalities of various variables (Dorfman, Robert, 1979; Gastwirth, Joseph L., 1972; and John, Weymark, 2003). So, in the present study, in order to eliminate the bias arises due to the changes in the number of each states, the Gini's Coefficient for the different periods have been computed.

The statistical presentation of the equation used for calculation of the Gini's Co-efficient is described as follows:

$$G = \frac{1}{100\ x\ 100} = \left| \sum_{i=1}^{n} \mathrm{Xi\ Yi} + 1 - \left(\sum_{i=1}^{n} (\mathrm{Xi} + 1\ \mathrm{Yi}) \right) \right|$$

Where:

Xi and Yi are the cumulative percentage distribution of the two attributes.
In other words, the Xi and Yi are respectively the cumulative proportions of number of operational holdings and area operated up to the j^{th} size class of holdings.

So, the concentration of land holdings in terms of Gini's coefficient among different states have been worked out for the periods 1960-61, 1970-71, 1980-81, 1990-91, 2000-01, and 2010-11 for the country, India as a whole.

6. STUDY AREA

India is situated to the north of equator, between the geographical extent of 08° 04' and 37° 06' north latitudes and 68° 07' and 97° 25' east longitudes. Physiographical features reveals that the lofty Himalayans covered with snow and glaciers are lying in the north. The Great Indo-Gangetic Planes with fertile land drained by navigable perennial rivers are lying below the Himalayas. The Peninsular India is geologically oldest stable landmass rich in mineral resources surrounded by seas as Arabian Sea, Bay of Bengal and Indian Ocean lying in the south as is evidenced by the Figure 1.

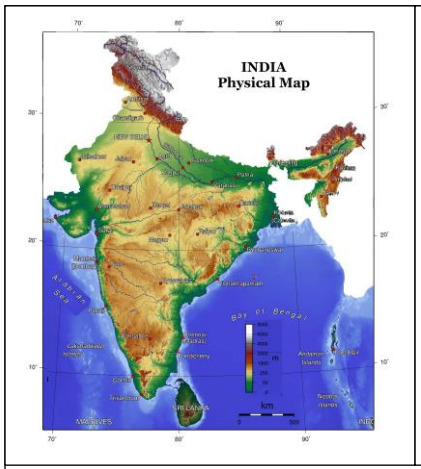


Figure 1: Physical Map, India.

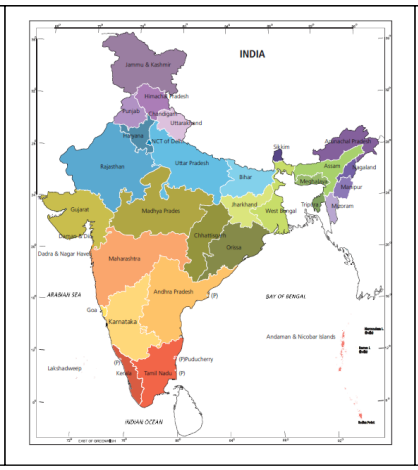


Figure 2: State level Divisions.

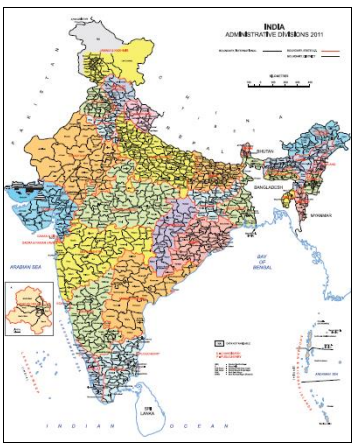


Figure 3: District level Divisions.

Source: CoI (2011) *Census of India 2011*, *Primary Census Abstract*, Office of the Registrar General & Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi.

Besides this, the States level as well as the districts level latest available administrative

divisions at the states level and districts level based on the Census of India, 2011 are also presented in the Figure 2 and Figure 3, respectively. However, the Land information in terms of administrative divisions' statistics showed that there were 28 States which contains about 640 districts in 2011. Likewise, there were around 5,924 sub–districts which comprised by tehsils, talukas and blocks. In addition to this, there was a large number of villages which accounted for about 6,40,930 villages in the country, India during 2011.

7. RESULTS AND DISCUSSIONS

7.1 Geospatial Trends of Land Utilisation

The Natural resources in terms of the land use and land cover statistics for the periods beginning from 1950-51 to 2010-11 and 2011-12 is presented in the Table 1. It is evident that there is about 328.7 million hectares of geographical area or the land cover found exist since 1950-51 till to 2010-11, in the country, India. The net sown area is accounted for about 46.00 per cent of the total reporting area of the country in the year 2010-11 which has increased from 41.80 per cent in 1950-51. Whereas, the world average is about 32.00 per cent in the same period of 2010-11. The forest cover was increased from 14.20 per cent in 1950-51 to about 22.90 per cent in 2010-11. On the other hand, the barren and unculturalable land was decreased from 13.40 to 5.60 per cent during 1950-51 to 2010-11, respectively.

Sl No	Classification	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12
I.	Geographical Area	328.7	328.7	328.7	328.7	328.7	328.7	328.7	328.7
II.	Reporting Area for Land Utilisation Statistics (1 to 5)	284.3	298.5	303.8	304.2	304.9	305.1	305.90	305.81
	1. Forests	40.48	54.05	63.92	67.47	67.81	69.62	70.01	70.02
	2. Not Available for Cultivation (A+B)	47.52	50.75	44.64	39.62	40.48	41.55	43.58	43.52
	3. Other Uncultivated Land Excluding Fallow Land (A+B+C)	49.45	37.64	35.06	32.32	30.22	27.71	26.16	26.10
	4. Fallow Lands (A+B)	28.13	22.82	19.88	24.75	23.36	25.03	24.60	25.38
	5. Net Area Sown (6-7)	118.8	133.2	140.3	140.00	143.00	141.2	141.56	140.80
	6. Total Cropped Area (Gross Cropped Area)	131.89	152.77	165.79	172.63	185.74	185.7	197.32	195.25
	7. Area Sown More Than Once	13.15	19.57	25.52	32.63	42.74	44.54	55.76	54.44
	8. Cropping Intensity *	111.1	114.7	118.2	123.3	129.9	131.6	139.0	138.7
III.	Net Irrigated Area	20.85	24.66	31.1	38.72	48.02	54.84	63.598	65.26
IV.	Gross Irrigated Area	22.56	27.98	38.2	49.78	63.2	75.82	88.630	91.53

Notes:

* Cropping intensity is percentage of the gross cropped area to the net area sown.

i. Figures given in above table are in million hectares.

ii. In 2002-03 there is significant decline in Total Cropped Area and Net Area Sown due to decline in net area sown in the States of Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh Maharashtra, Orissa, Rajasthan, Tamil Nadu, West Bengal and Haryana. This was mainly due to deficient rainfall on agricultural operations.

iii. In 2009-10 there is significant decline in Total Cropped Area and Net Area Sown due to decline in net area sown in the States of Andhra Pradesh, Bihar, Jharkhand, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. This was mainly due to deficient rainfall on agricultural operations.

Source:

Above table computed and compiled from the data collected from the MoA (2014) *Agricultural Census (2000-01, 2005-06 & 2010-11),* Agriculture Census Division, Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India.

Table 1: Trends of Land Utilisation in India: 1950-51 to 2010-11 and 2011-12.

It is also evidenced from the Table 1 that during 1950-51, the gross cropped area was about 131.89 million hectares, out of which 13.15 million hectares or 9.97 per cent, was as sown more than once and the cropping intensity was 111.10. Thereafter, over the period of about 30 years, in 1970-71 period the gross cropped area was increased to about 165.79 million hectares out of which 25.52 million hectares or 15.39 per cent was sown more than once and the cropping intensity value recorded of 118.2. Furthermore, over another 30 years period, during 2010-11 the gross cropped area was increased to about 197.32 million hectares, out of which 55.76 million hectares or 28.26 per cent was as sown more than once and the cropping intensity further increased to about 139.0 as is evidenced by the Table 1. Besides this, it is inferred from the results presented in the Table 1, that there is found changing patterns of land use land cover over the periods beginning from 1950-51 till to 2010-11 in the country, as a whole which is also graphically evidenced by the Figures 4 and 5.

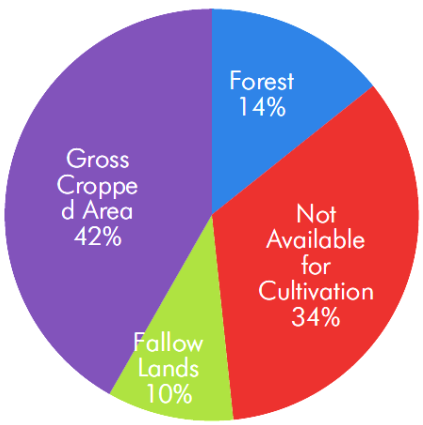


Figure 4: Land Use Land Cover: 1950–51.

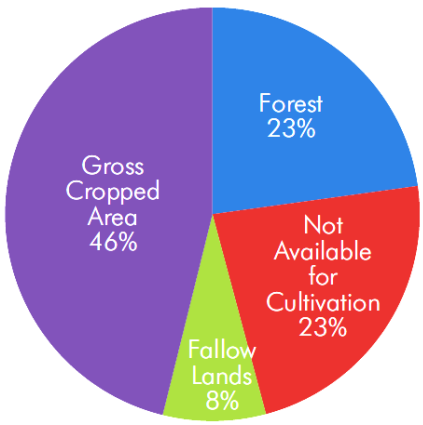


Figure 5: Land Use Land Cover: 2010–11.

Source:

MoA (2014) *Land Use Statistics at a Glance: 2002-03 to 2011-12*, Directorate of Economics and Statistics, Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India, New Delhi.

Figures 4 and 5: Trends of Land Use Land Cover in India: 1950-51 and 2010-11.

7.2 Geospatial Patterns of Natural Resources and Management

7.2.1 Land Use and Land Cover

National–level Land Use and Land Cover (LULC) map at 1: 2,50,000 scale using multi-temporal Resourcesat–1 Multi-temporal AWiFS data have been processed and analysed using hierarchical decision tree and maximum likelihood algorithm, and interactive classification techniques. In addition to this, the surface water bodies and snow cover, glaciers digital layers for entire country, India have also been generated using the satellite imagery. So, the different layers have been merged together and then integrated LULC map produced for the period of 2007-08 which is presented in the Figure 6. Whereas, the Major and medium irrigation command boundary maps were obtained from concerned departments of different states. There are 1,701 major and medium irrigation commands covering 88,896 thousand hectares, which is 27.04 per cent of the geographical area of the country. Number of major and medium irrigation commands are 429 and 1,272, respectively as is evidenced by the Figure 7.

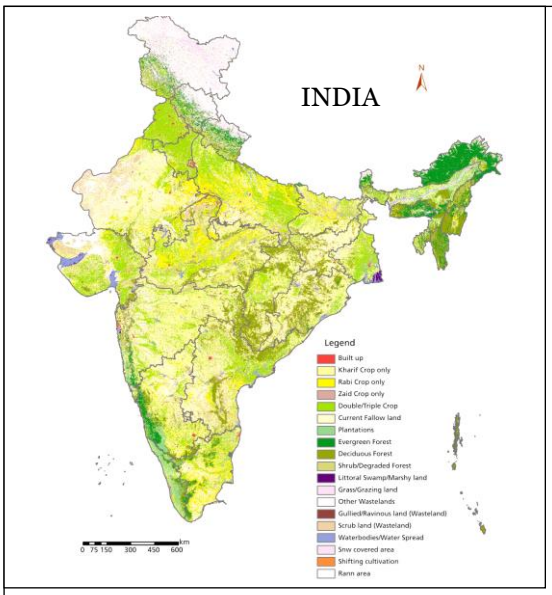


Figure 6:
Land use Land Cover, India, 2007-08.

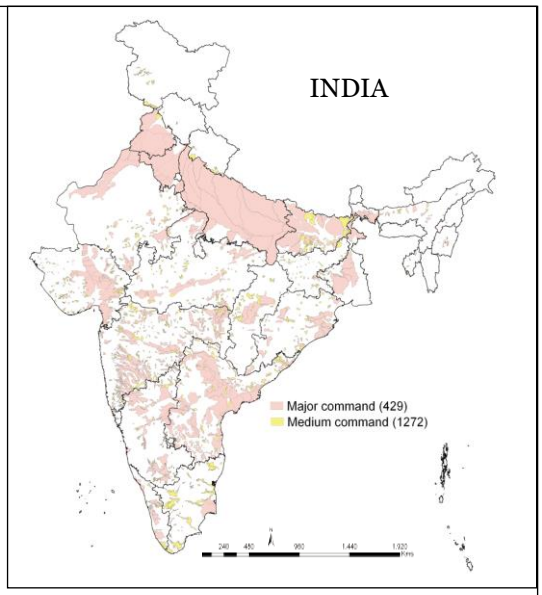


Figure 7:
Major & Medium Irrigation Commands, India.

Source:

NRSC (2011) *Natural Resource Census – Land Use Land Cover Database*, Technical Report – Ver.1, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

The Vegetation Types in India has been classified based on the IRS–6 satellite imagery for the period 2007–08 which is presented below in Figure 8. The Vegetation type map provides information on spatial extent and distribution of single species dominated vegetation formations, ecologically unique formations, mixed species formations and degraded formations. The spatial delineation of these habitats overlaid with 12,000 field species data in

digital domain helps evaluating the regions of bio-prospecting value.

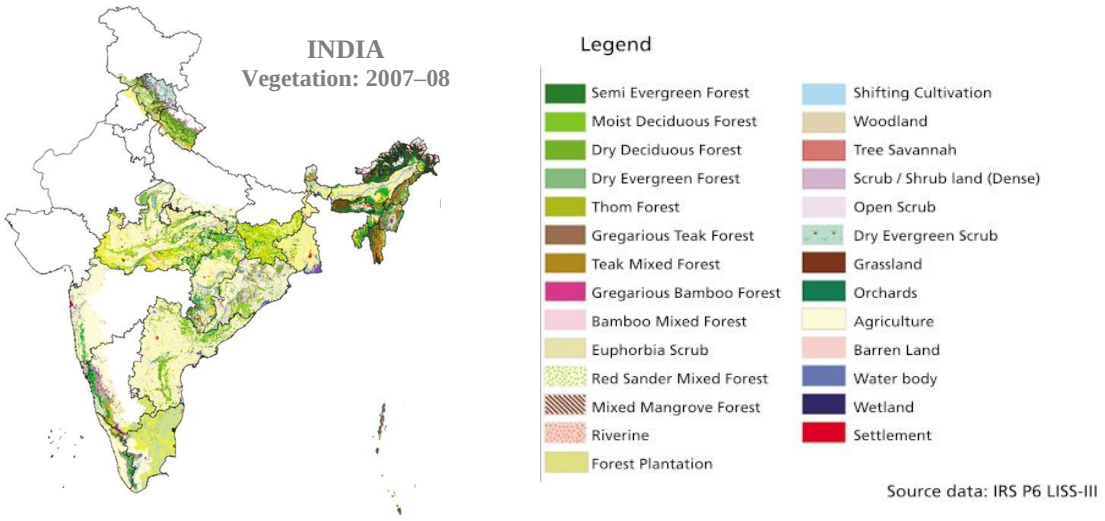


Figure 8: Vegetation Types in India during 2007-08

Source:

NRSC (2011) *Natural Resource Census – Land Use Land Cover Database*, Technical Report – Ver.1, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

So, the vegetation type map, the first of its kind of systematically organized databases has been developed for India, will serve as a primary database for all types of ecological studies and would serve as benchmark for further environment related studies. The vegetation type maps also provide basic inputs for identification of species habitats.

7.2.2 Land Degradation and Management

The Figure 9 and 10 shows the waterlogged area within major and medium irrigation commands in different states of the country, India. The perennial and seasonal waterlogged areas have been mapped using the satellite imagery. So, the total waterlogged areas or in other words, the land not available for cultivation due to waterlogging within major and medium irrigation commands in the country is accounted for about 1,719 thousand hectares which is about 1.93 per cent of the command area. Furthermore, the perennial waterlogging covers an area of about 173 thousand hectares, on the one hand. The seasonal waterlogging covers an area of about 1546 thousand hectares, on the other hand. However, the total waterlogged area within major and medium irrigation commands is accounted for about 0.52 per cent of the geographical area of the country, India. There is an urgent need for proper management of waterlogging problems in order to protect thousands of hectares of arable land which is normally caused by the perennial and seasonal running and stored water resources in the country, India as a whole.

The salted affected areas with major and medium irrigation commands for India have been generated using IRS P–6, LISS–III sensor of the satellite imagery for the country, India for the period 2003–05 which is presented in the Figure 10. So, in order to assess the salted affected areas caused by irrigation in the arable lands, the soil testing have been carried out for the country, India.

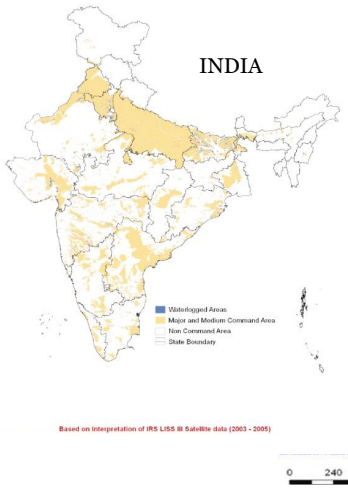


Figure 9:
Waterlogged Area within Major & Medium Irrigation Commands in India.

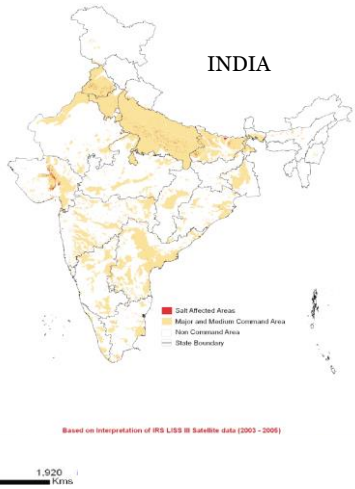


Figure 10:
Salt Affected Areas within Major & Medium Irrigation Commands in India.

Source:

NRSC (2007) *National Land Use and Land Cover Mapping using Multi-Temporal AWiFS Data*, Project Report 2005-06, NRSC, RS & GIS Applications Area, National Remote Sensing Centre, ISRO, Department of Space, Balanagar, Hyderabad, India.

The Soil samples were collected from major and medium irrigation commands of each state. The soil samples were tested for EC, pH and ESP. The salt affected areas are lying in different states in the country within major and medium irrigation commands. The Total salt affected area in the country as per the analysis is accounted for about 1,035 thousand hectares which is around 1.16 per cent of the command area. It covers a marginal land proportion of about 0.31 per cent of the geographical area of the country which is presented in the Figure 10. So, there is an urgent need to reclaim and rejuvenate the degraded land through application of geospatial tools and technologies for land management and sustainability of land resources in the different parts of the country, India.

7.2.3 Village Resource Centres – Cadastral Management

The Village Resource Centres (VRCs) is the unique initiatives that uses Satellite Communication (SATCOM) network and Earth Observation (EO) satellite data in a judicious combination to address the needs of the local people in villages of the country, India. The VRCs use a combination of SATCOM and EO to reach out to the villages and provides wide varieties of services, as agricultural advisories, non-formal education, computer education,

skill development and so on. Among the services, the cadastral mapping at the household's level of the villages is one of the important land resource mapping service performed at the VRCs for land governance in the country, India.

At present, there are about 461 village resource centres (VRCs) established in 22 states and union territories which are as Andhra Pradesh (17); Assam (13); Bihar (19); Delhi (2); Gujarat (10); Jharkhand (26); Himachal Pradesh (30); Karnataka (58); Kerala (21); Madhya Pradesh (24); Maharashtra (18); Meghalaya (1); Nagaland (8); Orissa (44); Puducherry (9); Rajasthan (21); Sikkim (19); Tamil Nadu (54); Uttarakhand (18); Uttar Pradesh (30); West Bengal (10) and Andaman & Nicobar Islands (4) as is evidenced by the Figure 11. The VRCs node also included about 81 Expert Centres set–up in the country, India. The major benefits of VRCs are as the rural empowerment, smart governance, computerised gram panchayats, distance education, remote health care services, employment opportunities, access to products and services available to city dwellers is schematically presented in the Figure 12.

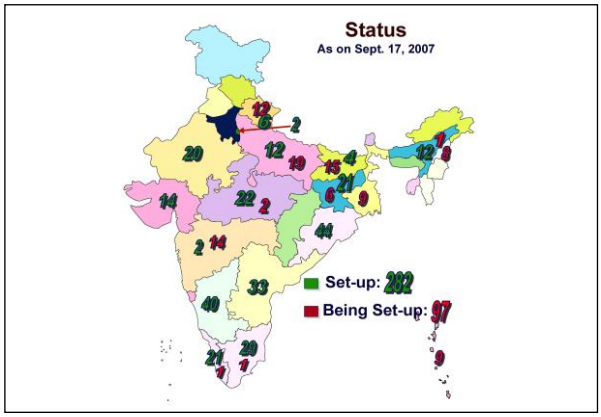


Figure 11: VRCs Centres in India

Figure 12: VRCs Satellite based Services

Source:

NRSC (2007) *National Remote Sensing Centre*, Indian Space Research Organisaiton (ISRO), Department of Space (DOS), Balanagar, Hyderabad, India.

There are more than 6,500 programmes which have been conducted by the VRCs in order to cater the needs of people in the areas like, agriculture and horticulture development; fisheries development; livestock development; water resources; tele health care; awareness programmes; woman's empowerment; supplementary education; computer literacy; micro credit; micro finance; skill development and vocational training for livelihood support etc. So far, more than five Lakh people each year have been benefitted by the VRC services in different parts of the country, India. Now, with the advancement in satellite communication technology, the VRCs are playing an important role in overall development of the country, India.

However, the Village Resource Centres (VRCs) programme launched by the Indian Space Research Organisation (ISRO) of the Department of Space (DOS), Govt. of India which disseminates a portfolio of services emanating from space systems directly to the rural

communities of the country, India. The programme is executed in association with NGOs and Trusts and the State and Central govt. agencies.

7.3 Geospatial Trends of Agricultural Development

The Agricultural progress of any region is generally influenced by the number of factors such as the physical, institutional, infrastructural and technological factors. All these factors are individually or collectively are responsible for the cropping patterns, level of agricultural development and agricultural productivity in an area or region. The institutional factors includes the land tenancy, land tenure and land ownership. These factors have their performance on field size, field patterns, farming type, crop land use, crop association and productivity of the crops, particularly in the country, India. In addition to this, there is found an increasing agricultural production due to the introduction of new technological inputs at large in different parts over the periods in the country, India. The details of the agricultural productivity since 1950-51 to 2010-11 is presented in the Table 2. For instance, during initial period 1950-51, the yield per hectare was about 522 kgs. per hectare which was continuously increased over the periods in different five year plans as evidenced by the Table 2. Whereas, there was about 124.75 million hectares of area under cultivation in 1981-82 and the total output in that period was of 1,032 kgs. per hectare. It was resulted due to the green revolution during 1960's in the country, India. In continuation to this, there was recorded an increasing output, as it was about 2,079 kgs. per hectare achieved during the period of 2010-11. In continuation to this, the trends of land use under major crops have also been found varying over the periods beginning from 1950-51 to 2011-13 as presented in the Figure 13.

Five Year Plans	Duration	Year	Area	Production	Yield	% Area Irrigated
		1950-51	97.32	50.82	522	18.1
First Five Year Plan	*1951-56*	1951-52	96.96	51.99	536	18.4
Second Five Year Plan	*1956-61*	1956-57	111.14	69.86	629	18.2
Third Five Year Plan	*1961-66*	1961-62	117.23	82.71	706	19.1
Fourth Five Year Plan	*1969-74*	1969-70	123.57	99.50	805	23.7
Fifth Five Year Plan	*1974-79*	1974-75	121.08	99.83	824	26.5
Sixth Five Year Plan	*1980-85*	1980-81	126.67	129.59	1023	29.7
Seventh Five Year Plan	*1985-90*	1985-86	128.02	150.44	1175	31.4
Eighth Five Year Plan	*1992-97*	1992-93	123.15	179.48	1457	37.4
Ninth Five Year Plan	*1997-02*	1997-98	124.07	192.26	1552	40.8
Tenth Five Year Plan	*2002-07*	2002-03	113.86	174.77	1535	42.8
Eleventh Five Year Plan	*2007-12*	2007-08	124.07	230.78	1860	46.8
Twelfth Five Year Plan	*2012-17*	2012-13	120.16	255.36	2125	49.0

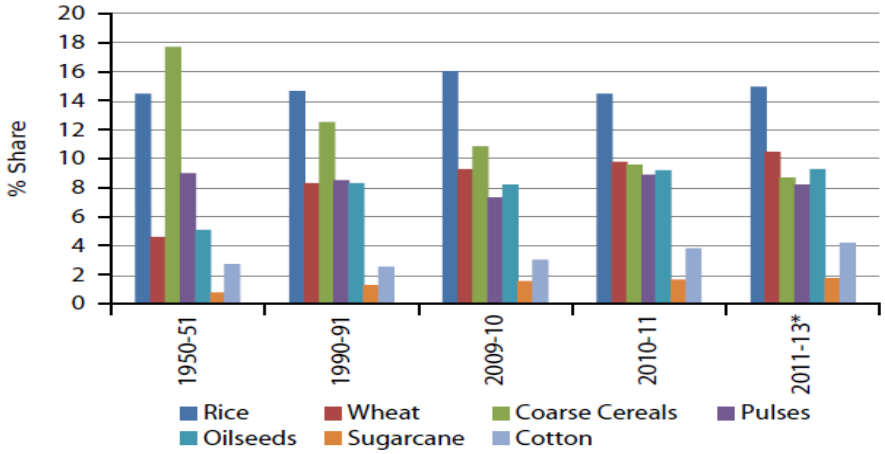
Note: Area in Million Hectares; Production in Million Tonnes; Yield in Kg./Hectare.

Source:

Above table computed and compiled from the data collected from the *Agricultural Census (2000-01, 2005-06 & 2010-11)*, Agricultural Census Division, Directorate of Economics and Statistics, Department

of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Table 2: Trends of Agriculture Production in India: 1950-51 to 2010-11 and 2011 to 13.



Source:

MoA (2014) *Land Use Statistics at a Glance: 2002-03 to 2011-12*, Directorate of Economics and Statistics, Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India, New Delhi.

Figure 13: Trends Land Use under Major Crops for India: 1950-51 to 2011-13.

Subsequently, the green revolution effected to an increasing trend in the output from 1980-81 onwards. It may also be remembered that the average holding in India is 1.33 hectares in 2000-01. So, the small farms ensure to have a direct impact on poverty. It is important to see on whose field the production takes place rather than how much the production has increased. The agricultural production by poor farmers will contribute the most towards decreasing hunger and malnutrition (Raj, 1975). So, it is evidenced that more equal distribution of land to small farmers is viable. And, the broad support base of redistribution should significantly raise productivity and improve the livelihood of the poorest peasant in the country, India.

7.4 Geospatial Trends of Agricultural Land Governance

7.4.1 Operational Land Holdings

An operational holding is well-defined as a unit of land used solely or partly for agricultural production and operated or managed by one person alone, or with the assistance of others without regard to the title, size or location (Sanyal, 1988). Area under operational holdings is called operated area. The number of operational holdings improved speedily from 51 million in 1960-61 to 101 million in 2002-03, which is reasonable considering the growth of population. On the other hand, the rate of growth of operational holdings, which enhanced over the three decades from 1960-61 to 1991-92, seems to have reduced miserable in the

decade preceding to 2002-03. Whereas, there was total operated area of 133 million hectares in 1960-61 which dropped to 126 million hectares in 1970-71 which was a net fall of about 5.8 per cent. It plunged by around 5.6 per cent once more during 1970-71 and 1981-82. Whereas, there was an area of 108 million hectares which extent decreased to about 8.0 per cent since 1981-82, that was in the last 21 years, which remained consistent with the declining trend as observed up to 1981-82.

7.4.2 Marginalisation of Holdings

Customarily, a common feature of the size distribution of operational holdings is that the percentage of holdings decreases as the holding size increases. The percentage distribution of operational holdings expose that the decline is getting progressively sharper with every decade over the periods. The percentages of large, medium and semi-medium holdings have been declining steadily since 1960-61 to 2000-01. The decline is sharpest for large holdings which decreased from 4.50 per cent to 0.80 per cent. On the contrary, it was witnessed that a great gathering of holdings found into the "marginal" category. The percentage of land holdings in this category was increased from 39.00 per cent in 1960-61 to 70.03 per cent in 1991-92 in the country, India.

7.4.3 Division of Operational Holdings

Due to the pressure of growing population on the limited land base and the subsequent division of holdings is obviously reflected in the variations in the absolute numbers of operational holdings in different size classes in the country, India. As it is evidenced that the trends in the number of operational holdings in different categories from the period 1960-61 to 2002-03 that the numbers of operational holdings in different categories are not changing at the same rate, or even in the same direction over periods. In the beginning, over the three decades the number of marginal holdings has increased from 19.8 million in 1960-61 to over 71.0 million in 1991-92 which shows an increase of over three and a half times over the periods. Similarly, the number of small holdings, too, has been found growing, though at a much slower rate, since 1970-71. On the other hand, the absolute numbers of large and medium holdings have declined gradually during this period. In addition to this, the number of semi-medium holdings, which had persisted unchanging at 10 million from 1960-61 to 1981-82 and even showed signs of an increase, was prompted to decrease.

7.4.4 Distribution of Operated Area by Holdings from 1960–61

The percentage distributions of operated area by category of operational holdings demonstrate that the portions of marginal holdings in total operated area, which was about 7.02 per cent in 1960-61, intensified rapidly over the last four decades and again increased by about 6 to 7 percentage since 1991-92 to equalise with the proportion of the semi-medium and medium holdings around 22.50 per cent. Likewise, the proportion of small holdings, as well, has been continuously increased and is currently over 20.03 per cent. While the proportion of large holdings has been gradually declined as from 29.04 per cent in 1960-61 to around 12 to 13 per

cent in 1991-92. The proportion of area operated by medium holdings has decreased gradually but more moderately, and the proportion of semi-medium holdings appears to have reached its highest level in 1991-92 and thereafter started to increase over the periods.

7.4.5 Distribution of Operated Area by Holdings from 2010–11

The agricultural land is bifurcated among the peoples according to the existing law of inheritance, due to the population explosion over the periods in the country, India. The average size of operational holdings was about 1.16 hectares in 2010-11 in India. Such figure is much below the world average size of about 5.50 hectares. The trends of agricultural output since the independence for over the periods 1950-51 to 2010-11 and for the latest period 2011 to 2013 for the country, India is presented by the Figure 13.

The details of number and area of operational holdings in the country, India, based on the results of latest Agriculture Censuses 2000-01 to 2010-11 are presented in the Table 3. There is found a large proportion of about 67.04 per cent of land holdings which are having less than 1 hectare in 2010-11 in India. In addition to this, the small land holding is accounted for about 17.93 per cent and possessed land ranges between 1 to 2 hectares. These holdings together accounted for about 84.97 per cent of the land holdings in the country, India as evidenced by the Table 3. So, such marginal and small land holding are not seems to be viable economically. The fact is that all these land holders cannot produce enough to meet out the cost of cultivation like irrigation, High Yielding Variety (HYV) seeds, chemical fertilisers, insecticides, pesticides and agricultural machinery.

Category of Holdings	Number of Holdings			Area			Average Size of Holdings		
	2000-01	2005-06	2010-11	2000-01	2005-06	2010-11	2000-01	2005-06	2010-11
Marginal	75408	83694	92356	29814	32026	35410	0.40	0.38	0.38
(Less than 1 hectare)	*(62.88)*	*(64.77)*	*(67.04)*	*(18.70)*	*(20.23)*	*(22.25)*			
Small	22695	23930	24705	32139	33101	35136	1.42	1.38	1.42
(1.0 to 2.0 hectares)	*(18.92)*	*(18.52)*	*(17.93)*	*(20.16)*	*(20.91)*	*(22.07)*			
Semi-Medium	14021	14127	13840	38193	37898	37546	2.72	2.68	2.71
(2.0 to 4.0 hectares)	*(11.69)*	*(10.93)*	*(10.05)*	*(23.96)*	*(23.94)*	*(23.59)*			
Medium	6577	6375	5856	38217	36583	33709	5.81	5.74	5.76
(4.0 to 10.0 hectares)	*(5.48)*	*(4.93)*	*(4.25)*	*(23.97)*	*(23.11)*	*(21.18)*			
Large	1230	1096	1000	21073	18715	17379	17.13	17.08	17.38
(10.0 hectares and above)	*(1.03)*	*(0.85)*	*(0.73)*	*(13.22)*	*(11.82)*	*(10.92)*			
All Holdings	119931	129222	137757	159436	158323	159180	1.33	1.23	1.16
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)			

Note: Figures in parentheses indicate the percentage to total.
No. of Holdings: (‘000 Number); Area Operated: (‘000 Hectares); Average size: (Hectares).

Source:
Above table computed and compiled from the data collected from the MoA (2000-01 & 2010-11)

Agricultural Census (2000-01, 2005-06 & 2010-11), Agricultural Census Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Table 3: Classification of Operational Holdings by Size Groups during 2000-01, 2005-06 and 2010-11.

During 2010-11, there was about 44.32 per cent of land area which was held by marginal and small holdings ranges less than 1 hectare and 1.0 to 2.0 hectares, respectively as evidenced by Table 3. The semi-medium holdings ranges 2.0 to 4.0 hectares accounted for about 23.59 per cent of the land area. The medium holdings accounted for about 21.18 per cent of the land area. So, there is majority of the marginal and small holdings as well as the semi-medium and medium holdings accounted large proportion of land area in the country, India. The small and marginal holdings while taken together i.e. the below 2.00 hectares is constituted about 84.97 per cent in 2010-11 against 81.80 per cent in 2000-01 and the operated area was about 44.32 per cent in the current census 2010-11, as against the corresponding figure of 38.86 per cent in 2000-01.

The semi-medium and medium operational holdings which are ranging between 2.00 to 10.00 hectares in 2010-11 were accounted for about 14.30 per cent with the operated area of 44.77 per cent. The corresponding figures for 2000-01 and 2010-11 censuses accounted for about 17.17 per cent and 47.93 per cent, respectively. The large holdings ranging between 10.00 hectares and above accounted for about 0.73 per cent of total number of holdings in 2010-11 with a share of 10.92 per cent in the operated area as against 1.03 per cent and 13.22 per cent, respectively in 2000-01 as evidenced by the Table 3. So, whichever momentous change occurs in agrarian structure would have some impact on the size distribution of land holdings in the country, India.

7.5 Geospatial State-wise Patterns of Average Size Operational Holdings

In the country, India as a whole, out of 35 States and Union Territories (UTs), there was found that 13 States namely the Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal altogether accounted for about 91.00 per cent of the number of operational holdings with a share of about 88 per cent operated area during the period 2010-11. Whereas, there was about 138.35 million operational holdings in the country, in which the highest one belonged to Uttar Pradesh State which accounted for 23.33 million and followed by Bihar 16.19 million, Maharashtra 13.70 million, Andhra Pradesh 13.18 million, Madhya Pradesh 8.87 million, Tamil Nadu 8.12 million, Karnataka 7.83 million, West Bengal 7.12 million, Rajasthan 6.89 million, Kerala 6.83 million etc. with the lowest of only 714 operational holdings in Union Territory of Chandigarh. Besides this, out of a total of 159.59 million hectares operated area in the country in 2010-11, the highest contribution was made by Rajasthan State with an area of 21.14 million hectares followed by Maharashtra 19.77 million hectares, Uttar Pradesh 17.62 million hectares, Madhya Pradesh 15.84 million hectares,

Andhra Pradesh 14.29 million hectares, Karnataka 12.16 million hectares, Gujarat 9.90 million hectares etc. with the lowest operated area of 923 hectares in the Union Territory of operational holdings as well as the operated area in the country in 2010-11.

As compared to 2005-06, percentage increase in number of operational holdings in 2010-11 was the highest in case of Goa which is 47.71 per cent followed by Madhya Pradesh 12.19 per cent, Rajasthan 11.35 per cent, Bihar 10.47 per cent, Daman & Diu 9.60 per cent, Andhra Pradesh 9.39 per cent, Chhattisgarh 8.26 per cent, Odisha 7.14 per cent, Pondicherry 5.56 per cent, Nagaland 5.41 per cent, and Jammu & Kashmir 5.20 per cent, and so on. Nevertheless, the operated area showed declining trend in most of the States. In addition to this, the Tables 4 presents figures for altogether state-wise average size of operational land holdings for all the social groups for the periods of 2000-01, 2005-06 and 2010-11 for country, India.

Country/(Periods)	Marginal	Small	Semi-Medium	Medium	Large	All Holdings
India (2000-01)	0.24	1.42	2.39	4.42	13.16	1.33
India (2005-06)	0.23	1.38	2.36	4.38	12.99	1.23
India (2010-11)	0.39	1.42	2.71	5.76	17.34	1.15

Note: The average size of operational land holdings in hectares.

Source:

Above table computed and compiled from the data collected from the MoA (2000-01, 2005-06 & 2010-11) *Agricultural Census (2000-01, 2005-06 and 2010-11)*, Agricultural Census Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Table 4: State-wise Average Size of Operational Holdings by All Social Groups, 2000-01, 2005-06 and 2010-11.

The Above Table helps in comparison of all the State-wise altogether average size of operational land holdings among the social groups as well as over the periods for the country, India as a whole. The size of marginal land holdings was marginally increased from 0.24 to 0.39 from 2001-01 to 2010-11 for the country as a whole, respectively. Likewise, semi-medium, medium and large land holdings showed an increasing trend over the periods. Whereas, it is important to point out that the all holding size was marginally decreased over periods as evidenced by the Table 4.

As per the Agriculture Census 2010-11, the total number of operational holdings in the country was increased from 119.93 million in 2000-01 to 137.76 million 2010-11 i.e. an increase of 17.83 million holdings over a decade period. Whereas, there was marginal decrease in the operated area from 159.44 million hectares in 2000-01 to 159.18 million hectares in 2010-11 showing a decrease of 0.26 per cent. The operated area was primarily

increased because the State of Jharkhand participated for the first time in Agriculture Census operation in 2010-11 after the state came into existence in the year 2000. The average size of operational holding was of 1.15 hectares during 2010-11 in the country, India.

7.6 Geospatial Concentration Trends of Operational Holdings

In order to comprehend the trends of operational land holdings, the Gini's coefficient of concentration is used to obtain an overall measure of concentration in the size distribution of operational holdings for the country, India. The values of coefficients are computed for the periods 1960-61, 1970-71, 1981-82, 1990-91, 2000-01 and 2010-11 as presented in Table 5.

Periods	1960-61	1970-71	1980-81	1990-91	2000-01	2010-11
Gini's coefficients	0.583	0.586	0.629	0.641	0.624	0.602

Source:

The Gini's Coefficients for the above table computed and compiled from the data collected from the MoA (2010-11) *Agricultural Census (2010-11),* Agricultural Census Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Table 5: Trends in Gini's coefficient of concentration of operational holdings in India.

In general, there is found an increasing trends of the concentration of operational land holdings over the periods in the country, India as also evidenced by the Table 5. In lieu of this, there is found an increasing trends of concentration at the states level in the country as is evidenced by the Gini's coefficient values which shows the degree of concentration in operational holdings which increased since 1960-61. Later on, such increasing trend has been slowed down since 1990-91 and further continued to decreasing over period's up to 2010-11 as evidenced by the Table 5.

7.7 Geospatial Concentration Patterns of Operational Holdings

The Gini's coefficient values presented in the Table 6 showed the deviations in the degree of concentration in the size distribution of operational holdings in all the 15 major States over the periods 1970–71, 1980–81, 1990–91, 2000–01 and 2010–11 for the country, India. To ensure proper comparability, it has been necessary to use, for computation of the coefficient, the distribution of land holdings by category at the state level for all the periods. Extraordinarily, there is a slowing down in the increase in concentration since 1980-81. In fact, the coefficient value for period of 1990–91 is slightly lower than that for period of 1980-81. It is also discernable from the Table 6 that there is a varying trends in the Gini's coefficient across the states in the country, India. Whereas, in case of the States like the West Bengal, Bihar (including Jharkhand), and Orissa, the index of concentration was decreased sharply since 1990–91. Similarly, in case of the Assam, Uttar Pradesh (including Uttaranchal), and Tamil Nadu, the index was decreased in both the periods 1980–81 and

1990–91. Similarly, in Kerala State, there was steady decrease in the index since 1970–71 as evidenced by the below Table 6.

States	1970-71	1980-81	1990-91	2000-01	2010-11
Andhra Pradesh	0.582	0.573	0.529	0.543	0.567
Assam	0.388	0.465	0.412	0.366	0.413
Bihar & Jharkhand	0.511	0.534	0.525	0.421	0.456
Gujarat	0.518	0.544	0.573	0.605	0.621
Haryana	0.436	0.571	0.645	0.675	0.698
Karnataka	0.509	0.562	0.577	0.543	0.556
Kerala	0.483	0.449	0.392	0.348	0.392
Madhya Pradesh & Chhattisgarh	0.508	0.520	0.533	0.527	0.565
Maharashtra	0.514	0.570	0.570	0.526	0.587
Orissa	0.466	0.504	0.462	0.381	0.432
Punjab	0.398	0.685	0.694	0.706	0.784
Rajasthan	0.599	0.551	0.590	0.610	0.589
Tamil Nadu	0.480	0.555	0.527	0.508	0.539
Uttar Pradesh & Uttaranchal	0.471	0.520	0.498	0.450	0.478
West Bengal	0.433	0.494	0.430	0.313	0.392
India	*0.567*	*0.596*	*0.591*	*0.557*	*0.587*

Source:

The Gini's Coefficients for the above table computed and compiled from the data collected from the MoA (2010-11) *Agricultural Census (2010-11)*, Agricultural Census Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, Krishi Bhawan, New Delhi.

Table 6: Gini's coefficient of concentration of the size distribution of operational holdings by States.

On the contrary, in case of the State Karnataka, Madhya Pradesh (including Chhattisgarh), Maharashtra and Rajasthan, there was no clear trend discernible in terms of the degree of concentration in the size distribution of operational holdings over the periods. However, it is noteworthy to mention that the two most agriculturally developed States of Punjab and Haryana were displayed the most pronounced increase in the concentration ratio since 1970–71. In case of the Haryana State, the ratio increased substantially over the periods since 1970–71. Whereas in case of the Punjab State, the ratio increased sharply from 0.398 in 1970–71 to 0.685 in 1981–82. This was followed by a smaller increase in the next two periods and so on up to 2010–11. In addition to this, in case of the Gujarat State, there was steady, though more gradual, increase in the index of concentration over the periods since 1970–71 to 2010–11 as evidenced by the Table 6.

8. CONCLUSIONS AND SUGGESTIONS

Geospatial land governance and management through digitalisation is a noteworthy matter of concern in the emerging economies and developing countries of the world, like India. In agrarian economies, the land is most important assets of the people. Besides this, 'to own the land is the highest mark of esteem; to perform manual labour, the lowest'. There is an ever-changing relationship between land, power and people. Ancient records show that, among the Indo-Aryans, arable land was held by family ownership. Later on, during the periods 1200 BC–1200 AD and AD 1540–1750, the principal unit of land settlement was the village. The British governed the land from 1750 to 1947. During this period, the Permanent Settlement Regulation was introduced to record all rights in respect of land in order to maintain an up-to-date record of land rights, but this remained unsuccessful. So, such was the beginning of land record digitalisation at different levels in the country, India

Since the country's independence, there has been an emphasis on the implementation of consecutive Five Year Plans addressing agriculture and related economic activities. Moreover, in India, about 58.40 per cent of the labour force is employed in agriculture and allied activities for their livelihood in 2001. Land accounts for more than 50.12 per cent of the total assets of rural households. India is one of the world's rapidly developing and emerging economies. There has been a continuous decline in the share of agriculture and allied sectors in its gross domestic product (GDP), from 14.60 per cent in 2009–2010 to 13.90 per cent in 2013–2014 (at 2004–2005 prices), which is an expected outcome for a fast-growing and structurally changing economy.

There are a number of strategic issues in land governance and development under different plans and policies. The main objective of land reform is to provide social justice for the people, particularly the cultivators, land owners, landless labourers, and rural populations. The main directives of land reforms are the abolition of intermediaries; land tenancy reforms; rent control reforms; ceilings on land holdings; consolidation of land holdings; security of land holdings tenure; reversal of forced evictions and relocations; women's land and property rights; and computerisation of land records. In addition to this, land digitalisation process is strengthened and speed-up with establishment of Village Resource Centre's (VRCs) for cadastral mapping and its connection with other services with the remote sensing satellite communication facilities provided by the National Remote Sensing Centre of the Department of Space of the Govt. of India.

In lieu of this, with the implementation of the land reform program, a certain specified limit of land belonging to landlords was set, and the rest would be taken over by the state. The ceiling on land holdings is an effective measure for land redistribution. In view of the prevailing social and political contexts, the ceiling law was neither politically expeditious nor administratively easy to implement. Kerala and West Bengal States, where rigorous implementation of tenancy legislation took place, have been successful role models of tenancy reforms for the country, India.

Land reforms are connected with the right to life and livelihood of a huge rural population. The government is obliged to protect farmers' land rights. The real threat to India's well-being and security is the displacement of its rural population from its roots. As long as the population is tied to the soil, there will be an increase in agricultural production and economic growth. Farming by smallholders continues to have a direct impact on poverty. More equal distribution of land to this group is viable, and the broad support base of redistribution should significantly raise productivity and improve the livelihoods of the poorest people.

In this context, the chronological analysis of the past 11 Five Year Plans makes it clear that, since the inception of the Planning Commission, industrialisation has been equated with development. The agricultural sector has always been a secondary priority in different plans. It must be noted that a majority of people living in rural areas have remained untouched by the trickle-down effect of industrialisation. Due to land reforms, a middle-level peasantry sharing the characteristics of capitalist farmers emerged, who were largely responsible for the green revolution of the 1970s and the 1980s. Today, decreasing sizes of farm holdings are a major challenge to their economic viability.

Consequently, the land reform has been focal point of the country's political and economic agenda. This also lays a sound foundation for growth, to enable India to compete in the global market. Land reform policy is fundamentally a politico-economic issue, and in most cases it is the result of a people's movement. Land reform means the distribution of surplus land to small farmers and landless cultivators. It has been a major instrument of social transformation, especially in an economy based on feudal and semi-feudal production relationships. The long-term solution is to reduce the dependence of the rural population on land through the expansion of non-agricultural activities.

So, the future growth must be based on higher efficiency and will require to invest in science and new technologies to harness natural land resources, optimise their economic structures for allocative efficiency, and reform their fiscal, financial, banking, and insurance systems which is only feasible through the geospatial digitalisation as continuing by the VRCs centers developed by the NRSC, govt. of India. Thus, the lessons learned from the experiences of India will also help other developing countries and in the global fight against hunger and poverty. So, the long-term solution is to lessen the dependence of rural population on land by the expansion of non-agricultural activities. Nevertheless, the grass root level change in rural society is primarily possible through the agricultural development in which the agrarian reforms have a greater role in fundamental development of the country, India.

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BIOGRAPHICAL NOTES

Dr. Madan Mohan is an Associate Professor of Geography at the Centre for the Study of Regional Development, School of Social Sciences of the Jawaharlal Nehru University, New Delhi. Specialised in the fields Geoinformatics – application in Land Governance and so on. His research acclaimed across the world, through academic deliberations and presentations in several countries as the Netherlands, United States (North America), France, Turkey, Australia, Chile (South America), Germany, Malaysia, People's Republic of China, Czech Republic and so on.

CONTACTS

Dr. Madan Mohan
Associate Professor of Geography
Jawaharlal Nehru University
Centre for Study of Regional Development
School of Social Sciences-III
New Delhi
INDIA

Tel. +091–011–2673–8960
Fax +091–011–2674–2641
Email: drmdnmohan@gmail.com
Web site: http://www.jnu.ac.in