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Development of Tall and Diara Land for Sustainable Agriculture in Central Bihar, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author SKC designed the study and wrote the first draft of the manuscript. Authors RK, SKG, AK and BKV managed the literature searches and helped in preparation of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Mokama tall (lake) area is located in central Bihar (India). It is ephemeral in nature and comprises a group of seven continuous tall. It is spread over a rest area and acts as a delta to several rivers that flow into it. This area is suffering due to stagnation of water during monsoon period; it is submerged under 4 to 6 meter deep water during monsoon. Cultivation of rainy season crops over it is not possible, even cultivation of winter season crops suffers if the drainage and reclamation of the area get delayed beyond sowing time (15 October); thereafter, this is a mono-cropped area with very low productivity. Though the fertility status of soil is good yet the quantity and quality of produce is poor. This is considered to be the main problem. A number of schemes have been executed to solve this but without any substantial success. The diara land is found in between the natural levees of the river and formed due to its meandering and course changing behaviour. The topography of diara land is mostly undulating and intersected with numerous dead and disconnected channels;- Remote sensing and Geographical Information System (GIS) are reliable techniques to prepare a comprehensive inventory of land use pattern of an area. The tall and Diara which are rich biodiversity of and biological resources, have not been given due attention and multiple uses of

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various resources have not been attempted. In this paper, authors have presented general features of the tall and diara lands; existing cropping pattern and sowing time, soil characteristics and major problems. Involvement of appropriate holistic management strategies have been suggested to improve the agricultural production in this area.

Keywords: Tall; Diara; Chaur; sustainability; and Bihar.

1. INTRODUCTION

Tall area (Mokama tall) is mainly located in central Bihar; it is a group of seven continuous taals. Tall area suffers continues water stagnation problem during monsoon period and due to lack of drainage facility, delay the drainage of excess water. It covered a large area and acts as a delta to several rivers that flow into it and Diara land is found in between the natural levees of the river and formed due to periodical erosion and deposition of sediments (alluvium) under the influence of meandering and course changing behaviour of the rivers. Such a land form is recognized as one of the most valuable natural resources [1]. The Diara land soils are distributed in an area of more than 11 lakh hectares on both sides of river Ganga, Gandak, Kosi, Sone and subsidiary rivers.

In tall area the cultivation of *kharif* season crop is not possible because during monsoon period most of the area under this region remains submerged under 4 to 6 meter deep water and even in winter season farmers wants to cultivate crop also suffers because of stagnation of water and lack of proper drainage. Tall are soil is unfit for crop for that purpose farmers reclamation the soil for better soil crop response and soil become fit for cultivation and during this activities of farmers delayed the crop sowing time (second fortnight of October). This is a major or main problem of tall land for delay the crop sowing as a result there is low productivity although the fertility status of tall soil is good. In tall area various project are worked to solve this problem and improve the production and productivity but yet there is no any substantial success this problem only can minimize by their involvement in holistic management will certainly ensure sustainable development. I have presented general features for solving the problem by management *viz*. cropping pattern and sowing time, soil characteristic and its behaviour is the major problem in tall area. Appropriate and sustainable management strategies of all have been worked out and suggested to farmers for improve the agricultural production of this area as a result farmers can achieve the double income.

'Diara' word comes to 'Dias' meaning 'earthen lamp' *i.e.,* bowl like land system on either side of the riverbank (Anonymous 1974). The definition of 'Diara land may be taken as the land lying adjacent to or surrounded by the perennial river and subjected to diluvion or alluvion action of that river'. Such lands are known by different names like khadar land, char land, mara land, majha land, dariayi land, kachhar land, riverine area etc (Anonymous 1982-83) [2] (Fig. 5). Diara lands are the landscapes around the rivers, especially in the northern and eastern regions of India, and are subjected to periodic inundation, erosion, flooding and fanned due to meandering, braiding and course changing of rivers. These riverine/diara landforms are used for agricultural production by the farmers in spite of the fact that the entire area forms a highly risky flood affected/prone area. Such areas if managed properly can greatly contribute to the economics of the people living in and around them, as well as of the country. It is at the moment difficult to say as to whether the diara areas are included under the domain of agricultural land statistics, but agricultural scientists have predicted that production in these areas can be increased by 40 to 60 % by providing proper inputs. As a category of land, out of the total area of 175 million ha of wasteland, 2.4 million ha have been considered to fall under riverine (diara) lands [3]. The All India Co-ordinated Research Project for Diara land Improvement [4,5] has reported that in all, about 40 million ha area in India is flood prone and within this, about 2.64 million ha is estimated to be under real diara in the three states, *viz*. Uttar Pradesh, Bihar and Assam.

The topography of diara land is mostly undulating and intersected with numerous dead and alive streams forming complex type of physiography [6]. Occurrence of flood is an annual feature. Erosion and depositions of new sediments take place almost every year during the floods. The soils of diara are excessively drained and constitute layered coarse sands to silt. The flood fluctuation and repetition depends on time,

intensity and duration of rain in the catchments of the Ganga and its tributaries. On uplands crops can be taken for 10-11 months if assured irrigation is provided and in medium land cultivation can be done for 9 months (2 crops can be taken) but low land diara, where crops can be taken for only 7 months. Since crop is being taken in this area as this land remains wet in Rabi and gets too dry during summer. Remote sensing has proved to be the most efficient, economical and reliable technique to prepare a comprehensive inventory of soil resources and land use pattern of an area (Venkatratnam, 1980; Patel et al. 2001) [7,8] and detection of special and temporal changes in these resources (Manchanda et al. 2002; Mini et al. 2007) [9,10].The present study was carried out for assessment of diara land under Bhagalpur district, Bihar using spatial software (TNT Mips).

Bihar state is a land-locked situated on the eastern part of India. It is situated between 830-30' to 880-00' longitude and 210-58' to 270-31' latitude. This state is roughly quadrilateral in shape situated on the north east side of India. After division of Bihar in 2000 Agriculture is the backbone of Bihar's economy, because major industry comes in Jharkhand and now farmers of Bihar, source of income is only agriculture. The State with geographical area of about 94.2 thousand sq.km, state have good fertile soil, good rainfall, plenty of water resources, and agro-climatic conditions suitable for growing three crops in a year and grow almost all types of crops. Agriculture is not only the source of livelihood but also it generates raw material for the agro based industries which has immense potential in the state.

Here we only discuss about Mokama Tall wetlands which cover more than 1,000 ha of shallow water bodies, situated in Patna, Samastipur and Begusarai districts of Bihar (fig 4). They lie about 75 km of Patna city towards the southern bank of the River Ganga. The topography of the area is generally flat land, just like most of the Gangetic plains. It is a fairly compact tract of alluvial plain, sloping gently from south to north. Mokama Tall is a perennial water system and exhibits enormous biodiversity. Mokama taal (lake), is the World's Largest Tall Region located in the Patna district of central region of the Bihar. It is a saucer shaped depression; it runs close to and almost parallel to the right bank of the Ganges. Mokama group of taal lands lies mainly in Patna, Nalanda and Lakhisarai district of Bihar. It extens in a length of about 104.60 km and width varying in the range of 6 to 17 km from Fatuha in the west to Lakhisarai in the east and covering an area of 1062 sq km. Mokama tall is the group of seven tall area namely Fatuha, Bakhtiarpur, Barh, Pandarak-more, Mokama, Singhul-sarmera and Barahiya, Minimum area covered in Fatuha taal and maximum area under in pandarak-more taal. (Report of mokama tall technical-cum-development committee, 1988) [11]. The area under this gets submerged during monsoon period and there is no chance of cultivation of *kharif* crops (grown during April to September). Cultivation of *rabi* crops (grown during October to March) also unfit because of lack of drainage facility.

2. TALL, DIARA AND CHAUR LANDS

Tall (low order monsoon stream) lands are the natural levee of the Ganga, there is a vast stretch of backwaters lands extending from Buxar to Pakur where most of the rivers and rivulets coming from the south get lost. The estimated area under "Talls" is about 1.00 lakh ha. In addition to the Tall lands, the state has about 4 lakh ha of 'Diara lands (saucer shaped flood plain of a river)' under the flood plains of rivers Ganga and Ghaghara. The state also has about 4 lakh ha of 'Chaur lands (remnants of river course)', which are highly suitable for fish farming *i.e.* land in submergence condition. The Tall, Diara and Chaur lands are inundated by water for varying periods, and are difficult to manage for crop production.

The concept of diara land varies from state to state. Therefore, the All India Co-ordinated Project for Diara land Improvement (AICRP-DI) [4], which was started in 1981, felt the need to define and differentiate between 'diara' and 'tal' lands. The term 'diara' is the area on either side of rivers like Ganges, Saryu and Brahmaputra etc., which gets flooded with swelling of the rivers and is drained out as the flood water recedes. Contrary to such lands, the 'tal' area may either be flooded through some water courses connecting the main river or even due to heavy rains and they do not drain readily with the receding of flood water. Common working definitions were finally adopted by the AICRP-DI (Anonymous, 1991) [5]. Diara lands - Such lands are situated in between the natural levees and get inundated for different periods of time and are periodically eroded and formed due to meandering, braiding and course changing of river; Tal lands - beyond the natural levees, there

are bowl shaped depressions geologically known as 'backwaters', which though inundated are not subjected to erosion.

2.1 General Features of Mokama Group of Talls

Mokama group of tall lies mainly in the kiul-haroher river basin. The kiul-haroher river system drains an area of 17,225 km^2 in Bihar. The average annual rainfall in the basin is 1104 mm and 90% of this rainfall occurs during monsoon months from June to October. The kiul and harohar rivers flow almost on the ridges in their lower reaches. The bankful capacity of these rivers as well as that of its tributaries like the sakari, the falgu, the mohane and paimar are inadequate due to which they are unable to contain the flood discharge and consequently spilling takes place over their banks causing floods in the basin. The Punpun River is also instrumental for water stagnation in low lying areas due to back water flow/over flow from the river. It drains a total catchment area of 9,026 km^2, which covers the districts of Patna, Jahanabad, Gaya, Aurangabad and Palamu. Average annual rainfall varies from 954 mm near its confluence with the river Ganga to 1817 mm in uppermost reaches. Due to low bank and inadequate channel capacity, all the channels in the lower reaches spill heavily over their banks even during normal floods. The spilling of floodwater on left bank of the Punpun has however been checked to a great extent after construction of its left bank embankment under Patna town protection scheme Sinha (1992) [12]. Some portion of the flood water on the right bank of the Punpun flows to the Dhowa river system and aggravate the flood situation in Mokama taal area. When water level in the river Ganga raises and the back water flow enters into the Punpun, the Dardha and the Dhowa river system, it results in inundation of a large area besides adversely affecting Mokama tall area. The rivers flowing from the south through the tall are generally rainfed and carry very little discharge during non-monsoon period. However, during monsoon months the flood peaks caused due to heavy rains pass quickly through the upper region of the river system having steep gradient and accumulate in lower region (taal area) where the gradient is mild. Further, flood water from the Ganga also finds its way in the tall and completely stops drainage out of it. The flooding is more acute when the Ganga remains in space for long duration and 75% to 100% of the tall area gets submerged. The maximum depth of the submergence in the recent past was recorded in 1987 which varied from 3.86 meters in Fatuha tall to 5.76 meters in more and Mokama talls. The total combined capacity of the tall at the highest flood level (average 46.025 meters above mean sea level) is 0.437 million hectare-meters (Fig. 3)

2.2 Cropping Pattern and Sowing Period in Tall Areas

Tall area is suitable for single crop which is only taken during *rabi* season so it is known as mono cropped area, for that purpose pulses is good option for farmers, regarding pulse like gram, lentil, lathyrus and pea are most common grown as a *rabi* crops beside this linseed, rai and toria are grown as mixed crop with pulse crop. In upland tall area, wheat is also grown as mixed crop with gram, now-a-days, in some area, where tall land farmers have facility of irrigation through tube wells, they are growing onion and another vegetable crop (ladyfinger, spongegurd etc) in their fields during summer season, after release of new short duration variety of rice farmers can also take summer rice during summer months, and if there are late onset of monsoon farmers take this summer rice and if early break of monsoon, most of the times whole of the crop was washed away from the fields, so this practices was abandoned (Fig. 2).

Tall area of Bihar covered large area and have distinct topographical features and removal of capture water occurs at different times. During survey of tall area, it was realized that due to blockage of existing drainage system and interference of man, water recedes gradually by first week of January in Pandarak-more tall and the farmers of the area usually sow their *rabi* crops around 15th January onward. In Mokama tall, the fields get free from flood water by the end of October and the farmers comfortably sow the *rabi* crops during the appropriate time *i.e.* first fortnight of November. In Barahiya tall, usually the sowing of *rabi* crops gets slightly delayed *i.e.* in the last week of November or first week of December due to delayed drainage. As a consequence of delay in the sowing of the *rabi* crops, less time is available for growth and maturity of the crops, resulting in poor production, productivity and also poor quality of the produce. The *rabi* crops (pulses) mostly suffer from the infestation of various disease and insects such as kajra pillu at the time of germination and flowering, and pod borer at the time of pod formation to the check pea, In

flooding condition to the fields, farmers are unable to sow the crops at appropriate time as a result there is loss in yield and quality of the produce. It seems to that if farmers; crop is sown at proper time the attack of insects could be minimized.

2.3 Soil Characteristics of Tall Area

Tall area soils are grey to dark grey in colour, medium to heavy in texture and neutral to slightly alkaline in reaction. Soil has less pore space as a result there is high bulk density, poor infiltration rate, and very sticky and plastic character. During summer season, the cracks in soil of 2 to 3 cm wide and more than 100 cm deep are seen in tall area soil. Among sand silt and clay, the Clay content is dominant and it varies from 50% to 70% throughout the profile. The soils become dry a few days after ploughing. Generally tall soils have a good fertility status and regarding organic carbon and available phosphorus it is poor to medium in content although available potassium is high in this area. About 35-45% soils of this area are deficient in available zinc, 35% soil deficient in boron but 4% in Fe, Mn is found in sufficient amount to meet the need of the crop.

2.4 Problems of Tall Lands

Due to continuous over flow of water in Ganga River as a result there is flooding situation (Fig.1) and most of the tall area in submergence condition, and in this area is those agricultural crop grown in July to September are not possible, *i.e. kharif* cultivation is not possible. Successfully cultivation of *Rabi* season crop is based on residual moisture which is left after drainage and land freed from submergence. If drainage of the tall is delayed beyond 15 October, *rabi* season sowing crop is delayed and the crops suffer moisture at the time of maturity or approaching towards state of maturity because in tall are there is no any irrigation facilities available. In tall area there is major problem of deposition of silt which is transported by the river as a result there is clogging of existing ways (locally called as plan) and collapse the drainage systems. There are many other problems of tall area in which some are as fallows *viz*. There is choking of the natural drainage ways (nailas) due to inadequate capacity or non-existence of culverts below roads. Most of the existing sluice gates are non-functional and broken. At many locations sluice gates do not exist where these are badly required. Due to delayed drainage, the sowing of *rabi* crops is delayed on account of which less time is available for growth and maturity of the crops, resulting in poor production and inferior quality of the produce and also in this area there is attack of pod borer and other insects like kajra pillu is very common, Grazing of crop by cattle without any control *i.e.* farmers crops are damage by wild and domestic animals, Lack of network of government or private tube wells for irrigation during *rabi* and summer season. Non-availability of diesel, and good quality inputs like seeds, agricultural implements, insecticides, pesticides and fertilizers at appropriate time. Low infiltration and hydraulic conductivity, and occurrence of hardpan in the subsurface layer. Bone-dry hardness of soil appears just after ploughing and leads to less soil seed contact after sowing resulting in poor germination and consequently low productivity. The tall area suffers from the two extreme problems of flood and famine, the former due to inadequate drainage and the latter due to delayed drainage and lack of irrigation facility. The area has only *rabi* crops and the productivity is generally adversely affected. Use of water and conservation of avian population are not given due to attention. Lack of shelter places kacha/pacca storage arrangements on the farm. Lack of road, infrastructure, communication, and marketing facility. Lack of schools and government hospitals. Lack of drinking water facility. Non-availability or frequent failure of electric power supply. Law and order problem by antisocial elements. Less availability of agricultural labours in the area and lack of knowledge among farmers about new farming practices, techniques and strategies for management of natural resources.

2.5 Classification of Diara Land

(A). Classification of Diara land on the basis of distance from the main stream (Kumari et al. 2018) [13]

1) **Lower diara lands:** This land are located in the main river beds that have fine sand to courses and deposits on the surface and are available for cultivation of different crops and vegetables during non-monsoon seasons (November/ December to May/June).
2) **Middle diara lands:** This land are located on the banks of the rivers. The width of such lands varies considerably as the areas are frequently inundated during rainy seasons by swelling flood

waters. The depth of flooding however varies considerably at different locations.

3) **Upper diara lands:** This land are those lands which, during the course of continuous depositions get elevated and are less frequently flooded, in comparison to the middle diara lands.

(B). Classification of diara lands on the basis of precise location from the main stream (Anonymous, 1974, 1982~83, 1994-95) [15, 2,16]:

1) **Main Riverbed (Low land) Diara** - The actual riverbeds, which have fine sand to coarse deposits on surface, become available during December or January to June until early rains set in.
2) **Main Land (Medium land) Diara**, These areas are located on the bank of the river and its width varies considerably. They are frequently inundated during rainy season by the swelling floodwaters. The depth of the main diara region varies considerably at different locations.
3) **Upland Diara** - Due to continuous deposition, such areas have been elevated and are relatively less frequently flooded than the main land diara areas. For all practical purposes, these areas are not very different from the normal (non-diara) lands.

(C). Other classification

1) **Riverbed diara:** The lands available for cultivation on both sides of the flowing portion of the riverbed during non-monsoon season.
2) **Riverbank diara:** Strips of land available for cultivation in between riverbeds and natural levees or existing embankments.
3) **Flood affected diara:** The lands available for cultivation adjacent to unprotected reaches.
4) **Flood prone diara:** The area on both sides beyond the levees or embankments of the river.

2.6 Classification of Char Lands in INDIA

(A). Classification of Char land on the basis of duration of water stagnation.

1) **Permanent chars:** Which are in existence for more than ten years.
2) **Semi-permanent chars:** which are in existence for less than ten years but more than five years.
3) **Temporary chars:** which are in existence for less than five years.

(B). Classification of Char land on the basis of inundation period.

1) **Chronically flood affected:** inundation throughout the monsoon season.
2) **Occasionally flood affected:** inundation for a short period due to flash flood.
3) **Almost flood free:** temporary inundation during high floods only.

2.7 Ecological Problems and Advantages of the Diara Lands

Every year, during the monsoon season, catastrophic flooding on the plains of the Ganges and Brahmaputra rivers is reported (Hofer, 1993) [17]. Vast areas in the Ganga are subject to large-scale inundation during monsoon months from June to September. In its lower course, the river is both a creator and destroyer depositing large amounts of fertile alluvial soil and also causing disastrous and frequent floods. Riverbed commonly known as Diara land is a basin or bank area or area between two or more stream of river. After the monsoon season, the water from the riverbeds retreats back to its channel, leaving large areas dry. These areas of land are generally left unused due to the austerity in management, conflicts of land ownership, difficult access and lack of overall motivation to cultivate marginal land. However, these riverbed areas furnish a diversity of natural resources. Proper management of the riverbeds would contribute to income generation as well as to natural resources management (minerals, forest, biodiversity, water, ecology and changing climate) and better disaster/risk management. Apart from these issues, riverbeds offer opportunities for the landless and land-poor people in their vicinity for income generation and food security. It can be concluded that from the land availability point of view, it is definitely worthwhile to explore in greater detail how riverbeds could become more relevant from a livelihood and social point of view. The cultivation practices on the riverbeds are of different nature and face a large number of problems, related to irrigation, fertilization, and seed problem etc.

Apart from some problems in diara land cultivation there are some advantage of diara

land agriculture in which some are includes *viz*. i) There are several advantages of river bed cultivation. ii) High net return per unit area. iii) Early and high yield. iv) Ease in irrigation. v) Low cost of cultivation. vi) Less mineral requirement due to high fertility. vii) Limited weed growth. viii) Easy in control of pest and disease by cultural means. ix) Low cost labour facilities. x) No land ownership required. xi) High economic returns of Rs 16,500 kg/ ha can get out of cucurbit vegetables cultivation. xii) Income and food security of landless and marginal farmers and xiii) Local adaptation to climate change.

2.8 Soils and Agriculture in Diara Land

Diara soils, which remain submerged for most part of the year do not have iron concretions but have illite as the dominant clay mineral with chlorite and kaolinite as a minor phase and show minimum horizon differentiation according to Chakraborty et al. [18]. Further, they found that all soils were acidic in nature and rich in organic carbon. Soils of the diara areas are alluvial in nature and it has been observed that the texture of the top soil varies with distance from the river bank, the texture becoming heavier as the distance from the river increases [19]. At some depth, fine to coarse sand layer in its profile has been detected [2]. Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms, on which they have developed [20]. Soil series in the surveyed areas are Kamlakund, Milki, and Motichak [21]. Soils of Kamlakund series are light throughout the profile and are of recent origin. They remain inundated during rains. Every year sand or silt is deposited according to the height and velocity of flood water at the place. Water dries up quickly after rains. pH is alkaline and percentage of free calcium carbonate varies between 5 and 16. Percentage of organic nitrogen varies between traces to 0.09 and that of available phosphorous between 2 to 10 parts per million. Colour varies between pale olive to olive grey. Soils of Milki series are of recent origin. Surface soil consists of medium soils underlain by medium and light. These are slight to moderate alkaline and percentage of free calcium carbonate in less than 5%. The soils are mostly under direct influence of the rivers and subjected to flood annually. The colour varies between brownish grey to olive grey. Organic nitrogen content varies between 0.05 to 0.1% and available phosphorous between 2 to 14 parts per million. Motichak series is characterized by light textured surface soil underlain by medium textured sub-soil or vice versa. The soils are of recent origin and occur in the vicinity of rivers. pH is alkaline and percentage of free calcium carbonate is less than 5. Colour varies between pale yellow to olive grey. This corroborates the findings of soil survey report [21]. Walker [22] found that surface soil nitrogen changes on a floodplain resulted from interactions between stochastic flooding and the influence of vegetation; soil nitrogen increases also resulted from frequent floods that deposited additional nitrogen rich alluvium. The Co-ordinated Project (Diara land) of Sabour had reported that soils at Kharaiya diara and Babupur diara in Bihar are young alluvium (fluvents) without horizonations but have distinct layerings, with sand layer of varying depth occurring in the profile [5]. Diwakar and Singh [23] had attempted to characterize the soils of the diara of Ganges in Bihar. They found that soils were characterized by light colour, sand to sandy loam texture, slightly alkaline in reaction, low CEC, high base saturation and poor pedogenic manifestations as seen in their morphology.

2.9 Agriculture and Allied Activities in the Diara Lands

Diara farmers follow two main cropping seasons in the eastern part of India *viz*. *kharif* (June-July to September-October) and *rabi* (October-November to March April). Often the crops planted during June are lost due to heavy floods and they may be able to harvest only those crops that are planted during October-November (Anonymous, 1981-1983). Usually diara lands are available only for a short period, and landless, small and marginal farmers cultivate on these lands the seasonal vegetables and fruits. River bed cultivation of cucurbits is practiced along the river Yamuna, Ganges, Gomti, Sarju and other distributaries in Haryana, Uttar Pradesh, and Bihar, Diara farmers often resort to mixed cropping as an insurance against crop failure due to flood waters. Maize, the most important crops of the area covers the highest proportion of the gross sown area. The cultivation of maize crops depends upon the situation of flood. In the Bhagalpur district diara farmers grow/sown maize in two season first in *rabi* maize (October-November) and second garma maize (March-April) depends upon rains and In Rabi season also grown wheat, maize generally grown in irrigated area where as pulses like gram, pea, mustard, lentil, kalai etc. are taken in non-irrigated areas. Among vegetables parwal, tomato, potato and brinjal are also grown

in the surveyed areas. About 65% of total cucurbit cropped area of the country falls under diara lands. Banana cultivation is famous of these characterized soils. The floating rice is also grown in the seasonally flooded lands in Bihar (Fig. 2).

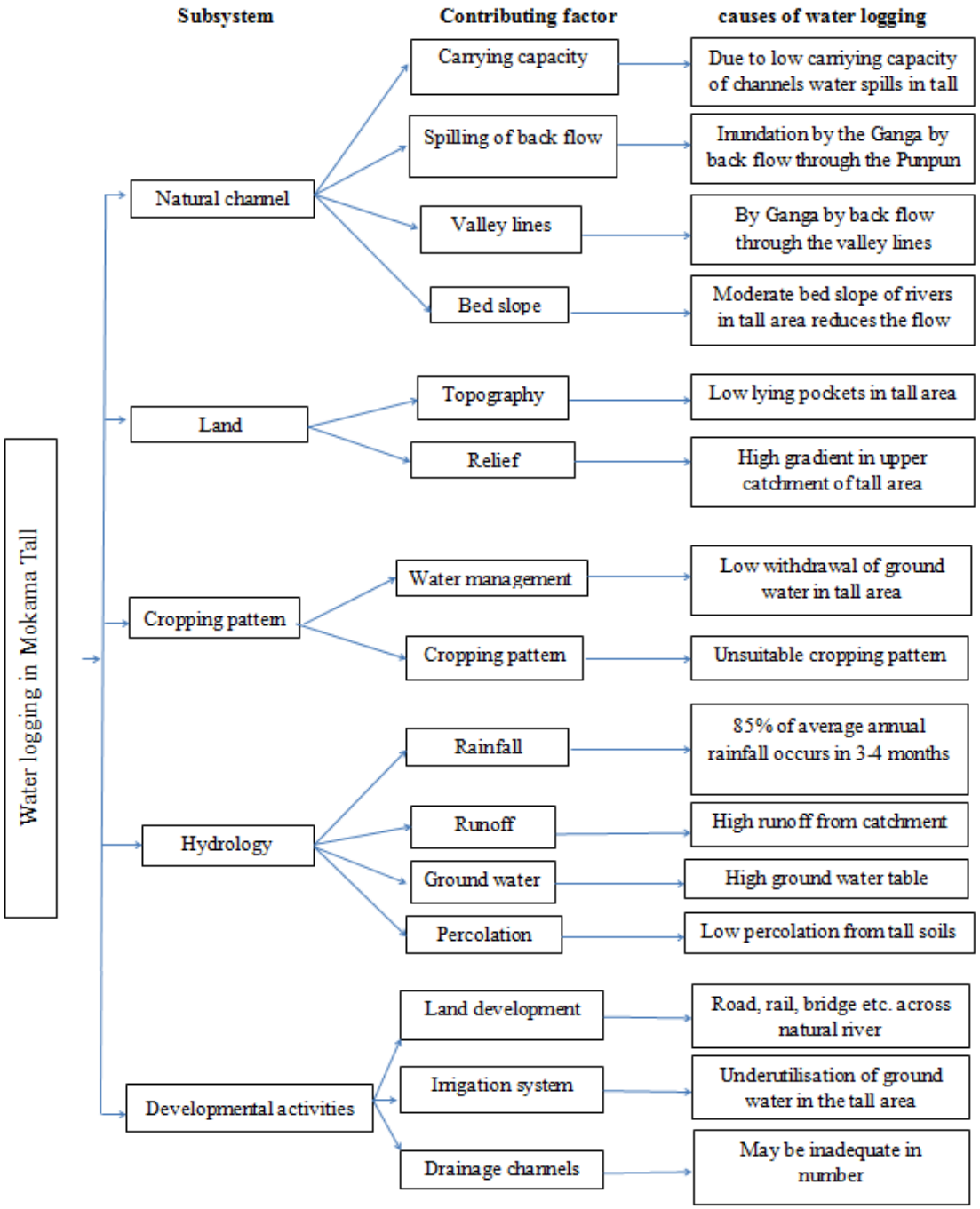

Fig. 1. Possible cause of water logging in Mokama group of Taals
(Source; Sinha 2007) [14]

Field preparation in diara land

Use of mulch in diara land vegetable

Field preparation in tall Area

Green Fields in the tall area

Fig. 2. General view of diara and tall area

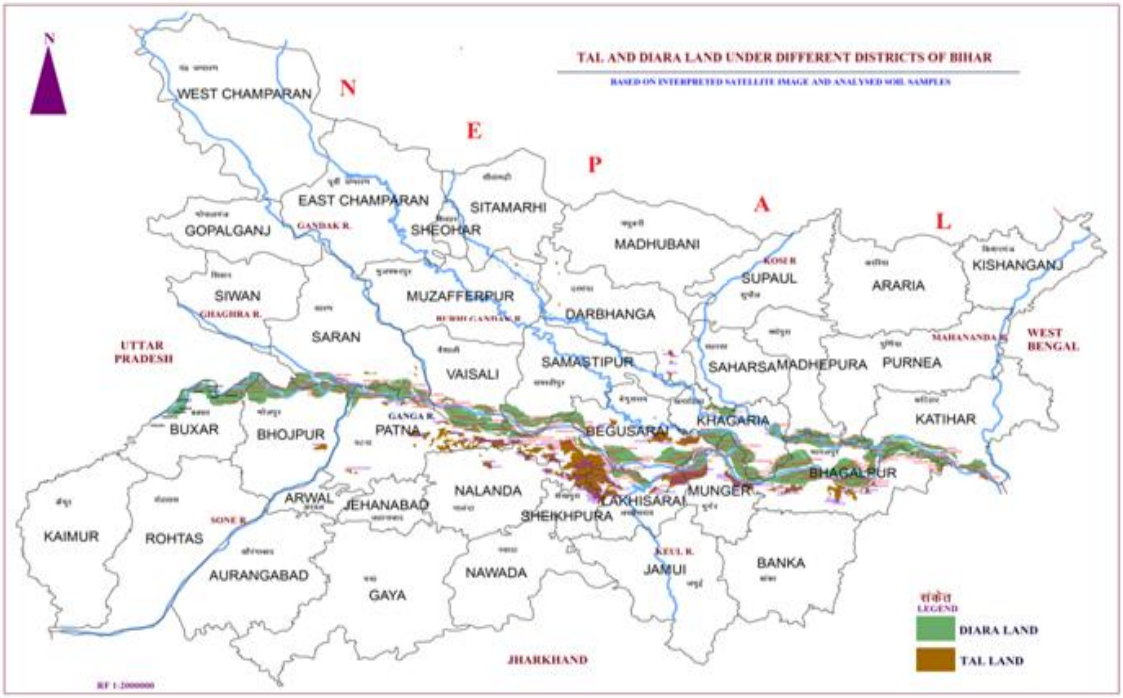

Fig. 3. Tall and Diara land derived from FCC image of different district of Bihar
(Source:- Department of SSAC, soil survey BAU, Sabour, Bhagalpur, 2013) [24]

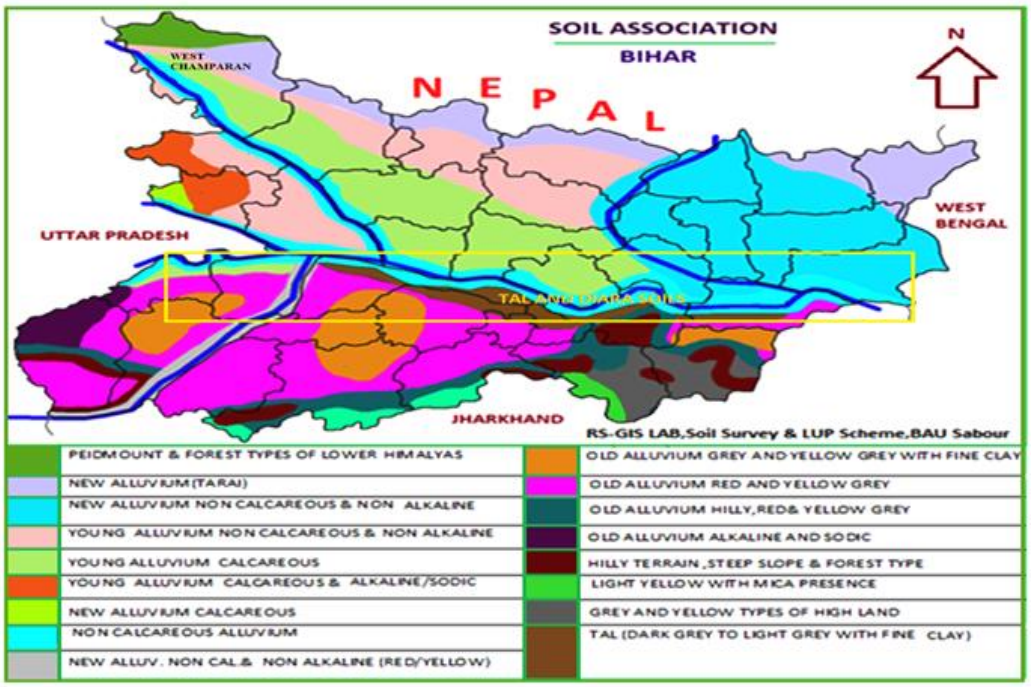

Fig. 4. Tall land derived from FCC image of different district of Bihar
(Source:- Department of SSAC, soil survey BAU, Sabour, Bhagalpur, 2013) [24]

Fig. 5. Diara land derived from FCC image of Bhagalpur district
(Source:- Kumar et al. 2013) [25]

2.10 Appropriate Management Strategies for Tall and Daira Lands

Development of the tall and diara area with a view to maximising agricultural production has been in focus for the last more than ten decades, but no substantial progress is visible on the grass root level. For successful implementation of any policy or programme, there is a need of political will positive thinking, dedicated efforts by all concerned sharing of responsibility by all stakeholders periodic review and monitoring of the work by various departments in participatory mode, co-operation and coordination among farmers and concerned departments develop-ment and maintenance of infrastructural facilities and improvement in law and order situation improvement in agricultural production may be expected if a system approach involving management of all resources is adopted. Some of the management strategies related to soil water crop and human resources which need immediate attention of planners and policy makers are listed below.

3. SOIL MANAGEMENT

Soils of tall area have cracks so to utilize the available moisture content in the soil sowing should be done within two days after ploughing. Soils need to be tested to known the status of nutrients since excess dose of any fertilizer and micronutrients is uneconomical, so balance dose of fertilizer should be applied on the basis of assessment of nutrient status and also incorporation of plant residues and organic wastes in the soil along with tillage practices improves physical condition of soil. Green manuring through Sesbania sp. May be effective in soil management. Experiments reveal that deep tillage upto 45 cm depth along with application of 100 q/ha rice husk during first week of June before the occurrence of flood lowers the bulk density and increases the rooting depth as well as grain and straw yield of wheat. In similar way in diara land soil have sufficient moisture and in this soil there is no formation of creak. For preservation of moisture there is application of mulch. For good soil management firstly level the lands and secondly for alkali soil application of gypsum and for acid soil there is application of lime in diara lands

4. WATER MANAGEMENT

Maximise agricultural production by increasing area under cultivation and creating irrigation facilities. Under the mokama tall drainage scheme seventeen channels from local depression to the main outlet channel were renovated. Government of India inspected the site and suggested some long-term and short-term measures including construction of reservoirs in the upper catchments, drainage channel on the southern periphery, soil conservation measures and contour bunding, prevention of entry of the Punpun and Ganga waters into the tall area. Creation of water storage and recharging structures in the upstream reach and collect the water for irrigation purpose and removal of obstruction and periodic repair and maintenance of existing drainage ways by farmers themselves (Kishore, 1992) [26]. Construction of new sluice gates wherever required and repair and maintaince of existing sluice gates to make them functional. Deepening/widening of drain and construction of new missing link drains. Introduction of horticultural crops like mango, litchi, guava, ber and plantation of bamboo, coconut, palm and neem in upstream side to check runoff as well as soil erosion in tall area. Construction of shallow tube wells to utilize good quality ground water during *rabi* and summer seasons. Appliying light irrigations through sprinkler or micro-irrigation systems so that seepage loss through large cracks reduces and flow in forward direction increases. Construction of ponds, reservoirs in the deep taal lands which can be utilized for growing fish and to provide supplemental irrigation in the nearby area during dry spells in *rabi* and summer seasons. In diara land there is no water stagnation problem, farmers some time face problem about irrigation facilities so that in diara land there is established the tube well for irrigation and also collect the water in pond for future use and famers should apply good quality irrigation water.

5. CROP MANAGEMENT

Selection of appropriate cultivars of lentil, gram, maize wheat, vegetable and mustard as per the recommendations of state agricultural university and other institutions related to agriculture for that purpose purchase of seed and other agricultural inputs from a reliable licensed shop. Before sowing the crop farmers must do seed treatment with fungicide like thiram/captan @ 2.5 g/kg of seed followed by chloripyriphos 20EC @ 8 ml/kg seed, protects the crop from pest infestation for leguminous crop rhizobium culture done after 24 hours of seed treatment helps in making atmosphere nitrogen available to plants, resulting in 15 to 20% increase in yield. The main

crops of tall and diara lands are severaly affected by cutworm and pod borer almost every year must be fallow control measure if the problem is further aggravated when sowing is delayed. Proper pesticide management is not being practised (ICAR 2003). Reckless exploitation of croplands for agriculture, and indiscriminate uses of chemical fertilisers and pesticides have adversely been affecting the faunal diversity in the tall area [27]. Sowing of recommended seed rate of lentil or gram between mid-October to mid-November give good yield and sowing thereafter results in deterioration of quality and quantity for weed control a spray of pendimethaline 30 EC @5 lit/ha is effective and economically. Introduction of additional crop in summer months like mong which is of shorter duration, needs minimum water and give good return. In irrigated areas onion is remunerative and less susceptible for grazing sunflowers, sesamum, maize and short duration paddy may also be tried during summer months.

6. HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT

Krishi vigyan kendra (KVKs) and other extension agencies need to be geared up for dissemination of suitable soil, water and crop management practices farm machineries and post-harvest technology, through front line demonstration, farmers fair training camps and other communication means. Extension agencies should help farmers to strengthen farmers association and committees. Few young persons need to be trained about crop and animal husbandry so that they can be self-reliant and help the farmers of their village in making available the quality inputs from reliable licensed shops in time. Farmers need to be educated about the loss in yield due to delayed drainage. They should be motivated to clean and maintain the existing drainage ditches in a participatory mode. Farmers should be informed about the financing institutions providing credit or loan for purchase of agricultural inputs or development of irrigation facilities. It is highly imperative that a holistic management approach is adopted for the tall area and its land and water resources are developed and managed not only for agriculture but also for meeting other requirements related to environment and ecology. Then only the measures will prove to be sustainable. A scientific study should be made for framing the strategy and local people may be fully associated and involved in policy making as well as implementation and management. Such an approach is bound to bring success in full measure.

7. CONCLUSION

The study demonstrated the potentiality of satellite remote sensing technique for preparation of more consistent and accurate baseline information on diara land. Study revealed that the diara lands of Bihar have potential for agricultural uses. However, such area can be utilized in a better way for development of agro forestry orchards and recreation zones (heritage). Mokama tall is a unique ephemeral lake and It is under constant exploitation for agriculture as a result there is tremendous potential for improvement in agricultural production because of good fertility status of the soil but due to lack of proper management of available resources yield potential has not been realized so far so holistic management of the tall is highly imperative. The main problem of tall lands is delayed drainage due to which farmers are not able to perform farming activities in time, resulting in poor agricultural production appropriate planning and implementation of management strategies by the government departments and voluntary organisation with farmers association in participatory made can improve the agricultural production many folds in this tall area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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