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ASSESSMENT OF SOIL SALINITY CONDITION IN DADINKOWA IRRIGATION PROJECT, YAMALTU DEBA, GOMBE STATE, NIGERIA.

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Abstract

The savanna soil is vulnerable to salinity problems due to insufficient rainfall to leach down the soluble salt, which consequently affect the quality of soil and its productive capacity. The aim of the study is to assess the soil salinity condition of the study area. Grid survey method was used for the collection of 30 soil samples from 0-30cm depth. The soil parameters were assessed for pH, EC, SAR, ESP, CEC, and Exchangeable Cations (K, Mg, Ca and Na) using standard laboratory procedures. One hundred and eight (108) copies of questionnaire were used to find out the system of farming and soil salinity management adopted in the study area. The Results shows that Furrows (surface irrigation) system is the system adopted by farmers in the area. The mean values of soil salinity indices were EC (1.18dS/m); ESP (1.19cmol/kg); SAR (0.17cmol/kg) and pH (6.5). The soil salinity status was found to be low. Crop rotation, use of organic manure and incorporation of farm residue were the major management practices adopted in the area. The crops grown in the area were not affected by salinity probably because the salinity level was found to be low. Use of PVC pipes was recommended to avoid future salt accumulation in the soil since continuous use of furrow system may dissolve the soluble salt in the soil and gradually accumulate to build up salinity in the soil.

Keywords: Assessment, Dadinkowa, Irrigation project, Soil, Salinity,

1. Introduction

The term salinity commonly refers to solutions in which sodium ions predominates. The most prominent anion is usually chloride. When plants use water, the salts left behind in the soil eventually begin to accumulate. Since soil salinity makes it more difficult for plants to absorb soil moisture, these salts must be leached out of the plant root zone by applying additional water (Kumar *et al.*, 2017). Salinity is defined as the concentration/amount of dissolved mineral salts in water and soil-water as a unit of volume or weight basis (Philip, 2014). Salinization is the accumulation of mineral salts; Sodium, Calcium and Magnesium in the top layers of the soil, including the root zone (Adams, 2014). Soil salinization is the process of salts accumulation in the soil surface and in the root zone, which causes harmful effects on plants and soil; it follows a decrease in yields, ultimately, soil sterilization. It reduces the area of farmlands by 1 to 2% per year and continues to increase (Rachid *et al*., 2014). Salinity may harm crops in different ways; it reduces uptake of water due to increased osmotic pressure of the soil water resulting from the increased concentration of salts. Salinity creates imbalance in uptake of essential mineral elements. Accumulation of salts especially sodium ions in root zone may be toxic. Excessive salts act as an environmental stress and decrease plant growth potential. Salinity decreases the rate of seed germination, growth and development of plant, photosynthesis per unit leaf area and the utilization of photosynthesis in growth of plant (Kumar *et al*., 2017).

In some countries, salinization may even threaten the national economy. This is particularly the problem of Argentina, Egypt, India, Iraq, Pakistan, Syria and Iran (Rachid *et al*., 2014). The salinity and alkalinity of agricultural lands is influenced by climate, topography, groundwater level and quality of irrigation water (Ali and Fereydoon, 2012). The most common reasons of salinity and alkalinity are low precipitation, high evaportranspiration and low quality of irrigation water. Saline soils contain soluble salts in sufficient quantities to interfere with the growth of most crop plants but they do not contain enough exchangeable sodium to alter soil characteristics (Ali and Fereydoon, 2012).

Soil salinization is a major driver of land degradation, which usually goes hand in hand with accelerated soil erosion rates, agricultural mismanagement, overgrazing, mining, and deforestation (Gomez-Acata *et al*., 2015). Soil salinity is a serious threat to global agriculture. About 20% of the world's cultivated area and nearly 50% of the irrigated croplands are affected by soil salinity (Devkota *et al*., 2013).

Salinization of soils is a consequence of both natural processes and human interference (Oo *et al*., 2015). Salinity particularly affects arid and semi-arid regions. Globally, about a third of all agricultural lands are increasingly saline, encompassing more than 100 countries and spanning all types of climate. While statistics vary on the extent of salt-affected areas, estimates suggest that close to 1 billion hectares worldwide are salinized, including 77 million hectares salinized because of human activity (Squires and Glenn, 2004). Soil salinization is spreading at a rate of up to 2 million hectares per year, offsetting a significant proportion of crop production (Rachid *et al*., 2014). About 1–2% of the irrigated areas in dry land regions become unsuitable for crop production for some fraction of the year due to salinity (Devkota *et al*., 2013). Salinity and alkalinity are two major problems of agricultural production in arid and semi-arid regions are threatening sustainable agricultural management (Ali and Fereydoon, 2012).

Poor irrigation agriculture in arid and semiarid regions results land degradation through soil salinity and sodic soil developments in different parts of the world. Hence, the study of arid lands and salt affected soils has been an important topic for modern agricultural management and particularly for a country like Nigeria were agriculture formed the second backbone of its economy while arid and semi-arid climatic zones occupy over 60% of the total land area (Awulachew *et al*., 2007).

To keep track of changes in salinity and anticipate further soil degradation, monitoring of soil salinity is essential so that proper and timely decisions can be made. At spatial scale, salinity monitoring allows detection of areas with greatest irrigation impact and delimitation of vulnerable zones where special attention is required for soil conservation (Nunes *et al.*, 2007). To avoid or reduce the risk of salinization, it is important to monitor the soil salinity and keep it below the plant salinity tolerance threshold (Bouksila *et al*., 2006). Olofin (1987) in Adamu (2011) recommended the prevention of water logging and erosion in soil by monitoring all irrigated fields on permanent basis.
The necessity for regular investigation of soil in order to evaluate their quality is due to the simple fact that land-use can change the capacity of the soil to function effectively (Samuel, 2009). Soil deterioration due to irrigation has led to the failure of many schemes that were started in many developing countries (Adamu, 2011). United Nations, (1975) estimated that the amount of land ruined by irrigation equals, if it does not in fact exceed, that of potentially irrigable lands. One third of all irrigated lands face salinity problems. Similarly a salinity survey of the major irrigation schemes in northern Nigeria by Murya (1979), in (Adamu, 2011), showed that all sample plots were either saline or alkaline.

Because of the erratic pattern of rainfall, both large and small-scale commercial farms use rivers, boreholes and other sources of water for irrigation without paying attention to their quality and impact on soil and crop losses. In as much as the quantity of water required meeting the demand of crop is vital, so is the quality and condition of soil under irrigation. From available literature to the researcher, no detailed study on the effects of soil and irrigation water salinity has been documented in the study area. This is probably because the damaging effects are often not immediate but comes with the continuous accumulation of salts. Moreover, investigation regarding the irrigation water quality and its suitability for crops is still lacking in the study area. It is against this background that this study assessed the salinity status of soil in Dadinkowa irrigation project in order to facilitate appropriate irrigation agriculture and to prevent foreseen future soil salinity and crop losses due to salinization and enrich irrigation water management for ecological sustainability.Because high yields are essential, most modern agriculture depends upon the continued addition of chemical fertilizers to the soil, which may cause uneven combination of soil nutrients if only applied without the knowledge or idea the particular soil properties and composition (Eziashi, 2008). The outcome and recommendations of the study will therefore provide guideline documentations on irrigation soil and water quality and measures to put in place to prevent land degradation due to salinity and or sodicity and crop losses thereby ensuring food security and possibly eradicating poverty in the study area. Therefore, the study also serves as a stepping-stone in contributing to strategies to reduce and protect the environment from further degradation caused by salinity and/or sodicity in order to ensure ecological sustainability (Philip, 2014). Finally, this research will be beneficial to farmers, local, district, country, and national governments as it is a base line data for further studies on policy intervention formulation and implementation, monitoring and evaluation in issues of irrigation soil and water quality in Dadinkowa irrigation project. Hence the aimed at assessing salinity pattern and condition of soil in Dadinkowa irrigation project.

2. STUDY AREA

2.1 Location and extent of the Study Area

The irrigation project is located in Dadinkowa town, about 35km away from the capital of Gombe state, along Gombe-Biu road, Yamaltu-deba L.G.A, Gombe state, Northeastern Nigeria. It Lies on Latitude 10˚ 17'N and 10˚18'N, Longitude 11˚ 30'E and 11˚ 32'E, (Fig.1) and on an altitude of 218 meters above sea level.Dadinkowa irrigation project is one of the irrigation schemes under the Upper Benue River Basin Development Authority (UBRBDA) established by the Federal government of Nigeria. The source of water is the Dadinkowa dam, which was built since 1984 to provide hydropower, irrigation and water supply to the Northeastern region of Nigeria (Ja'afaru and Abubakar, 2012). It has a total of about 424ha of farmlands presently under cultivation by participating farmers who are registered under the area office. The Authority's extension staffs are always around to render services to farmers during the operation period. The scheme also has a drawback area that comprises of irrigation farmland, grazing land and fishing activities at the reservoirs (UBRBDA, 2017.)

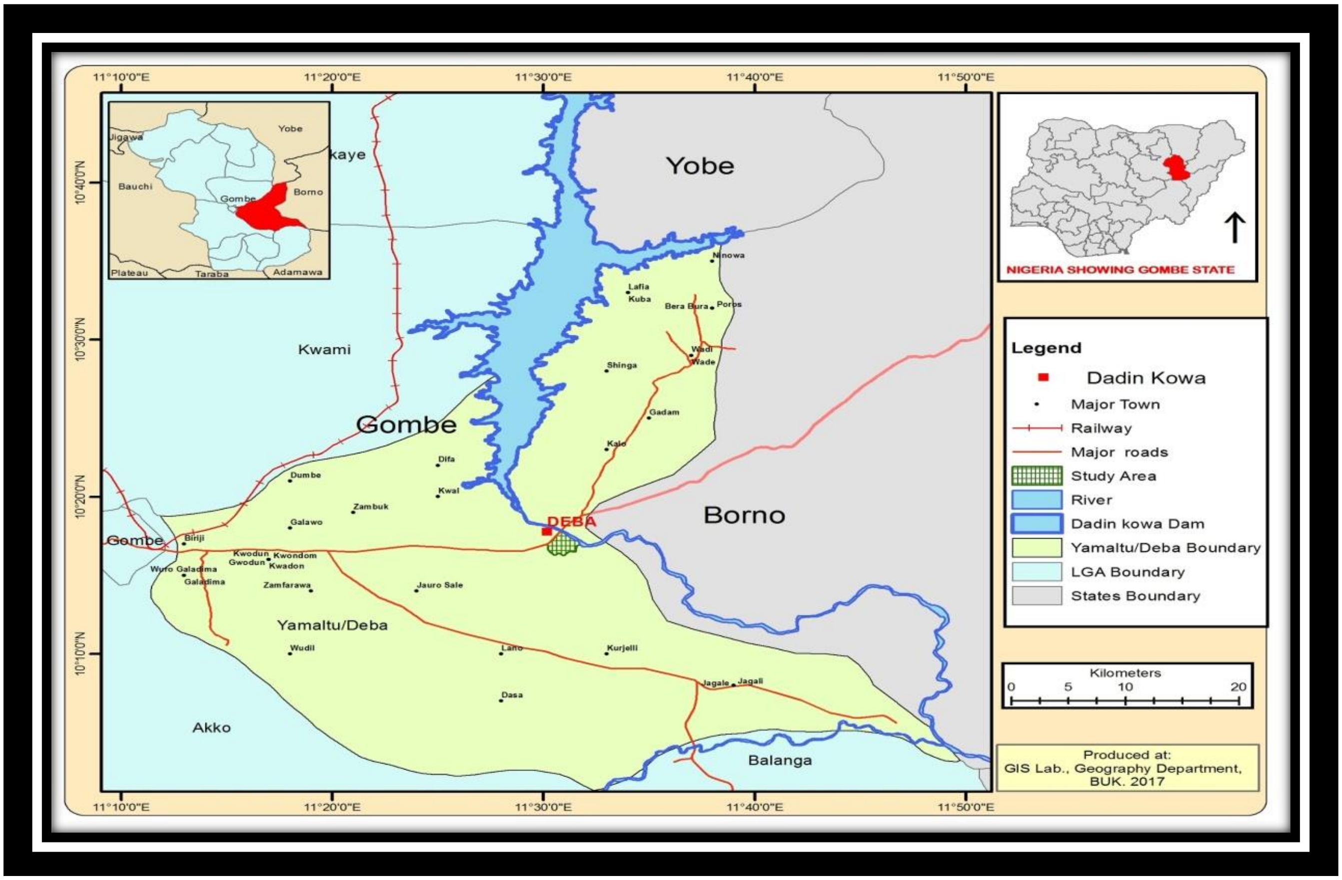

Fig. 1: Study area showing Dadinkowa Dam and irrigated areas.
Source: GIS Lab, Geography Department BUK. (2017)

3. MATERIALS AND METHODS

In carrying out this study, both primary and secondary data were used. The Primary data were sourced from field observations, measurements, questionnaires and analyses of soil and water samples collected in the field. Whereas the secondary data were obtained from documented materials relevant to the study such as Journals, Text books, Publications, Unpublished materials, occasional briefings of Upper Benue River Basin Development Authority among others. The data collected were analyzed using descriptive statistics. The results obtained were presented in tables and GIS Maps.

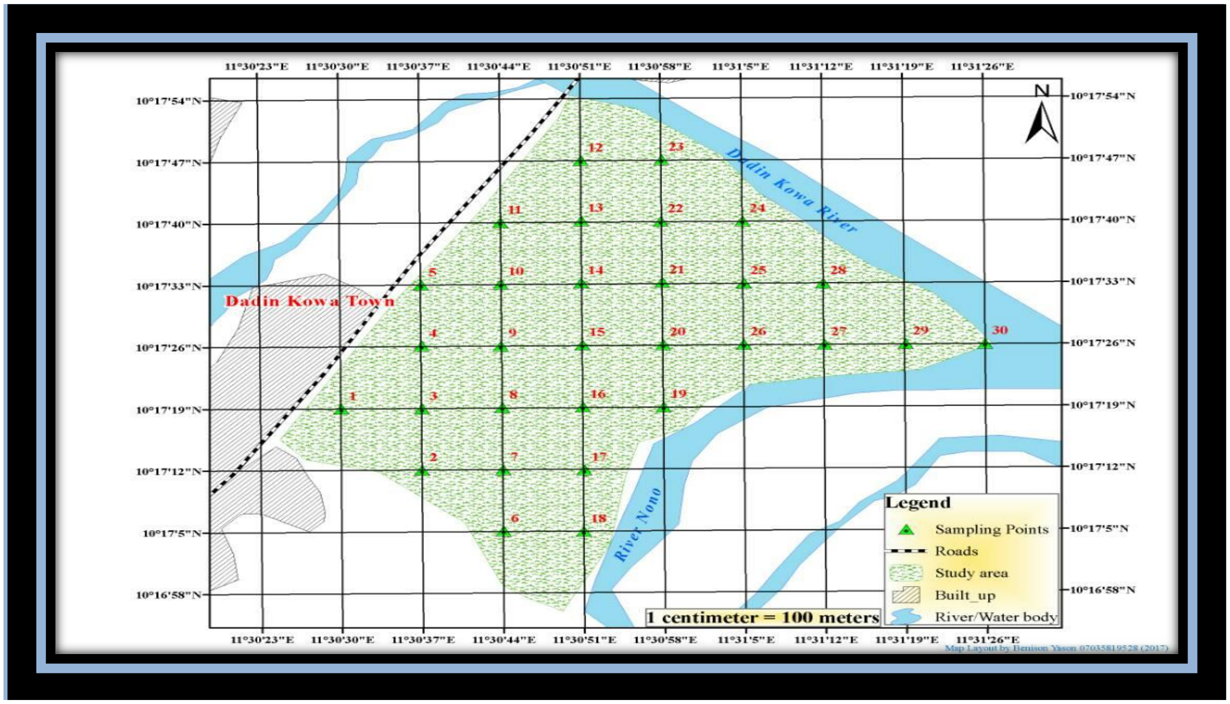

Figure 2: Distribution of Soil Sampling Points
Source: Google Earth, (2018)

4. Results and Discussion

4.1 Irrigation Farming Systems in Dadinkowa Irrigation Project

The irrigation farming systems in Dadinkowa irrigation project were mainly dominated by the old system of irrigation i.e. surface (Furrow irrigation). In this system water moves along parallel thin ridges on the surface that are aligned in long strips and in the process of moving the water is absorbed into the soil. From the analysis conducted, 97.36 % of respondents interviewed adopted the furrow irrigation system while 2.64% account for respondents that used watering buckets in raising newly germinated crops before transplanting Table 1. This system of irrigation requires a high degree of management and water control to achieve high irrigation efficiencies. Furthermore, there will be an accumulation of salinity between furrows and an increased level of tail water losses. The farming system adopted in the study area is presented in Table 1

Table 1: System of Irrigation Farming In Dadinkowa Irrigation Project

System of irrigation	Frequency	Percentage
Surface (Furrows)	75	90.36
Watering bucket	08	9.63
Cultivation seasons		
Dry season	50	60.24
Wet season	13	15.66
Both dry and wet	20	24.09

Source: Fieldwork, 2018

4.2 Types of Crops Cultivated

Table 2, shows four major crops cultivated in the study area. Crop production in the study area was dominated mainly by cultivation of Rice, Maize, Tomato and Onion. The result indicates that 75.90% of the respondents cultivate Rice in the dry season while 51.80% during rainy season farming. 15.66% and 25.30% account for Maize production in dry and wet season farming respectively. Tomato production in the dry season is 4.81% and 9.63% in the wet season, while 3.61% of the respondent accounts for Onion cultivation in dry season farming and 13.25% in the wet season. This is similar to the findings of most study in the area (Musa, 2008 and Samuel 2009).

Types of Crops Cultivated in the Irrigation Project are presented in Table 2.

Table 2: Types of Crop in the Study Area

Crops	Dry Season Frequency	Percentage	Wet Season Frequency	Percentage
Rice	63	75.90	43	51.80
Maize	13	15.66	21	25.30
Tomato	4	4.81	8	9.63
Onion	3	3.61	11	13.25
Total	83	99.98	83	99.98

Source: Fieldwork, 2018

4.3 Salinity Status of Soil and Irrigation Water

The salinity levels of the soil were determined using EC, ESP, SAR and pH value as described by Brady and Weil (2009).The salinity level of the sampled irrigated soils of the study area is presented in Table 3.

Table 3: Salinity Level of Irrigated Soil of Dadinkowa Irrigation Project

Parameter	Mean value	Salinity Level
EC	1.18 dS/m	Normal
ESP	1.19cmol/kg	Normal
SAR	0.17cmol/kg	Normal
pH	6.58	Normal

Source: Field Work, (2018).

Table 3 shows that the salinity level of the soil is low because the entire mean values of all the salinity parameters EC (1.18dS/m); ESP (1.19cmol/kg); SAR (0.17cmol/kg) and pH (6.5) were lower than the standard values describe by

Brady and Weil (2009). Malgwi (2001) and Jimoh et al. (2016) reported similar result in the soils of Northern Guinea Savanna, Nigeria. Generally the mean values were low indicating non-saline status of the soil according to the limits set by schoeneberger, *et al*. (2002). Soil salinity ratings base on EC and SAR are presented in Table 4.

Table 4: Soil Salinity Ratings Based on EC and SAR

Parameters	Mean Values	Ratings
ECe	1.18 dS/m	Low
SAR	0.17cmol/kg	Low

Source: Fieldwork, (2018).

From the analysis conducted, the findings of this study Table 4 revealed that the soils of the study area were found within the Normal range for irrigation of EC (<4dS/m) and SAR (<13) Brady and Well (2009). This is similar to the findings of Richard, (1954) and Aliyu et al (2016) who reported that SAR values below >9 is considered good for irrigation purpose. Under this situation, salinity or sodicity hazard might not occur and crops may grow without any deleterious effect on the soil and crop yield Rhoades, (1982). The soil salinity parameters investigated based on Mean, Standard Deviation and Variance are presented in Table 5.

Table 5: Salinity Parameters of Irrigated Soils of Dadinkowa Irrigation Project

Standard	pH	EC	Ca	Mg	K	Na	CEC	SAR	ESP
Mean	6.58	1.18	6.03	1.72	0.39	0.23	21.26	0.17	1.19
STDEV	0.55	32.21	4.49	0.15	0.14	0.12	7.80	2.53	0.83
VAR	0.31	1037.24	20.14	0.02	0.02	0.01	60.80	6.38	0.68

Source: Lab Analysis result, (2018)

Table 5 shows the salinity parameters of the irrigated soil investigated based on Mean values, Standard Deviation and Variance. The mean pH ranged between 5.46 and 7.61. The EC ranged between 40-170µS/cm. The concentration of Exchangeable Bases ranged from 2.40 to 16.5; 1.25 to 1.94, 0.10 to 0.67 and 0.10 to 0.59 cmol/kg for Ca, Mg, K and Na respectively. The CEC ranged between 8.40 to 34.40, cmol/kg. The SAR and ESP range from 0.04-0.17 cmol/kg and 0.31-4.52 cmol/kg respectively.

4.4 Soil Salinity Managements

Soil and water salinity management practices as engaged by farmers in the study area are presented in Table 6.

Table 6 Respondents' soil and water salinity management practices

Practices	Frequency	Percentage
Crop rotation	61	56.48
Use of organic manure	83	76.85
Use of boreholes	38	35.18
Waterlogging	99	91.66

Source: Field Work, 2018

The soil salinity management practices adopted by farmers in the study area are crop rotation, use of organic manure and incorporation of farm residue. Crop rotation is practiced by about 56.48% of the respondents (Table 6). The use of organic manure is a soil salinity management that is well practiced by the entire farmers in DKIP. All the respondents interviewed in this study use organic manures. The types of organic manures used include cow dungs, sheep dungs, domestic waste and plant ash. Incorporation of crop residues into the soil is not well practiced. Crop residues were usually fed to animals or burnt on the farm before the commencement of farming activities. However, Physical observation revealed that leguminous crops were not incorporated much in the rotation and there was no rotation of deep-rooting crops, therefore the benefits of the rotation to salinity/fertility may be very low. Crop rotation can reduce the soil salinity because different crops have different nutrient requirements based on that some can absorb large quantities of some nutrient that constitute the salinity of the soil. Anusuya, (2012) who stated that "understanding the basics of how nutrients are added to and released from soil organic matter will help the farmer in choosing crop sequences and amendments to optimize organic crop fertility, supports this.

The findings of this study revealed that >60% of the drainage channels in the scheme were blocked with weeds. Similarly, the main collector drains were poorly maintained and are densely infested with weeds and sediments. About 91.66% of the respondents (Table 6) interviewed had problems associated with waterlogging in the study area. Furthermore, 35.18% of respondents, (Table 6) interviewed had boreholes in their farms with a view to improving water distribution and enhanced dissolution and leaching of salt ions. These confirmed the findings of Musa, (2008) who reported that problems associated with irrigation agriculture in DKIP were excess evaporation and losses from unlined canals, water logging of field, and soil and water contamination by fertilizer by-product and pesticides on farm.

4.5 Summary

The irrigation farming system in Dadinkowa Irrigation Project was mainly dominated by Furrow irrigation system, which is considered as an old system that leads to loss of large quantities of water via infiltration. The crops grown in the area will not be affected by salinity; this is because the salinity level of the soil is within the normal levels. Crop production in Dadinkowa irrigation project is mainly dominated by the cultivation of Rice, Maize, Tomato and Onion. The salinity is spatially distributed along the study area, and crop rotations as well as use of organic manure are the major salinity management strategies adopted in the area.

4.6 Conclusion

The findings of this study have shown that the status of Dadinkowa Irrigation Project is good as reflected on the assessment of the key indicators of salinity in soil (pH, EC, ESP, and SAR) which were to be found in low to medium in concentrations and that cannot cause salinity problems. However, there are disparities in concentration of these parameters investigated as regard to the different irrigation activities taking place. The studies established that virtually all of the parameters investigated were within the WHO, FAO and NIS maximum allowable limits and are therefore, suitable for irrigation purposes.

The major implication of this study on land productivity of Dadinkowa irrigation project was to meet the food demand of the growing population. It also informs scientist/ planners about the status of soil and irrigation water and the need for proper management. And finally, it reveals information on the suitability of soils in the irrigation project and their limitations for sustainable crop production.

4.7 Recommendations

To create sustainable irrigation agriculture, food security and ecological balance, the following recommendations were proffered.

i. A modern irrigation method such as use of PVC pipes is recommended in the area to reduce the loss of water via infiltration and reduce the rate of soluble salt dissolving in the soil.
ii. Although the findings of this study has not yet indicated any immediate threat on the soil salinity, there is need for frequent and constant monitoring of soil and irrigation waters in order to detect salt built up as soon as it starts manifesting.
iii. Owing to the poor status of drainage channels in the project area, there is need for the construction of more drainage to drain excess water as well as boreholes to improve water availability for irrigation purposes.

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