ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 11, Iss 13, 2022**

CRITICAL REVIEW ON SALT AFFECTED SOIL WITH SPECIAL REFERENCE TO WATER ENVIRONMENT

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ABSTRACT:

The term 'salt-affected soil' to refer to soils in which salts interfere with normal plant growth. Salt-affected soils can be divided into saline, saline-sodic and sodic, depending in salt amounts, type of salts, amount of sodium present and soil alkalinity. Salt-affected soils refer to the presence of excessive soluble salts, sodium ions, and sometimes a combination of both of them. The process of salt-affected soil genesis is a slow, but continuous process. The causes and sources of such soils are multiple and long studied to explain their actual origin and formation. Water environment means all surface water, groundwater and wetlands. Water for the environment is used to target specific outcomes for plants or animals by providing the right amount of water at the right time for them to feed, breed and grow. So, in this article critical review on salt affected soil with special reference to water environment has been discussed.

Keywords: Salt, Soil, Water, Environment

INTRODUCTION:

Salt-affected soils have a broad distribution and a rich variety of types in India, totally accounting for approximately about 1/10th of the entire land area of the country. Climatic conditions, landform and geomorphology, and agricultural practices are key factors influencing soil salinization in this country.

REVIEW OF LITERATURE:

According to P. Kumar and P.K. Sharma (2020), India will need about 311 million metric tons of food grains (cereals and pulses) in 2030 to feed roughly 1.43 billion people. By 2050, when India's population is predicted to be over 1.8 billion, the requirement is expected to rise to 350 million t. The country needs to make efforts to increase both the area under agriculture and crop productivity if it is to attain food security. Land holdings are becoming smaller as a result of the

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved**, **Volume 11, Iss 13, 2022**

pressure that widespread urbanization is exerting on agricultural lands. Hence, rehabilitating the damaged lands offers the chance of increasing the area under cultivation. Over 147 million hectares of land are affected by soil degradation, including 94 million hectares due to water erosion, 23 hectares due to salinity, alkalinity, or acidification, 14 hectares due to water logging or flooding, 9 hectares due to wind erosion, and 7 hectares due to a combination of factors brought on by various forces. To safeguard the nation's food security, the Indian government has set a goal of recovering 26 million acres of degraded lands by the year 2030, including soils impacted by salt. The country has 6.74 million acres of salt-affected land. According to estimates, every year around 10% more land becomes salinized, and by 2050, about 50% of the world's arable land will be contaminated by salt. 12 states and one union territory have 44% of their land covered by saline soils, whereas 11 states have 47% of their land covered by sodic soils. Many state agricultural universities and the ICAR-Central Soil Salinity Research Center are researching salt-affected soils and developing technology and techniques for remediation. Many cutting-edge technologies have been created and tested on farms. Some of the well-adapted technologies in the nation include gypsum-based sodic soil reactions, sub-surface drainage of water-logged saline soils, salt-tolerant crop types, and better agroforestry techniques. The recovery of 2.18 million hectares of salt-affected soils (2.07 million ha of barren sodic soils and 0.11 million ha of saline soils) has increased the nation's food production by more than 17 million metric tons annually, generating an additional Rs 15.5 billion in revenue and 2.8 million man-days of employment. Alternative land-use systems, saline aquaculture, the use of salt-tolerant crop varieties, agro-forestry, phytoremediation, and bioremediation, among others, are other technologies for managing salt-affected soils that have benefited women's empowerment, food and nutritional security, the employment of landless laborers, reducing rural migration, and other factors. Hopefully, the nation's food security will be maintained by the continual scientific efforts being made to manage and regenerate such soils. Government policies must be conducive to the use of rehabilitation technologies throughout the nation. [1]

According to T. Gopalakrishnan and L. Kumar (2020), soil salinity poses a serious danger to agricultural output, water availability, and coastal as well as arid and semi-arid parts of the world. This results in desertification and has a very severe impact on the environment. In these conditions, keeping an eye on salt buildup in the soil is essential to preventing land deterioration.

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In this study, soil salinity in Sri Lanka's semi-arid Jaffna Peninsula was estimated and mapped. On the basis of field measurements of soil electrical conductivity (EC) and Sentinel-2A satellite data, a partial least squares regression (PLSR) model was created. Based on the PLSR model and Sentinel 2A satellite imagery, the findings demonstrated that the soil salinity could be satisfactorily predicted (R2 = 0.69, RMSE = 0.4830). Overall, 32.8% of the land and 45% of paddy fields in the Jaffna Peninsula are damaged by salt. The results of this study suggest that PLSR is appropriate for mapping soil salinity, particularly in semi-arid areas like the Jaffna Peninsula. The findings support the significance of developing adaptive capacity and putting appropriate preventive measures into practice for sustainable land and agricultural management. [2]

According to A. Wudu and W. Mahider (2020), one of the issues with chemical soil deterioration that affects soil production in Ethiopia's lowlands is soil salinity. This study attempts to compile the concept, causes, scope, and management techniques of soil salinity effects soil production in Ethiopia's lowlands is soil salinity. This study attempts to compile the concept, causes, scope, and management techniques of soil salinity. The issue of soil salinity, which is getting worse, is a problem for agricultural activity in Ethiopia's lowlands (cultivated plains). To adjust acid saline and increase yields of the crops of their choosing, farmers need quick and sustainable approaches. With new discoveries like gypsum, the use of salt-tolerant crop cultivars, integrated soil fertility management, and the use of organic fertilizers, recommendations on recreating saline soils need to adapt. Gypsum has been crucial in bringing down soil salinity and raising agricultural output. Because of the salinity of the soil and the consequent nutrient availability, the difference between Ethiopia's potential and actual output is very large. The use of inorganic fertilizers on saline soils without additions is ineffective and a waste of resources. To increase agricultural production and consequently sustain yield increases, it is essential to establish effective and efficient saline soil management strategies. The scope, causes, and management of soil salinity are the main topics of this review, as well as how it affects agricultural yield and soil fertility. Also, it offers crucial details on management alternatives for reducing soil salinity and enhancing soil fertility overall, as well as additional organic amendments that can be used to reduce soil salinity to the required level of electronic conductivity and enhance soil quality. The

ISSN PRINT 2319 1775 Online 2320 7876
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stability of yields is improved, and nitrogen utilization efficiency is maximized by integrated saline soil management. [3]

According to A. Hassania et al. (2020), understanding the spatiotemporal distribution and likelihood of (re)occurrence of salt-affected soils is essential for planning successful remediation measures in the face of upcoming climate uncertainty. Predictions on a global scale are challenging since standard methods for measuring the variations of soil salinity are highly localized. Here, we use machine learning techniques to create models that can predict soil salinity and sodicity at various longitudes, latitudes, soil depths, and time scales. Soil salinity is expressed as the electrical conductivity of saturated soil extract, and sodicity is measured as the soil exchangeable sodium percentage. We provide a global-scale quantitative and gridded dataset defining several spatiotemporal aspects of soil salinity and salinity fluctuation over the past four decades at a resolution of roughly one kilometer using these predictive models. In non-frigid zones, 11.73 Mkm2 of soil have had salt damage with a frequency of reoccurrence in at least three-fourths of the years between 1980 and 2018, 0.16 Mkm2 of which are croplands, according to the analysis of this dataset. The continents with the highest salt-affected areas are Asia (especially China, Kazakhstan, and Iran), Africa, and Australia, despite the fact that the total area of salt-affected soils and the net increases in soil salinity/sodicity have been geographically highly diverse. The spatiotemporal variability of additional dynamic soil variables, such as soil nutrients, organic carbon content, and pH, can also be quantified using the suggested method. [4]

According to S. Bhardwaj et al. (2020), the objective of the current study is to compare the soil quality of several Haridwar regions using physicochemical and heavy metal indices. In order to achieve the study's goals, soil sampling was done in the forest (the study's control site), industrial, residential, and agricultural areas in and around Haridwar. Several physicochemical and heavy metal characteristics were examined in soil samples. In comparison to other sites, the industrial area had the highest values for all of the measured soil parameters, including temperature (16.63 to 21.640C), soil moisture (13.05 to 28.39%), soil porosity (37.56 to 49.03%), water holding capacity (36.22% to 43.58%), conductivity (0.25 to 0.40 Mhos/cm), and chloride (16.67 to 53.97 mg/gm). Throughout the course of the investigation, all the metrics at all

ISSN PRINT 2319 1775 Online 2320 7876
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the locations showed an upward trend; this could be because of the discharge of industrial solid waste and effluent. The soil quality was not adversely affected, but continual dumping will have detrimental effects because of the buildup of pollutants. In order to manage the massive amount of industrial waste, safe and appropriate disposal and usage strategies are required. Cadmium was not present during the study period, but other heavy metals such as copper (0.050 to 0.055 mg/g), manganese (0.232 to 0.242 mg/g), nickel (0.035 to 0.036 mg/g), lead (0.039 mg/g), and iron (1.19 to 1.22) were all identified in greater concentrations. [5]

According to Z. Noreen et al. (2020), salt is a naturally occurring element in both soil and water. Natural processes like weathering or the mineral phase-out of an ocean can cause salinization. Moreover, artificial methods like irrigation can be used to produce it. The degradation of land due to salinity, sodicity, or a combination of the two is one of the main factors limiting global agricultural productivity. The majority of salt-affected soils are found in arid and semi-arid regions. 800 million hectares (mha), or 5–6% of the world's total land area, are impacted by salt. Although salt-affected soils are an issue, their severity has grown as a result of ineffective management strategies and unsuitable amelioration techniques. The leaching requirements of the soil in the lysimeter at the field site of the water management research center were computed while keeping in mind the salinity issue in the soils of Pakistan. The application of irrigation was based on the soil's need to drain the salts out of the soil through leaching. In comparison to tubewell water, which yielded 4.33 tons/ha, the canal water output was high at 4.99 tons/ha. The actual and modelled data were compared using the ANSWER model. In comparison to tubewell water yield, the R2 value for canal water yield was high (0.892). The measurements of evapotranspiration were also obtained using the water balance equation, and the findings revealed that the tubewell water ET was higher than canal water because more water was used to leach down the salts, which resulted in more water evaporating as well as compared to canal water. Because there were more salts in the tubewell water than in the canal water, there was a greater amount of leachate produced from the tubewell water as compared to the canal water. [6]

According to S.D. Shuvo et al. (2020), the goal of this study was to assess the effects of soil and water salinity on dietary practises and health risks in Bangladeshi coastal residents. A straightforward random selection technique was used to conduct this study among 240 respondents in rural coastal sub-districts of Bangladesh's Khulna and Patuakhali. A multinomial

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logit regression analysis was carried out to assess the relationship between salinity exposure categories and health risk, and statistical significance was set at p 0.05. Radish, potato, bean, bitter gourd, rice, shallow tube-well, and pond water from Patuakhali had a considerably greater salt (NaCl) level than water from Khulna. Men and the age groups 20–35 years (RRR:0.57, SE:0.18) and 36–50 years (RRR:1.89, SE:0.58) and 51–65 years (RRR:4.51, SE:1.81) were more likely to have hypertension than females. Rice with a high salt content (RRR:1.36, SE:0.50), vegetables with a high salt content (RRR:1.09, SE:0.09), fish with a high salt content (RRR:2.77, SE:0.47), and use of table salt (RRR:1.05, SE:0.03) were all significantly linked with risk factors for hypertension (p 0.01). Priority must be given to a sustainable strategy for salt reduction through dietary changes, as well as the promotion of low-salt foods and beverages, with a focus on coastal locations [7].

According to S. Arora and B.P. Singh (2020), with a total area of 24.09 million ha and a population density of 830 people per square kilometre, Uttar Pradesh is India's fifth-largest state in terms of land area. The majority of the state's 16.8 million ha of arable land is used for agriculture, making it the most common occupation. The state's overall geographic area, or close to 52.12% of it, is impacted by various soil degradation issues, mostly brought on by human activity. The most important issue is water erosion, which affects 11.39 million hectares (ha), or 38.69 percent of the whole area, including ravaged lands near rivers. Wind erosion has been noted in 2.12 million hectares (ha), or 0.72 percent of the entire geographical region. Flooding, wind erosion, and soil salinization affect, respectively, 4.65, 0.72, and 7.98% of the state's land area. [8]

According to A. Kabir et al. (2020), Bangladesh is one of the nations that is most susceptible to the effects of climate change. Agricultural sustainability, food security, natural resources, and rural life patterns are all seriously impacted by climate change. The study looks into how farmers in Bangladesh's coastal region perceive climate change and how they have modified their agriculture. A survey of 200 households was done in the Satkhira and Barguna districts. The study found that farmers understood the effects of climate change and had noticed an increase in temperature, rainfall, the frequency of cyclones, the severity of floods, etc. over time in the study area. Farmers believed that the change in temperature and rainfall was to blame for an increase in weed and pest infestation, disease outbreaks, and pesticide use. The main environmental issues in

ISSN PRINT 2319 1775 Online 2320 7876
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the research area were recognised as water logging, cyclones, river erosion, and salinity. Yet, the study found that farmers have used 28 adaptation measures to lessen the effects of climate change. The most frequent adaptation measures included crop diversification, the introduction of new crops that can withstand climatic stress, crop rotation, mix cropping, changing the dates of planting and harvesting, shortening the growing season, homestead gardening, the use of organic fertilisers and pesticides, increased irrigation, various soil conservation techniques, and income diversification. Regression analysis results revealed that the farmers' socioeconomic traits (age, education, farming status and experience, farm revenue, etc.) and perceptions of climate change affected their decision to use various adaptation techniques. Although lack of experience and knowledge, agricultural extension services, input availability, and lack of finance facilities were highlighted as the key problems in the area, the adaption strategies were commercially profitable as well as agriculturally sustainable. [9]

According to N.P. Singh et al. (2019), it is well known that agriculture is vulnerable to climate shocks and that this has an impact on farm livelihoods and food security. The road to sustainable development must include integrating climate adaptation into the political system. The strategy aims to implement development interventions for rural poor and small farm owners from a grass-roots and climate viewpoint. Although while macro-level planning is important and valuable, it is also important to offer micro-level solutions for surviving in various socioeconomic and agro-climatic contexts, particularly in developing countries. Farmers with little resources frequently find it difficult to adapt to weather irregularities because of a number of obstacles. In order to inform the government's policy alternatives, we made an effort to analyse potential agricultural solutions with a stronger emphasis on obstacles to adaptation. According to the authors, planning for climate adaptation should take into account micro-level conclusions from the management of natural resources, agricultural research and development, infrastructure, and human capital globally. The research also demonstrates how the development initiatives dispersed across many governmental spheres might jointly address the issues of rural development and climate adaption. Additionally, it is believed that enhancing local institutions' roles and capacities in gathering information from the ground up and in carrying out programmes is essential for managing vulnerability to both climatic and non-climatic causes. In a nutshell, the paper's goal is to help development practitioners and policymakers come up with a practical strategy for

ISSN PRINT 2319 1775 Online 2320 7876
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mainstreaming climate adaptation in the framework for rural development that already exists. [10]

Salinity-related land degradation is posing a significant threat to the food, nutritional, and environmental security of developing countries, according to G. Singh (2019). The salinity issue in coastal areas is projected to worsen as a result of predicted climate change-induced glacier melting and consequent rise in sea level. According to recent estimates, soil salinity and alkalinity have an impact on about 6.74 million hectares of land in India. In around one-fourth of the nation's total land area, there is subsurface water of poor quality that is used to irrigate agricultural crops. Also, with increased irrigation in dry and semi-arid regions without sufficient drainage plans, the salinity problem is getting worse. Throughout most of the country's canal command areas, a rise in the water table of 30 to 100 cm per year is observed. By 2025, more than 11 million hectares of otherwise productive land will have a salinity problem, posing a severe threat to the nation's ability to feed itself and its citizens. This situation will be difficult to handle without effective management measures. In several parts of the country, research and development are being done to reclaim and manage soils that have been damaged by salt. It has already been possible to reclaim almost 2 million acres of land that was formerly irrigated with saline or sodic water, contributing more than 15 million tonnes of food grains to the national supply. For the management of salinity when resources are scarce, alternative techniques to mechanical and chemical modes of recreation focused on biological ways have also been explored. Variety of rice, wheat, and mustard crops have been developed for use in soils with high salt contents. Numerous high-value aromatic and medicinal crops, including halophytes, have been identified as being salinity and alkalinity tolerant, and cultural and agronomic practises have been standardized for cultivation in salinity-rich soil and water environments without the use of mechanical or chemical methods of amelioration. This document reviews a quick summary of the technologies that have been developed, those that are in development, as well as the reclaimed land and future targets. Under the subheads of nature, distribution, and extent of salt affected soils and waters in India, sodic (Alkali) soil recovery by amendments, drainage including sub-surface and bio-drainage for managing saline waterlogged soils, salt tolerant crops and varieties, bio-saline agriculture, social economic perspectives and constraints, future policy for research and development, the information is discussed. [11]

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According to S.A. Shahid et al. (2018), it is well acknowledged that soil salinity has risen over time. Moreover, it is brought on by the effects of climate change. Prior to implementing the appropriate intervention measures, a good diagnosis of the soil salinity is crucial for its sustainable maintenance. To make things easier for readers, the concepts of soil salinity (dryland and secondary) and sodicity have been introduced in this chapter. A fictitious cycle for the development of soil salinity has been provided. Visual markers of soil salinization and sodicity, socioeconomic and environmental effects, and causes of soil salinization and its harms have all been documented. The US Salinity Laboratory Staff's 1954 relationship between ECe (mS/cm) and total soluble salts (meq/l) has been reported as a new relationship that was established on UAE soils. This suggests the 1954 relationship is unique to US soils, and other nations should establish comparable relationships based on their local conditions. Methods for measuring soil salinity and sodicity in the field are given, and variables that convert distinct soil: water (1:1, 1:2.5, and 1:5) suspensions to ECe from various regions are listed. This information is helpful for individuals who choose to employ these methods. Numerous salinity assessment, mapping, and monitoring techniques have been used, including traditional (field and laboratory) and modern (electromagnetic-EM38, optical-thin section and electron microscopy, geostatistics-kriging, remote sensing and GIS, automatic dynamics salinity logging system), and the results have been reported, providing comprehensive information for potential users to choose the most appropriate techniques. [12]

According to M. Salehin (2018), evaluating the soil salinity in the delta is essential because it is the primary factor affecting crop productivity. Climate variability, saline river water inundation, storm surge inundation, depth to groundwater table, groundwater salinity, and prawn farming are only a few of the interrelated factors that affect soil salinity (Bagda). In the research area, the soil salinity appears to be mainly affected by tidal river salinity, especially in the south-west of the delta. High groundwater salt levels and a high groundwater table are key causes of soil salinity in northern regions. Moreover, a rise in irrigation water salinity during the dry season is anticipated to result in a rise in salt accumulation in soils, with a salinity of irrigation water surpassing five parts per thousand being a possibility. [13]

Soils are essential for the main ecosystem services and crop production, according to L. Canfora et al. (2017). They safeguard and support life. One of the biggest risks to soil that lowers soil fertility and affects crop yield is salinity. The widespread lack of arable land and the rising need for ecological restoration in places affected by secondary salinization processes have received a lot of attention recently. Microorganisms in these ecosystems may have a common strategy, have evolved a variety of adaptations to support populations, and eventually adapt to harsh environmental conditions by acting altruistically or cooperatively to support the survival of their community. It's necessary to develop novel restoration strategies for soils impacted by salt, and it can be useful to comprehend and know the composition and distribution of microorganisms in natural ecosystems for ecological reasons. [14]

According to H. Elbasiouny et al. (2017), soil is crucial to both human health and environmental quality. Thus, it is crucial to improve soil quality and its ability to function within the constraints of ecosystems and land use. For the purpose of tracking changes in soil quality, it is crucial to measure changes in soil attributes. Although the idea of soil quality is evident, there isn't much agreement on how to evaluate it due to the various functions of soil and interactions among its components. By employing soil attributes as indications or a quantifiable alternative about how well the soil performs with respect to a certain function, soil quality can be determined. The identification of an effective technique to evaluate soil quality necessitates the integration of soil attributes through the establishment of minimum data sets (MDS). Every soil type and function has a unique MDS. Salinity should be an indicator in MDS for soils in dry and semi-arid regions but not for those in humid climates. To evaluate the soil status and select an effective technique for improving soil quality, the synthesis of soil quality indicators into an acceptable index is crucial. Salt-affected soils have been degraded and have low economic yields in arid and semi-arid areas. Some 75 countries have salt-affected soils, which account for at least 20% of all irrigated land on the planet. Because the restoration of these soils results in increased production, improved environmental quality, and soil carbon sequestration, it is vital to build MDS to evaluate and improve the quality of these soils. [15]

The purpose of this study, according to A. Bannari et al. (2017), is to map the salt-affected soil in an arid environment using an advanced semi-empirical predictive model, operational land imager (OLI) data, a digital elevation model (DEM), field soil sampling, laboratory and statistical

ISSN PRINT 2319 1775 Online 2320 7876
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analyses, as well as OLI data. In order to accomplish our goals, the OLI data were corrected for atmospheric effects, radiometric sensor drift was calibrated, and topographical and geometric distortions were addressed using a DEM. A semi-empirical predictive model based on the Soil Salinity and Sodicity Index-2 was then used to produce the soil salinity map (SSSI-2). The Transformed Differential Vegetation Index was used to produce the vegetation cover map (TDVI). Moreover, a 5-m-pixel-precise DEM was employed to generate topographic characteristics (elevation and slope). In order to verify the semi-empirical model's capacity for mapping moderate and strong salinity in an arid environment, visual comparisons and statistical validation of the model using ground truth were conducted. 120 soil samples with varying salinities, including non-saline soil samples, were obtained during fieldwork to complete this stage. A digital camera, a precise global positioning system (GPS) survey (30 cm), and a real-time connection to the geographic information system (GIS) database were used to automatically name each one. The sodium adsorption ratio (SAR) was then computed in the lab after the major exchangeable cations (Ca2+, Mg2+, Na+, K+, Cl-, and SO42-), pH, and electrical conductivity (EC-Lab) were extracted from a saturated soil paste. For statistical analysis and validation, the EC-Lab, which is usually regarded as the most efficient method for quantifying soil salinity, was utilized. The acquired results showed a very high degree of agreement between the ground truth and the soil salinity map created from OLI data, highlighting six salinity classes: extreme, very high, high, moderate, low, and non-saline. The chemical analyses performed in the lab support these findings. With a correlation coefficient (R2) of 0.97, an index of agreement (D) of 0.84 (p = 0.05), and a low overall root mean square error (RMSE) of 11%, the semi-empirical predictive model additionally offers good overall results in comparison to the ground truth and laboratory analysis (EC-Lab). Also, we discovered that topographic features significantly affect salinity's spatial distribution. Areas with hard bedrock and a relatively high height are less prone to salinity, whereas locations with Quaternary soil and a low altitude and slope (2%) are. The water table is quite shallow (1 m) in these low locations, and the lack of an effective drainage system greatly increases waterlogging. As a result, the high temperature and high evaporation rates, along with the intrusion and emergence of seawater at the surface, significantly contribute to the soil salinity in the studied area. [16]

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According to A. K. Mandal et al. (2016), poor-quality groundwater and low soil salinity or alkalinity are the two main factors reducing productivity in the dry and semiarid region of the TransGangetic plain of Central Haryana, which includes the Kaithal district. The presence of salt-affected soils was visually discernible from Resourcesat LISS-III data during the seasons of March, May, and October 2009 when compared to planted areas in the irrigated zones. Strongly sodic or salinized soils were first identified by their white to yellowish tones with high reflection from salt crusts on the bare soil surface. The existence of slightly to moderately salt-affected soils was suggested by the mixed signs (yellowish white and red mottling) of salt stress and patchy crop stands, which are authenticated by ground truth analysis. The lack of natural drainage made it easy to spot waterlogging for stagnant water bodies in irrigated areas since the higher energy absorption in the March and November data showed dark blue/black to gray colors. In the midst of the farmed regions, salt-affected soils with low permeability, infiltration, and hydraulic conductivity also displayed comparable signs. Long-term usage of subpar groundwater encouraged salt buildup in irrigated regions, which was visible in the satellite images as mixed spectral fingerprints (greyish red to reddish white tones). In the research area, it is typical to find sodic (an alkali soil dominated by sodium and carbonate salts) and saline (neutral salts dominated by chloride and sulfate salts) soils. Saline soils were dispersed in the southern part of the Kaithal district, covering the Kalayat (2.6%) and Rajaund (1.3%) blocks, whereas sodic soils were distributed in the northern and central regions, covering the Pundri (2.1%), Kaithal (3%), Guhla (1.1%), and Siwan (1.1%) blocks. The subsurface soils on the Ghaggar plain's fine texture (clay to clay loam) hindered natural drainage, which fostered the development of waterlogging and sodicity. Strongly sodic soils frequently contain precipitated calcium carbonate concretions (calcareous layer), which hinder salt and nutrient flow as well as root penetration. In the Kaithal district, a total of 26301 ha (11.3%) are impacted by salt, of which 17570 ha (7.3%) and 9388 ha (4%), respectively, are covered by sodic and saline soils. Saline in the east at Kalayat block (Sodium Adsorption Ratio (SAR) of 33.6), sodic (pH 9.2) in the middle portion of Kaithal block, and also demonstrating high RSC (6.5 meL/1) in selected samples, the groundwater quality was sodic in the north of Kaithal district (Guhla block). Appropriate restoration and management strategies were also recommended based on the physico-chemical properties of the soil and the quality of the groundwater. [17]

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved**, **Volume 11, Iss 13, 2022**

According to M. Parihar and A. Rakshit (2016), irrigated parts of the broad middle Indo-Gangetic alluvial plain with shallow water table depths and hot, dry moisture regions are where salt-affected soils are most prevalent. Two of the key limits in these irrigated agricultural areas are soil salinity and alkalinity. The problem of salinity and alkalinity gets worse every year as a result of secondary salinization, and as a result, fertile, productive land is slowly losing its productivity. The Varanasi district of Uttar Pradesh has been chosen as the focus location for this research project. The study region is a portion of the enormous alluvial plains commonly referred to as the Indo-Gangetic lowlands. The research area, which spans 1,535 square kilometers and is located in the hot, semi-arid ecoregion 4.3 between geocoordinates 25° 18" N and 83° 03" E, is a portion of the huge Indo-Gangetic alluvial plain with sandy soil and little rainfall. According to the findings, the soil reaction is slightly too alkaline. According to reports, the organic carbon ranged from 0.11 to 0.88%. Alkali soils with high pH are lacking in both soluble and exchangeable calcium, according to saturation extract analysis, where sodium ion was found to be the major cation, followed by calcium, magnesium, and potassium. [18]

According to P.K.R. Shrivastava (2015), salinity is one of the harshest environmental variables affecting agricultural plant productivity because the majority of crop plants are susceptible to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is growing every day. Average yields for all significant crops are typically only 20% to 50% of record yields, with the main causes of these losses being drought and excessive soil salinity, which will become more prevalent in many areas as a result of global climate change. To deal with such repercussions, a variety of adaptations and mitigation measures are needed. Salinity stress can be reduced through effective resource management and crop and livestock improvement for the development of superior breeds. Yet, because such solutions are time-consuming and expensive, it is necessary to create straightforward, low-cost biological techniques for managing salinity stress that may be applied temporarily. If we take advantage of the special abilities of microorganisms, such as their tolerance to saline conditions, genetic diversity, ability to synthesize compatible solutes, ability to produce hormones that promote plant growth, potential for biocontrol, and interaction with crop plants, they could play a significant role in this regard. [19]

IJFANS International Journal of Food And Nutritional Sciences
Official Publication of International Association of Food and Nutrition Scientists

ISSN PRINT 2319 1775 Online 2320 7876
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This research analyzes the anticipated effects of climate change, climate variability, and saline accumulation on food production in coastal Bangladesh during the dry season, according to D. Clarke et al. (2015). This is part of a coordinated set of initiatives on agriculture and salinity in Bangladesh under the British Council's INSPIRE program and the UK-funded Ecosystems for Poverty Alleviation program. The work was done by creating simulation models for soil water balances, the need for irrigation during the dry season, and the efficiency of rainfall during the monsoon season at leaching accumulated salts. Historical climate data and a daily climate data set based on the Met Office Hadley Center HadRM3P regional climate model were used to run simulations from 1981 to 2098. According to the findings, inter-annual and inter-seasonal variability are major determinants of how successfully dry-season vegetable crops can be grown. By the end of the twenty-first century (2014), it is anticipated that the dry season will last 2-3 weeks longer than it does currently. The length of the rainy season will be a little bit shorter, but monsoon rainfall levels will stay the same or potentially even slightly rise. By the end of the twenty-first century, dry-season irrigation water is likely to become more salinized due to predictions of sea level rise and increased salt intrusion into groundwater aquifers. According to a study done in Barisal, irrigation with water at up to 4 ppt can be sustainable. The lives of farmers in this region are in danger whenever the quality of the irrigation water used during the dry season rises above 5 ppt because the monsoon rains are unable to remove the salt deposits left over from the dry season, leading to major salt accumulation. [20]

According to F. Ndamani and T. Watanabe (2015), this study assessed the farmer's perception of the significance of adaptation techniques to climate change and looked at the obstacles to adaptation. Investigations were done into people's perceptions of the causes and consequences of long-term changes in climatic factors. In the Lawra district of Ghana, 100 farmer-households were chosen at random from four settlements. Semi-structured questionnaires and focus group talks were used to collect data (FGDs). According to the findings, 87% of respondents thought that rainfall had decreased during the previous ten years, while 82% thought that temperatures had risen. The study found that, rather than floods, adaptation was mostly a reaction to dry spells and droughts (93.2%). In response to climate change, almost 67% of respondents have changed how they farm. The weighted average index analysis' empirical findings revealed that farmers ranked irrigation and better crop types as the two most crucial adaptation methods. It also

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showed that farmers lacked the skills necessary to put the highly regarded adaptation strategies into practice. According to the analysis of the problem confrontation index, the most significant obstacles to adaptation were the unpredictability of the weather, high input costs for farming, restricted access to meteorological data, and a shortage of water resources. The creation and execution of government policy will be made easier with the aid of this analysis of adaptation techniques and restrictions at the farmer level. [21]

CONCLUSION:

Soils that are influenced by salinity are those that have high levels of soluble salts, sodium ions, or occasionally a combination of both. Soil genesis influenced by salt is a gradual yet ongoing process. To explain the true genesis and production of such soils, a variety of long-studied reasons and sources have been identified.

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