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A COMPREHENSIVE GEO –SPATIAL STUDY ON THE IMPACT OF SALINITY: CHALLENGES TO AGRICULTURAL YIELD IN MATLA – BIDYADHARI INTERFLUVE

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ABSTRACT

Increasing salinity is a major concern to the tropical coastline agricultural system. To ensure crop production and to satisfy food requirement, land reform system should be revamped in Matla – Bidyadhari interfluvial region, south 24 paraganas West Bengal. This study shows the effectiveness of GIS and Remote Sensing techniques in measuring impact of salinity on agricultural planning. The research work covers 809 sq. km area of Gosaba and Basanti Block, West Bengal. Soil samples were taken from various ground control points of these Blocks. After getting that information, soil clay fraction map, drainage map, land use map, salinity zonation map has been created by using satellite data on Arc GIS 10.6 software. These thematic maps can be use in agricultural planning. To cope with increasing salinity, it is recommended, deep water irrigation in dry season. Vegetables are more sensitive than cereal crops to salinity, so they can be yield in seasonal variation.

1. INTRODUCTION

To increase agricultural yielding and to satisfy food requirements land reform sequences should be revamped in Matla –Bidyadhari Interfluvial region, south 24 paraganas, West Bengal. Though this needs to assess huge quantity of spatial data, using traditional methods of surveying lands. It is also time consuming. Numerous land capability assessment techniques are used versions to the local settings of framework for Land Evaluation (FAO,2007) and centre on the sternness of land restrictions connected to crops and land use (Desmet, P., et. al., 2009). Hence the collected informations are included and organized in GIS to gain various thematic data for using in analysis process. Remote Sensing techniques are inevitable in assessing the satellite-based data sets and to realize the changes in land use patterns. As land capability assessment needs various spatial and non- spatial data (land use, topography, soil salinity etc.), GIS provides various tools to manipulate datasets into thematic maps. Now a day, soil salinity is a major concern to farmers. Crops grown in saline soil are prone to osmotic stress, nutrition disorder and toxicity, which reduce productivity. Saline stress is a major problem to cope with increasing food demand.

2. OBJECTIVES

1) To indicate the potentiality of Remote Sensing in salinity measurement.
2) To investigate the spatial planning for agricultural land use settings.
3) To study how land capability plays a significant role in detecting limits in sustainable agricultural planning.

3. STUDY AREA

3.1. LOCATIONAL EXTENT

The study area is situated in south 24 paraganas, West Bengal. Basanti Block with 13 GPs and Gosaba Block with 4GPs have covered the whole region. It extends from 21 0 29 ‘N to 22 0 30’ N and 88 0 29 ‘E to 89 0 E. The area covers 809 sq. km. with Matla River in the west, Bidyadhari River in the east, Herobhanga Reserve forest in the south, and Canning – 2 Block in the north.

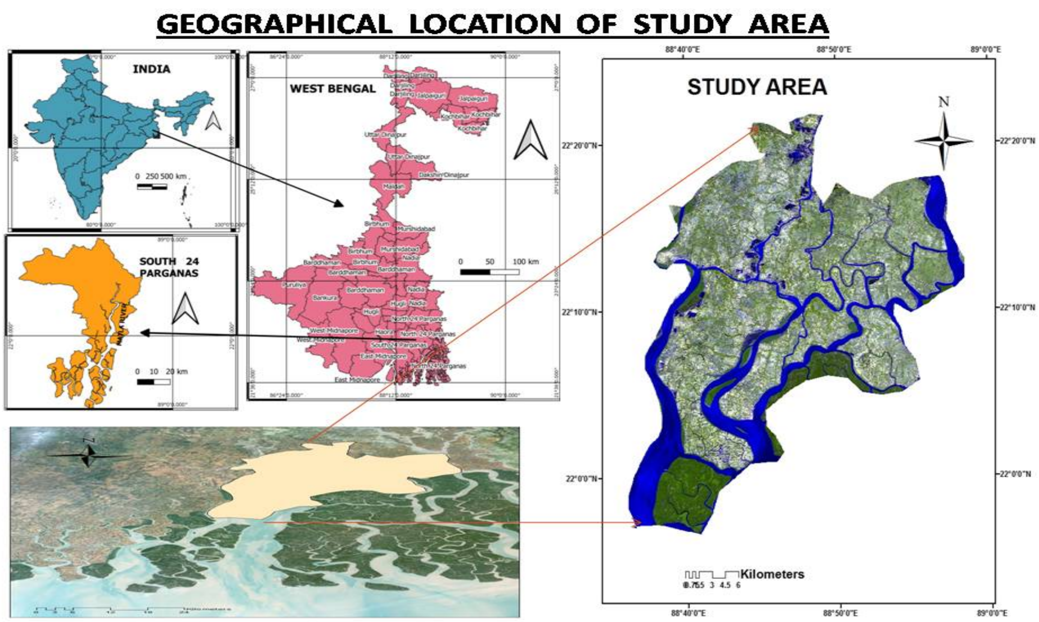


Figure 1: Location of Study Area

3.2. GEOLOGICAL FORMATION

This area originated during middle- upper Cretaceous period. Several subsidence and Gangetic deposition bring the recent changes in this region. The whole deltaic area has an easterly tilt, which gives the unique direction to drainage patterns.

3.3. THE INTERFLUVIAL RIVER SYSTEM

Matla and Bidyadhari are the two main tidal fed rivers with many distributaries, creates an estuarine river system. Ox – bow lakes, meander channel, mangrove swamp river bed islands, point bar/ charas are the various geomorphic features here. However cyclonic storms or high tidal water (7 m) flooded the southern part with various depths.

GLIMPSES OF STUDY AREA

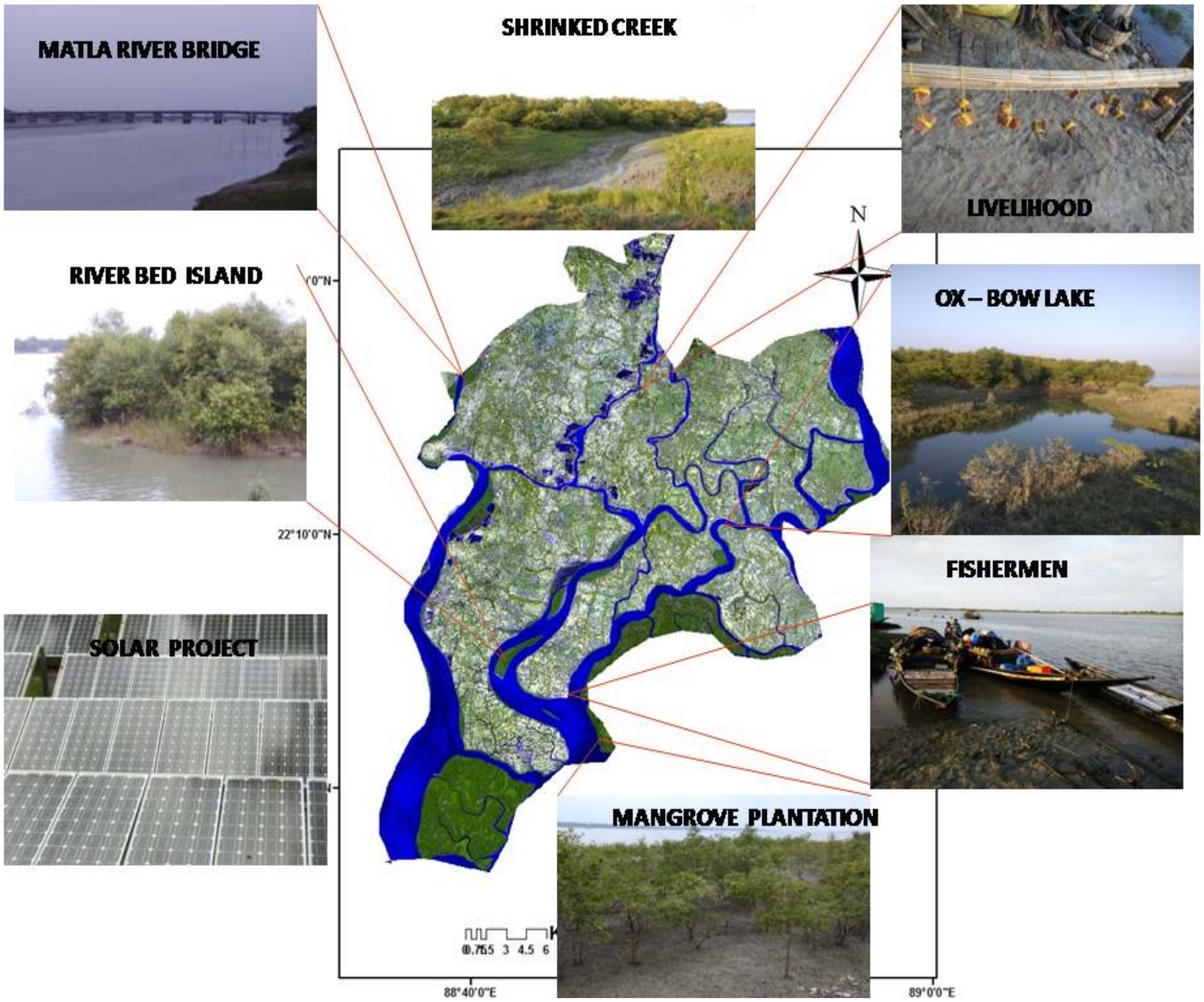


Figure 2: Some glimpses at a glance**.**

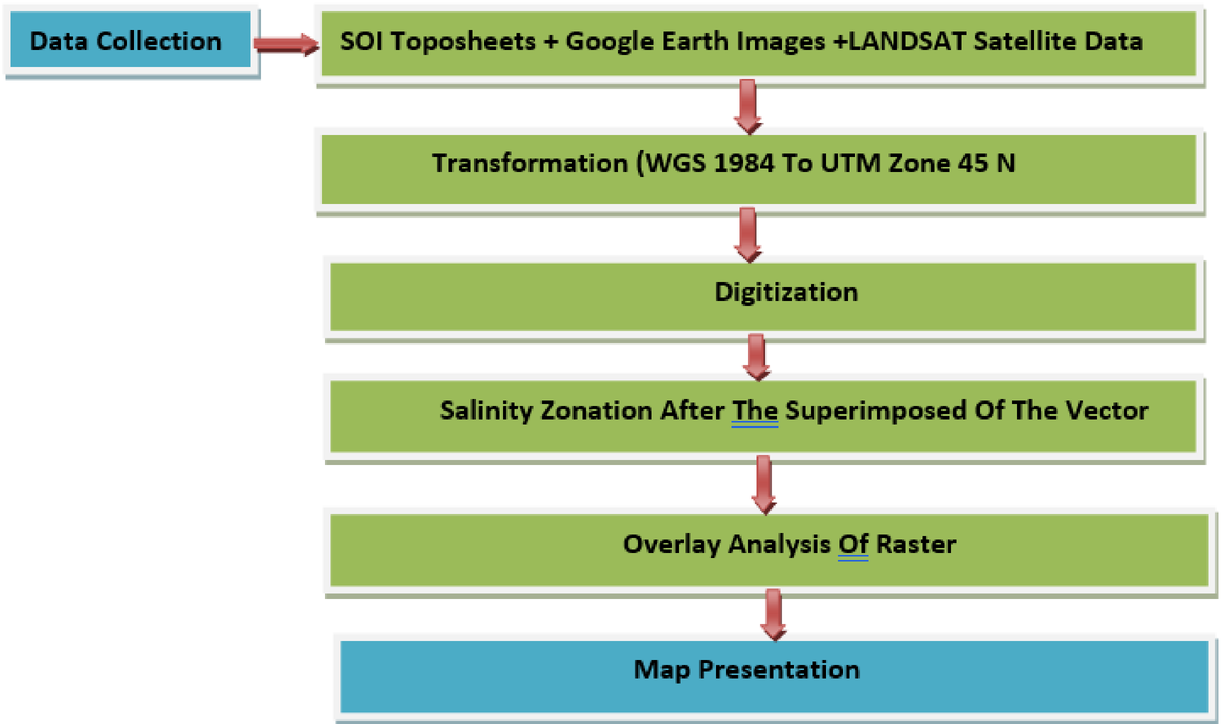
3.4. SOIL TYPES

Soils of this area are saline in nature and Azonal Type with little formed profile. Main soil types are –
a) Coarse Loamy Soil
b) Fine Loamy Soil
c) Sandy Loamy Soil
d) Silty Clay Soil
e) Silty Loamy Soil

3.5. CLIMATIC CONDITION

The average maximum and minimum temperature are 37 0c and 14 0c. Most of the rainfall occurs during month of June to September by south – west Monsoonal wind (400 cm – 500 cm). During March _April and October cyclonic storm develops on Bay of Bengal.

4. METHODOLOGY



4.1. REMOTE SENSING DATA COLLECTION AND PROCESSING

After obtaining satellite data from USGS Earth Explorer, it has to be gone through Radiometric and Geometric corrections (atmospheric corrections by computing reflectance, registered to UTM Map Projection). Field work had been done by using 28 ground control points. Using those data NDVI and NDSI was calculated. Data classification had done by using input training samples and Maximum Likelihood method. STRM data (90 mts. Resolution) had been utilized to create DEM, Slope, and Aspect.

NDVI = (NIR – RED) / (NIR + RED) [Where, NIR = Near Infra-Red, Red = Visible Red] (Equation -1)
NDSI = (Green – SWIR 1) / (Green – SWIR 1) [Where, Green = Visible Green, SWIR 1 = Short Wave Infra-Red] (Equation – 2)

Table 1: Satellite data characteristics

Satellite	Sensor	Path/Row	Year	Spatial Resolution(mts.)
LANDSAT- 5	TM	139/46	1999, 2006, 2010	30
LANDSAT -7	ETM	139/46	2002	30
LANDSAT – 7	ETM+	139/46	1999, 2015	30
LANDSAT - 08	OLI/TIRS	139/46	2014, 2019	30

4.2. COLLECTION OF SOIL DATA

To collect soil sample 1 meter depth bores were excavated. This was done to determine the physical and chemical properties of soil. It was tested at Soil and Salinity Research Center, Canning. Then, these informations are used to create thematic maps with Spatial Analyst Tools in Arc GIS 10.6.

Figure 4: Saline effect on soil**.**

5. RESULTS AND DISCUSSIONS

5.1. Landuse And Landcover

a) Major Landuse types are – 1) Agricultural Land, 2) Fallow Land,

b) Major Landcover types are – 1) Mangrove Forest, 2) Salt Pan, 3) Marshy Land, 4) Water Bodies

The area extends 809 sq. km., among which Drainage and Marshy Land covers 183sq. km.(22.63%) area, Fallow Land covers 163sq. km.(20.15%) area, Salt Land covers 159sq.km.(19.65%) area, Mangrove and Dense Forest covers 192sq.km.(23.73%) area, and Agricultural Land covers 112sq. km.(13.84%) area. Major cultivating crop is paddy. Besides this, tomato, beetle leaves, potato etc. are also grown by farmers. Recently many agricultural lands have converted into aqua cultural ground (shrimp, prawn fisheries).

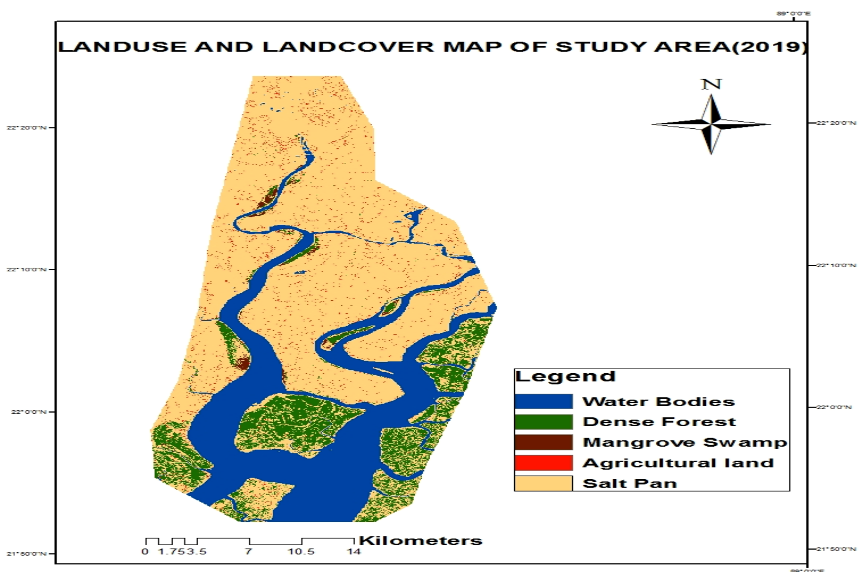


Figure 5: Land use land cover map of study area**.**

5.2. Soil Texture

To determine the surface run off, three major soil hydrological group has been identified, viz. – A, B, D.

Table 2: Hydrological Group of Soil

Hydrological Group	Soil Texture
A	Fine Loam, Coarse Loam
B	Silt Loam
D	Silty Clay

The Group A soil covers 363.61sq. Km, Group B soil covers 48.24sq.km, and the Group D soil covers 175.2 sq. km. This reveals that Group A soil is predominating with high infiltration, which causes water logging. Organic manure may apply by Mulching Process in Sandy soils, as sandy texture features excessive water loss. Loamy texture is also able to drain excess water but unable to hold nutrients.

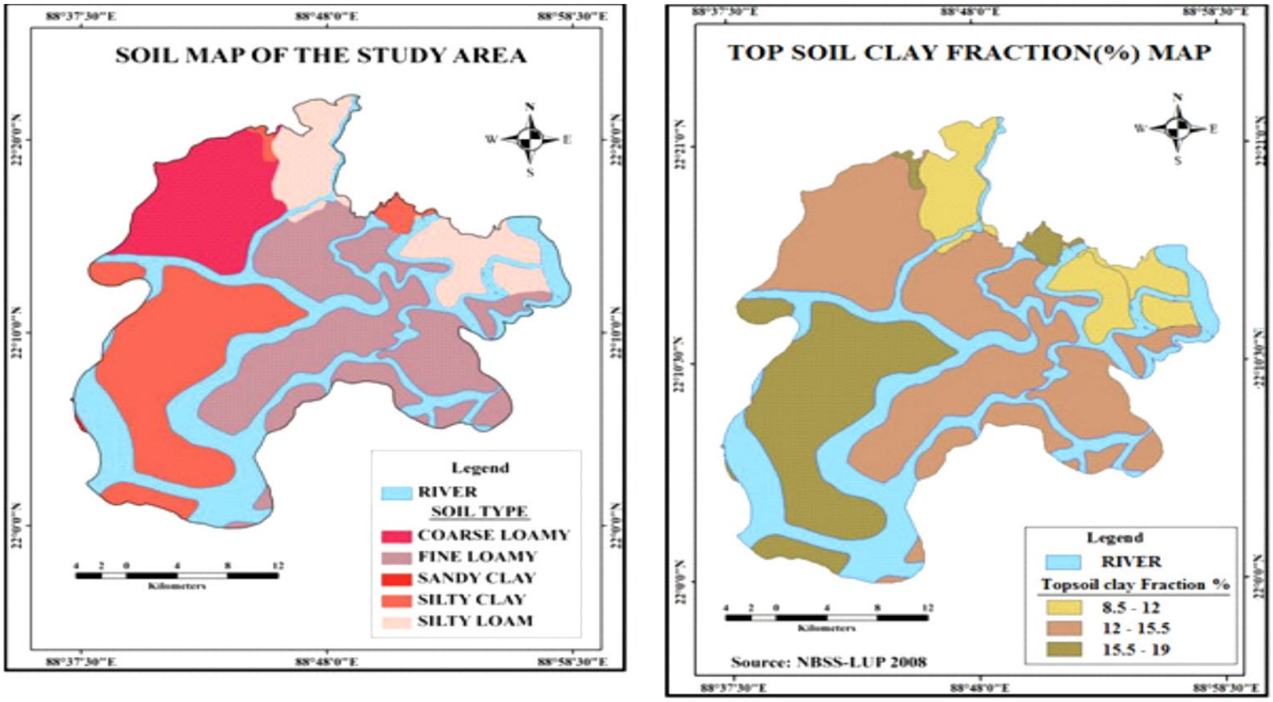


Figure 6: Physical Properties of Soil in Study Area.

5.3. Salinity Status

5.3.1. DERIVING SALINITY LEVEL WITH PH

Table 3: pH Level of Collected Soil Samples with Their Location Using GPS

Places	Latitude	Longitude	pH
Baria	22.303948	88.750847	7.62
Jharkhali	22.322239	88.785142	6.32
Bairam Chowranghee	22.044068	88.664728	8.1
Ramgopalpur	22.133235	88.729508	6.21
Simultala	22.191918	88.755038	7.98
Majherpara	22.201063	88.728365	5.3
Arampur	22.188488	88.778283	4.5
Gobindapur	22.098178	88.73408	4.52
Chandimore	22.222783	88.825915	5.32
Bara Mullakhali	22.248314	88.883073	5.02
Jyotiramghat	22.19268	88.87469	4.02
Choto Mullakhali	22.209446	88.925751	8.12
Kumirmari	22.217067	88.941755	8.2
Punjal	22.22507	88.923465	5.2
Gosaba	22.107324	88.899077	6.04
Harankhali	22.220012	88.641166	6.66
Harabaidya	22.360409	88.797521	4.04

On the basis of obtained pH values 5 Saline zonation has been created –

- Very Low (7 to >8) – Baria, Kumirmari, Choto Mullakhali, Bairam Chowranghee, Simultala etc.
- Low (6 to 7) – Harankhali, Gosaba, Ramgopalpur, Jharkhali etc.
- Moderate (5 to 6) – Punjal, Bara Mullakhali, Chandimore, Majherpara etc.
- High and Very High (4 to 5) – Harabaidya, Jyotiramghat, Gobindapur, Arampur etc.

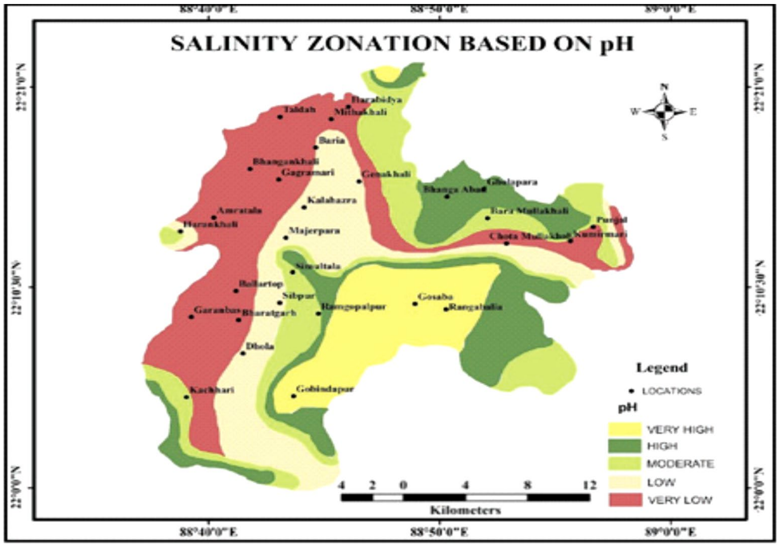


Figure 7: Salinity Zones at the Study Area (based on pH Level).

5.3.2. DERIVING SALINITY LEVEL WITH ELECTRICAL CONDUCTIVITY (DS/M)

Table 4: Electrical Conductivity and Sodium absorption ratio Of GCP Points

Places	Electrical Conductivity(ds/m)	SAR
Baria	1.72	199
Jharkhali	4.03	298.6
Bairam Chowranghee	0.13	9.73
Ramgopalpur	0.34	19.73
Simultala	0.91	194.2
Majherpara	0.71	40.1
Arampur	1.02	68.3
Gobindapur	1.06	42.6
Chandimore	1.72	241.4
Bara Mullakhali	0.34	22.44
jyotiramghat	2.06	44.8
Choto Mullakhali	1.5	253
Kumirmari	1.89	317.5
Punjal	1.02	190.2
Gosaba	4.22	253.8
Harankhali	3.12	30.2
Harabaidya	1.01	50.1

To measure the salinity status electrical conductivity method has been used. Salinity zonation map was made on the basis of EC using Arc GIS 10.6 software. Very high EC value concentration was found in Gosaba, Jharkhali, Harankhali, and Gobindapur. Low and Very Low EC values were in Bairam Chowranghee, Ramgopalpur, Simultala, and Bara Mullakhali. Various parameters like pH, Electrical Conductivity, Sodium Absorption Ratio has been obtained according to Indian Standard (pH <8.5 = Saline Soil, EC > 4 = Saline Soil, SAR < 13 = Saline Soil, SAR > 13 = Alkaline Soil).

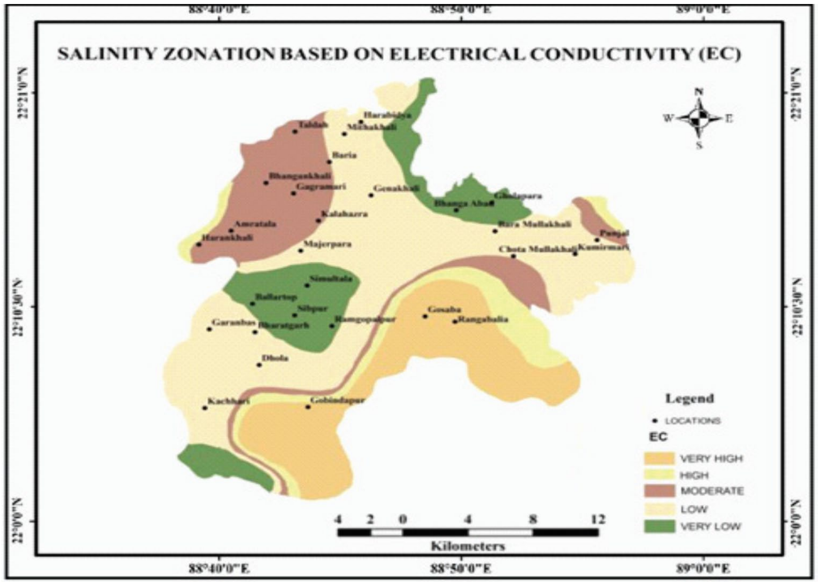


Figure 8: Salinity Zones at Study Area (based on Electrical Conductivity)

5.4. Climatic Factors

Fluctuation in rainfall and rise in temperature are the main causes behind climate change, which have various impacts on study area. Study reveals that increase in winter temperature creates higher evaporation rate from river surface. Also decreasing rainfall rate in dry season would result low flow situation in river. This will increase salinity level in near future. The study area receives average 475mm annual rainfall. Highest temperature (420c) recorded in month of May. Generally, June to September considered as rainy season, these are the main cropping period. But rain water can be store for dry season (mainly for paddy cultivation). Another important cause is intrusion of much tidal water in river. In dry season, when amount of rainfall decreases, the river fresh water recedes, which leads to increase in salinity level.

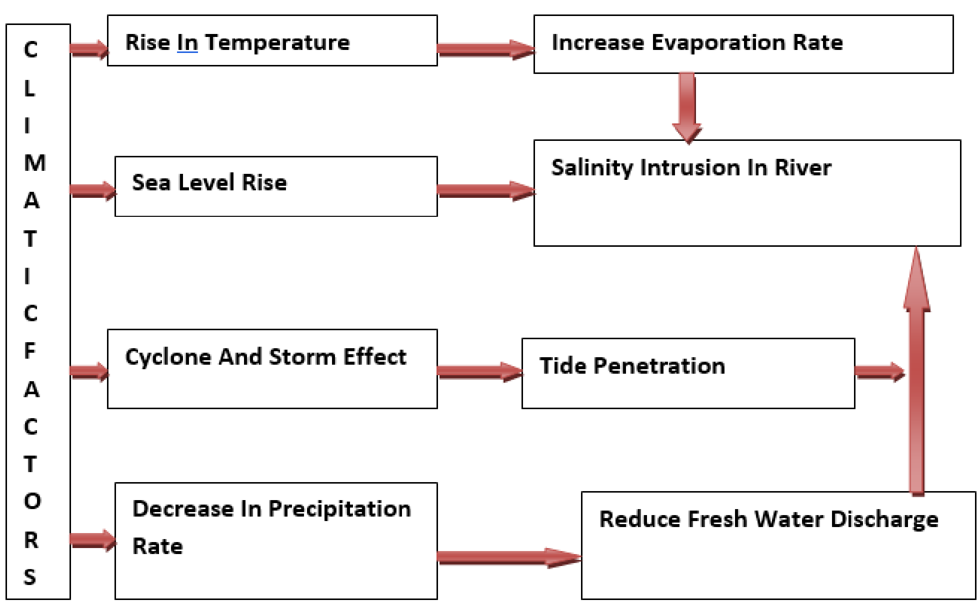


Figure 9: Simplification of salinity intrusion process.

6. IMPACT OF SALINITY IN RIVER WATER

Increasing salinity in river water leads to crop reduction, decline in industrial production, and decrease in forest species productivity and increase health hazards. This is the main cause of converting many agricultural lands into aqua cultural ground. Report also reveals that saline water has negative effect on domestic cattle (reduction in milk production and reproductive health).

7. IMPACT OF SALINITY ON AGRICULTURAL PRODUCTION

7.1. OSMOTIC EFFECT

Increasing salinity lowers the level of soil water potentiality and increase salt concentration at plant root. Thus, plant cannot extract adequate amount of water from surface. This osmotic effect reduces plant growth. Higher level of EC reveals that less water availability to plant. Current study shows that 1.84 ds/m EC in irrigation water is moderately saline, according to FAO (1992).

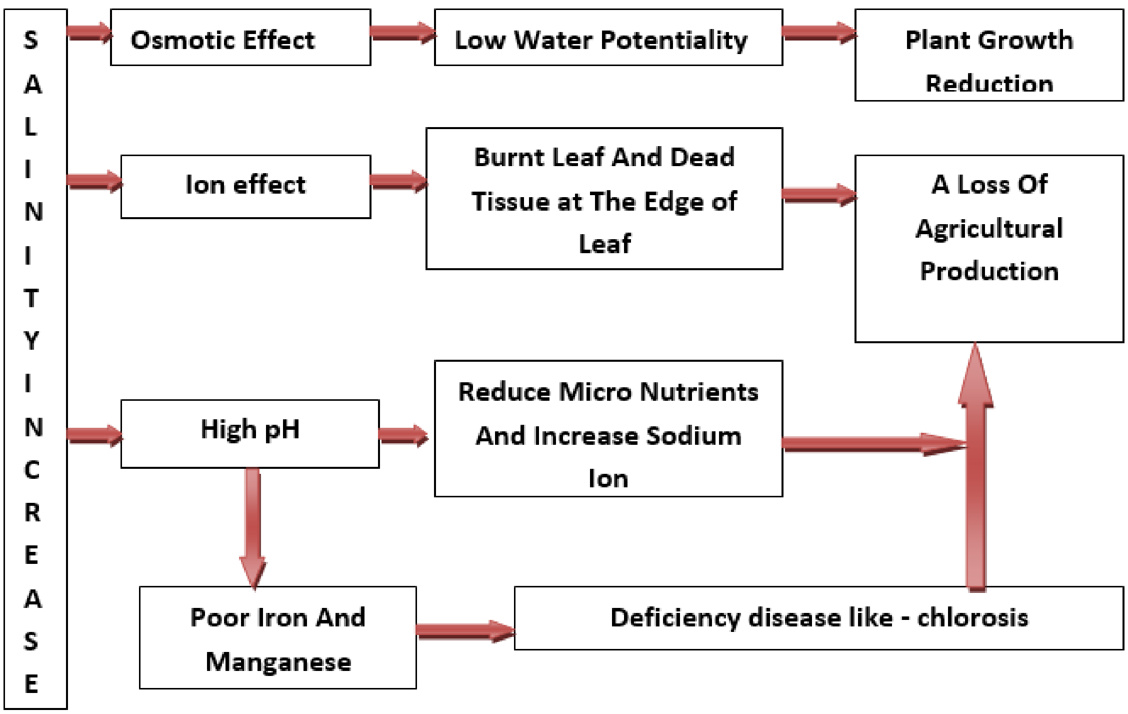


Figure 10: Effect of Salinity on Agricultural Production.

7.2. ION EFFECT

Higher concentration of Na and Cl may restrain plant growth. It causes burning leaf tip, reduce membrane function and hampers nutrient intake. This may happen either while the ions are extracted by the plant root or when get contacts with leaves. In this area, Cl concentration in irrigation water was measured as 435ppm (source: soil and salinity research centre, Canning), which reveals that crops are susceptible to ion effect.

Figure 11: Burnt Leaf and Dead Tissues at the edge of leaves

8. FARMER'S VIEWPOINT ON SALINITY

Survey was done among households, sharecroppers, who grow Aman and Boro crops (paddy, vegetables, pulses, oilseeds, spices). According to them, salinity effects more in dry season. Productivity has been decreasing for last 7 – 9 years. 10 % respondents argued that they facing fresh water crisis (drinking and irrigation), 28 % reported reduction in crop size and early yellowing of leaves. According to them, vegetables are more sensitive to salinity than cereals.

9. CONCLUSION AND RECOMMENDATIONS

The salinity level shows an increase trend in soil and surface water in the study area. Climate change, tidal water intrusion, storm surge – all are accelerating this salinization process. Higher pH incorporates deficiency of phosphorous, iron etc. Appropriate fertilizer should be applied to cope with this problem. Gypsum or Calcium sulphate could be applied to release Ca ion and replace Na ion. Deep water irrigation can also reduce the salinity some extent. Reduction in yield will affect the livelihood, income level, and food security of local people.

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CONFLICT OF INTEREST

The author have declared that no competing interests exist.

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