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FLOOD ASSOCIATED SAND DEPOSITION AND ITS IMPACTS IN SOUTHERN KAMRUP DISTRICT OF ASSAM

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Abstract

The river valley of Brahmaputra in Assam is affected by most recurrent water-induced hazards such as flood and riverbank erosion every year. The sedimentation by the Brahmaputra and its tributaries during flood causes substantial sand deposition over some sections of the fertile banks that are mostly used for agricultural practices. Therefore, to study the extent of sand deposits and their characteristics, ten villages of southern parts of Kamrup district, Assam, were selected. A physico-chemical examination of the soil properties was also undertaken. Satellite data of pre-and post-monsoon, IRS P6 LISS-III are used to quantify the affected area by sand deposition. Feedback from the farmers was also taken to supplement the collected information. It was found that during the period between 1991 and 2016, the area under sand deposits in the selected villages has increased from 33.36 per cent to 45.18 per cent with a varying depth of 0.20 m to 0.70 m. Because of such sand deposits, 42.31 per cent of total cropped area was found affected in 2016.

Introduction

Natural disasters can have devastating long-term impacts in terms of farm productivity (Zhao et al., 2007), physical and human capital stock (Skoufias 2003; Mueller and Quisumbing, 2010) and may cause great economic, social, political and cultural vulnerability in developing countries (Alcantara-Ayala, 2002, Chaliha et al., 2012). In Assam, over 40 per cent of its land surface (3.2 million ha) is susceptible to flood damages, which accounts for 9.4 per cent of the total flood-prone area in India. The Brahmaputra valley in Assam is one of the most acutely hazard-prone regions in the country. This river valley gets affected by most recurrent water-induced hazards such as flood and riverbank erosion every year. Due to the deposition of

sand by floods, fertile agricultural land in the state of Assam is being transformed into barren sand beds. Such event of sand deposition is also known as sand casting, which is of grave concern for the farmers who have been surviving on those fertile agricultural lands.

The sand deposition means, the covering of large tracts of land adjacent to an aggrading river with thick layers of sediment due to temporary avulsion of such river subsequent to a breach of its embankment. It causes deposition of sand on the land which is left degraded after the flood recedes. The soil left behind is very sandy and coarse and thus unfertile for agriculture. Sand deposition has, therefore, become increasingly devastating phenomenon in the recent years. The Brahmaputra, which is one of the most heavily

sediment-charged rivers in the world, second only to the Yellow (Hwang Ho) river in China is a major concern for the North Eastern Region as well as for the southern part of Kamrup district. The river generally carries an average annual suspended load of 400 million metric tons at Pandu at an average daily rate of nearly two million metric tons in the rainy season (May to October) (Goswami, 1985). Thus, the sediment carried by the river Brahmaputra and its tributaries such as Kulsi, Boko, Singra and Singua flowing through the southern part of Kamrup district cause a massive flood (Das and Deka, 2017) and sand deposition over the fertile floodplains during summer, which are intensively cultivated. However, quantity and quality of sand and silt deposition differ with the sources of these rivers. Thus, reclamation of these sand deposition areas and finding out alternatives for the affected farmers has become an utmost priority. The small per capita land holding coupled with low productivity poses a big challenge for crop production, which constitutes a substantial share to the livelihood of an agrarian society. A successful endeavour of farming in sand deposit areas thus, holds immense importance in the long run. This study therefore, is carried out to assess the impact of sand deposition on the agricultural areas of southern Kamrup district of Assam.

Objectives

Major objectives of the study are:

- to determine the extent and physico-chemical properties of sand deposits; and
- to study the cropped area affected considering sustainability of agriculture in the study area.

Study Area

The study area comprising ten selected

villages of the southern part of Kamrup district of Assam is located between 25°42'49" to 26°10'16" N latitudes and 90°56'30" to 91°44'17" E longitudes (Fig.1). The southern part of Kamrup district comprising three revenue circles of Chamaria, Goroimari and Palasbari and 649 villages covers an area of 2101.8 km². According to 2011 census, total population of the southern Kamrup district was 8,11,805 persons. The area is drained by the river Brahmaputra and its tributaries of Kulsi, Boko, Singra and Singua. The region falls in tropical monsoonal type of climate with annual average rainfall of 1400 mm. The principal crops produced in the area are rice (paddy), maize (corn), oilseeds, pulses and sugarcane.

Database and Methodology

The cloud-free pre-and post-monsoon IRS P6 LISS-III dated 14.11.2016 and 6.3.2017 and Landsat TM data dated 14.11.1990 and 6.3.1991 with a spatial resolution of 30 m (Path: 137, Row: 42) were collected and used to quantify the sand deposition affected area. Soil samples of sand deposition from the selected villages were collected and their physical and chemical properties were analyzed in laboratory. The areas covered by the sand deposits were delineated from the satellite images of 1991 and 2016 with the help of GIS software and ground truth verification was undertaken using a handheld GPS. Satellite images of the winter season were used so as to evade over approximation of the sand deposition area.

The land use/land cover estimations for the years 1991 and 2016 are done by ERDAS Imagine 9.3 software adopting hybrid classification which embraces the amalgamation of both unsupervised and supervised classification. In this method, the signatures of images are obtained initially following unsupervised classification and are

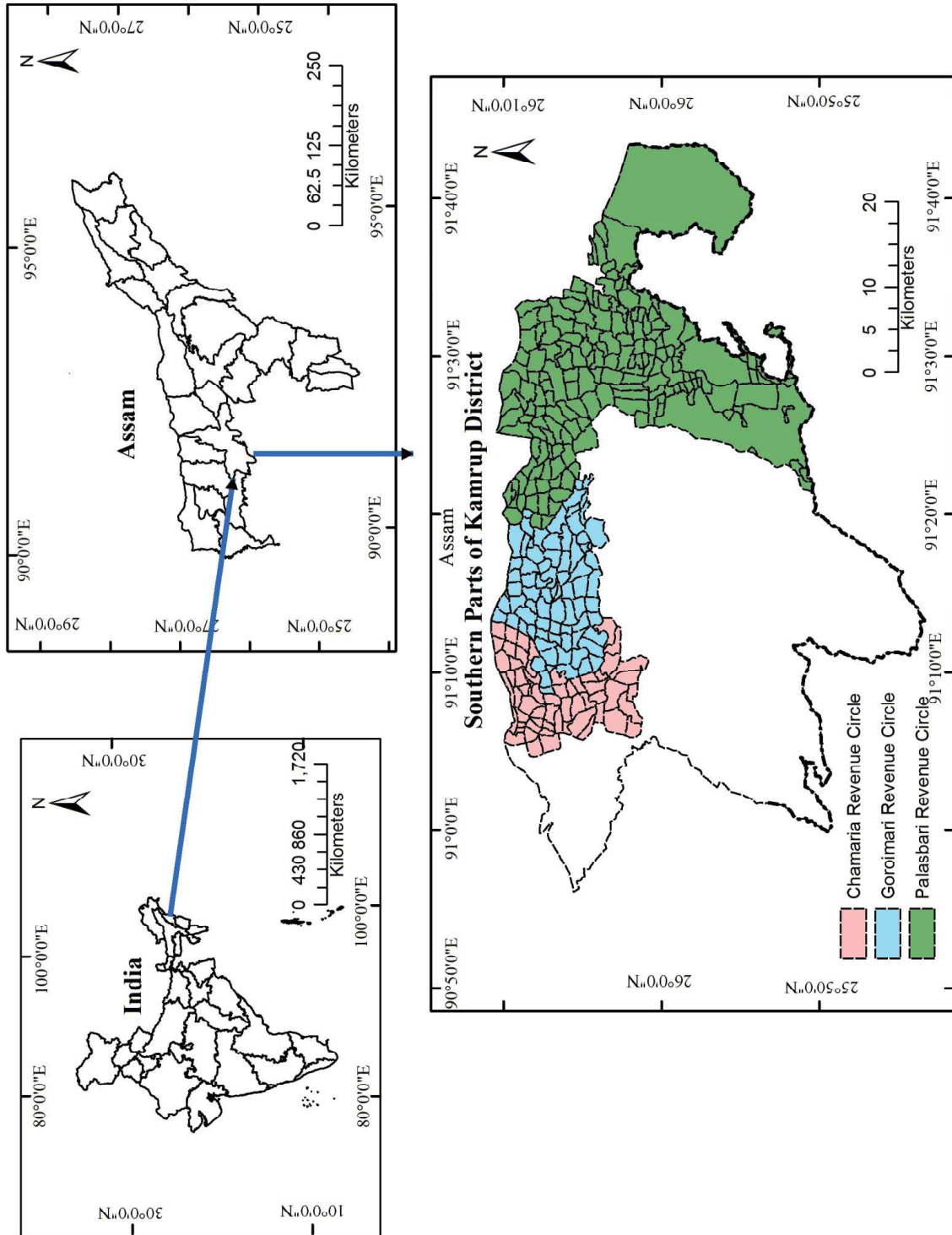


Fig. 1

represented in classes. These clustered signatures are used to reclassify the images using maximum likelihood classifier which classifies the pixels based on the maximum probability of belonging to a particular class (Richards and Jia, 2006). The classified images are filtered using a neighbourhood majority function which replaces the centre pixel in the matrix with the most common data file value in the window for removal of noise and smoothing of classes. To serve this purpose, a 3×3 matrix was selected. Recoding is performed for major misclassification of features such as shadow (Hazarika et al., 2015). Then precise analysis of satellite images, Google earth images and field verification were performed for ground truth authentication of classified image. Accuracy assessment was done thereafter. A set of 300 random called reference points are used to assess the accuracy of the classified images. A combined table was generated with a mixture of the reference points and the classified map. From this combined table, confusion matrix table was established using the pivot table tool box. To design the confusion matrix, it is essential to have the ground truth data, such as cartographic evidence, findings of a manually digitized image, field survey results verified with a GPS-receiver. Thus, overall accuracy and Kappa Coefficient was measured for each classified image. The classified image shows an overall accuracy of 92 and 94 per cent for 1991 and 2016 with kappa coefficients of 0.9, 0.93 respectively. In these classified images, the river and sand pixels show a highly reliable accuracy except on some occasions. The agricultural plantation is usually confused with the settlement because of mixed pixels in transition areas. The overall classification accuracies recommend that the classification is consistent and accepted for the study. Field survey and focused group discussions were

carried out with the farmers to know about their problems and changes they have done in agricultural practices due to the deposition of sand in their fields.

Results and Discussions

The land use maps of 1991 (Fig. 2) and 2016 (Fig. 3) exhibit the sand deposition in the study area. The study reveals a notable increase in sand deposition from 0.02 km^2 in 1991 to 0.80 km^2 in 2016 in the Achalpara Baghamara village; from 0.70 km^2 in 1991 to 1.40 km^2 in 2016 in Khalihamari village; from nil in 1991 to 0.32 km^2 in 2016 in Alikash village and from nil in 1991 to 1.05 km^2 in 2016 in Panikhaiti village. On the other hand, Dekaradia and Futuri No. 3 villages recorded a decline in the proportion of sand deposition from 55.55 to 35.55 per cent and 87.63 to 17.01 per cent, respectively during 1991 and 2016 (Table 1).

The study also highlights decline in the croplands on account of sedimentation, along with the floodplains at the time of high flood, induced by the river Brahmaputra and its tributaries. Due to increase of sand deposition area from 33.36 per cent in 1991 to 45.18 per cent in 2016 (Table 1; Fig. 4 & 5); the affected cropped area also increased from 7.20 km^2 in 1991 to 9.90 km^2 in 2016 (Table 1). However, the depth of current sand deposition varied between 0.20 to 0.70 m throughout the study villages (Table 2).

Thus, the dynamic nature of the Brahmaputra and its tributaries modify its floodplains frequently by inundating the adjoining areas during floods in summer (Goswami et al., 1999; Lahiri and Sinha, 2012; Das et al., 2012). However, the associated changes in land use/land cover (linking it with river dynamics) are rarely documented in quantitative terms (Kotoky et al., 2012; Mondal, et al., 2013) which are essential pre-conditions for the formulation of floodplain

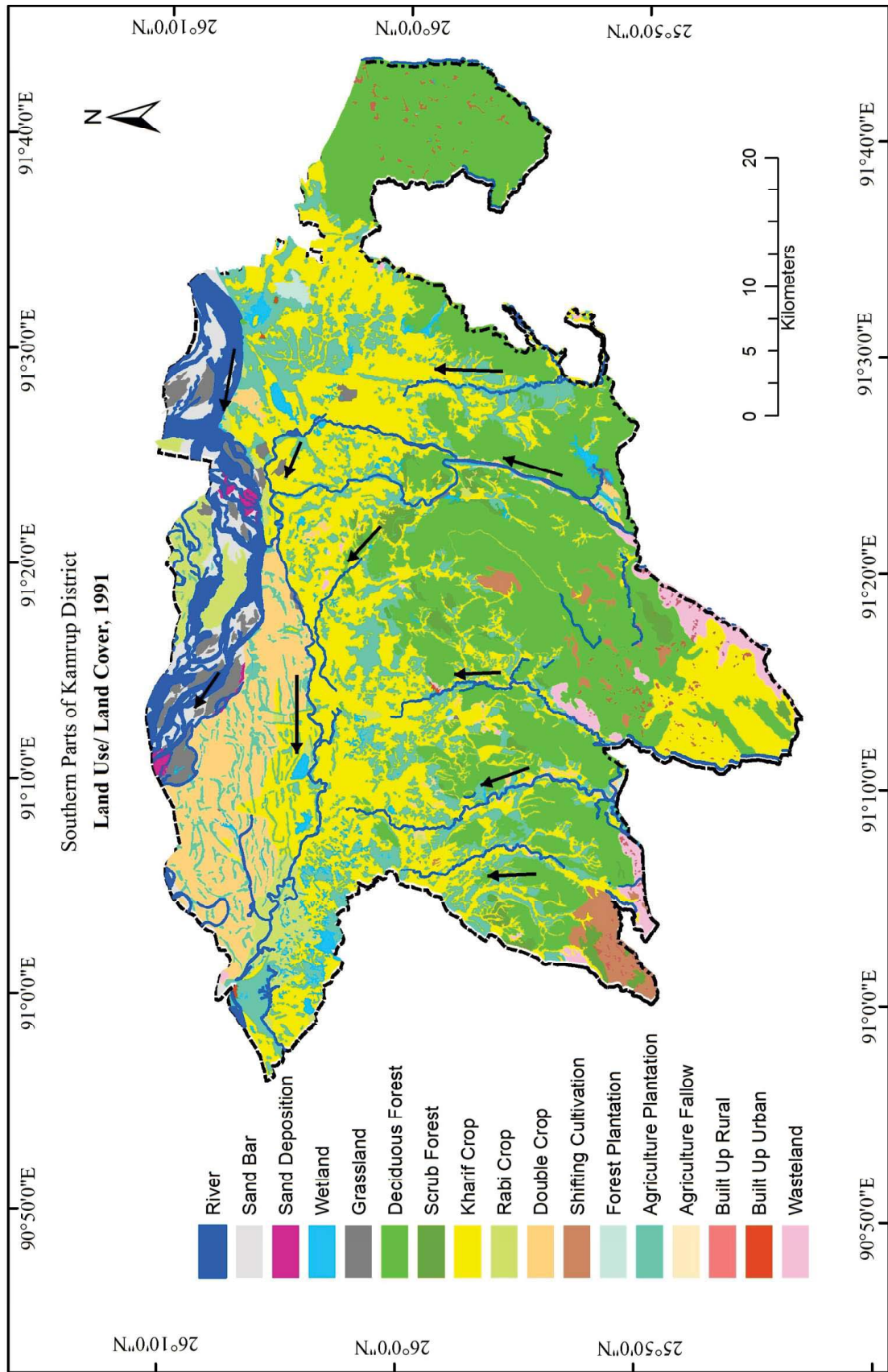


Fig. 2

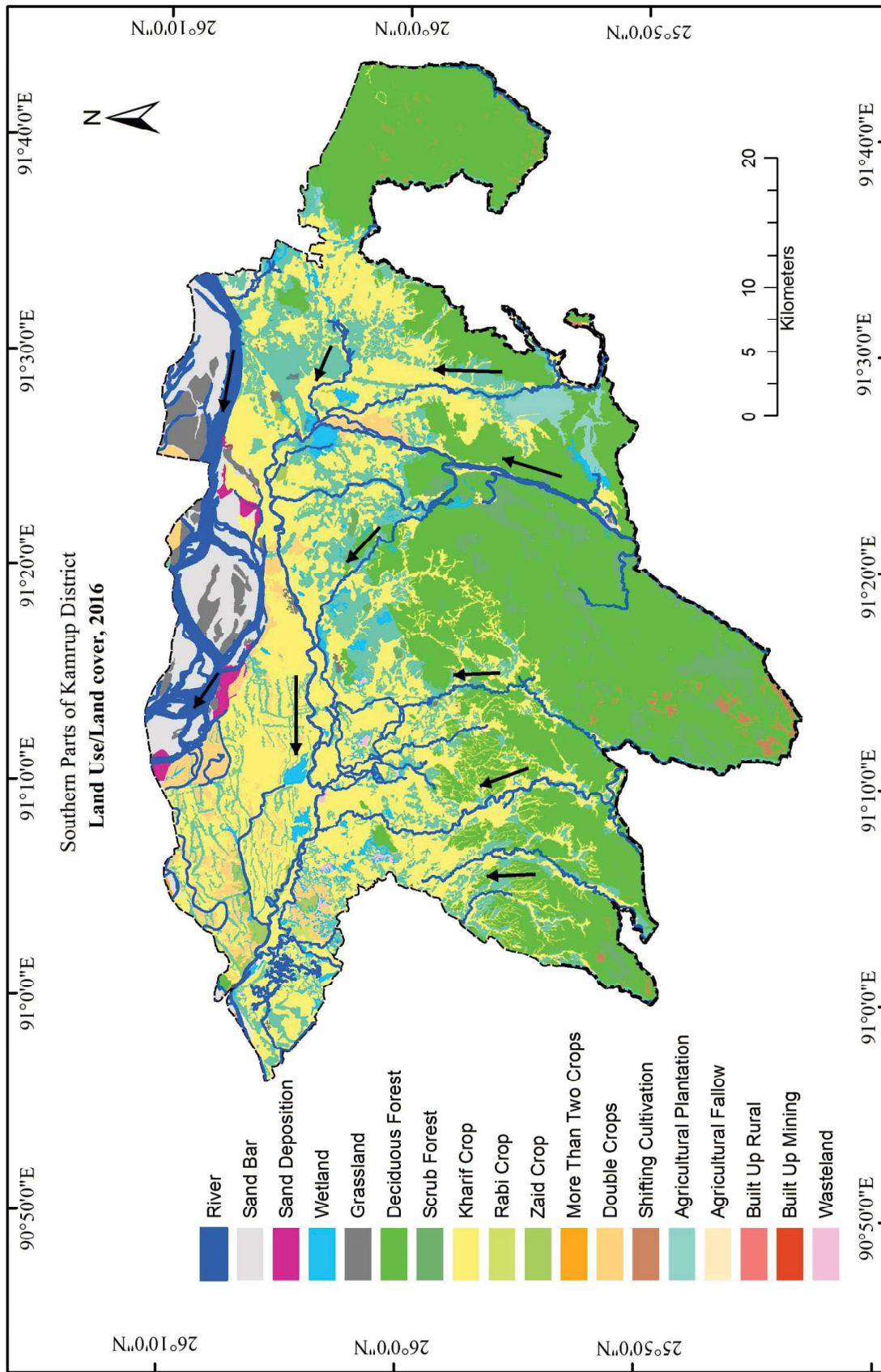


Fig. 3

Table 1
Southern Kamrup District: Area under Sand Deposition and Cropped Area Affected during 1991 and 2016.

Revenue Circle	Village	Village Area (km ²)	1991		2016		1991	2016
			Area under Sand Deposition (km ²)	Area under Sand Deposition (km ²)	Cropped Area Affected (km ²)	Cropped Area Affected (km ²)		
Chamaria	Lutitarti	3.33	0.74 (22.22)	1.50 (45.04)	AP-0.01, K-1.05 (31.84)	DC-1.10 (33.04)		
	Achalpara Baighamara	1.90	0.02 (1.05)	0.80 (42.10)	DC-1.60 (84.21)	K-1.00 (52.63)		
	Barakhat	3.20	1.42 (44.37)	2.11 (65.93)	AP-0.12 (3.79)	K-0.50 (15.63), M-0.50 (15.63)		
Goroimari	Khalihamari	1.60	0.70 (43.75)	1.40 (87.50)	R-0.80 (88.88)	K-0.020 (1.25)		
	Dekaradia	0.90	0.50 (55.55)	0.32 (35.55)	DC-0.71 (78.88)	DC-0.50 (55.55)		
	Alikash	1.90	0 (0)	0.32 (16.84)	AP-0.20 (10.53)	K-0.94 (49.47), DC-0.32 (16.82)		
Palasbari	Panikhati	3.16	0 (0)	1.05 (33.22)	R-0.50 (15.79)	K-2.00 (63.15)		
	Baniapara	3.02	1.51 (50.0)	1.52 (50.33)	DC-0.40 (13.25)	K-1.50 (49.67)		
	Kootpara	2.40	1.20 (50.0)	1.20 (50.00)	AP-0.005 (0.21)	K-1.20 (50.00)		
	Futuri No.3	1.94	1.70 (87.63)	0.33 (17.01)	DC-1.80 (92.78)	K-0.30 (15.46)		
TOTAL		23.35	7.79 (33.36)	10.55 (45.18)	7.20 (30.84)	9.90 (42.31)		

Source: Field survey and satellite imageries

K=Kharif crops; DC=Double crops; R=Rabi Crops; AP=Agricultural Plantation, M=More than two crops

Figures in parentheses are in percentage

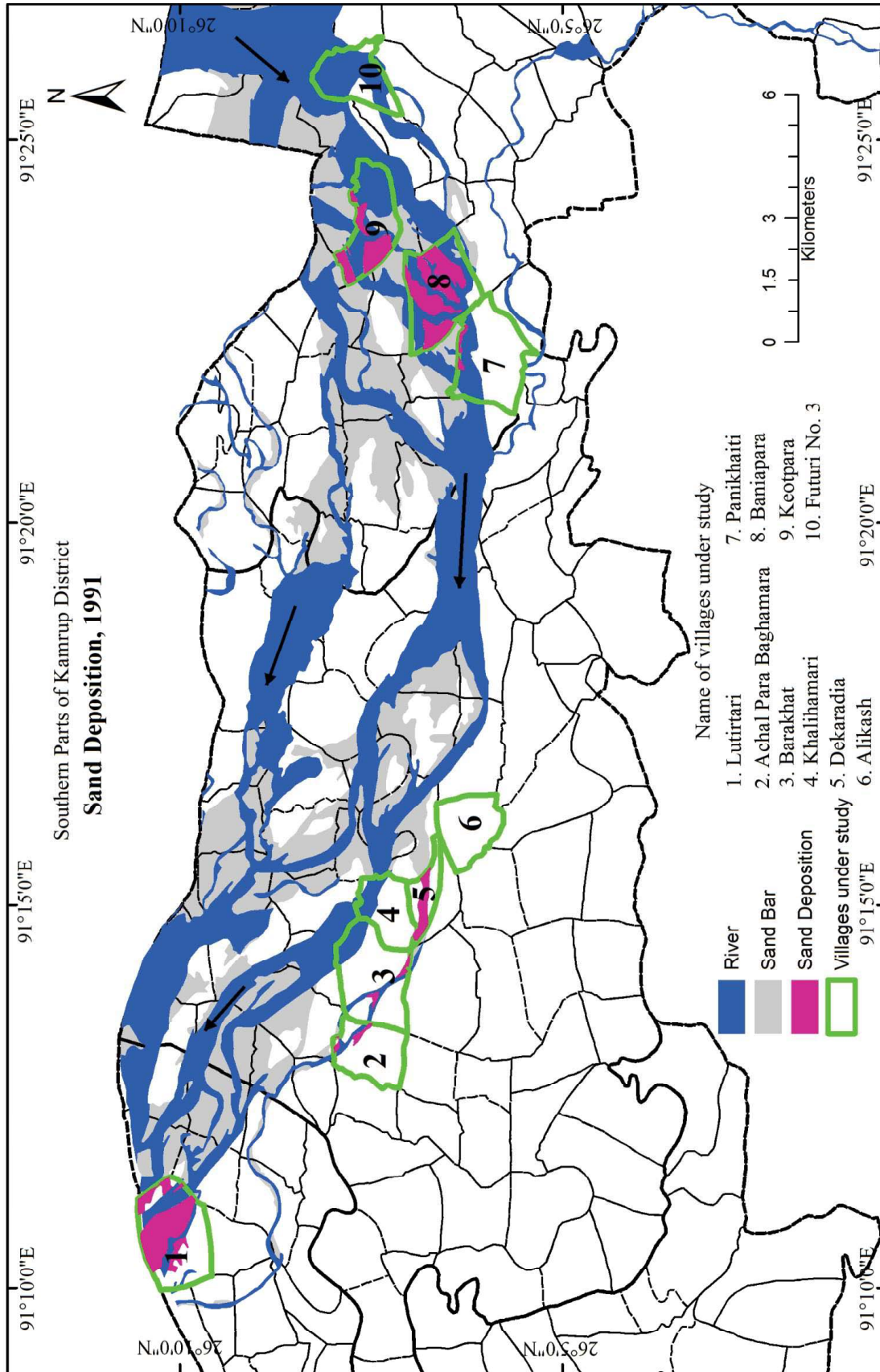
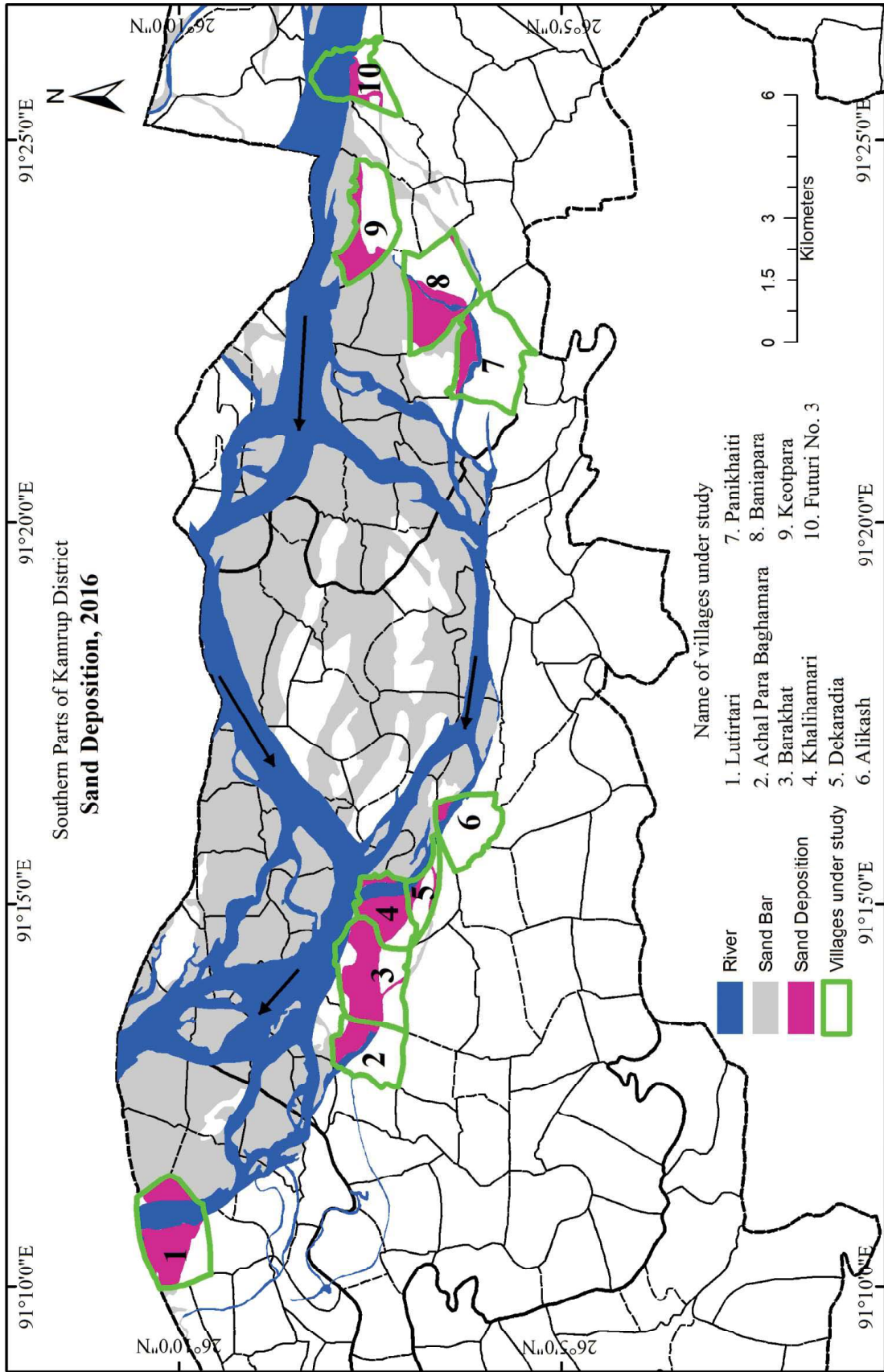


Fig. 4

Source: Prepared by authors



Source: Prepared by authors

Fig. 5

Table 2
Southern Kamrup District: Depth of Sand Deposit and Status of pH and Organic Carbon present in the Sand Deposition Areas

Revenue Circle	Village	Type of Deposit	Depth of Sand Deposit (m)	pH	Organic Carbon (g/kg)
Chamaria	Lutirtari	Fine Sand	0.30 - 0.70	6.10	1.40
	Achalpara Baghamara	Coarse Sand	0.20 - 0.30	5.70	7.10
Goroimari	Barakhat	Silt/sand	0.20 - 0.30	7.30	2.30
	Khalihamari	Fine Sand	0.30 - 0.50	6.20	1.30
	Dekaradia	Coarse Sand	0.30 - 0.50	5.20	7.50
	Alikash	Silt/sand	0.30 - 0.50	5.00	3.20
Palasbari	Panikhaiti	Silt/sand	0.20 - 0.30	5.00	3.20
	Baniapara	Coarse Sand	0.50 - 0.70	5.60	7.20
	Keotpara	Silt/sand	0.50 - 0.70	7.40	2.40
	Futuri No. 3	Silt/sand	0.50 - 0.70	6.30	4.20

Source: Field survey and laboratory analysis

management programme. In south Kamrup, a marked deposition of sand had largely affected the agricultural land.

The village heads and farmers of the revenue circles apprised the authors during fieldwork that there had been a noticeable decrease in agricultural output in the study villages. The agricultural land had become unsuitable for paddy cultivation; therefore, villagers are compelled to shift to vegetable crops like brinjal, pumpkin, sweet potato etc. The villagers revealed that prior to sand deposition in the area; the yield of paddy was 1336 kilograms per hectare, which declined to 590 kilograms in 2016 after sedimentation.

Thus, in the present study, to understand the degradation of agricultural land, affected due to sand deposit; physico-chemical analysis of the soils was done to understand the fertility of the soils towards agricultural sustainability. The findings of the analysis of soil samples collected from the villages are presented in Table 2. The study reveals that barring villages Lutirtari and Khalihamari which recorded 1.40 g/kg and 1.30 g/kg organic carbon content, indicative of very much acidic nature of soils, the organic compound content present in the collected samples varied between 2.30 g/kg to 7.20 g/kg in all other villages. However, the pH value of soils in the selected villages ranged from 5.00 to 7.40, which signify acidic to neutral properties of the soils (Table 2). Agriculture Extension Officer, serving in this area since 2010, revealed that the pH value of the soils was low previously in comparison to the recent sand deposits in the study area suggesting degradation of soils. However, physically the characteristics of the deposits varied from silt-sand to fine sand and coarse-sand (Table 2).

Conclusions

Sand deposition caused by flood is a

recurring annual phenomenon in southern Kamrup district. The sand deposition on adjacent fields is creating the fertile land into what appears like a vast beach. The floods also bring and deposit invasive vegetal species over agricultural lands. Due to flooding, area under sand deposition increased from 7.79 km² in 1991 to 10.55 km² in 2016 recording a growth rate of 35.43 per cent during the study period. Depth of the sand deposits varied between 0.20 to 0.70 m, while types of deposits varied from silt-sand to fine sand and coarse-sand. As a result, cropped area affected by sand deposition increased by 37.50 per cent during the study period. The soils turned out to be acidic as pH value of sand varied from 5.0 to 7.4 in the villages under study. Due to an outcome of these effects, the farmers of the study area face damage of cultivable land and losses in the yield. Therefore, the problems of sand deposition on the agricultural land, communities' adjustment and implementation of agricultural practices are of major concern in the study area. Thus, there is a serious requisite to consider the impacts of sand deposition as a component of pre-and post-disaster management for sustainable development of agriculture in the study region.

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