Research & Reviews: Journal of Agriculture and Allied Sciences

e-ISSN: E 2347-226X
P-ISSN: 2319-9857

Cultivation on Saline Soil and its Effect on Crops and Livelihood of People: Evidences from Kultali Block, South 24 Parganas

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Research Article

Received: 20-Apr-2022, Manuscript No. JAAS-22-61267; **Editor assigned:** 25-Apr-2022, Pre QC No. JAAS-22-61267 (PQ); **Reviewed:** 10-May-2022, QC No. JAAS-22-61267; **Revised:** 20-Jun-2022, Manuscript No. JAAS-22-61267 (R); **Published:** 27-Jun-2022, DOI: 10.4172/2347-226X.11.4.007

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Keywords: Soil salinity; Coastal; Livelihood; Kultali; Crop pattern; yield; Matla river; Income

ABSTRACT

Soil salinity represents a significant long-term environmental risk in coastal and deltaic environments in the Indian sub-continent. Excess soil salinity may exacerbate existing risks livelihood in densely populated tropical deltas, which is likely to have a negative effect on human and ecological sustainability of these regions and beyond. Indian Sundarban is traditionally backward, disadvantaged and exhibit high degrees of saline infestation with severe cyclonic storms. The farming community in this area is dominated by poor, marginal cultivators and landless people. This study is an attempt to access the causes related with the increase in soil salinity and its effect on soil, plant and livelihood in the riverine plain of Matla river of Kultali block in South 24 Parganas, West Bengal. The salinity in soil is a one of the culprit for agriculture potentiality which not only reducing crop production but also soil productivity. The most significant impact of salinity is the changes in cropping pattern and indigenous rice verities. Local people are facing increased pressure due to decline in production of yield and cause severe effect on income and food basket.

INTRODUCTION

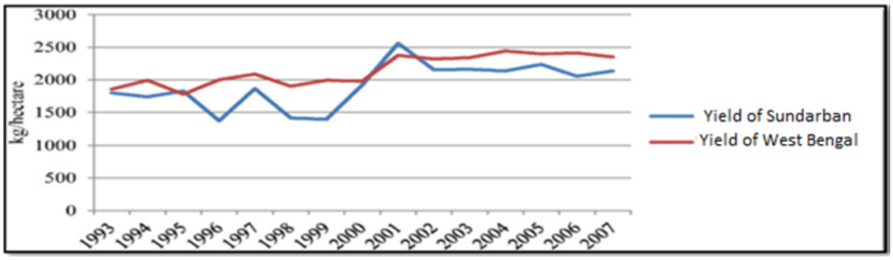
Soil salinity in Sundarban

Salinity problem is a new phenomenon in environmental science. But the scale of the problem of soil salinity is considerable and continues to grow [1]. Mainly, in the coastal areas due to rapid change in coastal environment in recent times [2]. Coastal agricultural lands in tropical regions often suffer from saline intrusion that prevents crop production and salt accumulation in the root zone of soil effects on plant growth [3]. This is a natural phenomenon in deltaic and estuarine environments because of seasonally varying freshwater input where agricultural lands in the brackish-water zone generally have lower productivity than those in the freshwater zone. Soil salinity reduces the productivity of agricultural lands and yield, if a threshold salinity level is exceeded the land becomes unfit for cultivation. The US Salinity Laboratory (1954) identify that in saline soil pH is less than 8 which reduces the availability of soil water due to osmotic effects and affect plant growth and yields. Recent study reported that there had loss 0.17 percent GDP in India for soil salinity [4].

The entire area of Indian Sundarban faces the problem of salinity and also there is a high degree of risk associated with agriculture as a result of high salinity levels which increases of soil salinity over time [5]. In Sundarban area agriculture land has been declining from 2149 sq.km in 2001 to 1700 sq.km in 2009 and simultaneously increasing saline area from 39 sq.km in 2001 to 75 sq.km in 2009 [6]. Earlier this region is a major supplier of rice for the Calcutta city. Study indicates that yield has been consistently declining at present compared to average yield in West Bengal (Figure 1) where soil salinity has been considered as one of the major factors in this area. The study found that every year crop production has been affected due to soil salinity in Sundarban. Number of studies related to ascertain the impact of soil salinity on yield of paddy and overall livelihood has found a strong co-relation between them.

This study attempts to explore the possible effects on soil, plant and people livelihood due to change of soil salinity.

Figure 1. Mean yield rate of Aman paddy (kg/ha) in the Sundarbans vis-à-vis West Bengal (1993–2007).



(Source: Sarkhel, 2015).

Location of the study area

The Kultali social–ecological system: We conducted our study to three villages *viz.* Gopalganj, Dakshin Garankati and Kaikhali, located in riverine plain of the Matla in Kultali block situating on the southern part of South 24 Parganas district (Figure 2), characterized as a unique and fragile ecosystem [7]. This block is selected for predominantly rural and backward in nature where household poverty ratio is 46.36% and more than 70% of the main workforce engaged in agriculture; poverty rank is 24 among 29 blocks in South 24 Parganas [8]. The selection of villages based on their level of salinity.

This area is hot and humid tropical climate. The mean annual rainfall is about 1800 mm to 2800 mm. The rainfall received mostly from south-west monsoon which contributes about 80% of total annual rainfall, and July to mid-September is the most wetted months.

Historical background of the study area: The Sundarban had been inhabited for thousands of years, as evident from artifacts dating back to before the Mauryan era (4th– 2nd centuries BC). Although the British had a key influence on land use change in the area due to tax collection (ibid).They was extensive forest clearing where large-scale clearance occurred between

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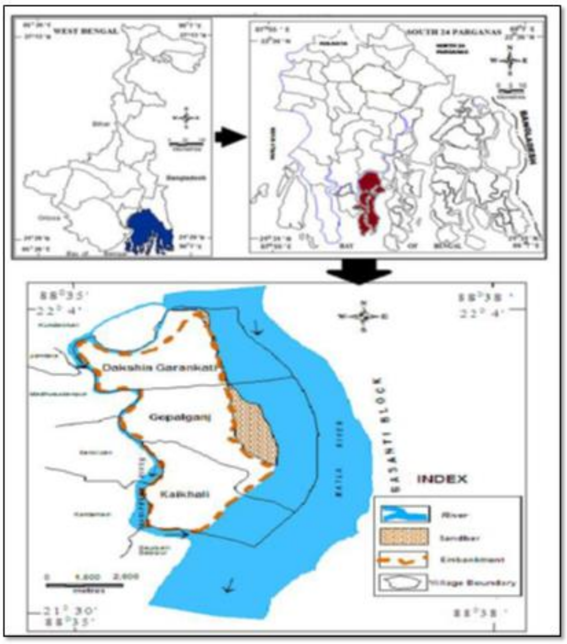
P-ISSN: 2319-9857

1940 and 1950 and land was reclaimed from the coastal area. The reclaimed land is locally known as abad and reclaimed land bounded by embankment for stop frequent inundation of saline water to agricultural field. Although the agricultural land frequent inundation to saline water by flood and storm surges in different time [9].

Figure 2. Location of the study area.



Source: Prepared by author based on mouza map.

Livelihood activities in the study area: Majority of people are traditionally engaged with agricultural activity in all three villages (Dakshin Garankati, Gopalganj and Kaikhali) in the Kultali block. The main source of income in all three villages is agriculture related livelihood. Another important occupation of the people is fishing activity. This activity continues throughout the season, production starts increasing at the onset of monsoon and reaches its peak during winter (November-January). But in general, agriculture contributes low income (less than half of the total income) in Sundarban (CSSIR, 2014:14); average annual income is US$180/capita. In the study area a paddy dominant cropping pattern is prevalent because of soil characteristics, flat topography, weather and climate. Paddy (except Aus paddy) is usually grown in the study area in the Kharif season of Aman paddy which is specifically rain water dependent cultivated in Ashar (Mid-June to Mid-July) - Pous (Mid-December to Mid-January) month and in Rabi seasons Boro paddy cultivated during Magh (Mid-January to Mid-February)–Jaistha (Mid-May to Mid-June) month. Furthermore, any inundation of low land and medium highland and delay in the water retention affect the cultivation of Aman paddy. In Rabi season people cultivated different vegetables *i.e.* chilli (*Capsicum frutescens*), uchhe (*Momordica charantia*), tomato (*Solanum lycopersicum*), beet (*Beta vulgaris*), cabbage (*Brassica oleracea ver. capitata*), coneflower (*Brassica oleracea ver. botrytis*) and brinjal (*Solanum melongena*).

MATERIALS AND METHODS

Change of soil salinity data in the study area has been obtained from the Vivekananda Institute of Biotechnology in Nimpith of South 24 Parganas and rest of the data has been collected from household survey through a questionnaire. This perception based study was conducted during August to December in 2016 in three villages. To obtain preliminary information on study sites like livelihood and cropping pattern has been done by a pilot survey in June 2016 and discussed the issues with local experienced farmers who are 40-60 years old. Additional information about soil salinity and cultivation were collected from soil scientist of Central Soil Salinity Research Institute (CSSRI) at Canning town of South 24 Parganas. This questionnaire has been administered among 15 farmers, 5 from each village. After pre-test, necessary correction, addition, alteration and rearrangements in the questionnaire were made. The questionnaire was then finalized for collecting data. To obtain data of pre-Aila (before 2009) to post-Aila (after 2009) experiences, purposive random sampling procedure was used to select respondents above 30 years, who have been living and engaged in farming in the area before 2009 and after 2009. Interviews were conducted among the respondents at their homes. Repeated visits have been done to clarify data after survey. All respondents for household survey were men. As Indian women move to their husbands home after marriage, women in the study areas may not provide pre and post Aila cultivation data for that area.

Same rice varieties (Dudhaswar and Kalomota which are local varieties cultivated to Kharif season) have been taken to understand the ffect of soil salinity on plant. Because these rice varieties were practicing prior and post Aila.

After completion of field survey, all the primary survey data were cleaned and edited and classified and then put those data to excel sheet. Data were analyzed in software-Stata Release 13 after conversion from excel sheet.

The respondents believed that salinity in the soil increases in their areas started in 2009. According to them, Aila (sever cyclone in 2009) was the major cause of soil salinity change where saline water intrudes into agricultural land and stagnant of saline water to agriculture field for long time. As well as soil salinity data (Vivekananda Institute of Biotechnology) is available from 2009. The 2009 has been selected base year for comparison of change in salinity. During the field survey it has been found one respondent reported multiple options to a particular question. We considered each option as one response. For example, one respondent reported various reasons like embankment breaching, capillary action in Rabi crop and intrusion of saline water by canal for soil salinity changes. Here we have taken causes of soil salinity change reason as embankment beaching is one response, capillary action in Rabi season is one response and ingress saline water by canal is one response.

Sampling: Households for survey were randomly selected. Only 5 percent of total populations in each study village were selected. Proportional sample was taken, 80 samples out of 1606 households in Gopalganj, 60 samples out of 1219 households in Dakshin Garankati and 64 samples out of 1294 households in Kaikhali were selected. For choosing the households in three villages, we have collected of farm household list and after then done lottery [10].

RESULTS AND DISCUSSION

Local farmers' perception of salinity levels and causes for the salinity increase

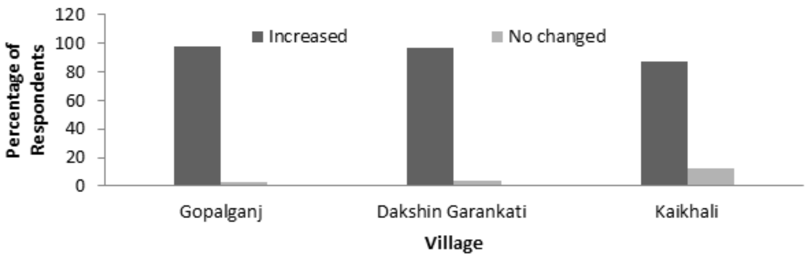
Table 1 shows that soil salinity level in the study area in different time. Soil salinity has been increased after 2009 although in Dakshin Garankati salinity in the soil reduced but peoples' perception it was increased. Nearly all the respondents perceived the salinity level in their localities to be changed. The majority of persons of the respondents (96.67 percent in Dakshin Garankati, 90.00 percent in Gopalganj and 79.69 percent in Kaikhali) believed that the salinity increased to after Aila in 2009 (Figure 3), when saline water inundated in their village. The situation, explained by a farmer in Gopalganj, reflected what all respondents expressed:

"We did not have nona (soil salinity) problem in our village before Aila. It started to increase after Aila due to embankment breaching and which is mainly found on Falgun- Chaitro month which creates a white layer of nona on soil."

Table 1. Soil salinity data in the study area

Name of the village	Soil pH	
	2009	**2015**
Gopalganj	6.21	6.65
DakshinGarankati	6.08	5.49
Kaikhali	5.1	6.57
Source: Vivekananda Institute of Biotechnology, 2016		

Figure 3. Local people's perception about level soil salinity in the study area.



Source: Field survey, 2016

Various causes are responsible for the change in soil salinity in the study area- some are natural and some are manmade (Table 2). The major part of the respondents in all study areas perceived the main causes for salinity increase to be embankment beaching (96.67 percent in Dakshin Garankati, 95 percent in Gopalganj and 90.62 percent in Kaikhali) and capillary action in dry season (68.75 percent, 48.28 percent and 43.75 percent in Gopalganj, Dakshin Garankati and Kaikhali respectively). In Dakshin Garankati, 18.33 percent of the respondents identified the cause of increase in soil salinity to be ingress of saline water for shrimp cultivation. The local perception of shrimp cultivation was explained by a shrimp cultivator in Dakshin Garankati:

"As the net income from shrimp farming is higher than for rice cultivation, people are more interested in cultivating shrimp. You know agriculture practice is not profitable than before due to increasing the agricultural cost and also have crop failure."

Haribhasania, north-eastern part of the Dakshin Garankati, is embankment breaching prone area where almost every year happened that phenomena.

Table 2. Respondent's perception of the causes of salinity in their village.

Cause of salinity increase factors	Gopalganj	Dakshin Garankati	Kaikhali	Combined
Embankment breaching	76 (95.00)	58 (96.67)	58 (90.62)	192 (94.12)
Capillary action in *Rabi* season	55 (68.75)	28 (48.28)	28 (43.75)	111 (54.41)
Increasing river water salinity	2 (2.5)			2 (0.98)
Increasing over flow of the river	1 (1.25)		2 (3.15)	3 (1.47)
Ingress saline water by canal		11 (18.33)	1 (1.56)	12 (5.88)
Source: Field Survey, 2016				

e-ISSN: E 2347-226X
P-ISSN: 2319-9857

Note: Figures in parentheses denote percent of respondents

During the *Rabi* season water in the soil bringing up salt from the layers below. Under ground water-table is shallow and is enriched with high salt conte nt in the Sundarban soil. Generally, the water table in the landscape is at or very close to the soil surface, where piezometric surfaces lie between 0.50-2.00 m. During the *Rabi* season of the year the salt move along with water of the water-table to the soil surface by capillary action. In this period, the driving force for upward movement of water and salts is evaporation from the soil plus plant transpiration but dissolve salt not evaporated which is a lie against surface cover and concentrate on surface as a result soil salinity has been increase on Baisakh (Mid-April to Mid-May) to Joystho (Mid-May to Mid-June) month.

Effect of soil salinity on the soil characteristics

Table 3 shows the respondent's perception about changes of soil characteristics after changes in soil salinity. Primary survey indicates that 181 respondents out of 204 samples *i.e.* 88.73% respondents believe there have been a reduction in soil fertility in the study area. It is higher (91.67%) in Dakshin Garankati compared to the Gopalganj (88.75%) and Kaikhali (85.94%). It is also observed that 135 respondents out of 204 samples (66.18%) replied a reduction in soil cohesiveness in these villages. In Kaikhali 70.93% of the respondents mentioned about a reduction in soil cohesiveness whereas it was relatively lower in Dakshin Garankati (65%) and Gopalganj (64%).

Changes in soil salinity also lead to change in the colour of the soil. Nearly 46% age respondents mentioned about the change in the colour of the soil in the study area. Highest (53.33%) of respondent reported change in Dakshin Garankati than combine level. It was followed by Kaikhali (48.44%) and Gopalganj (37.5%). Most of the respondents reported that their soil became white.

Table 3. People perception about changes of soil characteristic.

Name of the village	Reduced of soil fertility	Reduced of soil cohesiveness	Change of soil color
Gopalganj	71 (88.75)	51 (63.75)	30 (37.5)
Dakshin Garankati	55 (91.67)	39 (65.00)	32 (53.33)
Kaikhali	55 (85.94)	45 (70.93)	31 (48.44)
Combined	181 (88.73)	135 (66.18)	93 (45.59)

Note: Figures in parentheses denote percent of respondents

Source: Field Survey, 2016

Salinity degrades soil properties and fertility as the organic elements in the soil gets degraded. Accumulation of salt to plant root has been damaging for crop production and soil fertility as well. In other words, a rise in soil salinity adversely affected soil productivity. The soluble salts mainly comprise of chlorides and sulfate of sodium, magnesium and calcium and these salts are found in the soil of our study area. In a recent study it was found that all the 19 blocks in Sundarban there has been a decline in soil fertility due to salt water intrusion. As a physical properties soil colour has been changed, it is more white for accumulation of salt to surface that indicates became soil more saline. During field survey it was observe soil surface color is white. Farmers are easily seen salt accumulation on surface to their field when they irrigated in Rabi season. The local farmer, Hasem Laskar (name changed) in Dakshin Garankati expressed this in his own way:

"I did separate the entire agriculture land into 'vhatti' (small part of field) for advantage of irrigation in Boro season. I have seen that salt was concentrated to the last 'vhatti' after irrigation."

Effect of soil salinity on plant (paddy) characteristics

Traditional rice varieties like Dudheswar and Kalomota were cultivated in before and after soil salinity changes which physiologically affected by soil salinity. Primary survey indicated that 41% respondents replied that there has been a decrease in plant height. As a result, they explained that it has resulted in slow growth of plant (44.61%) along with a decrease in the growth of plant roots (36.76%) and reduced of panicle (44.61%) (Table 4).

Table 4. People perception soil salinity effect on plant (Dudheswar and Kalomota paddy) characteristic.

Village plant characteristics	Gopalganj	Dakshin Garankati	Kaikhali	Combined
Decrease plant height	40 (50.00)	15 (25.00)	29 (45.31)	84 (41.18)
Slow growth of plant	40 (50.00)	24 (40.00)	27 (42.19)	91 (44.61)
Decrease growth of plant root	6 (7.5)	34 (56.67)	35 (54.69)	75 (36.76)
Reduced panicle of paddy	41 (51.25)	4 (6.67)	46 (71.88)	91 (44.61)
Other	11 (13.75)	2 (3.13)	3 (4.67)	16 (7.84)
Note: Figures in parentheses denote percent of respondents Source: Field Survey, 2016				

Salinity affects plants in different ways such as osmotic effects, specific-ion toxicity or nutritional disorders. The osmotic effect initially reduces the ability of the plant to absorb water because salt have an affinity for water; in water contains salt, more energy per unit of water must be expended by the plant to absorb relatively salt-free water from a relatively salty soil-water solution. Under the saline affected soil plant not able to extracted sufficient water from soil (ibid). Even salinity also osmotic stress reduces water uptake into plant roots. On the other hand nutrient disturbances under salinity reduce plant growth by affecting the availability, transport, and partitioning of nutrient. Under saline effected soil nutrient has deficit in soil and plant did not uptake of nutrient for that effect on plant growth.

Salinity reduces plant growth and yield through ion toxicity and osmotic stress. Ion accumulation (mainly Na^+ and Cl^-) in the soil solution causes osmotic stress, which decreases the water availability to the roots (ibid) and cause plant to wilt as roots cannot absorb sufficient water to replace that lost from transpiration [11]. Ion toxicity, which occurs when Na^+ and/or Cl^- taken up by the plant roots accumulate in large quantities in the leaves, this is harmful for the plants, which may also cause nutrient deficiencies. Saline soil significantly reduces plant phosphorus (P) uptake become P ions precipitate with Ca ions [12]. Nebraska researcher found that increasing soil salinity decreased both P uptake and P concentration. N and P are important nutrient for plant. However deficit of nutrient in soil and nutritional imbalance adverse effect on plant growth and development at physiology and biochemical level. So panicle length, spikelet number per panicle and grain yield gets significantly reduced under saline conditions. It also delays the emergence of panicle, flowering and decrease seed through reduced pollen viability [13].

Rice is considered to be moderately sensitive to salinity. The symptoms of salt injury in rice are stunted growth, rolling of leaves, white tips, drying of older leaves and grain sterility. Soil salinity limits the rice plants growth and development, resulting in yield losses of more than 50%. Sensitivity of rice to salinity stress varies with the growth stage. Though salinity affects all stages of the growth and development of the rice plant, when the rice is at the young seedling stage it becomes even more sensitive to salinity, where plant height was negatively associated with salt concentration; salt accumulation in the root zone of soil affected plant growth in coastal soil. However similar kind of things like reduction of plant height, decrease in crop size was also observed in a study in Bangladesh. In our study area, the agricultural crop especially paddy has been adversely affected due to rise in soil salinity. Sanat Das (name changed) a farmer in Gopalganj- "My cultivable plots are in low lying area and every year they are transformed into stagnant pools during the monsoon. So I always cultivated traditional variety of paddy e.g. Kalomota for greater plant height. But during past few years I have observed that the plant height of this variety of paddy have a reduced height, the plant size have reduced from 6 feet to 5 feet, similarly, the length of panicle has also been lesser by of 2-3 inches. This phenomenon has been more evident during the last 3-4 years."

Effect of soil salinity on crop (paddy) production

Aman is the major paddy crop and it consists of both, the traditional as well as the High Yielding Varieties (HYV). However, during the Boro paddy, only HYV is cultivated (Table 5). It is interesting to note that some local varieties have also been transformed into HYV by CRRI e.g. CR 1009, CR 1018, CR 1036 etc. in our survey, we have attempted to ascertain what has been the impact of a rise in soil salinity on crop yield and productivity? We have compared the average of three years yield during the pre-Aila period *i.e.* along with (2013-15) because crop production is not only affect by salinity and also rainfall, fertilizer, HYV seed and irrigation facilities. Primary survey indicates that the yield for Aman variety now is 1774.26 kg per hectare whereas it was 2373.3 kg per hectare in the pre-Aila period (Figure 4). In other words, there has been in an average about 25% age reduction in yield for the Aman variety of paddy. For Boro variety, the reduction has been from 5139.98 kg per ha to 4164.11 kg/ha between the two periods*, i.e.* a decline of 18%.

Table 5. Variety wise rice cultivation in different season.

Season	**Type of variety**	**Name of Varieties**
Aman	HYV	Geetanjalli, Pankaj, Masury, Super Shyamoli, CR 1017, CR 1009,CR 1036,CR 1018
	Local variety	Dhudheswar, Patnnai, Moochisal, Netashal, Kalomota
Boro	HYV	Bidhan-1, Bidhan-2,Lalat, WGL 20471 (Lalminikiti), Boby, Super Shyamoli, Jhatti Pankwaj, Swarna Pankwaj, Super Swades
Source: Field survey, 2016		

The flood salinity of the soil increased highly which affect agricultural production. This decline in yield in the surveyed villages has been ascribed to an increase in soil salinity by the respondents because it has a negative effect on production of agricultural crops. Both Aman and Boro yield have declined in the study area but Aman has been higher compared to Boro because the eluviations process the dissolution and downward mobilization of minerals by water in the soil that led to loss of minerals of surface horizon in monsoon season in the study area. In addition, fertilizers are easily washed off the land during heavy rains.

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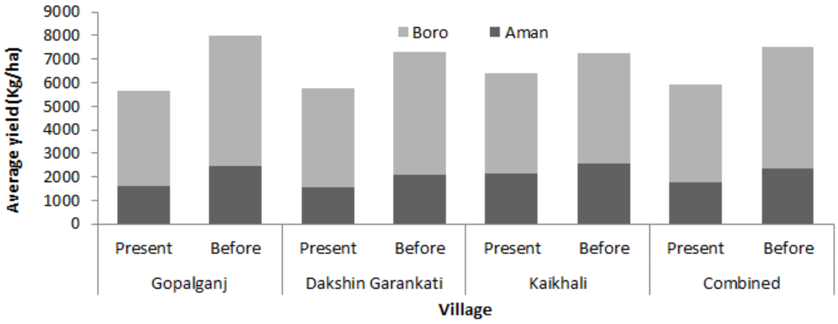
Figure 4. Average yield (kg/ha) at present (2013-2015) and before 2009 of both Aman and Boro in the study area.



Source: Field survey, 2016.

Primary survey indicates that reduction in yield has been maximum in Gopalganj village, both for *Aman* and *Boro* varieties. Average *Aman* paddy production has decreased by 1.5 times in Gopalgang or by 33.78%. In other words, the reduction of yield has been from 2441 kilogram/ha to 1616.46 kilogram/ha from 2009 to 2015. On the other, *Boro* yield has decreased by 27.76%, from 5549.46 kilogram/ha to 4036.74 kilogram/ha during the same time period. In Gopalganj village there has been no intervention by agencies from outside and the communities are dealing with the increase in soil salinity in their own way.

In Dakshin Garankati village indicated that average production of *Aman* has reduced by 26.5 % and for *Boro*, the reduction has been 18.45% during the period 2009 to 2015. For *Aman*, yield reduced from 2104.98 kg/ha to 1546.14 kg/ha and for *Boro* paddy, it reduced from 5188.74 kg/ha to 4231.26 kg/ha. In Dakshin Garankati, there has been intervention by the Bayer Company, which devised ways to deal with the adverse effects of an increase in soil salinity on cultivation. The company propagated the cultivation of a variety of paddy called Male Female paddy, locally knows as May moddyo paddy during the Rabi season.

Kaikhali village provides with a contrasting picture. It was evident during the primary survey. While the increase of soil salinity in terms of pH value has been maximum (pH increased from 5.1 to 6.57) in this village compared to the other two villages, yield reduction has been lowest here compared to the rest. During the primary survey, the respondents stated that this has been possible only because of the intervention of an NGO, Ramkrishna Ashram KrishiVigyan Kendra (RAKVK). This NGO has been working in this village since 1983 and has been a pioneer in disseminating ideas on how to deal with the adverse effects of increased soil salinity. The respondents stated that they have been largely successful in minimizing the effects of soil salinity on agriculture in general and paddy cultivation in particular. In Aman yield has reduced from 2573.88 kg/ha 2009 to 2160.18 kg/ha in 2015, a reduction of 16.07 % followed by Boro, from 4681.74 kg/ha to 4224.54 kg/ha, or by 9.77%. The farmers said that the NGO helped them by providing expertise on land shaping, a technique which has helped to minimize the adverse effects of salinity, along with providing information on salt tolerant paddy varieties (Super Shyamoli, Swarna Pankwaj, Jhatti Pankwaj, CR 1036 etc.) and introduction of other salt tolerant crop varieties. They have also advocated the farmers to use organic fertilizers in the post Aila phase, which according to the cultivators have also yielded results in minimizing the effects of soil salinity in the village.

Effect of soil salinity on cropping pattern: It was evident from our field survey that there has been a change in the cropping pattern as a consequence to the increase in soil salinity. While some crops were introduced, some others were discarded. Primary survey indicates that 56.37 percent of the respondents have reported to have introduced newer varieties of crops that they did not cultivate earlier (Figure 5). Amongst the crops introduced by the farmers, chilli and uchhe (bitter gourd) occupied the major share. In Kaikhali (73.44 percent) respondents have been introduced new crop that followed by Dakshin

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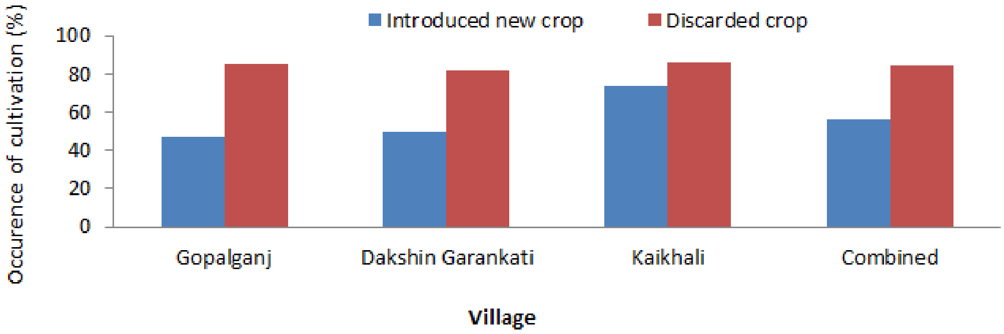
Garankati (50 percent) and Gopalganj (47.5 percent). More than 84 percent of the respondents have said that they have discarded earlier crop varieties (Khesari and Mung Bean) since they were no more feasible to cultivate under conditions of high salinity. Amongst the crop variety discarded includes Bullet chilli, which has been now replaced by Tejaswini chilli.

Figure 5. Change nature of cropping pattern in the study area.



Source: Field Survey, 2016

Both chilli and Uchhe are more practiced in all three villages as medium salt tolerant varieties.

Before 2009 almost all people cultivated Khesari which is locally known as tebre karai and Mung Bean which is locally known as choitomukh karai. They cultivated Khesari after Aman to same field. It is sowing in Kartik-Agrahan month. This seed propagated after sowing. As seed of Khesari ripen in Magh month, they are harvested during Falgun-Chaittro months as the pods become fully ripe where yield is 1000 -1200 kg/ha. On the other, Mung Bean is sown during Falgun-Chaittro months, after harvesting Khesari and grows in summer season. Since summer Mung Bean does not mature at a time and pods of the crop are plucked and kept separately by the cultivator on request of the labor. Production is almost equal as to Khesari. However both Mung Bean and Khesari have low input cost; are used for both household consumption and cash crop as well. As these crops are salt sensitive and are cultivated under low soil pH so people now did not cultivate in the study area due to an increase in soil salinity. It not only affects on farmer's income and also soil heath because these pulse varieties are help to nitrogen fixation which increase soil productivity. Meelu and Morris reported that incorporation of Mung Bean residues gave a rice yield increase equivalent to 25 kg nitrogen fertilizer per hectare. At present farmers are more practiced salt tolerant crops (Table 6).

Table 6. Changes of vegetable cultivation in the study area.

Name of the vegetables	Botanical name	Ideal pH	Gopalganj/ Dakshin Garankati/ Kaikhali	
			In 2015	Before 2009
Mung Bean	*Vigna radiata*	4.5*	Did not cultivate	cultivated
Khesari	*Lathyrus sativus*	5.6-5.8 ±	Did not cultivate	cultivated
Potato	*Solanum tubersosum*	5.0-6.0 ¥	Low cultivated	More cultivated
Chilli	*Capsicum frutescens*	5-8.5 #	More cultivate	Low cultivate
Bitter gourd	*Momordica charantia*	5-8.5#	More cultivate	Low cultivate
Note: *Wilson and Wilson, 1987, Plant Physiology, Vol.84, pp. 93-98 ± Kumar et al., 2016, Plant Biotechnology Journal, 14:pp. 1394-1405				

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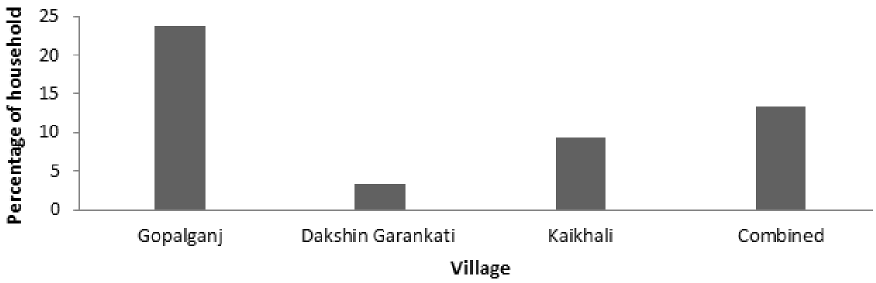
P-ISSN: 2319-9857

¥ http://growgreatpotatoes.com/2010/soil-ph-for-potatoes/
Personal communication with Dipak Kumar Roy, agronomist of Ramkrishna Ashram Krishi Vigan Kendra.

Effect of soil salinity on food shortage

There has been a problem of food shortage in the study area due to the declining yield of paddy (Figure 6). According to the respondents, it is highest in Gopalganj, 23.75% household are facing food shortage followed by Kaikhali (9.38%) and Dakshin Garankati (3.3%). Before the change of salinity, these households had little dependence on the market in terms of purchase of rice, which has now changed completely. Most of the household 3-5 months have food shortage (Table 7). Impact of saline intrusion on food security is a major concern for agriculture based countries such as Egypt, Moroccan coast and Vietnam, were reducing crop production. Recent study found that increased of soil salinity with water salinity in interior coast of Bangladesh as result decline of rice production which effect on food security [14-18]. Another study conducted by Szabo et al. in South West coast of Bangladesh where soil salinity has a significant negative effect on household food security. During field survey respondents explained that effect of soil salinity on food security is varies among household and more depend on market for purchase of rice. In aggregate terms, more than 13% household in our sample now purchase paddy from the market now compared to prior 2009.

Figure 6. Percentage of household suffers food shortage in the study area.



Source: Field survey, 2016

Table 7. Number of household shortage of food during month.

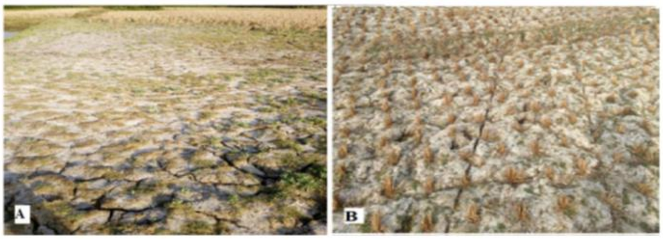
Month / Village	Two Months	Three Months	Four Months	Five Months	Six Months	Seven Months	Eight Months
Gopalganj	2	4	5	5			3
Dakshin Garankati		1		1			
Kaikhali	1	2	1	1	1	1	
Combined	3	7	6	7	1	1	3
Source field survey, 2016							

Effect of soil salinity on people's income

The majority of people have decreased income due to increase soil salinity; 95.83% households in Gopalganj, followed by Dakshin Garankati (85.19 %) and Kaikhali (81.97%). Before salinity changed there have been high yield both Aman and Boro and in Rabi crops *i.e.* tomato, khesari, Mung, sweet potato against low production cost (Figure 7). But now days farmers have been loss their yield and also simultaneously increased fertilizer, pesticide and labor cost. Labor cost was Rs. 180-200 in Gopalganj, Dakshin Garankati and Kaikhlai in 2008 now it is 300-350 in those villages. Sahabuddin Mondal (name changed) a farmer in Gopalganj reflected that thing [19].

"I am losing rice and vegetables production due to salinity intrusion in the agriculture fields. Before salinity increased I sold 20-30 basta (one basta=56 kg.) paddies to market but now I do not sell paddy to market which is directly affecting my income [20]."

Figure 7. A typical salt concentration on surface of agriculture field in (A) Kaikhali on March month and (B) in Dakshin Garankati on December month.



CONCLUSION

The salinity in soil is a one of the culprit for agriculture potentiality which not only reducing crop production but also soil productivity. The most significant impact of salinity is the changes in cropping pattern. Local people used to cultivate wide varieties of paddy (particularly traditional variety) before changes in salinity level to their land. But farmers are practicing high yielding salt tolerant rice varieties. Thus, the salinity changes cause significant negative impact on the agro-biodiversity. Local people are facing increased pressure due to decline in production of yield and cause severe effect on income and food basket. So salinity intrusion significantly influences on soil, crop and livelihood strategies of the people.

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e-ISSN: E 2347-226X
P-ISSN: 2319-9857

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