Chapter 5

LULC pattern within the Basin Area

5.1 Introduction

The solid portion of the earth's surface is called land. Land is a three dimensional (3D) natural body with mosaic of topography, soils, vegetation, human habitations etc. and the complexity of land is very much related with underground or subsurface geology, climatic factors and hydro geomorphic processes (De and Taraphder, 2003). Human needs both basic and advanced are fulfilled by the natural resources explicitly from land as resource. Land use and land cover of an area is characterized by biophysical and economic attributes better to say the man-environmental relations. Land use for clear understanding should be thought as economic activities out of the landscape. Land cover, on the other hand, explains the natural vegetation and man-made construction covering the land surface. Man as it instinctive approach requires bringing changes in the geomorphic outcome of the land for his needs reaching sometimes beyond to the ludicrous greed. Land use land cover changes respond to socio-economic, political, cultural, demographic and environmental conditions and forces which are largely characterized by high human populations (Cheruto et al, 2016). The term land use describes series of operations on land, carried out by humans to obtain products for benefits through land resources. Land cover is also used as interchangeably with land use (Brar, 2014) over time. Both the terms are different from each other. Land use explains the way of using the land and the pattern of its development. On the other hand land cover refers to the vegetation, structures or other features that cover the land (Brar, 2014; Dempsey, R., & Fisher, A., 2005). Human being is the most active agent to remake up of the land quite more than any other. Mother Nature is itself deterministic in character and in temporal spectrum it is not always directly reactive to man than to indirectly reactive. Pristine forests are being cleared for both logical and ridiculous usage mostly radical to the conservation. Transformation of LULC for agriculture, industry and human settlement is no longer the only issue. Whereas marketoriented and non substantive characters are more having onus to the accelerated and changed situations. The quality resources are being degraded and altered for low quality resources of very shorter run. The multidimensional prospects of land are often

threaten by deforestation, misuse and overuse of land, surface and subsurface water depletion, water stress on vegetation, laterisation of soil, rill and gully erosion (Basu, 2002).

Land use is the use actually made up of any parcel of land (Mandal, 1982). Land use of any region is the result of the inhabitants activity on the land through their perception of landscape ecological factors in that region, developed by the capacity of the generations for absorption the different mechanical and technical skills. On a specific point, at a given time and space the utilisation of all type of land is land use. Primary activity on land by man is Agriculture which is based on utility of land. Land ecosystem is mainly carried by land, acts as result of all the interacting systems and therefore it displays the phenomenological appearance of their interaction in land use conditions (Vink, 1975). Land is the main source for food, shelter to the human society and the base of other economic activities especially primary activity as a result land has given a special attention for the study. The study of land use provides much relevant information related to different crops, cropping pattern, year wise production of crops, changing pattern of crops and cropping pattern over time. This study also gives emphasis on conversion of land from one major use to another use (Prakasam, 2012). For instance whether a particular portion of land has been converted from agricultural land to built-up area or forest area converted to agricultural land by cutting the forest for the need of human being is one of the prime focuses of land evaluation. The land use study deals with the study of problems related to the method of deciding and putting land into its right choice (Prakasham, 2012). Human according to his needs changing the land and its use. The statuses of socio economic changes, different climatic and geomorphic changes are the key factors for invention of new type of land use. Development of scientific technologies also provides enhanced ways of using the land surface. Therefore researches to find best land use practice for particular piece of land considering it's geomorphic, climatic and socio economic condition etc. of that particular area.

In India till 1949-59, the land area was classified into five categories (ICAR' 1980): 1) forest, 2) area not available for cultivation, 3) other uncultivated land excluding the current fallow, 4) fallow land, 5) netarea sown. In 1948 the Technical Committee on Co-ordination of Agricultural Statistics by the Ministry of Food and Agriculture recommended nine fold land use classification 1) forests, 2) land put to non agricultural uses, 3) barren and unculturable land, 4) permanent pastures and other grazing ground, 5) miscellaneous: tree crops, groves, not included in the netarea sown, 6) culturable waste, 7) fallow land, other than current fallows, 8) current fallows, 9) netsown area.

5.2 Importance of RS-GIS in Land Use Land Cover Analysis

Land use and land cover statistics can be produced by using remote sensing data under GIS environment. These data gives us the clear idea regarding utilisation of land for different purpose of a particular region. Remote sensing and GIS are useful equipment for mapping the existent Land Use Land Cover (Skidmore *et al.,* 1997, Anderson *et al.,* 1976; Roy *et al.,* 1991) and their changes over time through overlapping and feature extraction of past maps and images of the same area to forecast future trends (Biswas & Saha, 2018). Different parameters of satellite images like tonal variations, hydrological and land surface features helps to interpret land utilisation (Roy *et al.,* 1985; Keil *et al.,* 1990; Congalton *et al.,* 1993). Satellite based modern technology of remote sensing helps us to gather lot of physical data easily, within short span of time and on repetitive basis. Modelling and possibility of different types of planning can be done using altogether RS and GIS systems. The analysis of physical data with socio-economic data using RS-GIS provides vital linkages to planning processes in the domain of recent technological advancement. Satellite imagery is basically responsible for multi-spectral and multi-temporal scanning of the earth's surface. Land use and land cover data directly cannot be recorded by satellite images. Satellite images rather measure the different properties of electromagnetic radiation being reflected with the certain quantity of multispectral energy from each small area of the earth’s surface. The type of material at the earth's surface determines the amount of multispectral energy in form of different wavelengths. These reflected energies categorises each type of LULC (Shetty *et al.,* 2005). Different analytical procedure on the remotely sensed data, statistical methods and human interpretation helps to prepare maps and measure of land use land cover. Modern techniques allow in-depth mapping of LULC or able to identify all the small or minute features or fractional cover of the land surface by diverse LULC classes which is more viable than conventional maps of LULC.

The identification of change detection of Land Use Land Cover (LULC) became possible with the help of remote sensing technology at minimum time with higher accuracy and lower cost over a period of time (Kachhwaha, 1985) which requires make use of at least two period data sets (Jenson, 1986). The change of Land use or land cover is significantly correlated with environmental change and the change caused by the intersection of natural and human influences on earth’s surface. The diverse changes in land use and their continuation alter the state of the biosphere and bio-geochemical (Turner, 1995). The temporal and spatial variation of spectral reflectance provides suitable information for classification land use and land cover

of an area from satellite images, since it is very essential to verify with ground based data to enhance the level of accuracy.

5.3 Focal themes of the chapter

Focal themes of this chapter are mentioned below

1) Identification and preparation of the land use and cover map of the study area of different time frame.
2) Measuring changes in LULC pattern over time and mapping of the same.
3) To study the LULC properties of different terrain units and villages to understand the variability of LULC characters.

5.4 Materials and methods

Data products

(a) The Survey of India (SOI) Topographical maps (73I/4/NW, 73I/4/NE, 73I/4/SE, and 73I/4/SW) with scale 1:25,000 for the time frame 1983-84.

(b) Land Sat- 5 for the time frame November 1992(TM) path 140 row 44.

(c) Land Sat- 8 November, 2018 (OLI) path 140 row 44 and.

The geo-coded digital data was downloaded from Earth Explorer and Bhuban and were analyzed under GIS platform.

(d) Census of India (2011) provides village wise data of land use classes and their areal share.

Methods

The methodology for the above is as follows —

1. ***Data Acquisition*:** Data for land use and land cover analysis has been extracted from Survey of India topographical maps and satellite images. Landsat satellite images which cover the basin downloaded from earth explorer (https://www.earthexplorer.usgs.gov).
2. ***Pre processing***: Pre processing of images sometimes referred as image rectification and restoration. Through this process distortions are basically modified namely sensor noise, atmospheric situation, and geometry of sensor. Spatial resolution of Landsat 5 and Landsat 8 are 30 meters. Area of Interest (AOI) polygon prepared for cropping the Sanka basin from satellite images maintains the projection system and appropriate

datum. GIS software has been used to consider different bands and stake to create FCC images. 'Nearest neighbour assignment' technique have been used under GIS environment for cropping and re-projecting of AOI to store maximum data and no loss any values in respect to tone, colour and edges.

3. ***Visual Interpretation***: The main elements for visual interpretations of images and aerial photographs shape, size, pattern, tone, texture, shadows, location, association and resolution. From topographical maps preparation of land use land cover map was easy by identifying the different components. The base land use land cover map has prepared using SOI topographical maps by digitizing the different classes. For satellite images image enhancement techniques were used to aid visual interpretations. To increase the tonal variation, grey scale manipulation technique were used to increase the intensity of tone. For example cultivated land and forest land and water bodies were easy to identify and their boundary due to combined effect of tone, pattern and size. Sometimes it was difficult to differentiate different features for example scrub and fallow land having similar type of tone, to solve the problem or to identify the features properly different techniques were used.
4. ***Unsupervised classification***: This method acts as the base of supervised classification. On the basis of spectral signature, pixels are grouped together using Isodata technique of unsupervised classification. This technique group together the similar pixels and indentify different classes using software based algorithms.
5. ***Development of Spectral Signature Set***: To define a class, training sites are very important for supervised classification of images. The development of training set is a crucial action in supervised classification of image because these training sets act as true representative of ground surface or LULC. Training sets are collected from homogenous ground surface areas by demarcating polygons for the known surface or land use land cover areas and created a signature files. Special care has taken during the collection of training sets from the satellite images by ground truthing using topographical maps, Google Earth images, field verification with GPS etc. and mixed pixels are avoided which may contain more than one class. The collected training sets are merged according to each spectral signature of different surface areas to produce unique signature file for land use land cover classes. These signature files have applied for supervised classification procedure to classify the image of the total basin area into different classes.

6. ***Supervised classification***: The classification of images have done using Maximum Likelihood Classifier (MLC) rule, which has been widely used for classification of remotely sensed data under GIS environment (Foody *et al.,* 1995). The covariance matrices of each reference class considered in MLC rule to understand variability of each class for the classification (Schriever and Congalton, 1995; Lillesand and Kiefer, 2000), commissioning the information which contained in a signature file. The estimated Gaussian probability density functions for each class is the base of MLC which expressed by the following expression (Pandey *et al.,* 2006; Sahu, 2007):

$$D = \log (a_c) - [0.5 \log (|Cov_c|)] - [0.5 (X - M_c) T (Cov_c^{-1}) (X - M_c)]$$

where, D: weighted distance (likelihood); c: a particular class; X: die measurement vector of the candidate pixel; M_c: mean vector of the sample of class; a_c: percent probability that any candidate pixel is a member of class c; $|Cov_c|$: determinant of Cov_c (matrix algebra); Cov_c: the covariance matrix of the pixels in the sample of class c; Cov_c^{-1}: the inverse of Cov_c; T: transposition function.

7. ***Recoding and Accuracy Assessment:*** Recoding has used to define some pixels for a particular class when they have similar DN value. For example sometimes the shadows of the peak and water body represent same value and similar problem faced for built–up area and sand deposition or barren land. To solve this recoding has done. The correctness of classified map verified through the process of accuracy assessment.

8. ***Village-wise and terrain class-wise LULC analysis:*** Village-wise land use data has been represented with suitable cartographic technique. The superimposition of latest LULC classes using Landsat 8 (OLI) image on terrain classes of Sanka basin to measure the area wise distribution of LULC.

5.5 Land Use Land Cover (LULC) Classes

The Sanka River Basin has classified with different land use land cover classes on the basis of previously mentioned data and methods are mentioned. The findings after applying the classification techniques are contrasting and more conforming to the preserved assumptions. The base LULC classes were extracted from SOI topographical maps and the change detection is calculated with help of different satellite images discussed in later part of this chapter. The LULC classes (Table 5.01) and their each class wise share of area (Fig. 5.01) of the basin from SOI topographical maps has discussed here.

1. **Forests**

Forest is an important land cover of the Sanka River Basin which is environmentally very significant. The forest area is mainly composed of various types of trees which has significant impact on climate, water, soil and also provides timber and other forest products to local dwellers.

The northern, north-western and central parts of the study area are mainly occupied by forest. Some parts of the forest area also fall within Matha Protect Forest (*P.F*). The *Ajodhya* ridges in north and north-western part of the basin at area are mainly occupied by dense and open mixed jungle of mainly Sal (*Shorea robusta*) trees. The other species mixed with Sal are eucalyptus, Palash (*Butea monospema*), Kusum (*Scheichera oleosa*), Mahua (*Madhu longifolia*) and Shimul (*Bombax ceiba*). The central part of the basin mainly occupied by open mixed jungle of mainly teak (*Tectona grandis*) and Palash (*Butea monospema*) trees. The forest of the Sanka Basin occupied a total 56.376 sq. km or 29.49% area of the basin as per Survey of India topographical maps (Surveyed 1983-84).

2. **Plantations**

Plantation simply refers to manmade forest. Plantation are clearly can be indentified on the basis of its particular structure and pattern. Plantation areas easily identified from survey of India topographical maps because these areas are clearly demarcated by boundary. Through the satellite images the mixed forest and mature plantation area demarcation is problematic due to its similar type of spectral signature (Raghavswamy et al., 1983). In the Sanka Basin mainly two types of plantation can be observed acacia (*Acacia arabica*) and teak (*Tectona grandis*) plantation. Majority plantation is mainly acacia which are spread all over the basin area excluding the northern part. In the northern part the basin area is dominated by teak plantation. A total 8.123 sq. km or 4.25% area occupied by plantation of the Sanka Basin according to SOI topographical maps (Surveyed 1983-84).

3. **Scrub**

The scatter natural plants with bushy scrub have observed throughout the basin area which is termed as scrub. Open scrub mainly observed at surrounding the hilly areas and natural forest areas, consists of various types of plants. Maximum scrubs are observed mainly central and southern part of the Sanka Basin. A total 6.07 sq. km or 3.17% area of the Sanka Basin occupied by scrub according to SOI topographical maps (Surveyed 1983-84).

4. Agricultural Land

The land which mainly utilized for production of different crops and other food items are known as agricultural land. Agricultural fields are mainly located in comparatively gentle slope and less elevation areas where the supply of water is main concern. Apart from normal scenario agricultural practice has also observed at high altitude and steep slope of the hilly areas either clearing the terrace or near river valley. The agricultural land are locally classified on the basis of distance of available water source mainly river and elevation like *Tanr, Baid, Kanali* and *Shoul* or *Bahal. Tanr* is high land of undulating plateau with maximum elevation and away from river valley. *Tanr* type of land mainly composed of lateritic type of soil. *Baid* lands are characterised with moderate undulation and away from river valley. *Kanali* are moderate to low slopy land which are located at moderate distance from river valley. *Baid* and *Kanali* mainly composed of eroded material from granite-gneiss-schist type of rock. *Shoul* or *Bahal* are the low land areas of near the river valley. These are fertile soil due sufficient supply of water from the river. These are mainly composed of silty loam and clayey loam. Majority of the agricultural fields are occupied by monoculture. At the *Shoul* or *Bahal* areas duo culture has observed on the basis of availability of water from the river. A total 107.41 sq. km or 56.19% area occupied as agricultural land of the Sanka Basin according to SOI topographical maps (Surveyed 1983-84).

Table 5.01: LULC Classes and area wise share of each LULC class

LULC Classes	Area (Sq. km)	Area (%)
Forest	56.376	29.49
Plantation	8.123	4.25
Scrub	6.068	3.17
Agricultural area	107.405	56.19
Built-up area	3.876	2.03
Dams/Tanks/Ponds/Lakes	2.601	1.36
River	2.874	1.50
Stony Waste	1.362	0.71
Barren Land	2.469	1.29
Total	191.15	100

Source: *SOI Topographical Maps (73I/4/NE, 73I/4/NW, 73I/4/SE and 73I/4/SW)*

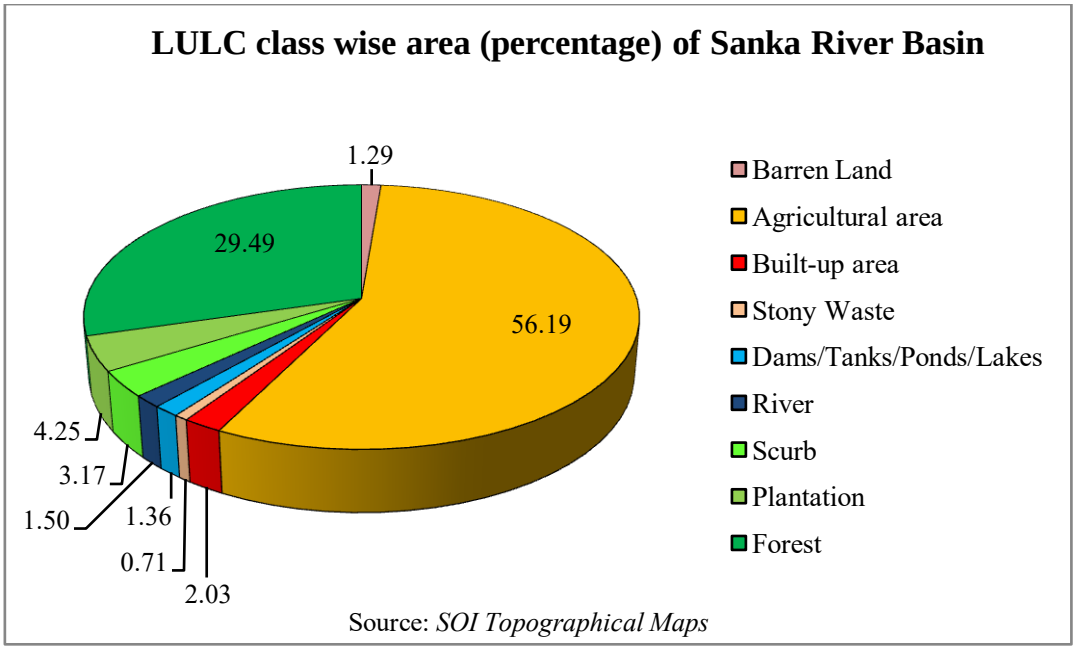


Fig 5.01

5. Built-up area

The land areas which are covered by manmade structure for settlement (Fig 5.02), roads etc. are considered as Built-up areas. The basin area mainly covered by rural settlement as a result scattered type of settlement has observed throughout the basin. A total 3.88 sq. km or 2.03% area of the basin occupied by built-up area (Fig. 5.02) according to SOI topographical maps (Surveyed 1983-84).

6. Transport Network

The transport network of the Sanka Basin mainly composed of metalled roads, unmetalled roads, railway lines, cart track, pack track and footpaths. The roads are generally extracted from the SOI topographical maps of the 1980s. The roads and other transport network have gone under change due to development and construction purpose with the span of time. The principal road of the basin area is SH-4 which is passing from west to east of the basin through the near central part of the basin connects Bhaghmundi to Balarampur. Another important road is NH-18 (earst while NH -32) which connects Balarampur to Chandil. This road did not go through the basin but follows the south east margin of the basin. The south eastern railway (Howrah- Jamsedpur) line of Bokaro Kana Chandil section passes through the basin (Fig 5.03). The Barabhum railway station is located near the eastern part of the basin at Balarampur (CT).

PLATE- VI

(a), (b), (c), (e), (g), (h) Unmetalled roads approaching to the villages of study area; (f) State Highway approaching to and fro *Bagmundi*; (d) and (j) Types of metalled roads exhibit the stages of socio-economic development of different parts of SRB; (i) and (K) Causeway and rural *Kuccha paths.*

PLATE- VII

(a), (b), (c) and (d) Plantation of *Sal* and *Palash* as judicious initiative for ecological and environmental development of the parts of study area especially for the enhancement of soil quality and rainfall prospect over time; (d) Fencing for the protection of newly planted saplings in and around *Bagri* area as protection initiative against gully erosion; (e) & (f) land preparation for plantation near *Haripaldih* area on barren land; (g) Rill formation over barren land of *Sindurpur*.

Picture Courtesy: Author, 2018

PLATE- VIII

(a), (b), (c) & (d) Channel bed encroachment for wet cultivation due to scarcity of water; (e), (f) & (g) Rock outcrops in agricultural fields. Furthermore (e) & (g) Agricultural field of different season namely pre-monsoon and post monsoon; (h) Rice cultivation before over terraced land using naturally stored water by Happar and Dova.

7. Water Bodies

The water which is stored on earth's surface in low lying zones and visible to open eyes known as surface water. Runoff leads to store the rain water as surface water chiefly in low lying areas. Seepage is another source of surface water from ground water in existing canals, river and surplus water from irrigation field as return flow. Surface water presents on earth's surface in two kinds of water bodies. Surface water bodies are in form of water courses like canals, rivers and in stagnant form, such as tanks, ponds, reservoirs etc.

- **Streams:** Stream is natural flow of water through a particular path. The Sanka River and its tributaries are flowing through the basin area which considered as the main source of water for different purposes. The valley of Sanka River and its tributaries occupied 2.874 sq. km or 1.50% area of the whole Basin according to SOI topographical.
- **Canal:** This is manmade structure to divert the surplus water from reservoir to certain place where the supply of is much needed. Within the Sanka Basin there is one canal from pardih dam to *Dava* village area. The length of the canal is 4.04 km. as per SOI topographical maps (Surveyed 1983-84).
- **Reservoir/ pond/ lake/ tank:** when the water is stagnant in a natural or artificial low depression area that is termed as pond or lake or tank. This pond or lakes are locally known as *bandh* in the Sanka Basin area. Reservoir basically means man made structure to block and store the water from river like dams for future use and other purposes. There were a total of 508 reservoir/ pond/ lake/ tank within the Sanka basin and these were occupied 2.6 sq. km area according to SOI topographical maps (Surveyed 1983-84).

The identification of small tanks or pond or reservoir or even small streams are easy from Survey of India topographical maps but from satellite images it is quite difficult to differentiate the particular signature. The change detection of LULC will be discussed later part of this chapter, during that time on the basis of spectral signature major river and reservoir/ ponds/ tanks will be considered.

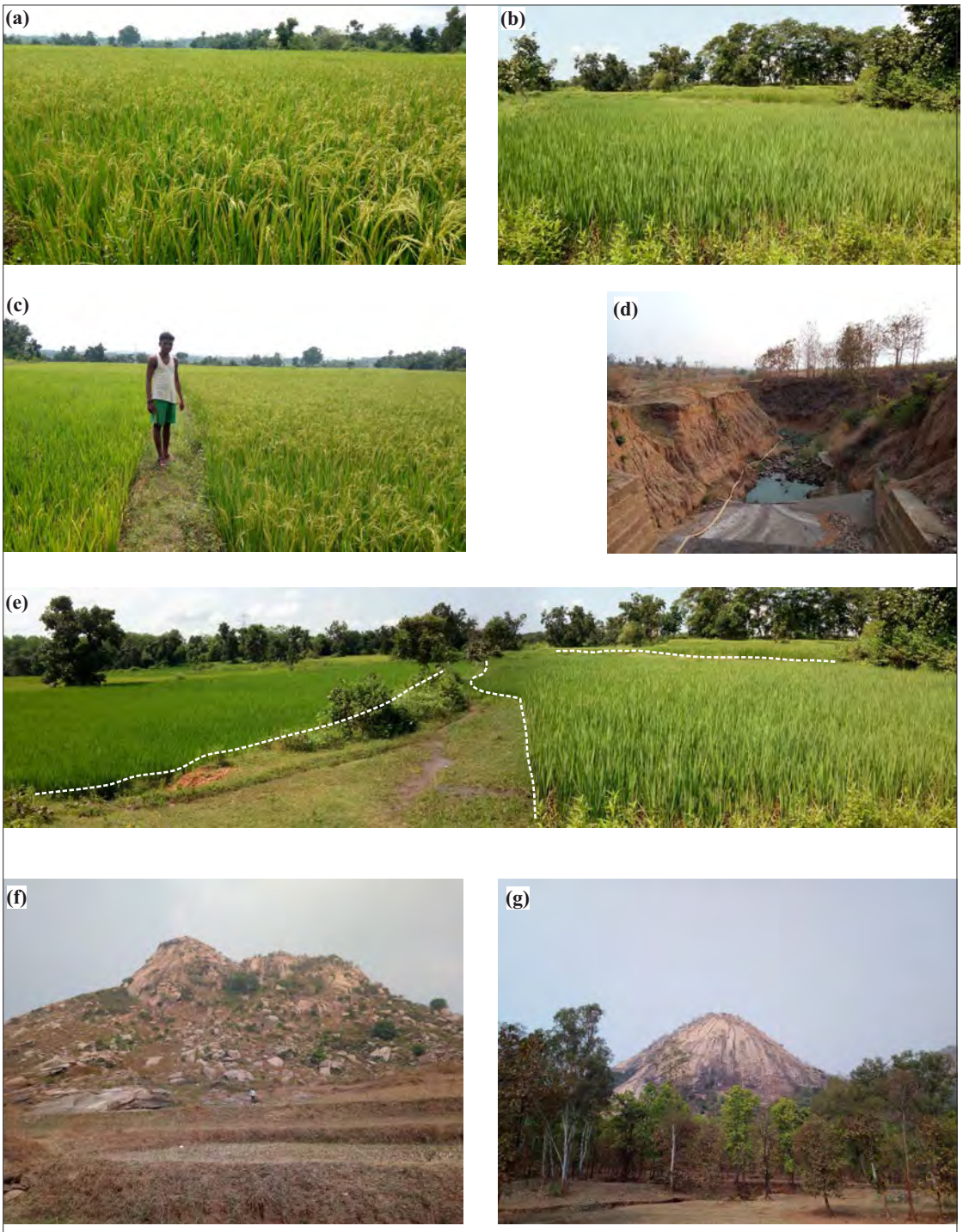
8. Stony Waste

Stony waste are highly characterized by bare and rocky outcrops and sometimes covered by thin layer of soil surrounding the outcrops. Majority of the stony waste areas observed in north eastern part of the basin and small patches of stony waste are also observed in other parts of the basin. The stony waste is receiving of 1.362 sq. km or 0.71% area in 1983-84. It is indicating their incapacitation towards cropping practices may be due to lack of money and infrastructure (Biswas and Saha, 2018).

PLATE- IX

(a), (b), (c), (d), (f), (g), (h), and (j) Landscape phenomena, rock-outcrops and stony wastes signifying thin soil matrix being one of the major impediments of agriculture; (e) Rills and gully formation over the barren land (i) Author himself during field investigation.

PLATE- X



(a) & (b) Farmland of paddy of two different rotations (c) Farmland of paddy of two different rotations right one signifying penultimate stage and left of one signifying post primordial stage (d) Imprints of gully erosion being protected by masonry structure (e) cropping over a 3 tier terraced land in and around *Genrua*, *Balarmpur* block during October, 2017. (f) Senile and exhumed topographic outcome exhibiting sub surface harder rocks of older Chhotanagpur plateau affected by mechanical weathering being sources of weathered rock flour impacting upon litho-genesis of the surrounding area.

Picture Courtesy: Author, 2017-19

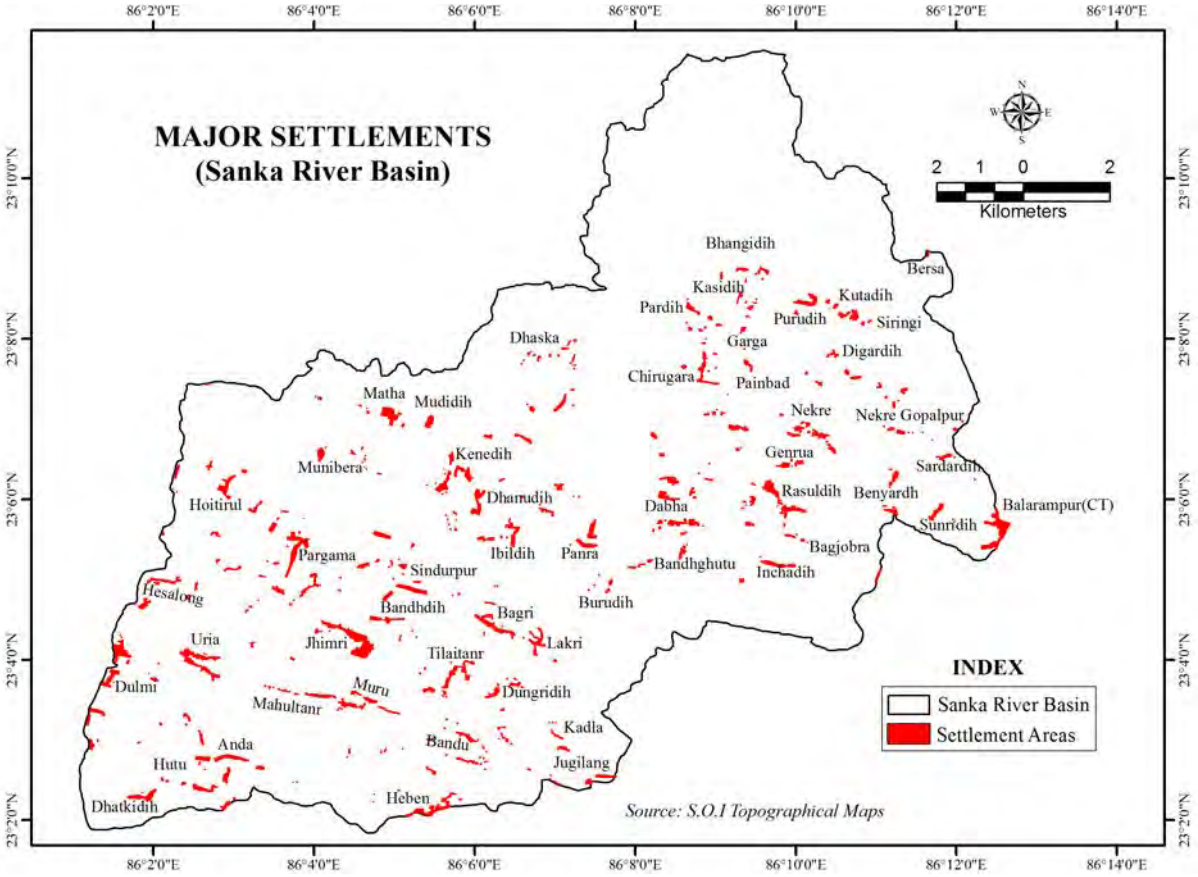


Fig. 5.02

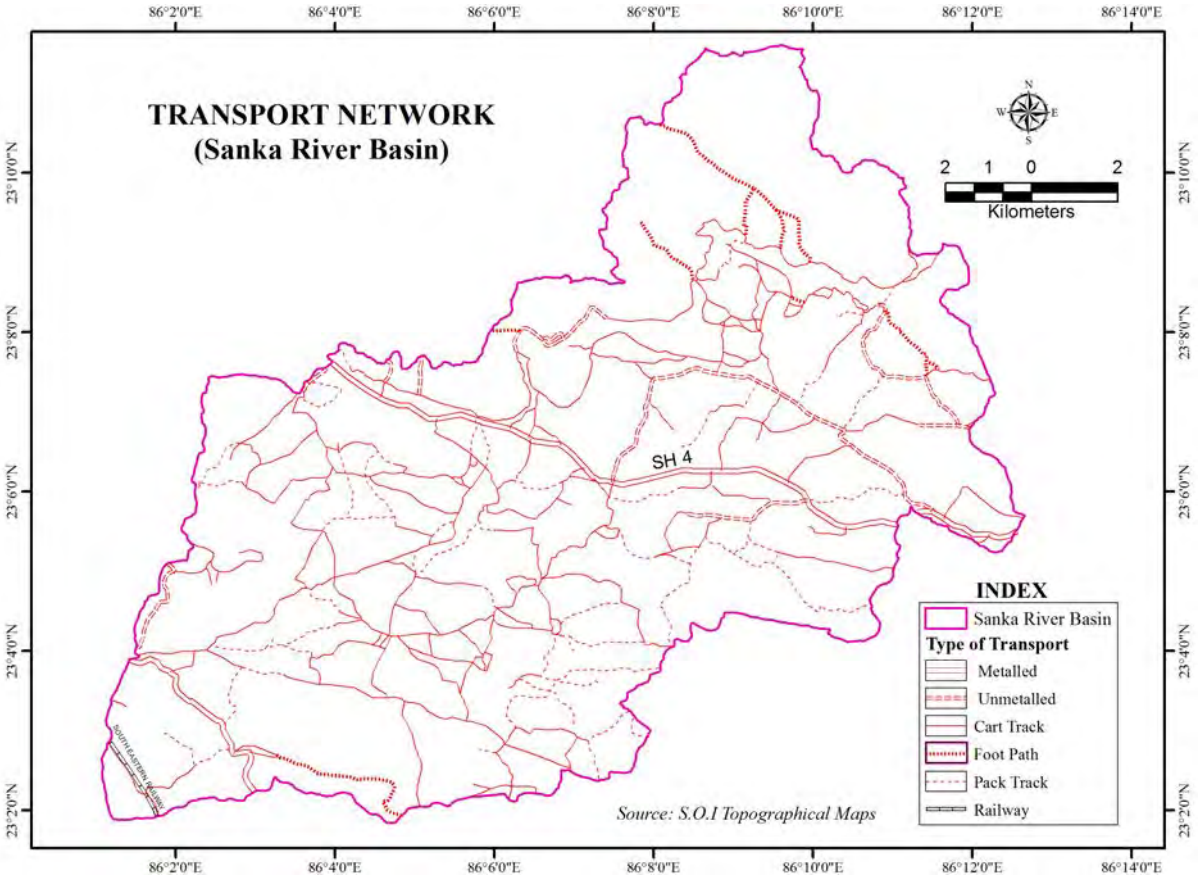


Fig. 5.03

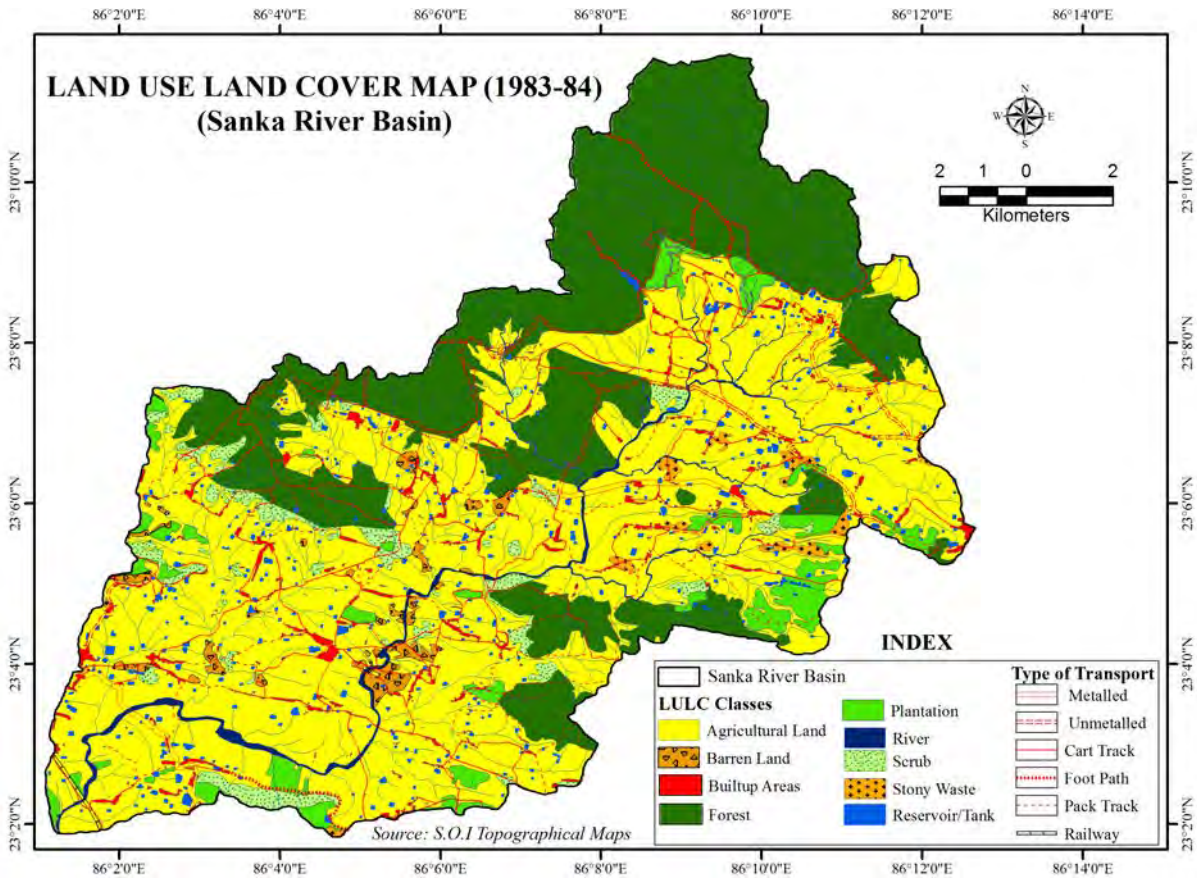


Fig. 5.04

9. Barren land

Barren lands are highly characterized by bare surfaces of tremendous low infiltration falling within the plateau regions of Puruliya and Paschimi Singhbhum. The barren land is occupying 2.469 sq. km area in 1983-84. It has indicated their incapacitation towards cropping practices.

The extracted LULC classes of the basin from SOI topographical maps have depicted (Fig. 5.04) area wise share of different classes. To understand the change detection of LULC, satellite images of different time frame have utilised. As earlier mentioned landsat satellite images of 1992 and 2018 have analysed. The FCCs (Fig. 5.05 & 5.06) of satellite images, after processing the different bands of the images, provides a broad idea about different LULC classes. Unsupervised and supervised classification method produces LULC of 1992 (Fig. 5.07) and 2018 (Fig. 5.08) of the Sanka River Basin. The produced land use land cover classes need to test the level of accuracy. The accuracy assessment has executed with the help of ground points and Google earth. The comparison of these LULC classes of different time helps to understand the change detection which has executed in later part of this chapter.

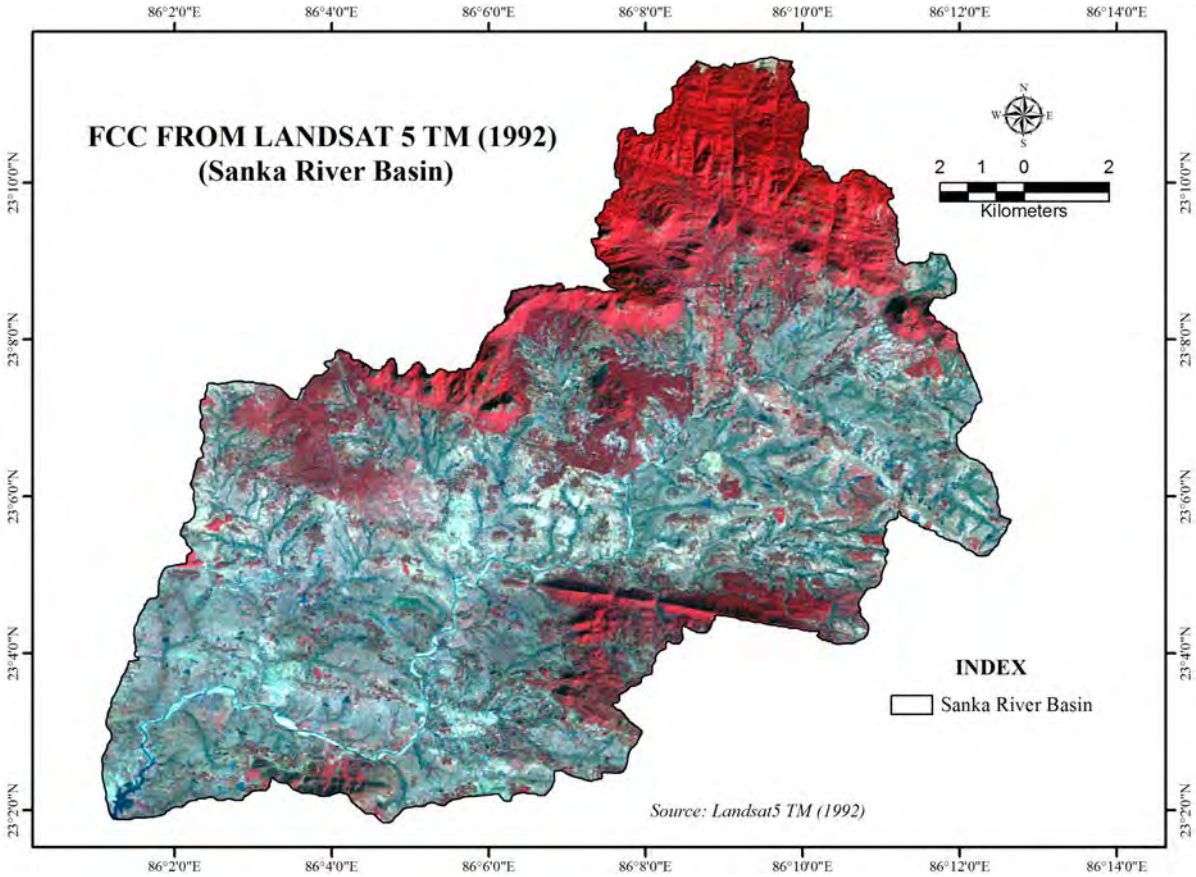


Fig. 5.05

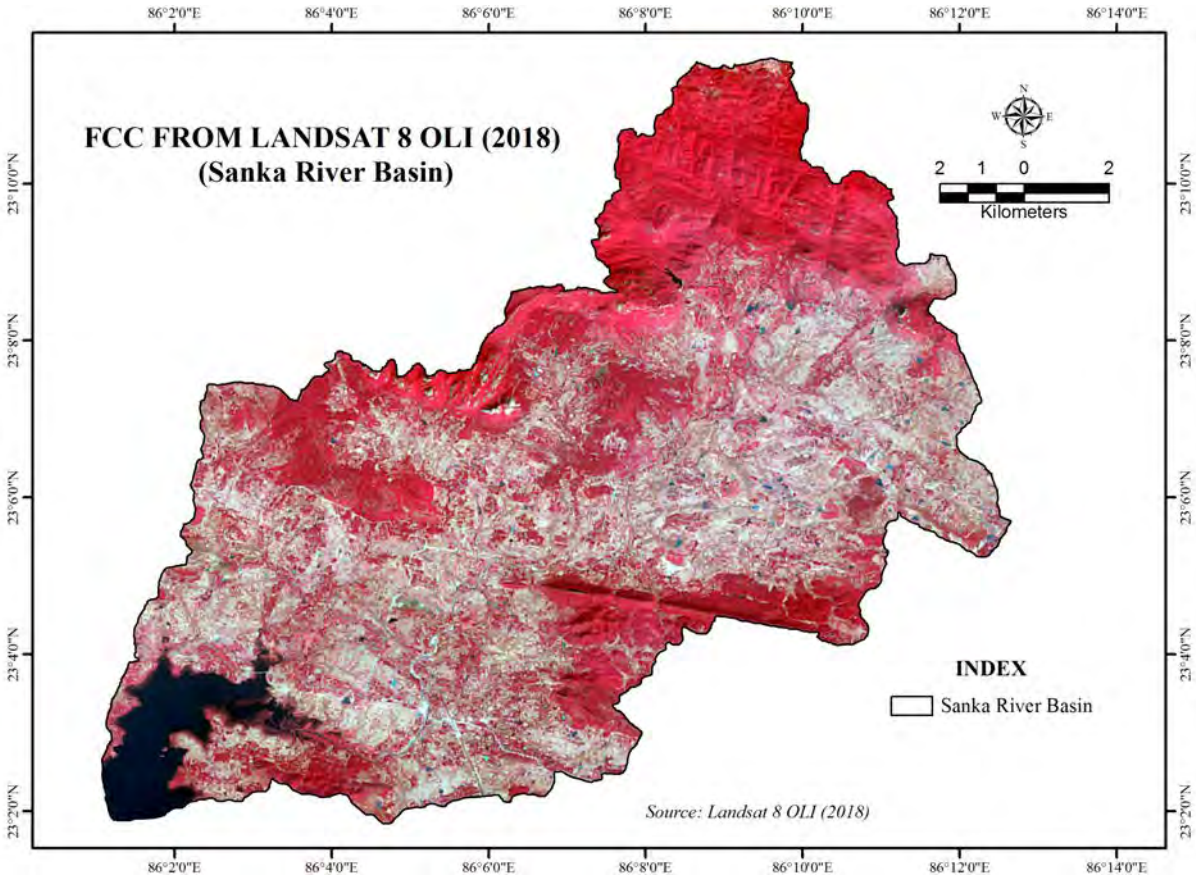


Fig. 5.06

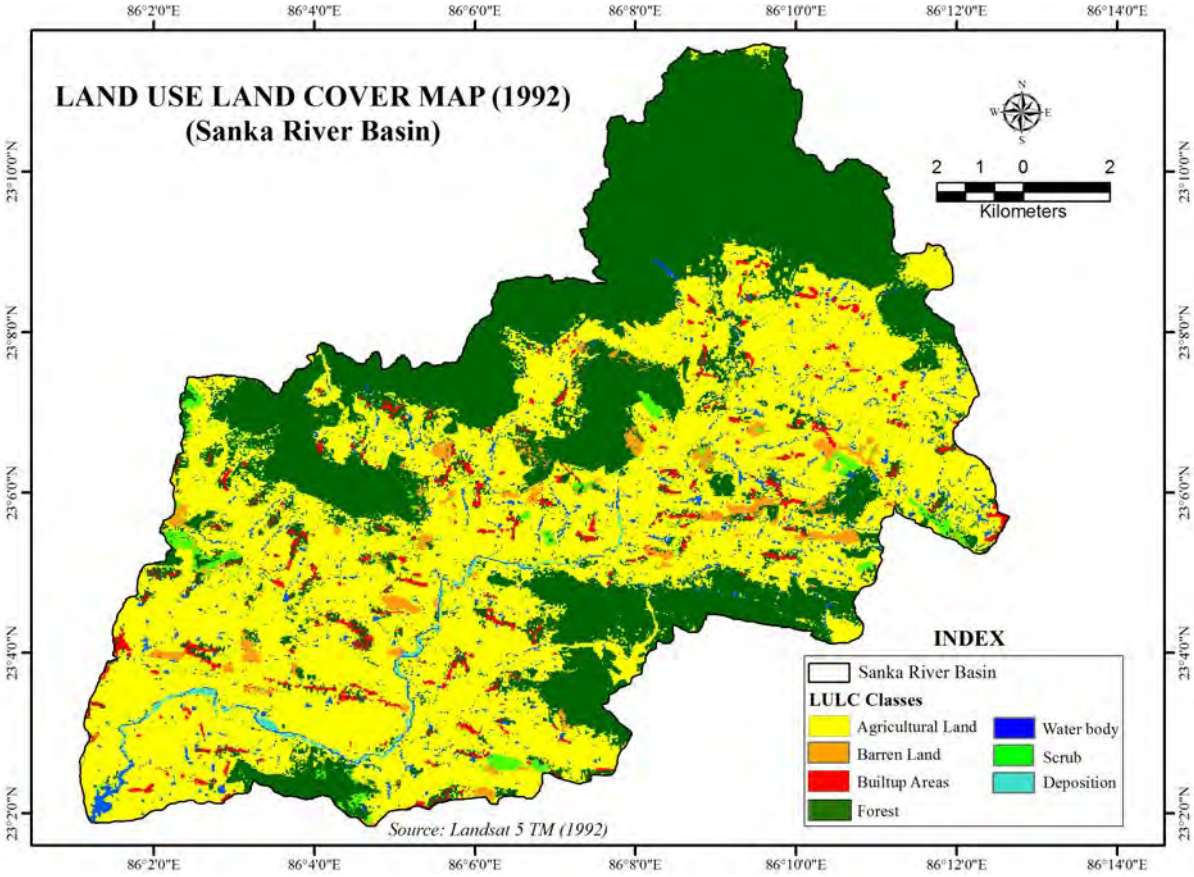


Fig. 5.07

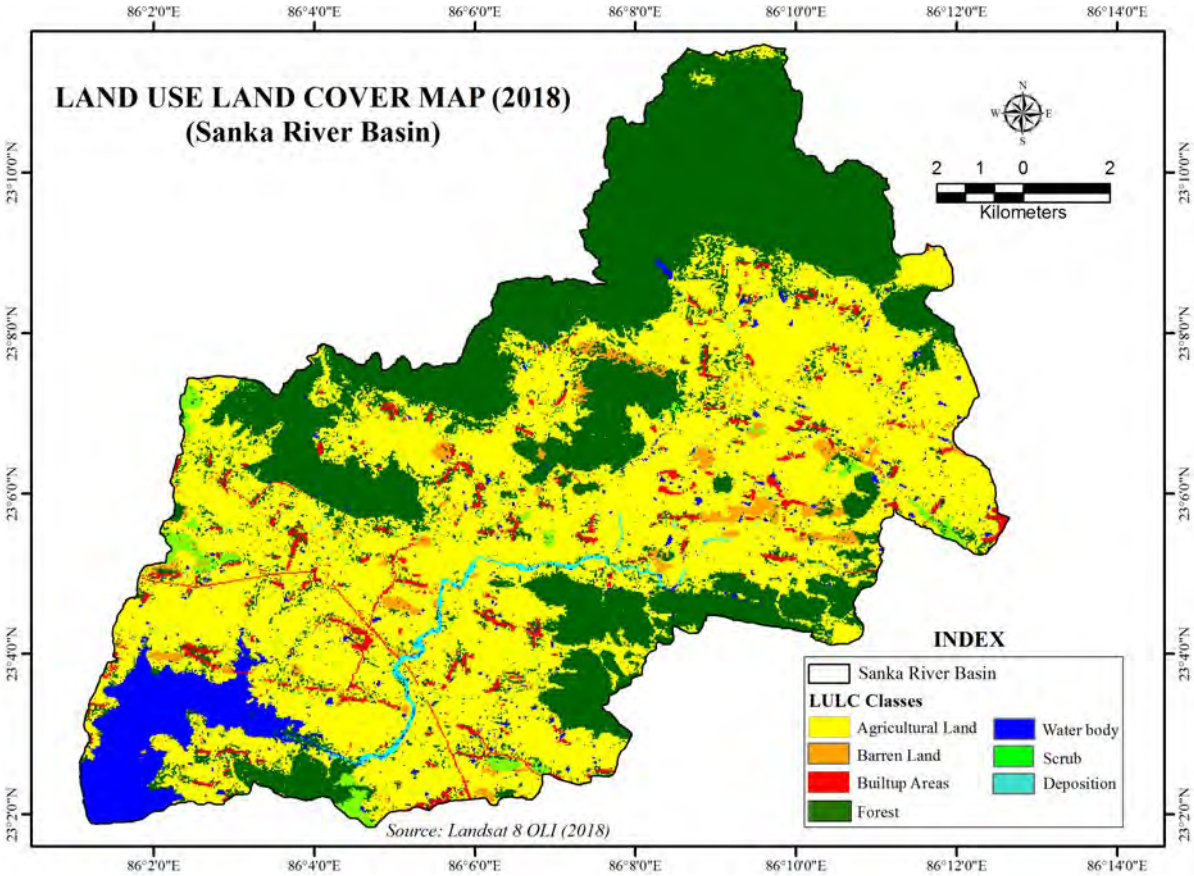


Fig. 5.08

5.6 Accuracy assessment

The 'correctness' of a land use land cover map expressed by the term 'accuracy' and which is executed by constructing the error matrix (Foody, 2002). Some errors may generate during the time of classification of land use and land cover. As a result the originated maps using satellite images are required to test for accuracy which is termed as accuracy assessment. Accuracy assessment can be done with error matrix, user's accuracy, producer's accuracy and overall accuracy (Olofsson et al., 2013). Cohen's (1960) kappa (k) is extensively used in statistics to measure and assess the inter-raster agreement between categorical variables. The calculation of overall accuracy and Kappa coefficient has executed using the mentioned formulas

$$\text{Overall accuracy} = \frac{\Sigma_{i=1}^{r} x_{ii}}{x}$$

Where, x is the total number of samples in error matrix and x_{ii} is the diagonal elements in the error matrix

$$\text{Kappa coefficient (K)} = \frac{n\Sigma_{i=1}^{r} - \Sigma_{i=1}^{r} x_{i+}x_{+i}}{n^2 - \Sigma_{i=1}^{r} x_{i+}x_{+i}}$$

Where, r is the number rows in the matrix, x_{ii} is the number of observations in row i and column i, x_{i+} and x_{+i} are marginal totals for row i and column i respectively and n is the total number of observations (pixels).

An equalised random sampling design was adopted in the accuracy assessment. The raster layers of classified images of the Sanka Basin (1992 and 2018) have assessed for the construction of an error-matrix. A total of 56 ground points has taken for accuracy assessment for each classified image and to determine kappa coefficient. The ground points are verified with field verification for the map of 2018 and Google earth for 1992. The error matrix (Table 5.02 & 5.03) and overall accuracy (Table 5.04 & 5.05) for the maps of 1992 and 2018 are 92.86% and 89.29%. The error matrixes clearly represent the correctly classified samples according each ground points. The values of error matrix, overall accuracy and Kappa Coefficient describe the maps which are prepared with the help of satellite images with higher accuracy.

Table 5.02: Error Matrix of LULC maps obtained from Landsat 5 (1992) satellite image

Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	RT
Class 1	*7*	0	0	0	0	1	0	8
Class 2	0	*7*	0	0	0	1	0	8
Class 3	0	0	*8*	0	0	0	0	8
Class 4	1	0	1	*6*	0	0	0	8
Class 5	0	0	0	0	*8*	0	0	8
Class 6	0	0	0	0	0	*8*	0	8
Class 7	0	0	0	0	0	0	*8*	8
CT	8	7	9	6	8	10	8	56

Source: *Calculated and compiled by author, 2019*
Correctly classified samples for each LULC class represented diagonally in Italic numbers.
Class 1: Built-up area, Class 2: Water bodies, Class 3: Forest, Class 4: Barren land, Class 5: Scrub, Class 6: Agricultural field, Class 7: Deposition, CT: Column total, RT: Row total

Table 5.03: Error Matrix of LULC maps obtained from Landsat 8 (2018) satellite image

Class	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	RT
Class 1	*7*	0	0	1	0	0	0	8
Class 2	0	*8*	0	0	0	0	0	8
Class 3	0	0	*8*	0	0	0	0	8
Class 4	0	0	0	*6*	1	1	0	8
Class 5	0	0	0	0	*7*	1	0	8
Class 6	0	0	0	0	0	*8*	0	8
Class 7	0	0	0	1	0	1	*6*	8
CT	7	8	8	8	8	11	6	56

Source: *Calculated and compiled by author, 2019*

Correctly classified samples for each LULC class represented diagonally in Italic numbers.
Class 1: Built-up area, Class 2: Water bodies, Class 3: Forest, Class 4: Barren land, Class 5: Scrub, Class 6: Agricultural field, Class 7: Deposition, CT: Column total, RT: Row total

Table 5.04: Accuracy of LULC maps obtained from Landsat 5 (1992) satellite image

Class Name	Reference Totals	Classified Totals	Number Correct	Producer's Accuracy	User's Accuracy
Built-up area	8	8	7	87.50%	87.50%
Water bodies	7	8	7	100.00%	87.50%
Forest	9	8	8	88.89%	100.00%
Barren land	6	8	6	100.00%	75.00%
Scrub	8	8	8	100.00%	100.00%
Agricultural field	10	8	8	80.00%	100.00%
Deposition	8	8	8	100.00%	100.00%

Source: *Calculated and compiled by author, 2019*

Overall Classification Accuracy = 92.86% and Kappa coefficient = 0.9167

Table 5.05: Accuracy of LULC maps obtained from Landsat 8 (2018) satellite image

Class Name	Reference Totals	Classified Totals	Number Correct	Producer's Accuracy	User's Accuracy
Built-up area	7	8	7	100.00%	87.50%
Water bodies	8	8	8	100.00%	100.00%
Forest	8	8	8	100.00%	100.00%
Barren land	8	8	6	75.00%	75.00%
Scrub	8	8	7	87.50%	87.50%
Agricultural field	11	8	8	72.73%	100.00%
Deposition	6	8	6	100.00%	75.00%

Source: *Calculated and compiled by author, 2019*

Overall Classification Accuracy = 89.29% and Kappa coefficient = 0.8750

5.7 Changing Pattern of LULC and its comparison

The land use land cover maps of different time frame provide suitable information to understand the changes of areas of different classes from 1983-84 to 2018 and compare among them (Table 5.07). The change detection clearly indicates that there is a significant increase and decrease of areas of some LULC classes. There is a huge increase of water body in 2018 image, nearly double to previous classified image of 1992, from 5.31 sq. km to 10.24 sq. km. This has occurred due creation of dam on the Subarnarekha River downstream of the confluence of Sanka and Subernarekha River and creation of Chandil Dam and many small tanks, check dams within the basin areas. There is slight increase of built-up areas from 3.88 sq. km in 1983- 84 and 4.73 in 1992 to 5.74 sq. km in 2018. The poor economic condition and less development in industrial sector lead to low rate of increase in built-up areas.

Table 5.06: Land Use and Land Cover Change Detection (1983-84 to 2018)

Time Frame	Forest Area (Sq. km)	Scrubs (Sq. km)	Agricultural land (Sq. km)	Barren Land (Sq. km)	Built-up Area (Sq. km.)	Water Bodies (Sq. km)	Deposit-ion (Sq. km)
1983-84	64.499	6.068	107.405	3.831	3.876	5.475	NA
November, 1992	71.8335	3.2994	102.106	3.7179	4.7349	5.3064	0.7191
November, 2018	67.8312	3.6369	98.955	4.0905	5.7411	10.2447	1.2195

Source: *Calculated and compiled by author from satellite images and SOI topographical maps, 2019*

Deforestation is main reason behind decrease of forest cover areas. Afforestation has also taken place by the forest department in deforested areas and also in barren lands. Both the process occurs simultaneously. As a result it has clearly observed that there is increase of

forest areas from 1983 to 1992 and then decrease of forest area. Another major change occurred for the agricultural field from 107.41 sq. k. areas in 1984 to 102.11 sq. km areas in 1992 and then to 98.96 sq. km in 2018. This has taken place in two directions. One is the conversion of some forest areas into agricultural field near hills areas mainly at the both sides of small tributaries of Sanka River and loss of huge agricultural areas near the confluence areas due creation of dam, which can be easily identified LULC map of 2018. There is also slight increase in sediment deposition areas. This occurred due to construction of Dam at the confluence and small dam like *Purudih* dam and check dams in upper reach of the Sanka River.

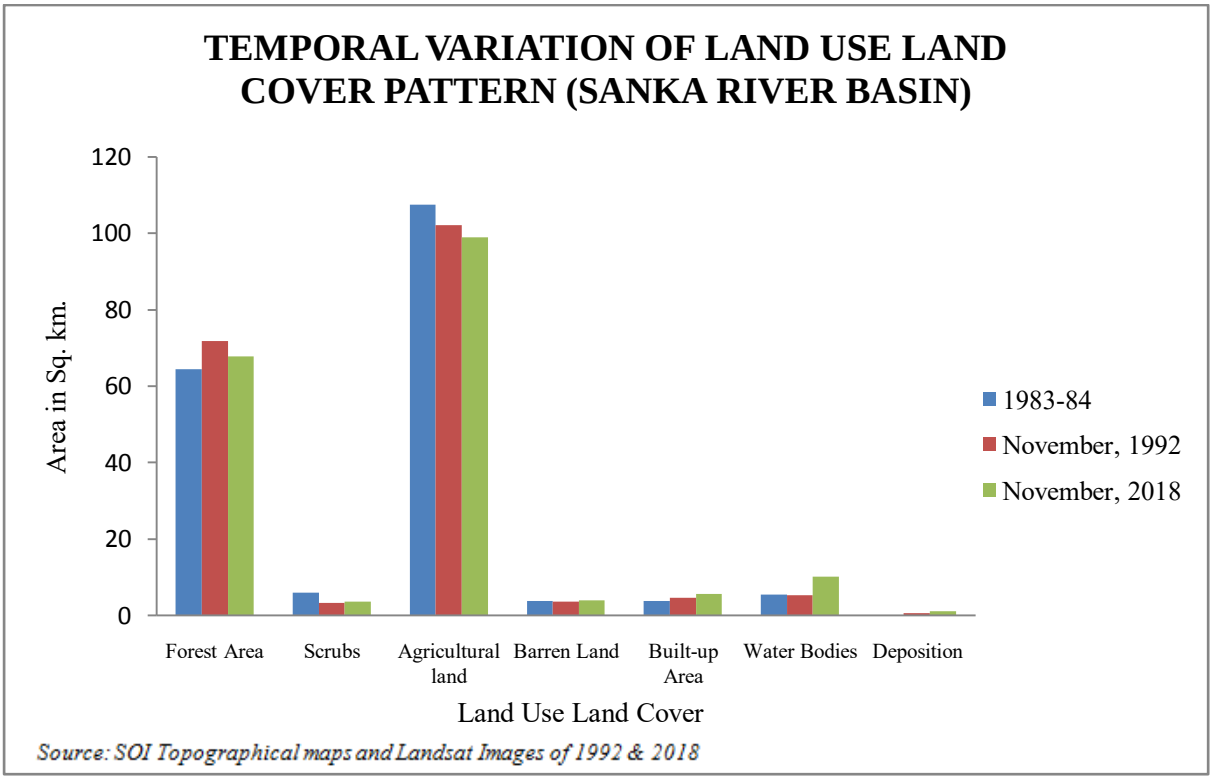


Fig. 5.09

Change detection matrix is suitable to understand the changes of area and it also provides the idea about from which type of land has changed in which category (Table 5.07). The pixel wise analysis under GIS environment provides more specific information in change detection. It analyses each pixel of both the satellite images and identified which pixel has converted in which type of LULC class. To calculate the areas of from pixels, simple multiplication has done of total pixels with pixel size for each category. The sizes of pixel for both the images are identical to each other. Diagonally present value representing no change of area of that particular category of LULC in the change detection matrix (Table 5.07).

Table 5.07: Land Use and Land Cover Change Detection Matrix (1992- 2018)

Class	Built-up Area	Water Body	Forest	Barren Land	Scrub	Agricultural Land	Deposition	**Total in 2018**
Built-up Area	3.27	0.09	0.89	0.08	0.06	1.34	0.01	**5.74**
Water Body	0.11	1.52	0.36	0.10	0.05	7.78	0.32	**10.24**
Forest	0.47	0.33	59.47	0.63	0.66	6.22	0.04	**67.83**
Barren Land	0.06	0.07	0.84	2.17	0.16	0.78	0.01	**4.09**
Scrub	0.04	0.02	0.97	0.14	1.28	1.17	0.00	**3.64**
Agricultural Land	0.78	3.06	9.27	0.57	1.07	84.11	0.09	**98.96**
Deposition	0.00	0.21	0.03	0.02	0.01	0.69	0.26	**1.22**
Total in 1992	**4.73**	**5.31**	**71.83**	**3.72**	**3.30**	**102.11**	**0.72**	**191.72**

Source: *Calculated and compiled by author through processing of satellite images, 2019*
N.B: *Areas in Sq.km*

From the change detection matrix it has clearly revealed that the major contributors of the land for built-up areas are agricultural land and forest areas. In a similar way the major contributor of the land for water bodies' areas is agricultural land which has observed from the LULC classes of 2018. Another major changes of areas occurred in agricultural field, the matrix clearly shows that which type of land has converted in which category.

5.8 Village-Wise Land use Pattern

Agriculture is the main economic activity in that region. Village wise land use (Fig. 5.10) pattern reveals the different pattern of land use according to different terrain class or topographic condition. The graphical representation of village wise land use has prepared with the help of census data (2011). First a brief discussion has done about different types of land use which are slightly different than the previously done LULC classes and then detailed explanation has given about different land use in different terrain class.

Forest area:

It includes the lands which are permanently covered under forest. The forest may be government or private owned. Some portions of the forest are considered as protected forest (P.F) in the Sanka Basin. The villages located in comparatively high elevation and slope regions in north, north-west and middle- east portions of the Sanka River basin highly occupied by forest. The villages in the north and north west portion of the basin namely *Garga, Pardi, Gobaria, Edelbera, Kamarjara, Bersa* and villages in the middle-east portion namely *Burudih, Chatarma, Inchadih, Kadla and Lakri* (Fig. 2.03 & 5.10) were highly occupied by forest cover near to 50% area to more than 90% geographical area of the basin.

The cliff like slope, higher relative relief and coarser surface soil of these villages of north and north west portion of the basin helps to develop forest cover. Other villages like *Hesalang* and *Berasisiram* in west also have more than 50% of the area under forest. The forest cover areas of villages are mainly covered by forests of *Sal, Teak, Palash, Mahua* trees.

Net sown area:

It depicts the total area cultivated or sown with crops. It has observed mono or duo cropping pattern in the basin. Cropping pattern depends on the availability of water. The lands which are close the river and getsupply of water during lean season, duo cropping pattern has observed there. Each village of the study area have occupied by certain amount of agricultural field. The degree of occupancy of netsown area has varied from one village to another depending upon the diverse physical properties of terrain like slope, relative relief, soil properties, diverse morphometric parameters and supply of water from river, tank, canal and underground etc. The field investigation (Plate VIII & X) in different villages reveals that the villages located in high elevation and slope areas agriculture mainly observed at foot hill areas and near within the upstream tracts namely *Garga, Pardi, Gobaria, Edelbera, Kamarjara, Bersa, Jugidi Kasidih, Karma.* In some areas it has also observed creation of agricultural field by clearing the forest cover near streams. The villages located in the east and middle portion of the basin have higher percentage of net sown areas due to their physical setup and good supply of water. The major villages located in the east and middle portion of the basin are *Berma*, *Sunidih, Benyardih, Kana, Rugri, Nekre, Siringi, Bersa, Giting Lahar, Ulidi, Deuli, Chirugara, Chaunla, Banshidi, Matha, Haridih, Dhanudih, Munibera, Madhupur, Rabar*, *Neudih, Brindabanpur, Barah Chatarma, Sankupi, Lawakui* occupying more than 50% to near 95% of the geographical areas of these villages as net sown area (Fig. 2.03 & 5.10). *Uria* and *Heben* also occupied by higher percentage of net sown area in lower reach of the basin. Field investigation also provides sufficient information about monoculture, duo- culture and agro horticulture (Plate XI, XII, XIII & XIV) on the basis of supply of water during lean periods.

Non agricultural area:

This covers those areas which are occupied with buildings, roads, railways, ponds, tanks, canals, dams, rivers and other non-agricultural activity. Each village of the study area have occupied by certain amount of non agricultural area. The maximum share of non agricultural

areas of the total geographical areas of the village has observed in the villages of lower reach areas of the basin due construction of reservoir of Chandil dam namely *Kumari, Dayapur, Dulmi, Kalyanpur, Kashipur*. The shares of non agricultural of these villages are more than 50% to near 75%. Other villages like *Berasisiram, Hesalang, Erka, Genrua, Heben* (Fig. 2.03 & 5.10) also have higher percentage of non agricultural area.

Barren land and fallow land other than current fallow:

It includes all lands with outcrops, rugged rocky hillocks, sandy patches etc. major portion of barren land has observed in the villages of middle to lower portions of the basin. The maximum areal coverage of barren and fallow land has observed in the villages *Berasisiram* and then *Jhimri.* The villages which have occupied certain percentage of barren and fallow land other than current fallow mainly located within Saraikela Kharsawan district of Jharkhand. The name of those villages which have considerable percentage of barren and fallow land other than current fallow are *Kadla, Karka, Chatarma, Bagri, Burudih, Sindurpur, Bandu, Hutu, Muru, Hesalang, Pargame, Anda* (Fig. 2.03 & 5.10).

Culturable waste land:

It depicts about those available lands which can be utilized for cultivation but did not use once or long time in the past for agriculture. These types of land are either wholly or partly covered by jungles and shrubs. Basically the lands which had cultivated earlier but not cultured for many years fall under this category. The land use land cover change detection study provides about sufficient information about that in many parts deforestation occurred and used for agricultural practice and later on these lands converted to jungles or shrubs area through the government influence. The census data (2011) of village wise share of LULC showing the fact clearly. The maximum percentage of culturable waste land has observed in north top most village named *Kalijharna* where more than 50% area of the village has considered as culturable waste land. The villages located in the north, north- west and west have maximum percentage of culturable waste land. These have occurred due to clearing of forest besides the river bank to getwater for the cultivation purpose. The name of the villages which have considerable percentage of culturable wasteland are *Edelbera, Kamarjara, Karma, Dhaska, Lawakui, Matha, Haridih, Dhanudih, Sankupi, Dabha, Panra, Hebe, Kashipur, Dulmi and Kumari* (Fig. 2.03 & 5.10).

Current fallow:

This covers those land areas which are not currently used for agriculture. These lands are basically cropped area but did not cultivate the same year due to some reason. The villages located in lower portion of the basin have maximum current fallow areas. Maximum areal coverage of current fallow has observed for the villages like *Jhimri* and *Chatarma*. The late arrival of monsoon rainfall in these villages kept major portion of the land as current fallow during that census year.

Permanent pasture: The lands which are covered by permanent grass are considered as permanent pasture. The percentage of permanent pasture is very less throughout the basin. Only five villages have certain percentage permanent pasture throughout the study areas which are *Chunchuria, Karargama, Sindurpur, Haitrial* and *Berasisiram* (Fig. 2.03 & 5.10). Among all these five villages highest percentage share to the village geographical area found in *Sindurpur* for permanent pasture.

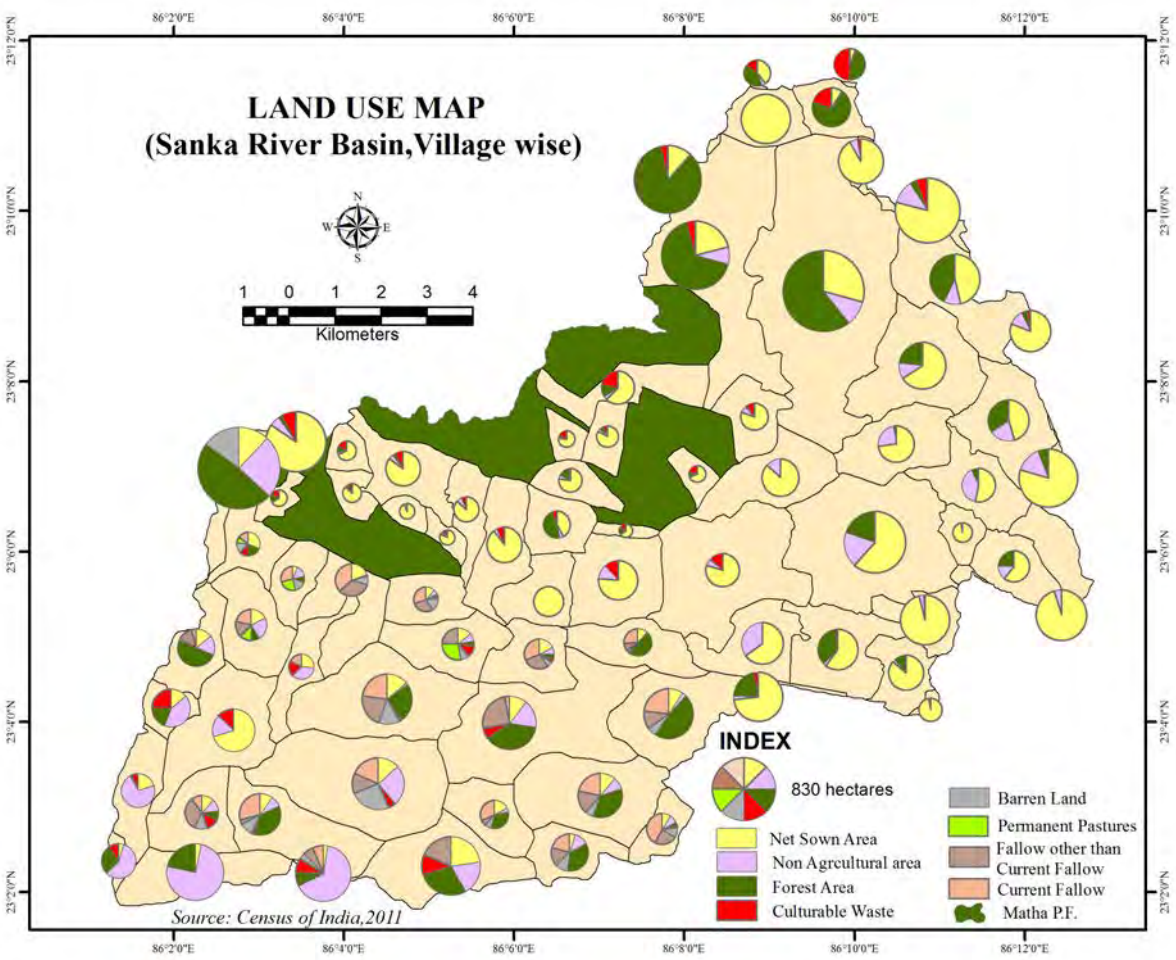
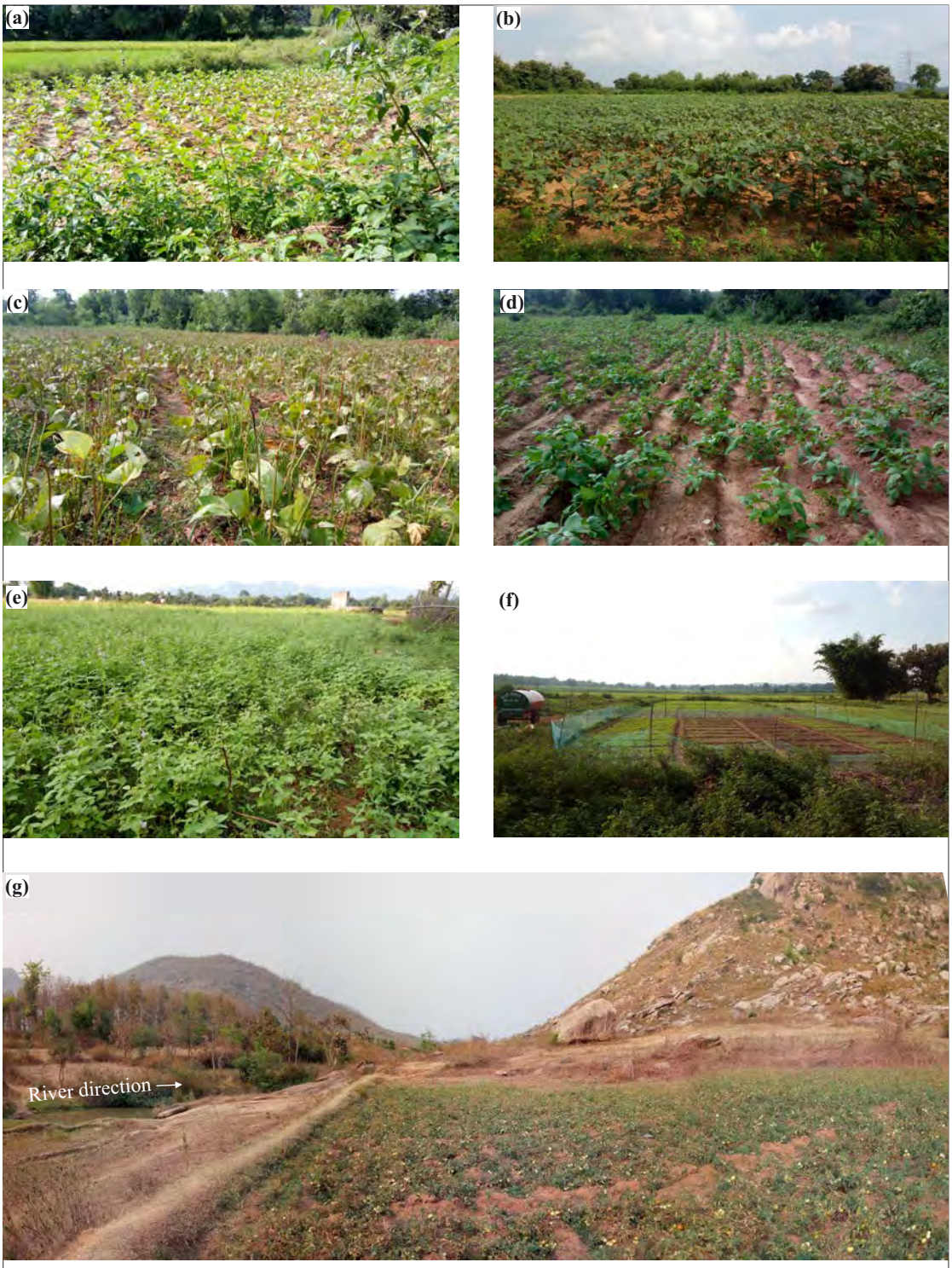


Fig. 5.10

PLATE- XI

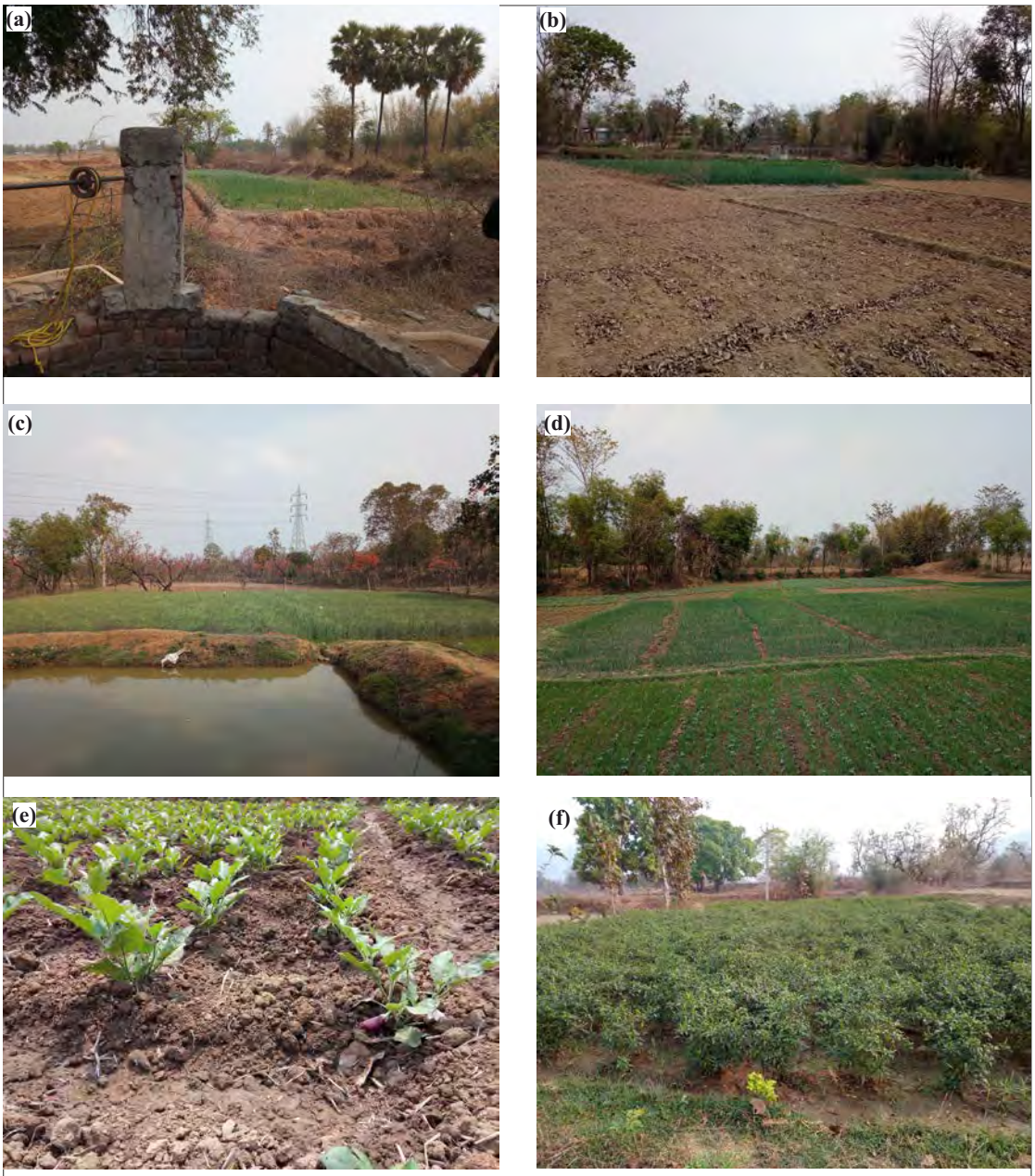
(a) Agro- horticulture near the *Kenedih* village. Cultivation of wet paddy and radish or '*mula*' simultaneous to maximize the production from land; (b) Land use along river corridor at Parna village. Cultivation of bottle gourd or '*lau*' and onion using the supply of river water during non-monsoon period; (c) Cultivation of taro root or '*kachu'* at *Sringi* villlage; (d) Cultivation of bottle gourd or '*lau'* at Sringi village as evident of induction of new pattern of landuse; (e) Utilization of fallow land for cultivation of horse gram or '*kulthi kalai*' behind houses of settlement area of *Gopalpur*; (f) Author himself in front of brinjal cultivated field at *Nekre;* (g) & (h) Cultivation of horse gram or '*kulthi kalai'* for vast field of *Rangadih.*

PLATE- XII



(a) Agro- horticulture near at *Benyardih* village. Cultivation of wet paddy and brinjal simultaneous to maximize the production from land; (b) Cultivation of ladies finger during non-monsoon season at village *Deuli*; (c) Cultivation of string bean or 'barbati' at village Genrua; (d) Cultivation of potato during winter at village *Garga*; (e) Cultivation of peas at *Sindurpur;* (f) Fencing within agricultural field for Cultivation of different vegetables with supply of water at village *Muru;* (g) The agricultural field at foothill region produced tomato with the help of water from the river at *Khutadih.*

PLATE- XIII



(a) & (b) Cultivation of vegetables like tomato, sweet gourd, potato & onion during non-monsoon season with help of dug well at village *Karka*; (c) Cultivation of mustard with stored surface water in *Happar* during non-monsoon season at village *Lakri;* (d) Cultivation of diverse vegetables like potato, cucumber, onion with the help of water in river bed through the *bund* in river at village *Jhimri*; (e) Cultivation of ladies finger during non-monsoon season at village *Inchadih;* (f) Chilli cultivation at the village *Uria*.

Picture Courtesy: Author, 2017-19

PLATE- XIV

(a) The supply of water from river allow to cultivate within the fields which is near to the water supply areas of the village *Dhaska;* (b) The author himself within the cucumber cultivated field at the village of *Dabha*; (c) Cultivation of Ground nut in the agricultural field of Bandu during non-monsoon period. (d) Irrigation facility is rarely available for parched fields of *Chirugara*; (e) Cultivation of peas during non-monsoon season with help of dug well at village *Bagri*.

5.9 Terrain class Wise Land use Land cover Character

The village boundaries are political boundary which does not clearly indicate terrain wise land use land cover pattern. Terrain classes have identified on basis of natural properties of the basin. The detailed analysis (Table 5.08) and discussion provide a vivid knowledge about terrain class wise land use land cover pattern of Sanka Basin. The latest classification of LULC that is 2018 has consulted here to understand terrain class wise land use land cover pattern. The terrain class wise discussion of LULC will help to analyse the effect of terrain characteristics combinedly on LULC and that will be executed in chapter seven.

1. **Hilly Areas (1a)**

This terrain zone is occupying the highest elevation zone covering the hills of *Ajodhya Pahar*. The LULC study according to this terrain zone depict that this terrain class has occupied only 5.49 sq km area of the basin which is near about 3% area of the total basin (Table 3.53). Out of the total area of the terrain class near about 93.6% area of this terrain zone is occupied by dense forest, 1.1 % area occupied by water bodies of river and remaining 5.3% area being utilised for agricultural activity mainly near or within the upstream tracts (Table 5.08). This information clearly reveals that the high elevated terrain with greater value of slope controls the land use land cover of this zone with maximum coverage of forest.

2. **Dissected hilly area (1b)**

The LULC study according to this terrain zone depict that among the total area of the terrain class near about 86.33% or 13.26 sq km area of this terrain zone is occupied by dense forest, 0.26% or 0.04 sq km area occupied by scrub, 0.46 % or 0.07 sq km area occupied by barren land, 0.13 % or 0.02 sq km area occupied by built- up area and similar percentage area occupied by water bodies of river and *Purudih* dam like barren land and remaining 12.7% or 1.95 sq km area utilised for agricultural activity mainly at foot hill areas in west and near within the upstream tracts (Table 5.08). This terrain class has occupied only 15.34 sq km area of the basin which is near about 8.03% area of the total basin (Table 3.53).

3. **Hilly Dissected upper plateau (2a)**

This terrain class has occupied only 14.06 sq km area of the basin which is near about 7.36% (Table 3.53) area of the total Sanka Basin. Among the total area of this terrain class 65.55% or 9.19 sq km area has occupied by dense forest, 0.43% or 0.06 sq km area occupied by scrub, 2.14 % or 0.30 sq km area occupied by barren land, 1.28 % or 0.18 sq km area

occupied by built- up area, 0.50% or 0.07 sq km area occupied by water bodies of river and tanks or ponds and check dam and remaining 30.03 % or 4.21 sq km area being utilised for agricultural activities mainly at foot hill areas in middle west portion of the study area.

Table 5.08: Terrain Class wise Land Use Land Cover Properties

Terrain Id	Terrain Class	LULC Properties							Total LULC (%)
		Forest (%)	Scrub (%)	Built-up area (%)	Barren land (%)	Agriculture Field (%)	Water body (%)	Deposition (%)	
1a	Hilly area	93.58	0	0	0	5.32	1.10	0.00	100
1b	Dissected hilly area	86.33	0.26	0.13	0.46	12.70	0.13	0.00	100
2a	Hilly Dissected upper plateau	65.55	0.43	1.28	2.14	30.03	0.50	0.07	100
3c	Moderately dissected upper plateau with hills	57.75	0.34	1.45	0.76	38.94	0.69	0.07	100
4d	Upper plateau with gentle undulation	12.86	0.90	3.13	1.68	79.75	1.32	0.36	100
5d	Low hills in dissected upper plateau	49.39	1.83	2.44	0.61	41.46	4.27	0.00	100
1e	Plateau Rim with low residual hills	46.89	1.20	3.11	0.24	45.22	2.15	1.20	100
1f	Plateau Rim	37.70	3.52	2.47	2.51	51.36	1.21	1.21	100
1g	Moderate undulating topography	24.33	2.73	4.13	3.15	63.83	1.47	0.37	100
1j	Low lying land with gentle undulation	6.11	0.80	3.73	2.03	63.67	22.24	1.43	100

Source: *Calculated and compiled by author through processing of satellite images, 2019*

4. Moderately dissected upper plateau with hills (3c)

This zone has occupied 14.98 sq km area of the basin which is near about 7.84% area of the total basin. The LULC study according to this terrain zone depicts that among the total area of the terrain class near about 57.75% or 8.38 sq km area of this terrain zone is occupied by dense forest, 0.34% or 0.05 sq km area occupied by scrub, 1.45 % or 0.21 sq km area occupied by built- up area, 0.76 % or 0.30 sq km area occupied by barren land, 0.69 % or 0.10 sq km area occupied by water bodies of river and tanks or ponds and check dams, the deposition within river bed has occupied 0.07% or 0.01 sq km area and remaining 38.94 % or 5.65 sq km area being utilised for agricultural activity mainly at foot hill areas in middle west portion of the study area.

5. **Upper plateau with gentle undulation (4d)**

This terrain unit is supportive of good settlement assemblage occupying 3.13 % area of this terrain class as built-up area. The availability of water body is also signifying the nature of good existence of water compared to the surrounding terrain units, and has occupied 1.32 % area of this terrain class. The vast area near to 79.75 % or 13.27 sq km area has been utilised for agricultural activity.

6. **Low hills in dissected Upper plateau (5d)**

This zone has occupied only 1.77 sq km area of the basin which is less than 1% area of the total basin. Though this terrain unit has small areal coverage still near about 41.46% of this unit has occupied by agricultural field and 49.39 % area has been occupied by forest cover.

7. **Plateau Rim with low residual hills (1e)**

This terrain zone has occupied only 4.26 sq km area of the basin which is near about 2% area of the total basin. Limited farming practices can be selected proximity to the stream and streamlets but due to small areal coverage, these limited farming practices occupying 45% of area of this terrain zone.

8. **Plateau Rim (1f)**

The LULC study according to this terrain zone depict that among the total area of the terrain class near about 37.70% or 9.0 sq km area of this terrain zone is occupied by dense forest, 3.52% or 0.84 sq km area occupied by scrub, 2.47 % or 0.59 sq km area occupied by built- up area, 2.51 % or 0.30 sq km area occupied by barren land, 1.21% or 0.29 sq km area occupied by water bodies of river and tanks or ponds and check dam, the deposition within river bed has occupied 1.21% or 0.29 sq km area and remaining 51.36 % or 12.26 sq km area utilised for agricultural activity. This zone has occupied 24.38 sq km area of the basin which is near about 13% area of the total basin.

9. **Moderate undulating topography (1g)**

This terrain zone has occupied the largest area of the basin near about 30% or 57.57 sq km area of the total basin. This is one of the major undulating topographic being recipient of considerable amount of water supply which and can be stored for future land use practices especially agricultural practices like cropping of wet paddy, jowar, bajra etc. and other horticulture products like cucumber, tomato, brinjal, different types of pulses etc. as evident during field investigations (Plate- XI, XII, XIII & XIV). Wet Paddy is the major crop (Plate-

X). This terrain unit is manifested of good settlement assemblage occupying 4.13 % area of this terrain class as built-up area. The layer of water body is also signifying the nature of good existence compared to the surrounding terrain units, occupied 1.47 % area of this terrain class.

10. Low lying land with gentle undulation (1j)

This zone is located near the lower reach of the basin. Downstream of the Sanka River is flowing through this terrain zone up to the confluence of Subarnarekha River. The LULC study depicts near about 6.11% or 2.23 sq km area of this terrain zone has occupied by dense forest, 0.80% area occupied by scrub, 3.73 % area occupied by built- up area, 2.03 % area occupied by barren land, 22.24% or 8.11 sq km area occupied by water bodies of river and tanks or ponds and *Chandil* dam, the deposition within river bed has occupied 1.43% or 0.29 sq km area and remaining 63.67 % or 23.22 sq km area utilised for agricultural activity. *Shoul* or *Bahal* are the low land areas near the river valley. These are fertile soils due to sufficient supply of water from the river. These are mainly composed of silty loam and clayey loam. *Shoul* or *Bahal* areas are found with '*duo culture'* which has observed on the basis of availability of water from the river. Field investigation shows that *Bahal* areas of the villages namely *Jhimri, Lakri, Bandu, Heben and Uria* practices '*duo culture',* agro-horticulture and olericulture

5.10 Conclusion

Ajodhya Pahar is a hill station in Puruliya district having serious attraction for tourism and trekking. As a result construction of both for roads and inns like resorts, hotels, holiday home etc. are lucrative economic actions here which has a bit reasonably affecting the declining trend of forest loss during the past thirty years. The local people of the area are also depending on forests as *Matha* Protected forest has been converted into scrubs over time. Observations of afforestation programmes by Forest department affirm the role of authority even. Huge area of the basin has been converted into reservoir area of Chandil dam and interest for agriculture due to scarcity and unavailability of water. Not only this the increment in the area under built up lands and scrubs may lead to a lot of environmental and ecological problems in near future.

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