Impact of Landform on Agricultural Land Use Pattern: A Case Study of Salda River Basin in Purulia District, West Bengal

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ABSTRACT

The present study is concerned with the analysis of landform characteristics of Salda River basin and its impact on agriculture land use pattern. The Salda basin is one of the sub-basins of Subarnarekha River, with diversified landscape pattern in the western part of Purulia district in West Bengal. This basin is constituted by plateaus, plains with terraces, scarps, inselbergs, which is evolved under polycyclic evolution. The development of polycyclic geomorphic processes in this basin is typified by diverse morphology and drainage, which largely influence the land use pattern in this area. These diverse landscape patterns indicate the interaction of litho-tectonic-structural and various geomorphic processes with recent human intervention.

The main objectives of the present study are to analyse the landforms characteristics, correlate them with land use and identify problems as well as prospects of agricultural land utilization. The entire study is based on both primary and secondary data. Extensive field survey has been conducted to collect primary information regarding terrain characteristics, micro relief, slope characteristics, hydrological attributes, soil character, natural vegetation, environmental hazards. The Survey of India topographical sheets, meteorological data, agricultural production data, land use and land cover data have been collected for the analysis of geomorphological characteristics, land classification, and agricultural land use pattern.

This study reflects the typical land characteristics of the fringe area of Chhotanagpur plateau, where some typical geomorphic attributes control the productivity of the land and also controls the socio-economic conditions of the local people. The present authors have tried to examine the typical geomorphic attributes and their effects on present productivity of the land in a micro level study, where agriculture is the main source of income.

Keywords: Landform, land use, agriculture, river, geomorphic, landscape pattern.

1. INTRODUCTION

A landform is a natural feature of the solid surface of the Earth or other planetary body. Landforms together make up a given terrain, and their arrangement in the landscape is known as topography. Land is a product of nature and three dimensional dynamic bodies. Actually the advent of civilization and their further development are intimately linked with the land (**1**). It is well-known that the rational and sustainable use of land is one of the most important Indicators of economic growth **(2**). Land use suitability analysis is the process of determining the suitability of a given land area for agricultural use (**3**). Agricultural land use of any area is primarily dependent on the geomorphological characteristic (**4**). Due to poor-socio-economic status, the land of the area under study is not being properly utilized.

The Salda basin is one of the sub-basins of Subarnarekha drainage basin, with diversified landscape pattern in the western part of Purulia district of west Bengal. Salda River and its tributaries drain a part of eastern fringe of Chhotanagpur plateau. The basin covers an area of about 94 sq. km or 23287 acres comprising portion of Jhalda-I Community Development Blocks of Purulia district in West Bengal. The Salda basin is constituted by plateaus, plains with terraces, scarps, inselbergs, which is evolved under polycyclic evolution. The development of polycyclic geomorphic processes in this basin typified by diverse morphology and drainage which are largely influenced the land use pattern in this area. Those diverse landscape patterns

indicate the interaction of litho-tectonic-structural and various geomorphic processes with recent human intervention in the evolution. The present study is concerned with the analysis of landform characteristics of Salda River basin and their impacts on agricultural pattern in this area.

1.1 Objectives of the Study

The main objectives of the present study are:

1. To analyze the landform characteristics of the study area.
2. To make correlation between landform characteristics and agriculture.
3. To analyze the problems and prospects of agricultural land use.

2. METHODS AND MATERIALS

2.1 Area and Location

The Salda River basin is bounded by latitudes of 23°18'00"N to 23°22'30"N and longitudes of 85°53'30"E to 86°02'36"E (Fig.1)The basin includes a small tract of 48 mouzas of Jhalda-I Community Development Block of Purulia district. The basin with its great diversity both in the polycyclic landscape and the land use pattern extends through the undulating Archean plateau being delineated by73 I/ 3, 73 E/15, numbers Survey of India maps.

It is a small tributary of Subarnarekha River. It originates from a dome-shaped hill (618 Metres above sea level), known as Pokhriya Pahar. It drains the undulating highland of Jhalda-I C. D. Block and flows westwards ultimately joins with Subarnarekha River near Magha mouza. The height of the confluence is 238 m.a.s.l. The geographical area of this basin is 94 sq. km or 23227.9 acres.

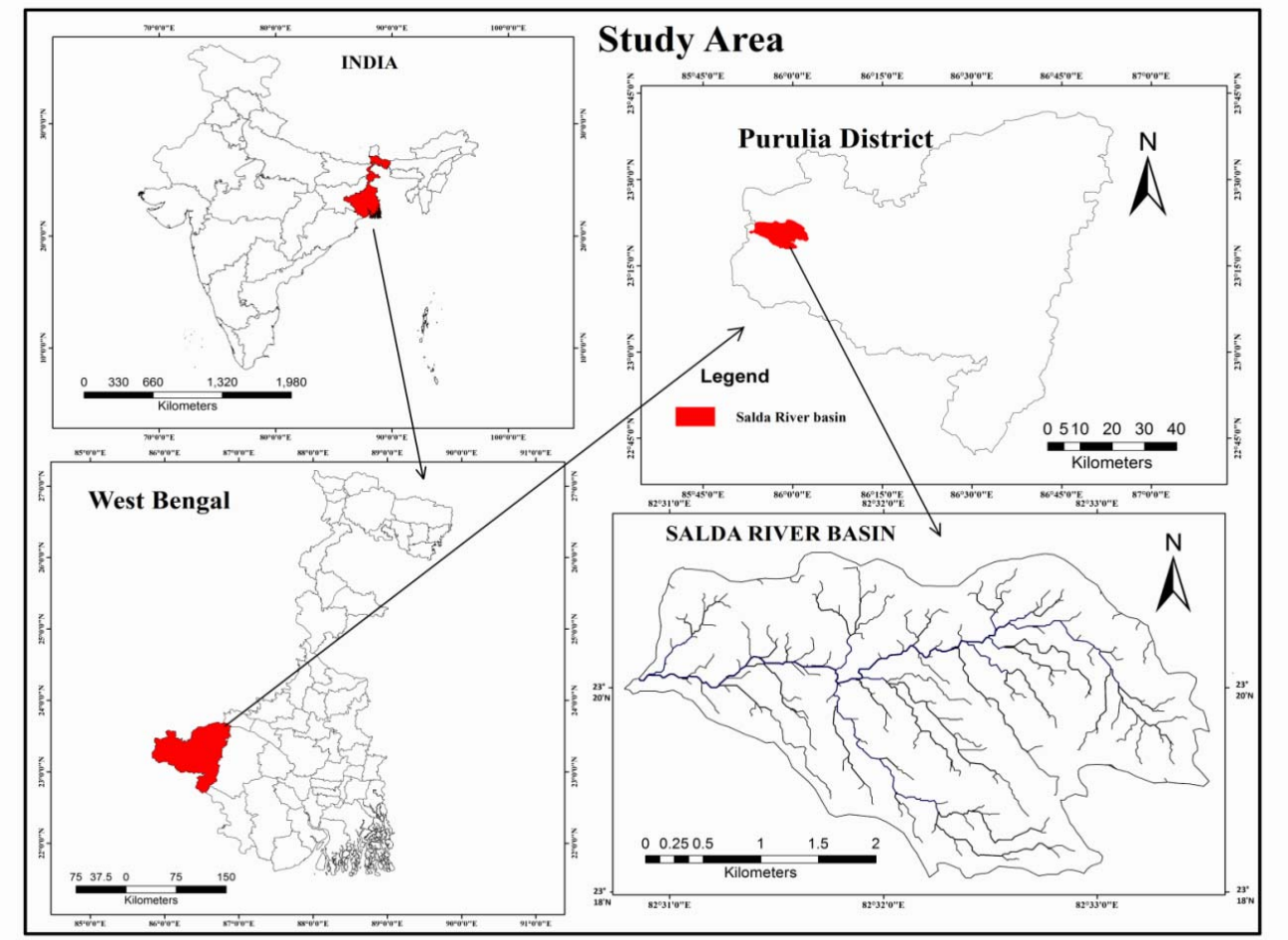
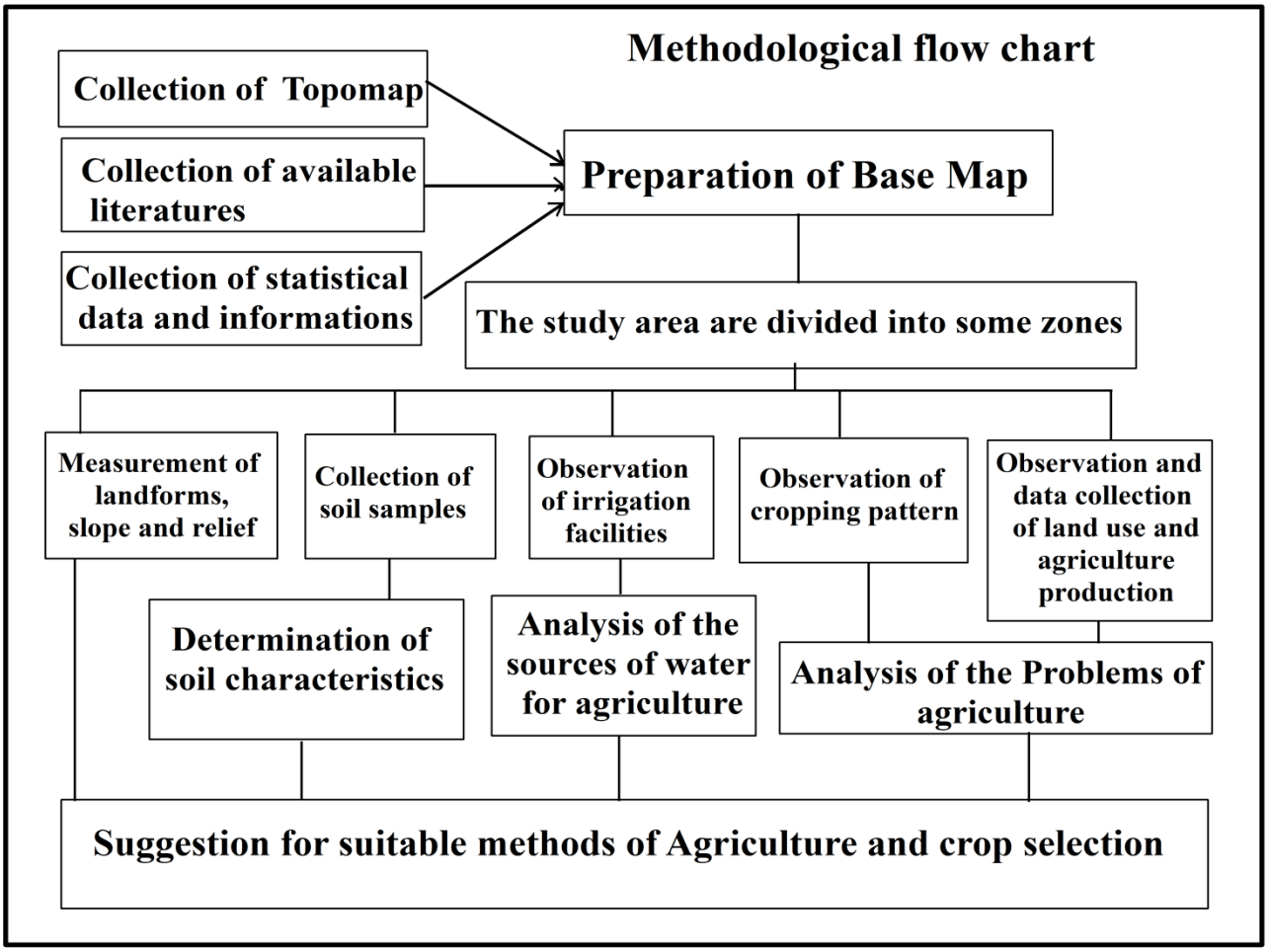


Fig.1. Location of the study area

2.2 Methodological Flow Chart



To gain insight into the cropping pattern in Salda basin, the spatial distribution pattern of crops and their problems and prospects, crop diversification pattern are also analyzed. Such an exercise helps to identify the most important crops of the region and their areal differentiation in the diversified agricultural economy of the basin.

The authors have converted all the production's units through "***Google unit converter***" for better understanding of the actual scenario regarding the status of production.

The variables have been calculated by using these following formulas-

* ***Percentage of total area under crops = (particular crop coverage area/net cropped area) x 100***

** ***Per Acre production = total particular cropped production of surveyed area/ bearing cropped area.***

2.3 Data Collection

The entire study is based on both primary and secondary data, the detail are:

- Extensive field work was conducted to collect primary information regarding terrain characteristics, micro relief, slope characteristics, hydrological attributes, soil character, natural vegetation, environmental hazards etc.
- The Survey of India topographical sheets have provided an excellent base to understand the realistic geographical situation through the entire study.
- Meteorological Data have been collected from The Indian Meteorological Department, Kolkata.
- Land use and Land cover data have been collected directly from Cadastral maps and secondary data from Block Land Records Office, Jhalda-I and District Census Handbook Puruliya", Directorate of Census Operations West Bengal (Retrieved 6 December 2016).
- Agricultural production data were collected directly from household survey and District Statistical Handbook, Purulia 2013, 2014 and 2015.

2.4 Tectonic History

The study area is a part of the ancient (Pre-Cambrian) landmass of the Peninsular India, which have been stable and unaffected by any recent geological movement. The only structural disturbance in this part was vertical downward or upward movement. These structural upliftments are mainly due to tectonic disturbances (**5**). Tectonically the study area is an old land surfaces with inselbergs prevail of eastern part of Ranchi peneplain (**6**). This old land surface suffered from tectonic disturbances due to drifting of Gondwana landmass during Permo-Carboniferous to Jurassic period. More recent evidences shows Tertiary upliftments occur in younger landscape. These Tertiary uplifts of this study area have acted for the side effects of the Himalayan orogeny. It seems possible that the epeirogenic uplift during the Tertiary period has been responsible for initiating successive cycles (**7**).

2.5 Geological Structure

The western part of Purulia is well marked by its varied geological formations. The study area is constituted by various stratigraphic units, ranging from the oldest Archaeans (Pre-cambrain) to the younger Tertiary - Quaternary formations (**7**).To study the regional geological accounts of this areal units distribution of various rock groups, tectono-structural history is essential for the analysis of the terrain pattern. The role of these rock formations, including the structural and tectonic characteristics in the development of present multi-cyclic landscape patterns as well as the land use pattern is significant. The unequal uplifts or tilts in the different parts of the study area have also caused the development of striking differences in the topographic expressions in the different terrain units within the region.

The major part of the present area is occupied by various types of granitic rocks. Maximum area covered by Granite-gneiss and migmatite. Northern, north-eastern and south-eastern portion of the basin are dominated by Pre-Cambrian Intrusive Granite, basically Manbhum Granite Intrusive body. Beside small tract of Dolerite is found in the central portion of area. The stratigraphic succession of various geological formations found in the Salda River basin is given below (Fig.2):

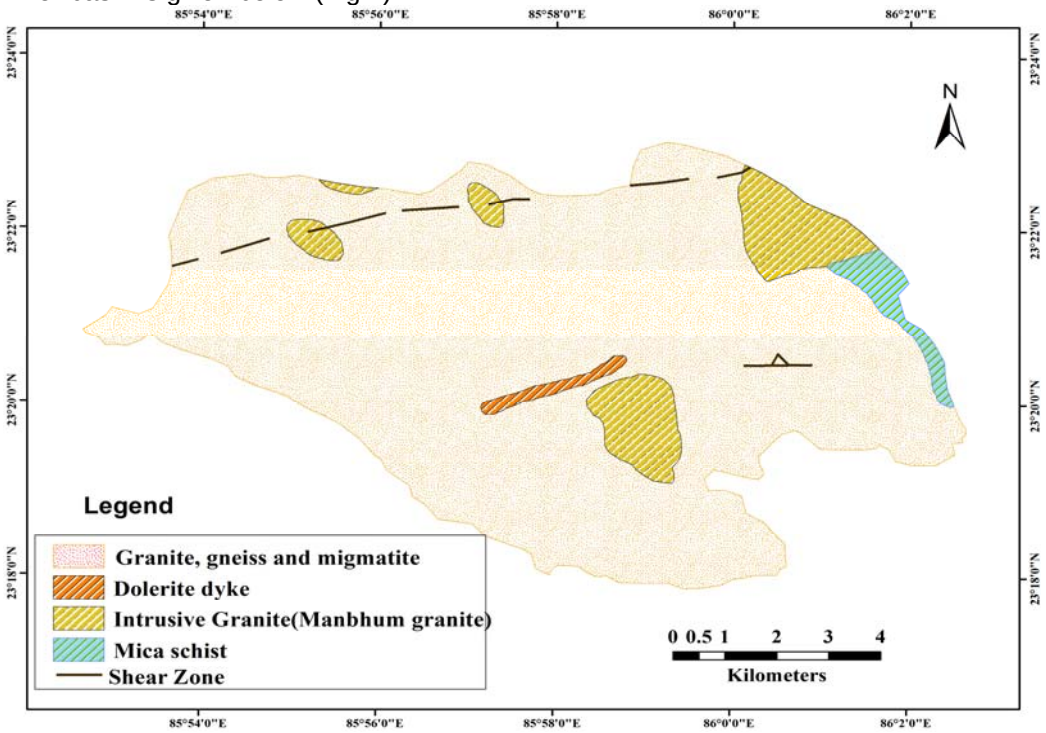


Fig. 2. Geological structure of Salda River Basin

Source: *Geological Map, published by Geological Survey of India, 2001*

2.5.1 Granite Gneiss and Migmatite

These are the main rock types of the Salda River basin, which are well exposed in hilly terrains, where dome shaped hill, steep and smooth slopes formed. Mainly these areas have no vegetation cover, except the hill

tops are covered by little vegetation. The flat ground of these rocky terrains is covered by laterite soil and alluvial outcrops. Alluvial outcrops of these rocks are found in the side of river and Jore.
Most of these rocks are greatly heterogenetic in structure, texture and mineral composition. The granite-gneiss with good gneissose structure lying all over the area, but is abundant in the south. The gneissose structure is defined by alternate granulose and schistose bands of quartz and feldspars, and biotite and muscovite.

2.5.2 Intrusive Granite

Granite intrusive body is very much common in the study area, which are collectively termed as Manbhum granite intrusion. Presently these are exposed by poly-cyclic erosional work. All of these intrusion bodies presently formed as a dome-shaped hill. Granite intrusions have sitting among the granite, gneiss and migmatite. It occupies in the hill area of south-eastern, eastern and north-western part, nearly Lagam-Iphurhatu Pahar (23°21'00"N, 86°1'30"E); Narahara Pahar under Mahakudar mouza (23°20'00"N;85°59'30"E); Sikra Pahar under Mosina mouza(23°22'30"N;85°57'26" E) and Bansa Pahar(23°22'00" N; 85°55'30"E).
Among them Bansa Pahar is completely barren and open rock masses are exposed as a hard rock body. It is located in the lower part of the basin, so its surrounding area is covered by laterite and alluvial soil. Although Lagam and Narahara Pahar are having vegetation cover but the slope of the hills are demarcated as a Manbhum Igneous Intrusion. In present geological period Sikra Pahar shown as a form of batholith, where exfoliation is active as a weathering agent.

2.5.3 Dolerite

Small intrusion of dolerite within the Granite gneiss are observed horizontally along the 23°20' N latitude extending 85°57'28" E to 85°59'00" E, near Narahara Pahar Gotilwa to Tarhad. At Gotilwa to Tarhad the dolerite body runs almost E-W direction. Its length is approximately 2.8 km. The rock have medium grained and shows subophitic texture with lathes of plagioclase. Quartz and iron oxides are small proportions in this rock body under interstices portion.

2.6 Topographical Characteristics

Topographically this area is very much diversified with dome-shaped inselbergs, spurs, escarpments, undulating upland and erosional plain. Salda River Basin has different areas of elevations ranging from 238 meter to 618 meters. We can see the south-eastern part of the basin having an elevation 618 meter whereas the eastern part having an elevation 220 meter.
As a part of the Chhotanagpur Granite-gneiss tract, the Salda Basin did not experience any severe diastrophic disturbance in its long geological history, but it could not escape the impact of orogenic forces. The Salda Basin occupies the eastern part of the Pre-Cambrian Granite-gneiss tract. These tracts are very little disturbed and there are very few signs of structural disturbances throughout the basin.
The physiographic divisions of the Salda River basin are: (i) The hill region, (ii) The escarpment zone, (iii) Flat and gently undulating terrain, (iv) Lower plain region.

2.6.1 The hill region (375 meters and above sea level)

The hill region with an elevation of more than 375 meter above sea level is highest surface in the basin area. This portion lies in the eastern and south-eastern portion of the basin. Besides in the north and north-western portion Sikra Pahar with 491 meter, Pat-Jhalda Pahar with 483 meter and Bansa Pahar with 544 meter elevation from sea-level is small segment of this hill region. The significant geomorphic feature in this region is dome-shaped inselberges. There are number of dome-shaped inselberge, among of them Pokhariya Pahar (618 m), Baghbinda Pahar (543 m), Mahakudar Pahar (502 m), Narahara Pahar (446 m), Iphuratu Pahar (475 m), Metalya Pahar(544 m), Bansa Pahar (540 m), Sikra Pahar (491 m) etc. are significant. Among them Pokhariya Pahar, Baghbinda Pahar, Mahakudar Pahar are covered by little vegetation, whereas Bansa Pahar, Sikra Pahar is completely devoid of vegetation. There are several theories on the formation dome-shaped inselberges, but *Exhumation* hypothesis is most applicable towards such of formation within the Salda basin.

2.6.2 The escarpment zone (320 meter to 374 meter form sea level)

The escarpment zone of eastern and south-eastern part of the basin and adjoining upland is also a geomorphological division sculptured mainly in Granite and Granite-gneiss by the parallel retreat of scarps and headword erosion of Salda River. Here land use pattern is more selective, depending upon morphology and slope of the terrain. The scrape face and tops are thickly forested while the adjoining level of flat and undulating terrain are cultivated.

2.6.3 Flat and Gently undulating terrain (283 meter to 320 meter above the sea level)

Below the escarpment zone, a gently undulating Granite-gneiss terrain towards west is found having an elevation of below 320 meter. This is the largest part of the basin, which are gradually slopes down towards south-east of study area. This area is characterized by flat and gently undulating terrain with numerous gneiss domes and wide valley with Multi-channel River, large terraces, conspicuous gullied surface and small and large rocky exposures. Agricultural landscape is predominating but their main resistances are hard laterite soil, gullied surface, stony wastes and barren gravelly upland.

2.6.4 Lower plain region (280 meter to 238 meter above from sea level)

The lower Salda Plain is located in central to western, north-western and south-western portion of the basin. This part is slowly and gently sloping towards west and south-west with 238 meter to 280 meter elevation. Economically this portion is better than other area of the basin, because existence of suitable agricultural land. Lower plain is intensively cultivated due to plain surface, fertile land and sufficient supply of surface and ground water.

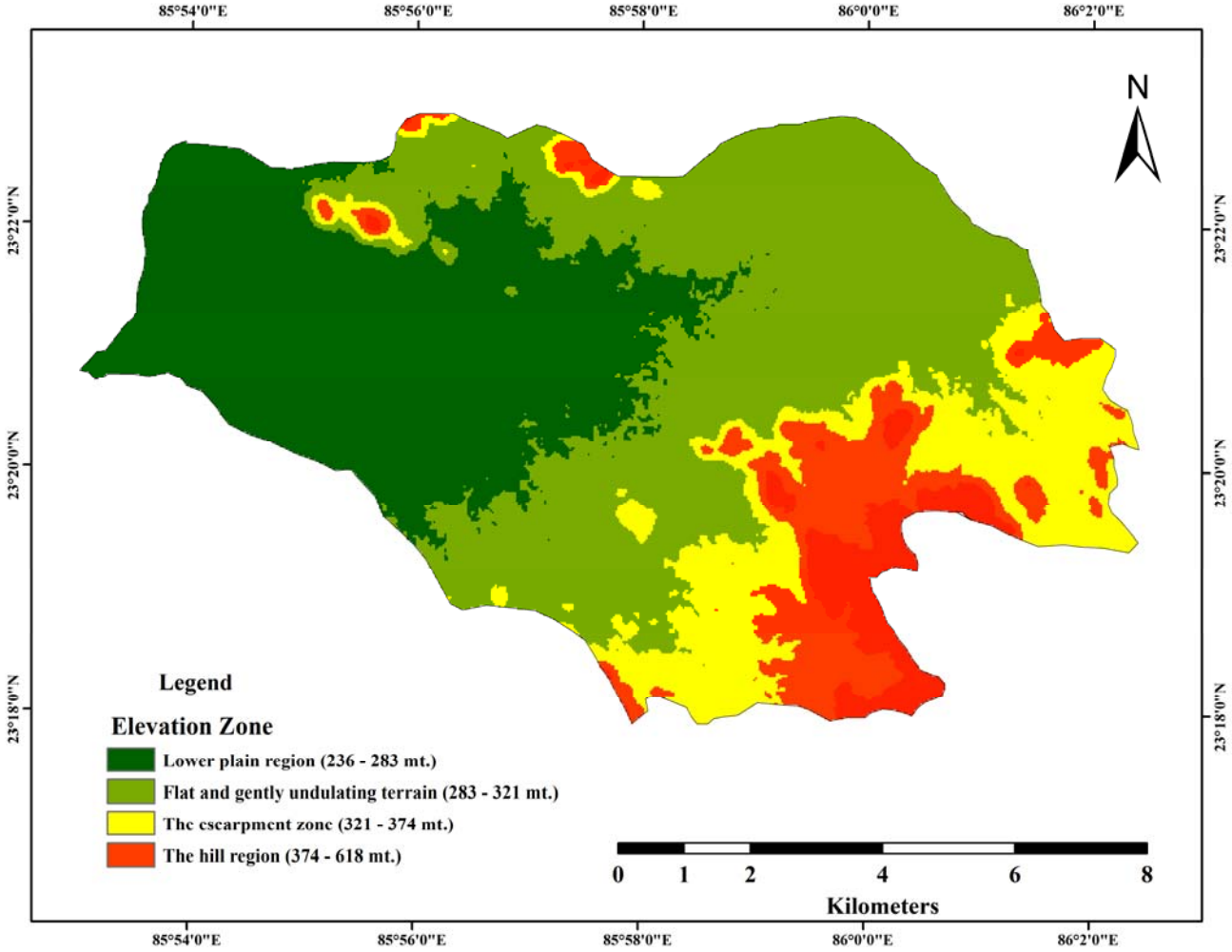


Fig. 3. Physiographic division of Salda River basin

Source: SRTM DEM, LISS-III

Plate no.1

Plate no. 1. **Dome-shaped inselberge Of Pokhariya Pahar**
Source: Field survey on September, 2018

Plate no.2

Plate no. 2. Flat **and gently undulating terrain at Mahuldih Mouza**
Source: Field survey, September 2018

2.7 Climatic Characteristics

The climate of the Salda basin is a very significant factor both in the formation of variegated landscape and diversified land use in the area. Tropic of Cancer helps in the receipt of greater amount of insolation for the region in summer, which makes temperature condition high. Even during winter the temperature hardly drops below 7°C. Beside, altitude acts as one of the important modifying agents of climate inside the basin. Geomorphologically, the basin is an area of varying levels, e.g., Upper basin of 618 m elevation, and lower plain of 238 m elevation. So the landforms are affected differently by their climatic elements.

The Salda Basin being located in the fringe areas of the eastern Chhotanagpur is characterized by tropical Monsoon type of climate. This can be well studied in the occurrences of seasonality of temperature and rainfall along with several local storms like Nor'wester and other associated features both in temporal and spatial dimensions. The mean annual rainfall of the basin varies from 1000 to 1400 mm. and means annual temperature varies from 30°C to 34°C.

2.7.1 Temperature

Mean annual temperature varies from 30.22°C to 33.77°C in different years of the basin. Temperature rises rapidly from the beginning of March. May is the hottest month with mean daily maximum temperature of 40.3°C and means daily minimum temperature of 27.2° C. On some days of May and June, the day temperature is sometimes pushed up above 45°C to 48°C by the dry land winds (Loo). January is the coldest month with the mean daily maximum temperature at 25.5°C and mean daily minimum at 12.8°C. In cold season sometimes minimum temperature is below 5°C due to the Western disturbances.

2.7.2 Rainfall

The average annual rainfall in basin area is 1363.10 mm. The rainfall during June to September constitutes about 80% of annual rainfall, July being the rainiest month of the year.

2.7.3 Humidity

Relative Humidity is high during the monsoon season, being generally between70% to85%. After the withdrawal of south-west monsoon relative humidity decreases gradually, the driest part of the year is the hot season, when the relative humidity is 30 % to 45 %.

Table 1. Monthly average rainfall of study area during 1960 to 2010

Months	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Rainfall In Mm	19.1	32.8	25.1	23.4	65	217.2	324.6	315.8	213.9	89.96	15	3.8	1353.46

Source: District Gazetteer, Purulia (1985) and Indian Meteorological Department, Kolkata

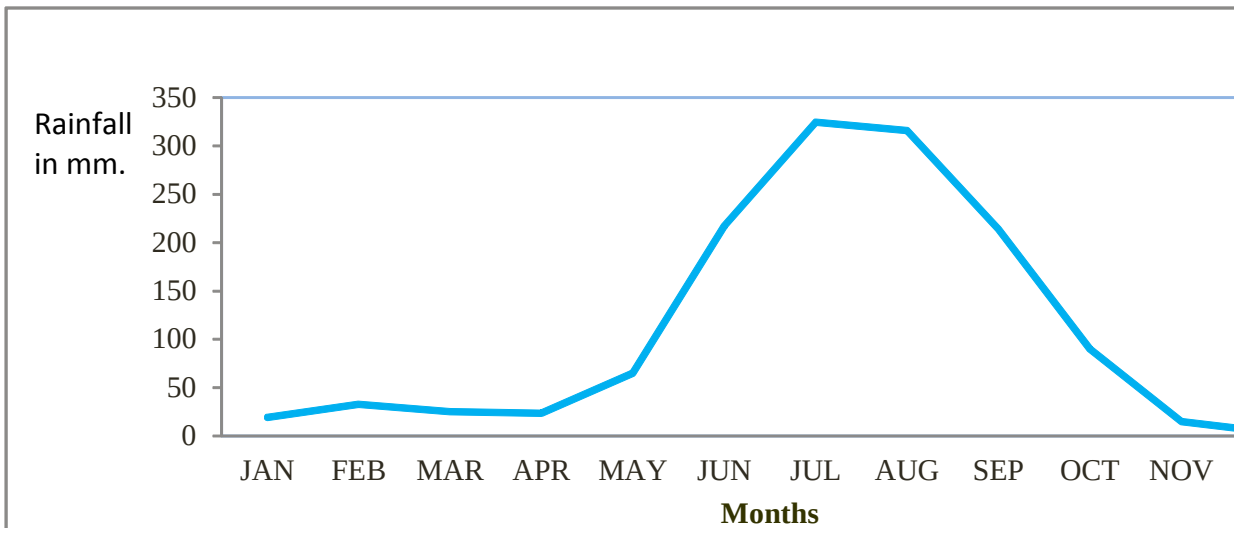


Fig. 4. Monthly average rainfall 1960 to 2010
Source: District Gazetteer, Purulia (1985) and Indian Meteorological Department, Kolkata

Table 2. Range of Rainfall (1960-2010)

Range in mm	No. of years
801- 900	1
901- 1000	0
1001- 1100	2
1101- 1200	10
1201- 1300	11
1301 – 1400	8
1401 – 1500	3
1501- 1600	7
1601- 1700	5
1701- 1800	1
1801-1900	2

Source: Indian Meteorological Department, Kolkata

Fig. 5. Frequency of annual rainfall
Source: District Gazetteer, Purulia (1985) and Indian Meteorological Department, Kolkata

3. RESULTS AND DISCUSSION

3.1 Influence of Climate on Landform Development

The present study shows the landscape system, time lag in the response of evolutionary process, pedogenic processes with the respect of climatic element, which is present on polycyclic landscape including some traces of residual soils on soil profiles. The inherent landforms as well as the land use patterns of the polygenetic Salda basin are largely controlled by different climatic elements.

It has been observed that the landform of Salda basin exhibits many features. Advanced erosion generally exists with steep slopes viz. Pokhriya Pahar (618 m), Bighbinhdya Pahar (543 m) Iphuratu Pahar (475 m). Valleys broaden into wide depressions with flat and slightly undulating floors. The width of such lowlands

often reaches in several kilometers in the lower part of the basin. Asymmetric, and cuesta-like ridges are common (Pokhriya Pahar). The stream beds are far from having regular profiles even if the stream flows on a level or slightly undulating surface, which will justify the name of planation surface with inselbergs.
Mention should be made of inselbergs (residual hills), stone lines, gullied-surfaces, laterite capping or duri-crusts, scarpfalls, wide level plains at different altitudes in erosion surfaces, pediment like slope, terraces, floodplain deposits and planation surface, which constitute the polycyclic landscape of Salda basin. These topographic forms appear to affirm the change of climatic conditions which have played an important role.
The Salda is also a small river basin, so it is difficult to identify the influence of past climatic regime within this small latitudinal and longitudinal extension. However, indications of the effects of climatic change are mainly obtained from the inselberge dominated land surfaces on the lower reaches of the valley.

3.2 Influence of Climate on Agricultural Land Use

Each of the climatic elements has its own way of influencing land use. During June to September, the total rainfall is 1071.5 mm. of the basin. Rainfall is negligible in the rest of the year. Besides being concentrated in four months, it might delay in coming, it might stay longer or it might occur at longer intervals. All these peculiarities affect rice cultivation, which is the main crop of the basin. Yet the relatively high average rain makes rice predominant crop. The rains which are torrential are very damaging also to the surface of the lower basin because it creates inundation. Damages occur in the form of several types of soil erosion such as sheet erosion, rill erosion, gully erosion on the upper basin etc.
Temperature can affect land use adversely if it touches extremes. However, none of the months except mid-April to mid-June is injurious to plants in the basin. The temperature in the basin for major part of the year remains constantly high and aid evaporation. Only during winter temperature is lower. On an average, the climate of the basin can be said to not congenial for successful land use in the basin, provided precaution against some of the adverse elements are taken.

3.3 Land Classification

The total land of the study area is 23287 acres. As the Salda River Basin is a part of the eastern fringe of Chhotanagpur plateau, so the general slope of the land is from west to east. But the actual slope of the Salda basin is opposite to regional slope direction from east to west. The land of the study area is also characterized by degradation surface which experiences accelerated soil erosion, mainly caused by gully and rill erosion, leaching and human interference through deforestation.
The land of the area under study is classified into five categories: (1) Tikro land/ Degraded upland, (2) Tanr Land/Barhi, (3) Baidh Land, (4) Kanali Land, (5) Bahal Land /Low land/ Garha

Table-3: Areas under different land Classes (in 2007-2008)

Land Classes	Area in Acre	In percentage
Tikro	1240.59	5.34
Tarn	4258.56	18.32
Baidh	8926.85	30.05
Kanali	2759.94	11.87
Bahal	1345.90	5.79
Others	4755.16	28.61
Total area	**23287.00**	**100.00**

Source: Block Land Records Office, Jhalda-I

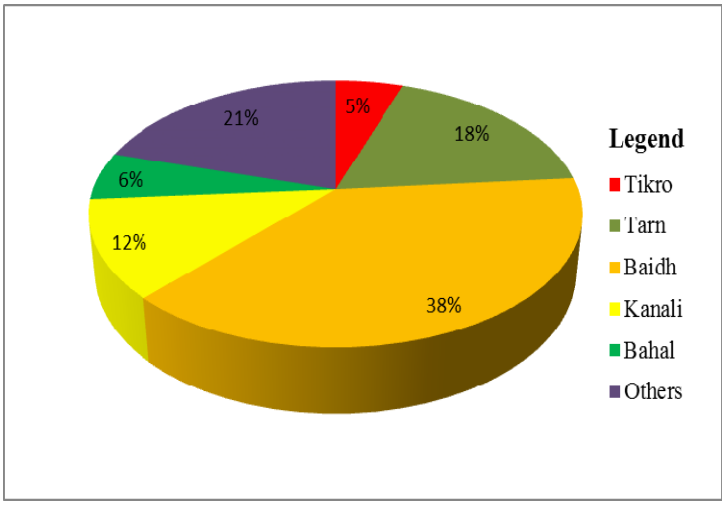
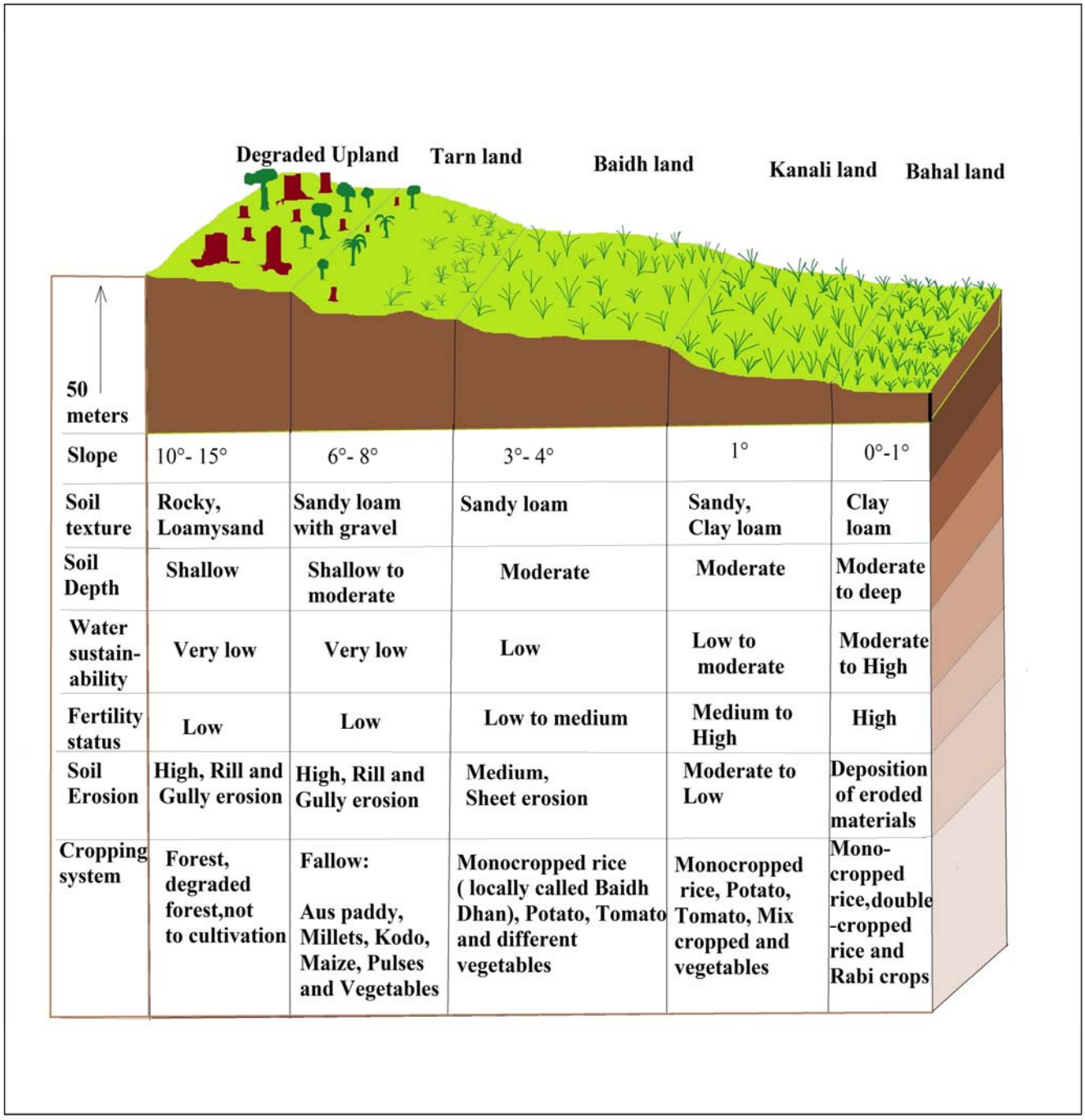


Fig. 6. Land* Classes of Salda River basin (**In this pie chart others refers to Pahar, Pahar with forest, only forest, settlement and water body)***

Source: Block Land Records Office, Jhalda-I



	Degraded Upland	Tarn land	Baidh land	Kanali land	Bahal land
Slope	10°- 15°	6°- 8°	3°- 4°	1°	0°-1°
Soil texture	Rocky, Loamysand	Sandy loam with gravel	Sandy loam	Sandy, Clay loam	Clay loam
Soil Depth	Shallow	Shallow to moderate	Moderate	Moderate	Moderate to deep
Water sustain-ability	Very low	Very low	Low	Low to moderate	Moderate to High
Fertility status	Low	Low	Low to medium	Medium to High	High
Soil Erosion	High, Rill and Gully erosion	High, Rill and Gully erosion	Medium, Sheet erosion	Moderate to Low	Deposition of eroded materials
Cropping system	Forest, degraded forest,not to cultivation	Fallow: Aus paddy, Millets, Kodo, Maize, Pulses and Vegetables	Monocropped rice (locally called Baidh Dhan), Potato, Tomato and different vegetables	Monocropped rice, Potato, Tomato, Mix cropped and vegetables	Mono-cropped rice,double -cropped rice and Rabi crops

Fig. 7. Land classification and their characteristic features *Source: Field Survey*

3.3.1 Tikro Land

This area is situated in the upper part of the land classes. It is covered by rocky surface, boulder and gravels. It is totally unproductive and fallow land. Vegetation cover is also very low in this category. Somewhere this area is fully covered by opened Pre-Cambrian granite and gneiss rocks. Main soil texture is rocky and gravelly loamy sand, which are infertile and unproductive. This land spreads all over the study area, but upper and middle portion of the basin cover maximum portion. Mainly on the lower basin this rock masses

are open on the surface by long geological erosional activities. The soil erosion is very rapid in this part due to absence of vegetation cover and wind action during long summer season.

3.3.2 Tanr Land

Tanr is the lower portion of the Tikro Land. Laterite and Red-gravelly soils are present here, which represent low fertility and or soil capability. This area is characteristics by gentle slope towards flat upland. So water holding capacity is very low. As a result agricultural productivity is also very low. In the study area this land is mainly used for short duration Kharif crops, grazing and forestry.

3.3.3 Baidh land

The next category is Baidh, which is better than Tarn land for land utilization. The soil types in this land are laterite with sand, sandy loam, and sometimes fine sandy soil is also found. Percolation rate is also high, so it is less fertile land. The depth of soil horizon in this region is only 2 to 5 feet. Below 5 feet the parent materials are found. This land covers the largest area (8926.85Acre) of the basin, which are maximum belong to north-eastern and central portion of the basin. Jhalda-Darda, Iloo-Jargo, and Khamar Panchyet cover largest amount of Baidh Land.

3.3.4 Kanali land

Kanali is that type of land which is relatively better than the Tarn and Baidh. Kanali land is generally situated between Baidh and Bahal. The water availability is good to moderate in monsoon season, so it is suitable for paddy cultivation. The soil in this land is alluvial and fine silt to clay. This type of land covers only 11.87 % of total land of the study area. Eroded materials of upper lands are deposited in this land. So, if people ignore to prevent deposition then this land also becomes sandy and gravelly. Because main deposited materials are sand, gravel, pebble, bolder, stone. Besides, little amount of clay and silt is also deposited.

3.3.5 Bahal land

Bahal is the lowest most land surface of the study area and is the most valuable land for agricultural use. The soil in this category is fertile alluvial soil and clay-loamy in texture. Water table is very near to the ground and infiltration rate is very low so the water holding capacity is very high in this portion. This land is existing near the river bank and below the water body, which are mainly found in the lower basin area.

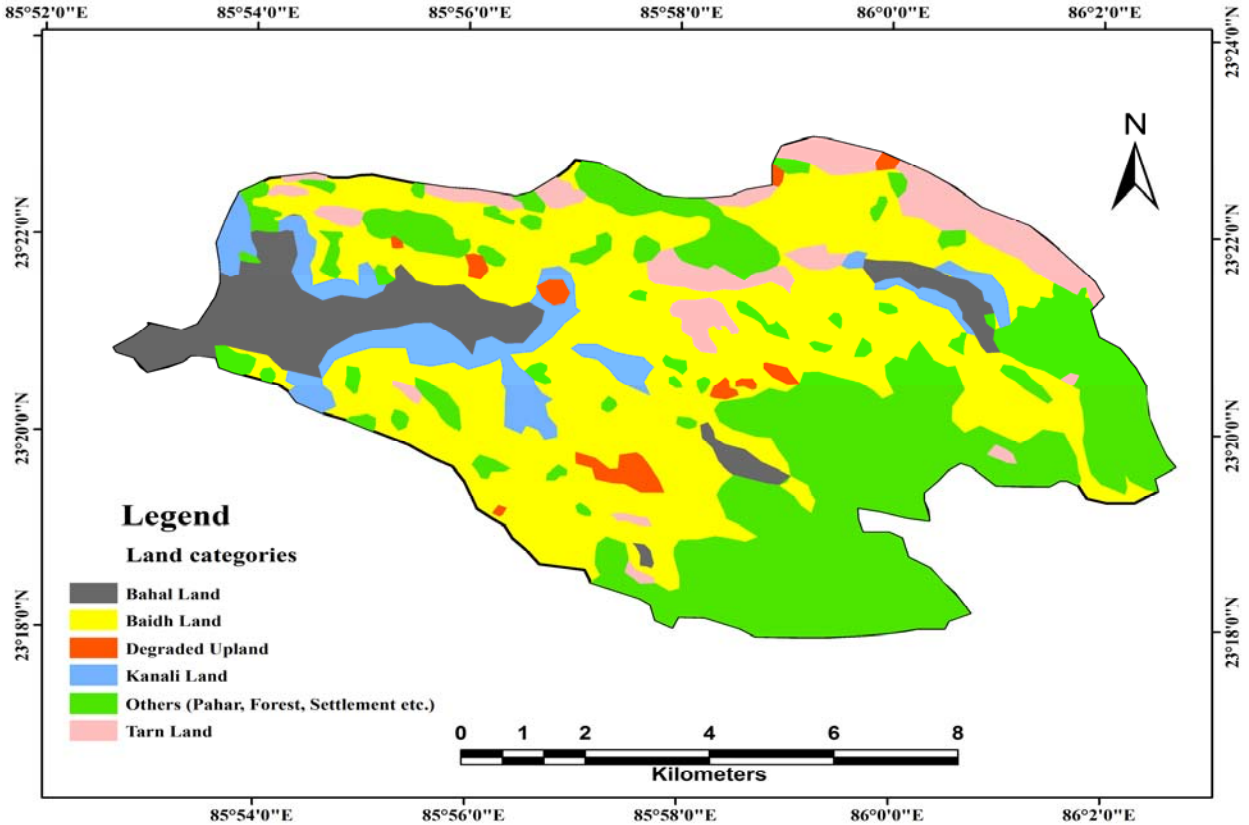


Fig.8. Different types of land classes of Salda river basin

Source: SOI Topographical Map, 2010 and field survey

Plate no. 3.Tikro Land at Mahakudar Mouza
Source: Field Survey, September 2018

Plate no. 4.Bahal Land at Baruakocha Mouza
Source: Field Survey, September 2018

3.4 Land Utilization in Salda River Basin

This Basin area is located in the plateau fringe, so land utilization here is very much diverse type. Most of land are forest and unavailable for cultivation, which lying over the upper basin area. On the other hand, eastern, south-eastern, and northern part of the basin is mostly covered by forest and non-cultivated land. More than 51% area belongs to these categories. Only 43.37% area is used for agricultural purpose, of which 70% is found in the lower basin. In summer season, Rabi crops are practiced in the lower basin area, which is mentioned as Area shown more than once. Land utilization of the study area is gradually changing in slower rate. Areas under forest, area are not available for cultivation and current fellow land are decreasing and net shown area and total cropped area are increasing in recent decade. Table-4 shows the diverse land utilization in basin area:

Table-4: Different types Land Utilization in the Basin area, 2001-2011

	2001-02		2010-11	
Types of land use	Area (acres)	Percentage (%)	Area (acres)	Percentage (%)
Total area of basin	23287.00	100.00	23287.00	100.00
Area under forest	5842.71	25.09	5458.56	23.44
Area not available for cultivation	5321.08	22.85	4967.68	21.33
current fallow	1766.62	7.58	1684.5	7.23
Net shown area	10356.59	44.47	11076.26	47.56
Area shown more than once	2415.13	10.37	2821.4	12.12
Total cropped area	12771.72	54.84	13897.66	59.67

Source: Census of India 2001 and 2011, PART XII-A

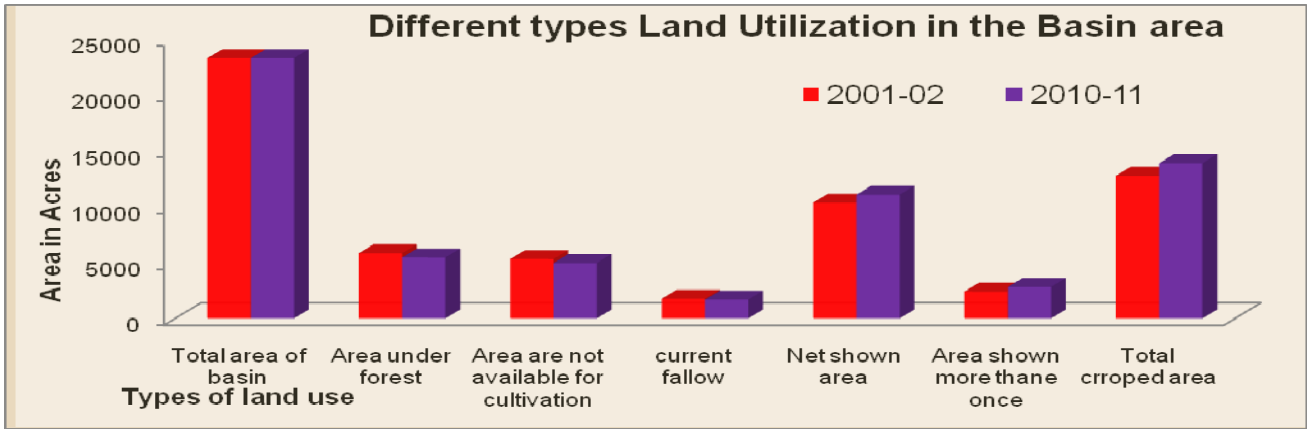


Fig. 9. Different types of Land utilization in Salda Basin
Source: Census of India 2001 and 2011, PART XII-A

3.5 Cropping Patterns

The Cropping pattern in the Salda basin in relation to the importance of different crops has grown, especially in terms of their spatial and temporal context, represents the hierarchical order and in association with different crops at a point of time in the particular areal unit within the basin.

In the study area agriculture is the main occupation of the people, so the study of crop cultivation and its planning is of great importance.

The diversity of crop farming is the result of diversity in topographic, socio-economic and technological conditions of the basin. The main crops, crops coverage and production of the study area are mentioned in Table-5.

Table-5. Crop-wise coverage area, percentage under net shown area, per acre production and total production under Salda River Basin in 2017-2018

Name of crops	Cropping area (in acres)	Percentage of total area under crops	Per Acre production (in Kg.)	Total Production (in Tons)
Aman paddy	6682.94	52.22	1072.84	7164.11
Aus paddy	26.87	0.20	734.11	19.72
Boro paddy	502.64	3.92	972.48	488.80
Wheat	297.06	2.32	781.46	232.14
Maize	551.42	4.30	974.09	537.13
Groundnut	337.88	2.64	673	227.39
Mustard	1139.86	8.90	331.04	377.34
Til	36.09	0.28	129.09	4.65
Arhar	201.44	1.57	435.85	87.79
Masoor	351.76	2.74	219.34	77.15
Chickpea	281.11	2.19	381.22	107.16
Linseeds(Tisi)	65.26	0.50	118.57	7.73
Peas	95.7	0.74	495.34	56.87
Potato	266.19	2.079	8885.06	2365.11
Vegetables	1972.89	15.41		
Total	**12797.66**	**100.00**		

Source: Field survey on September, 2018

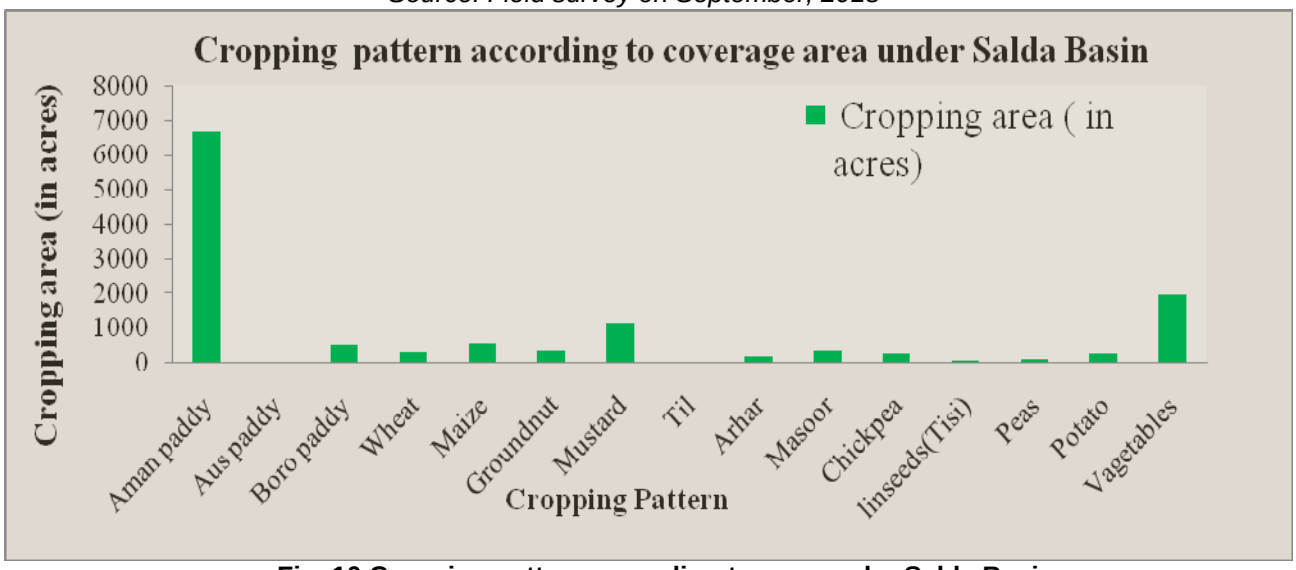


Fig. 10.Cropping pattern according to area under Salda Basin

Source: Field survey on September, 2018

Table-5 shows different types of crops of the total Basin area, the total area is 23287.00 acres of 48 Mouza, where 10076.26 acres having net sown area and Gross cropped area is 12797.66 acre. Gross cropped area refers as cropping area. The table-5 has shown the variables such as crop coverage areas, crops production, and diversified cropping practice regarding the land classes. The data has been collected in the form of local units that are commonly used by the local stakeholders, ***Bigha***, ***Mon*** but this information are converted into traditional units like, ***Acres, Kg.*** and ***Tons*** etc.

3.5.1 Paddy

Paddy is the most important food grains in the Salda basin area. It has covered the largest portion (56.34%) of the total net cropped area and the production (7672.63 tons) of this crop is also highest compared to rest of the crops during the period 2017-2018. Due to lack of irrigation facilities this crop is being totally dependent upon the monsoon rainfall. This crop has been cultivated by using two methods, such as (i) transplantation method in low lands and (ii) broadcasting method in the uplands. The spatial distribution of paddy cultivation indicates its close relation with soil, water and topography. In the study area paddy are mainly of three types: ***Aus, Aman and Boro***. *Aman* has been largely cultivated all over the region during monsoon season, which is sown in June and reaped in mid-October. *Aman* has covered the largest portion the total cropped sown area in comparison to other crops. The cropped area is 6682.94 acres, which is 52.22 % of total sown area. Whereas, *Aus* and *Boro* paddy was cultivated in small scale i.e.26.87 acres and 502.64 acres respectively. In this basin area, *Aus* and *Boro* have been cultivated during the period of mid-June to September-December to March respectively.

3.5.2 Pluses

Pulses are the second important cereal in the Salda Basin. It is cultivated as dry crops, because ***Tarn*** land is mainly used for pulses cultivation in the monsoon season. The cereals like **Tur (Arhar), Moong, Chickpea** and **Gram** are cultivated for domestic consumption. Masoor is another pulse which is cultivated (351.76 acre in 2017-18) in *Kanali* land in winter season. Pulses are important because it is cultivated in less moisture with moderate fertile soil and also in the low rainfall conditions and prolonged dry spells. These pulses are used both for human consumption and cattle feed. Agricultural operation such as preparation of land for these type of pulses cultivation is very easy rather than the other crops. Pulses are grown well on a variety of soil; however, it is generally grown in the poorer soil.

3.5.3 Pea

Pea is grown as Rabi crop. The local people consider Pea as vegetable rather than pulse. Total peas cultivated area is 108.82 acres and total production is 53.81 tons.

The cultivation of the total pulses has spread over only in9.94 % of the total cultivated area in 2017-18.

3.5.4 Oil seeds

Various types of oilseeds are cultivated all over the basin area such as Kharif and Rabi in both the seasons. *Oil seeds like Til, Line seed (Tisi), Groundnut, Khasla* except *Mustard* are practiced during the Kharif season. Til, Line seed (Tisi), Groundnut, Khasla and Khasari are cultivated in red, sandy loam soil of Tarn land. All of those oil seeds are cultivated during the onset of monsoon. Sub-tropical monsoon weather and well drained light sandy loam, red soils are well suited for this type of cultivation.

Mustard cultivation has been very much suitable for sub-tropical dry and cool winter climate. So it is practiced in largest area rather than others oilseeds. Mustard has covered 1139.86 acres area that is 8.90 % of total net sown area and the amount of total production is 377.34 tons in 2017-18. It is cultivated on winter season in Baidh and Kanali land.

3.5.4 Potato

Potato is the important food crops of Salda River basin. It is grown in the subtropical condition in winter season on sandy-loam to loamy soil with 5.5 to 6.5 pH value. It is also known as 'friend of poor men', so most of the people select this crop after paddy cultivation in Kanali land. However, due to lack of water it is practiced in short duration providing 3 to 4 times irrigation. Therefore, total area coverage for potato is only266.19 acre and total production is 2365.11 tons in 2017-2018.

3.5.5 Wheat

The percentage of wheat cultivation is only 3.19 % of net cultivated area of the basin. It is a Rabi crop, which requires low temperature, available irrigation and well drained fertile loamy-clay soil. This nature is rare in this area. So it is cultivated only in297.06 acres and total production is232.14 tons in 2017-18.

3.5.6 Maize

Maize is one of the most versatile emerging crops having wider adaptability under the basin area. It has the highest genetic yield potential among all the cereals. In the study area Maize cultivation mainly starts before the onset of monsoon, so it is a Kharif crop. Maize cultivation has been successfully done in Tarn and Baidh

land, where soil is sandy-loam to loamy and pH value is 5.5 to 7.0. It is also cultivated under rainfed conditions on poorer soil.

3.5.7 Vegetables

Vegetables are most revenue earning crop in this area. In both Kharif and Rabi season this area produces different types of vegetables. Table-7 shows the different types of vegetables with growing season in Salda Basin.

Table-7 Various types of vegetables grown around the year in Salda Basin area

Month	Vegetables
January	Brinjal, Tomato, Cabbage, Cauliflower, Peas, Sem, Carrot, Beet,
February	Bitter Ground, Cabbage, Cauliflower, Peas, Carrot, Beet
March	Cucumber, Bitter Ground
April	Capsicum, Bottle Ground, Onion
May	Onion, Brinjal, Pepper, Bottle Ground, Watermelon
June	Bottle Ground, Okra, Pumpkin, Cucumber, Spinach, Bitter Ground
July	Same to June
August	Radish, Pumpkin, Spinach
September	Okra, Spinach, Brinjal
October	Tomato, Pepper
November	Brinjal, Tomato, Cabbage, Cauliflower,
December	Same to November

Source: Field survey in September, 2018

3.5.8 Zaid crop

These crops are grown during the period from March to June. The zaid crops like Bitter Gourd, Sponge Gourd, Bottle Gourd, Watermelon, and Pumpkin are cultivated in the Basin area.

3.6 Irrigation Facilities

Owing to the peculiar topography the basin area has little irrigation facilities. Soil erosion is the main problem of upper basin for irrigation, where erratic and scanty rainfall is another problem of irrigation in whole basin area. Irrigation in the area is mainly facilitated from wells, bandh, and check dams, which is accumulated from run-off water. As the availability of water depends on rainfall, it is not assured for irrigation always. During summer months most of the Wells and Bandh get dried-up and hence irrigation is not possible. Two check-dams: Narahara Dam and Baghbinda Dam are small scale irrigation project; these are also dried-up in summer. Only lower basin has potentialities for irrigation in summer season from river. In addition to Salda River, people used to get irrigation water from the Rupai and Subarnarekha River. Therefore, lower basin has potentialities of irrigation in summer and hence this portion has huge capability of agriculture.

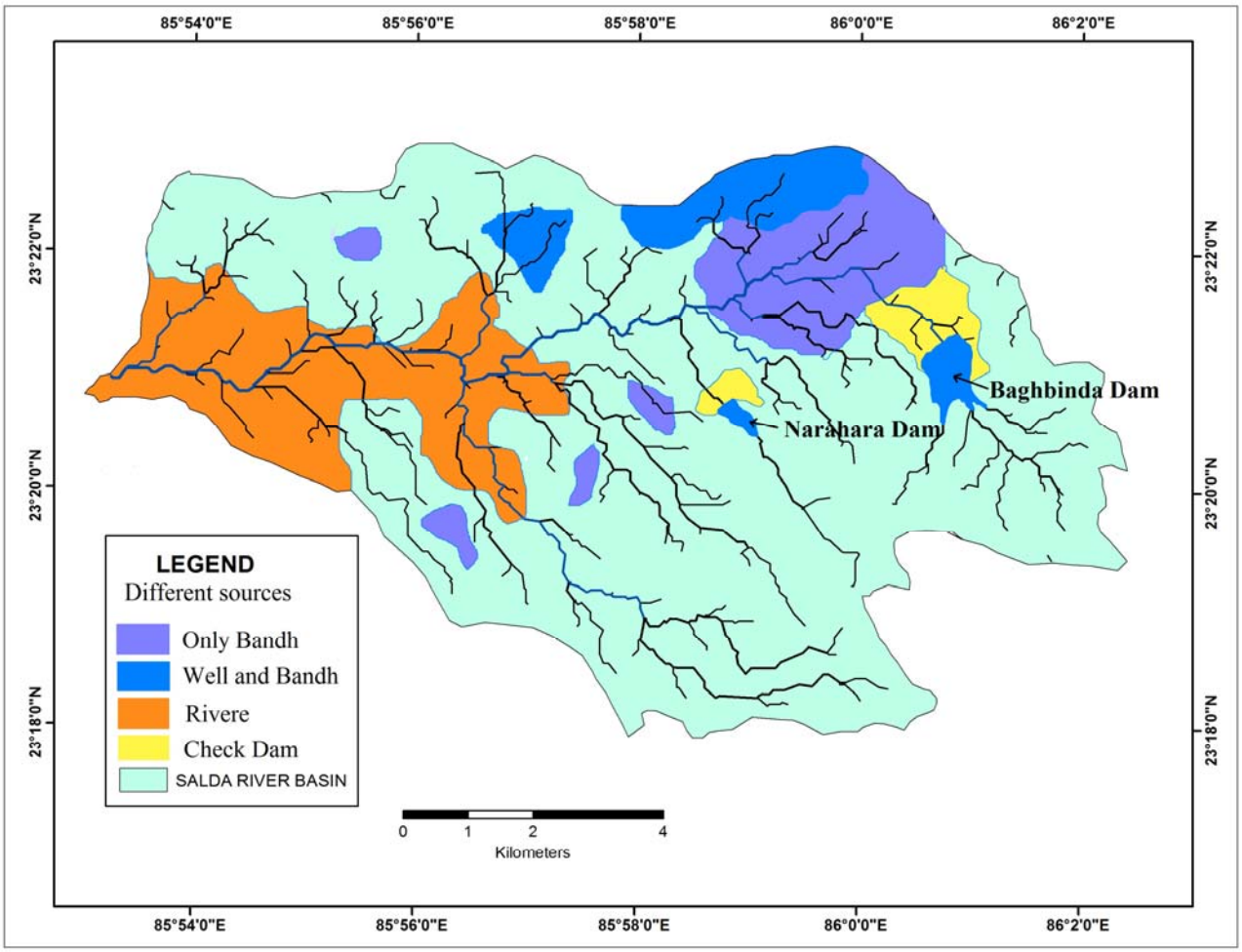


Fig.11. Different sources of irrigation facilities in Salda River Basin

Source: Field survey on September, 2018

3.7 Land Classification and Its Impacts on Crop Selection

In this basin area land has been classified into five categories, such as Tikro, Tanr / Barhi, Baidh, Kanali and Bahal. The regional soil texture, soil fertility, water holding capacity, surface and ground water potentiality, irrigation facilities etc. are depended on those land categories. So, agricultural system and cropping patterns are fully influenced by the characteristics of land categories.

Tikro and Tarn land are not suitable for crop production. These lands are infertile and have high infiltration capacity. Due to undulating and sloppy character Tarn is suitable for pulses, maize and vegetable cultivation in monsoon season. Baidh land is also not suitable for agricultural practice like paddy cultivation. The cultivation in this type of land has increased with the growing demand of food grains with the passage of time. This type of land is used for paddy, oilseeds, and pulses cultivation with the help of irrigation facility.

Kanali and Bahal are most appropriate for cultivation. These types of land are suitable for both Kharif and Rabi crops with the help of irrigation facilities. Bahal land is basically used for paddy cultivation in monsoon season and Rabi season also. In the basin area main constraint for agriculture is lack of water, but Bahal is that type of land where water is available for both season. It is not suitable for potato, pulses, nut and oil seeds production.

Table-8 Cultivated crops, their problems and essential crop selection according to land classes

Land Classes	Cultivated Crops		Problems	Suitable Crops		Remarks
	Kharif	***Rabi***		***Kharif***	***Rabi***	
1.Tikro	Not Cultivated	Not Cultivated	Drought, infertile, rapid soil erosion, rocky surface	Til	None	For the preventing soil erosion plantations measures are required.
2.Tarn Or Bari (near to settlement)	Aus Paddy, Maize, Groundnut, Til, Tur, Tisi, Pepper, Okra, Spinach, Radish, Brinjal, Sponge Gourd.	(near to settlement) Onion, Cucumber, Spinach, Cauliflower, Cabbage, Tomato, Coriander.	Water scarcity, Low fertility, Shallow soil depth, Soil erosion	Maize, Tur, Spinach, Tomato, and other remunerative vegetables	Spinach, Cauliflower, Cabbage, Tomato, and other remunerative vegetables	This land covers large area. So people want to cultivate selective remunerative vegetables. The crops having market demand need to be cultivated.
3.Baidh	Medium duration traditional paddy, locally called Baidh Dhan	Potato, Tomato, Mustard, Peas, Cauliflower, Cabbage, Chick Pea.	Water scarcity, need irrigation for suitable high yielding medium duration varieties. Low fertility.	Tomato, Radish, Pepper and other crops with market demand.	Same as practiced crops.	As this land has low fertility, sandy-loam soil and water holding capacity is very low, so, it needs short to medium duration crops.
4.Kanali	Medium to long duration Aman Paddy	Onion, Wheat, Chick Pea, Bitter Gourd, Pumpkin,	Lack of water. Unavailability of HYVs. Lack of irrigation facilities.	Same as practiced crops.	Same as practiced crops.	Need rigorous attention for cultivation, crop rotation. Emphasis on irrigation facilities.
5.Bahal	Long duration Aman Paddy	Short duration Boro Paddy	Excess water, Lack of proper nutrient management	Same as practiced crops	Same as practiced crops	Emphasis on well drainage.

Source: Field survey on September, 2018

4. Conclusion

The present study has analyzed the landform characteristics, impact of landform and climatic elements on agricultural land use pattern of Salda River Basin. This area has unique characteristics of a complex and composite land unit. It has been classified into four geomorphological regions and five land classes, which have been considered as an important influential factors and one of the important determining elements upon the agricultural landuse pattern. The characteristics of soil depth, soil texture, fertility, surface and ground water availability, irrigation facilities etc. are very much dependent upon the land categories.

The Salda River basin is a micro-basin of the Subarnarekha Drainage system, but it reflects the typical land characteristics of the fringe area of Chhotanagpur plateau, where some typical geomorphic attributes control the productivity of the land and also controls the socio-economic conditions of the local people. The present authors have tried to examine the typical geomorphic attributes and their effects on present productivity of the land in a micro level study, where they studied the land surface characteristics on the basis of Cadastral maps and extensive field works.

It is clear that the economy and livelihood of this area is very much dependent on the agricultural production which is influenced by unfavorable terrain conditions and unreliable monsoon rainfall. The western and central part of the basin is comparatively better in terms of the agricultural activities. The eastern and south-eastern parts are suffering from acute problems due to the existence of large tracts of barren land and forests. Each geomorphic division with its particular geomorphic processes is responsible for the development of distinct land use patterns within the Salda basin.

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References

1. De. N.K, Jana, N.C. The Land: Multifaceted Appraisal and Management, Sri Bhumi publishing co., Calcutta; 1997.

2. Feizizadeh, B., Blaschke, T; Land suitability analysis for Tabriz County, Iran: a multi-criteria evaluation approach using GIS. Journal of Environmental Planning and Management 2012, 1–23.
Available: https://www.tandfonline.com/doi/abs/10.1080/09640568.2011.646964

3. Al-Shalabi, M.A., Mansor, S.B., Ahmed, N.B., Shiriff, R., GIS based multicriteria approaches to housing site suitability assessment. In: XXIII FIG Congress, Germany, October 8–13, 2006.
Available:http://fphid1076751.testsider.dk/resources/proceedings/fig_proceedings/fig2006/papers/ts72/ts72_05_alshalabi_etal%20_0702.pdf.

4. Hironi, K, Landuse Planning and Geomorphology - A Study of Sawai Madhopur, Concept Pub. Co., New Delhi, 1991.

5. Ghosh, S. Geomorphic Land Evaluation for Sustainable Use of Land Resources in Puruliya District, West Bengal, *Journal of Landscape Systems and Ecological Studies*, Vol. 35, No.1 pp.263-274, Kolkata, 2012.
Available: https://www.ceeol.com/search/article-detail?id=29113

6. Bhattacharya B.K., Ray P., Chakraborty B.R., Sengupta S., Sen N.N., Sengupta K.S., Mukherji S., Maity T. West Bengal District Gazetteers, Purulia; Government of West Bengal. Published by Narendra Nath Sen, State Editor, West Bengal District Gazetteers, and Calcutta, 1985.

7. Dunn, J.A. and Dey, A.K. The geology and petrology of eastern Singhbhum and surrounding areas, Mem. Geol. Surv. Ind. Vol. LXIX, pt. 2, 1942.

8. Banik P. Studies on paddy-based cropping system under different agronomical practices in eastern plateau area, Ph.D. thesis submitted to Calcutta University, 1996.

9. Banik P, Ghosal P, Bagchi DK. Production potential, economics and water use efficiency of different crop sequences in Bihar plateau area, Indian J. Dry land Agric. Res. Dev. 8(2):119-124, 1993.
Available:https://scholar.google.co.in/scholar?hl=en&as_sdt=0%2C5&q=Production+potential%2C+economics+and+water+use+efficiency+of+different+crop+sequences+in+Bihar+plateau+area&btnG=

10. Jana. N.C. Transformation of Land: Physical properties and Development initiatives; published by Prof. Bhaskar Chattopadhyay Director, Research Studies, Bharata Vidya Charcha Kendra, Burdwan, West Bengal, India, 2002.
11. Sen. S. Landform of the Kanchi basin and its impact on land use; P. hD. Thesis submitted to The University of Calcutta, 1990.
12. Mustafa, A.A., Singh, M., Sahoo, R.N., Ahmed, N., Khanna, M., Sarangi, A., Mishra, A.K., Land suitability analysis for different crops: a multi criteria decision making approach using remote sensing and GIS. Researcher 3 (12), 61–84, 2011.
Available: http://www.sciencepub.net/researcher/research0312/014_7181research0312_61_84.pdf
13. Halil A., Ayse Y. O., Bulent T. Agricultural land use suitability analysis using GIS and AHP technique; Journal of Computers and Electronics in Agriculture 97 (2013) 71–82, 2013.
Available: https://www.sciencedirect.com/science/article/pii/S0168169913001567
14. Murthy CS, Sesha Sai MVR. Agricultural drought monitoring and assessment. Remote Sensing Applications, pp: 303-330, 2010.
15. District Statistical Handbook, Purulia- 2013, 2014, 2015.