SPATIOTEMPORAL IMPACT ASSESSMENT OF WATER LOGGING AND SALINITY ON CROPS YIELD (2009-2019): A CASE STUDY OF TEHSIL SHORKOT, DISTRICT JHANG, PAKISTAN

M. Muneer[1], M. A. Sial[2], M. Mohsin[3*], I. Younes[4], M. Saeed[5] and A. Rehman[6]

[1-2]Department of Geography, Govt. Graduate College, Jhang, Pakistan
[3]Department of Geography, Govt. Sadiq Egerton Graduate College, Bahawalpur, Pakistan
[4-5]Institute of Geography, University of the Punjab, Lahore, Pakistan
[6]Department of Earth Sciences, University of Sargodha, Sargodha, Pakistan
[*]Corresponding author Email: mohsinshahzad10@yahoo.com

ABSTRACT: Agricultural practices are tremendously affected by the water logging and salinity worldwide particularly in agrarian developing countries like Pakistan. The main objective of this research was to highlight the impact of water logging and salinity on the production of the selected crops in Tehsil Shorkot, District Jhang from 2009-2019. The study utilized the remote sensing data of Landsat 5 TM, October 2009 and Landsat 8 OLI, October 2019 at 30 meters spatial resolution derived from USGS website freely. In present research, various spectral indices were examined from the reflectance bands of the spatial Landsat images. Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and Salinity Index (SI) were applied by using the GIS and Remote Sensing methods to recognize the effects of the water logging and salinity on the production of the crops in the study area. NDVI was incorporated in order to estimate the vegetation land use in the study area. The NDVI results showed that the production of the wheat and rice was less as compared to the production of the sugarcane. The SI technique was used to examine the salt index of the study area. The SI results showed a very high quantity of the red and low bands of the green color and a general decrease in the SI in the selected areas. The secondary crops data gathered from Agriculture Department also verified the notable decrease in the production and area of wheat and rice in the study area i.e. In 2009, total area under wheat was 33 *Monds* (1 *Mond*= 40 kg) per acre and the cultivable land was 182,250 acres that decreased to 26 *Monds* per acre with a considerable decrease in cultivable land area of 167,340 acres in 2019. Overall, the study results concluded that the production and cultivated area of these crops was greatly impacted by the waterlogging and the salinity in the study area. The study will be beneficial for policy makers and land use planners for agricultural policy and decision making.

Keywords: Water Logging, Salinity, NDVI, SI, GIS, Shorkot, Pakistan.

(Received 04.07.2024 Accepted 05.09.2024)

INTRODUCTION

Globally, the human induced changes in land use land cover (LULC) are considering main forces of change in various sectors like agriculture, environment and others. Many socio-economic factors (i.e. income, occupation, conveyance availability etc.), population growth, advancements in agro-technologies and many other natural factors are also responsible for undesired changes in land use and agricultural practices (Mohsin and Khan, 2017; Sajid *et al.*, 2023). These are counted as vital attributes for finding the association between population growth, conversion of land use and various ecological and environmental concerns (Mohsin, 2014; Khan *et al.*, 2014). The salinity or salinization is a global issue that jeopardizes the quality of the water and hampers the use of the freshwater resources for the human; it also threatens the agricultural production and the aquaculture. Pakistan is located in arid and semi-arid region where the climate is hot subtropical continental with the continuing processes of salinization and sodification. The salinity directly affects the properties of soil including physical, chemical and biological (Syed *et al.,* 2021). In Pakistan, agriculture is the mainstay of the economy and the water logging and salinity is one of the chief agricultural problems along with rapid population growth, natural hazards, pest and viral attacks and others. It is estimated that more than 6 million hectares agricultural lands in Pakistan suffering water logging and salinity (GoP, 2006). Punjab province is at the top most in the production of the many crops in the Pakistan. The farmers face several challenges in successfully carrying out their activities. The farmers face many grave issues in order to carry out the farming activities in wake of the salinity and the water logging. It is the most attention seeking issue of the present times (Khan and Chaudary, 2003). When the land holds much water and unable to absorb it completely so that it becomes thoroughly saturated and soggy, the passage of oxygen through soil is blocked and this situation is termed as water logging. Salinity and water logging can highly affect the orchard fields and other crops (Mohsin *et al.,* 2015). Water logging is occurred due to a large number of the reasons like excessive rainfall, very poor internal and the external drainage system, runoff of the water and the soil inability to hold or absorb the redundant water. Man-made activities are the source of the water logging, for example floods, heavy rainfall, seepage of the water from the canals and the poor irrigation technique. When the canal water percolates in the neighboring areas and it reaches at the top water table via infiltration. It results in the raising of the water table resulting in the water logging and the salinity (Khan and Chaudary, 2003). The downward water seepage through canals leads towards accretion of the salt (Manik *et al.,* 2019). Lands with the concave sloppy lands may also suffer from the water logging. In the absence of the proper water drainage system the likelihood of the concave sloppy may also rise (Qureshi *et al.,* 2008). The soils having thick top soil store more water. Due to the depositing of the flood water at the place having very poor drainage system, the crops roots are drowned or submerged as no air is present in the soil (Kaur *et al.,* 2020). With the help of the suitable irrigation techniques the issue of the water logging can be solved to great extent (Qureshi *et al.,* 2008). When presence of the salt in water is in huge amounts such water body causes the water saline (Khan and Chaudary, 2003). The presence of the dissolvable salts in saturated soils rises the minimum pressure which basically prevents the flow of the water towards plants, in this way it destroys the plants (El-Nashar, 2013). Deforestation is basically the main reason of the presence of the salinity in the water. Exorbitant use of the fertilizers may augment the salinity and growth of the heavy metals (Ziad *et al.,* 2016). Water logging increases the temperature of the soil (Kaur *et al.,* 2020). Process of the cultivation is hampered in the soil in the waterlogged area due to the buildup of the salts (El-Nashar, 2013). This resulted in the decreased crops yield because of the maturity duration of various crops become very low (Singh, 2016; Zeng *et al.*, 2013; Yu *et al.,* 2019). In Pakistan, water logging and salinity have severe socio-economic impacts including forced migration and health issues, reduced crop yields and poverty, infrastructure damage and transport disruptions, decreased living standards and livelihood opportunities. Therefore, urgent action is needed to address these issues to protect vulnerable communities and promote sustainable development in affected areas (Sandhu and Qureshi, 1986). Similarly, the study area is very much affected from the salinity and the water logging in the Punjab. The main objective of the research was to highlight the impact of water logging and salinity on the production of the selected crops in Tehsil Shorkot, District Jhang from 2009-2019. The study would be very helpful from agricultural planning perspective and future research on the water logging and salinity and agro-ecological problems.

MATERIAL AND METHODS

In order to full fill the objectives of the present research primary and secondary data was gathered about the yield of the selected crops, salinity and water logging data in the study area. Its impacts on the selected crops i.e. the wheat, sugarcane and rice for the designated years from 2009 to 2019 were monitored and highlighted in the current research.

Study Area: The study area Shorkot is a Tehsil of District Jhang. It lies on the boundary of central and southern Punjab. The area is home to the confluence of three rivers: Chenab, Jhelum and Ravi. It is also adjacent to Head Trimmu hence several irrigation canals and a few link canals pass through it. Jhang is a major region of the Punjab-Pakistan and its population is in excess of 3 million individuals. It is situated in the focal point of the Punjab region. Jhang is circumscribed by Sargodha toward the north, Chiniot toward the north east, Faisalabad and Toba Tek Singh Districts toward the east, Khanewal and Muzaffargarh located toward the south while Layyah and Bhakkar located on the North West (Figure 1). Jhang city is the capital of region which is encompassed by two waterways Jhelum and Chenab. Jhang locale is severely influenced by surge and Monsoon’s overwhelming downpours consistently as a result of the Trimuu flood and juncture purpose of the two streams in the point zone. The climate is sweltering and dry in summer and cold and dry in winter. The most blazing months are May, June and July. Most extreme mean temperature amid summer is 44°C.

Data Collection: For assessing the impact of water logging and salinity on growing crops the remotely sensed data has been utilized. Temporal change in cropped are for a time span of 19 years was explored. It needed the chosen chronological satellite images for the different periods of time. Secondary data of the satellite images for the years 2000, 2010 and 2019 were collected from the website of United States Geological Survey (USGS). Additionally, the crops production data was collected from the Agriculture Department, Tehsil Shorkot District Jhang from 2009 to 2019.

Satellite Images: Landsat satellite images of were acquired from the website of USGS, a free source of geospatial data. For this purpose, Landsat 5 Thematic Mapper (TM) for October 2009 with a spatial resolution of 30 meter and Landsat 8 (OLI) for October 2019 with a spatial resolution of 30 meter were chosen Table 1 below shows the brief of the downloaded satellite images.

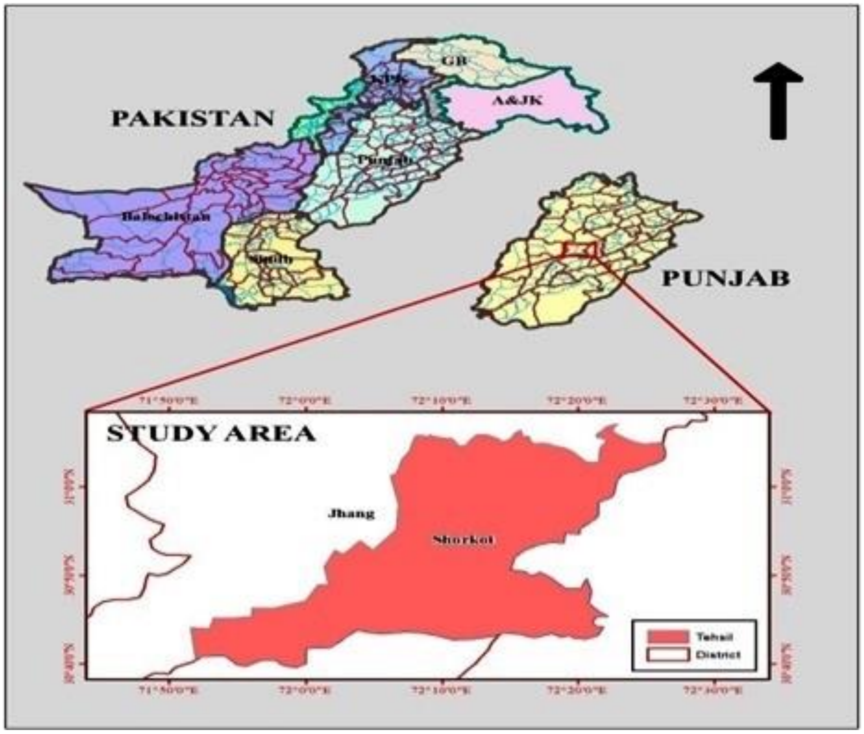


Figure 1: Study area map

Table 1: Satellite Images and their Specifications

Sr. No.	Satellite Images	Time/Year	Spatial Resolution
1	Landsat 5 TM	October 2009	30 m
2	Landsat 8 OLI	October 2019	30 m

Source: www.usgs.com

Data Processing: To justify aims and purposes of the current study, Remote Sensing (RS) and Geographic Information Systems (GIS) techniques were employed. For this, Erdas Imagine 14, ArcGIS 10.7 and MS Excel software were used. The following techniques were employed to analyze the remotely sensed data;

Supervised Image Classification: For division of the image the supervised image classification was used. Each class denotes to the specific band of digital resolution so its wave lengths were interlinked to particular objects on the land.

Images Pre Processing: It was performed to increase the systematic and radiometric images features. Usually, the stages in image preparation are radiometric alteration and geometric review was also accomplished to reconstitute the surrounding effects of the environment.

Image Enhancement and Comparison Classification: Image enhancement technique allows the system to enhance the precise sub-division of the highpoints or databases in the same image. Various ranging techniques were utilized for the enhancement of an image. The technique of the nearest neighborhood was used in the present research. This method basically emphasizes the decision making of the test subordinate for smallest division calculated among them using various visual bands. In order to make another class, a related model was chosen subject for its powerful response. The collective orders comprise soil water bodies nurturing area and shaped region.

Ground Truthing: Remote sensing indices and distant detecting proceedings of the satellite image analysis were utilized for the planning of the water logging and saltiness change detection which included the three selected cultivated crops of wheat, rice and sugarcane. Lists were also prepared by utilizing in excess of two separate groups. The saltiness change and its sub classes were also checked by using the blends of the both discrete groups.

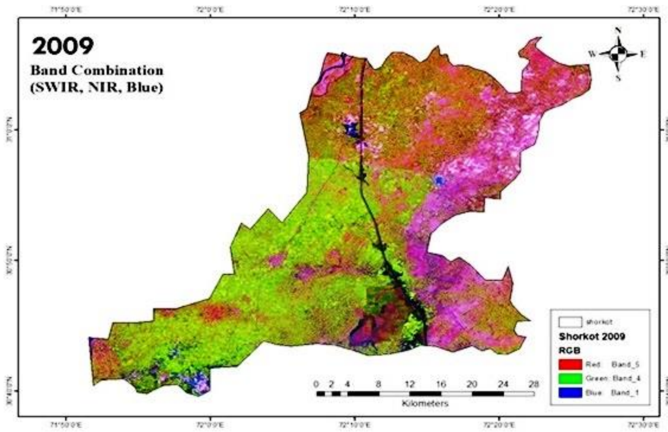


Figure 2: Band Combination Study Area 2009

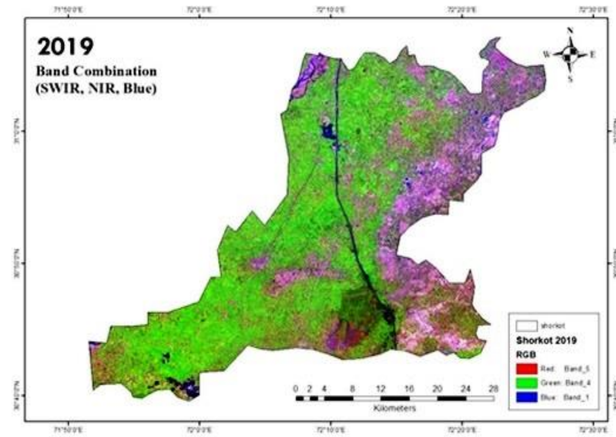


Figure 3: Band Combination Study Area 2019

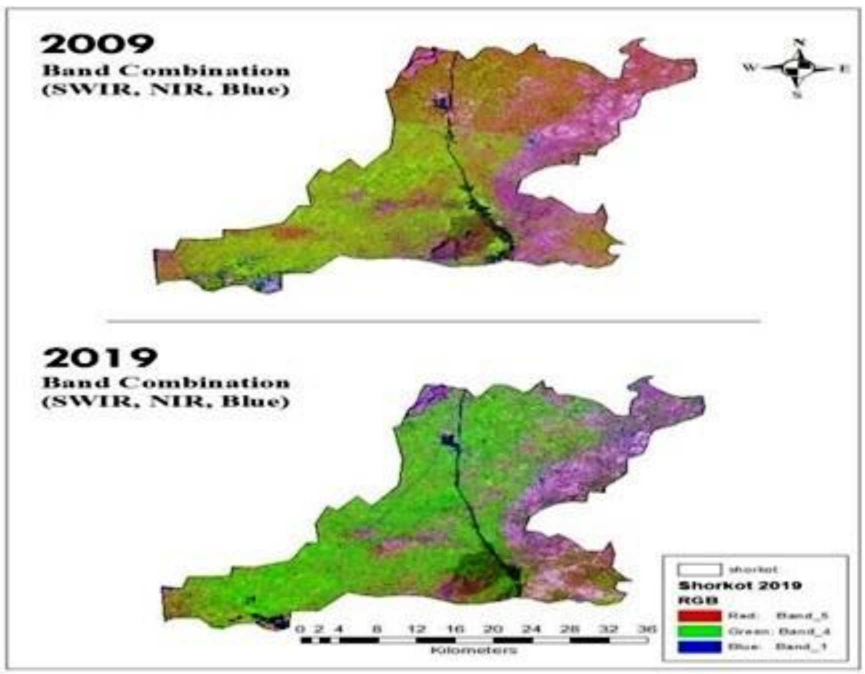


Figure 4: Band Combination 2009-2019 Comparison

Spatial Data Acquisition: Spatial water logging information was also generally achieved through methods of distant detecting. Remote sensing and satellite images make the distant detecting data. Such information is obtained over an enormous region and is then arranged carefully or actually and then characterized.

Method to calculate the NDVI: Normalized Difference Vegetation Index (NDVI) is commonly used tool in remote sensing and environmental assessment to assess the health and density of vegetation. Sentinel 2 imageries were used in order to calculate the NDVI. The NDVI was examined by using the following formula:

$$NDVI = \frac{NIR-RED}{NIR+RED}$$

The NIR & Red (spectral bands) are the spectral reflectance sizes. These were acquired from the near infrared spaces and from the red visible bands. Spectral reflectance is basically those portion of the reflected radiations in whole the spectral images bands. Such values range from 0.0 to 1.0. As a result, the values of NDVI differs between the "-1.0" and "+1.0" (Figure 5). Many scholars have calculated the limits of the vegetation as "0.2" [11] (Gandhi *et al.*, 2015). Moderate values of the NDVI (ranges approximately, 0.2 to 0.5) can display the vegetation for example the plants and grass lands. In contrast the high NDVI (usually, 0.6 to 0.9) values are linked with the extreme dense vegetation which are usually situated in the moderate and tropical forests (USGS, 2021).

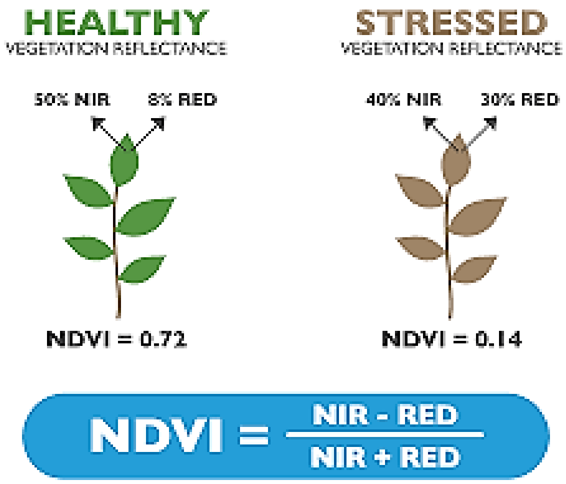


Figure 5: NDVI Spectral Reflectance Values

Salinity and Water Logging Change Detection: Salinity and water logging variation observation usually incorporates a judgment of two or more remotely sensed images that are always in accordance with respect to the scale, specific classification and precision. Many change detection techniques are available which allow a user to select a way that is most appropriate for the image. Various Change detection analysis along with GIS and Remote Sensing practices have excessive potential in exploring and forecasting the changes in the agricultural crops yield as found in case of Multan district (Sajid *et al.*, 2020). Likewise, the wheat yield of Muzaffargarh district has also greatly reduced due to water logging and salinity (Makhdum and Ashfaq, 2008). Supervised classification technique helped in generation of water logging maps for three different years. Change in the area maps was created from the most popular superimposed classification method with the equal interval of 10 years. Bar graphs, pie graphs, tables and maps were generated to interpret and know about the changes.

RESULTS

The analysis of the study carried out with the help of remotely sensed data processed in GIS environment to monitor the impact of water logging and salinity on the crops production and change in cultivated area during the stipulated time period. Additional data of crops production gathered from Agriculture Department to verify the results of the spatiotemporal analysis.

Normalized Difference Vegetation Index (NDVI): The normalized difference vegetation index (NDVI) is a very simple spectral index used for analyzing the near infrared sensory calculation, frequency from a single space area, to ascertain whether the study area possesses healthy green vegetation or not.

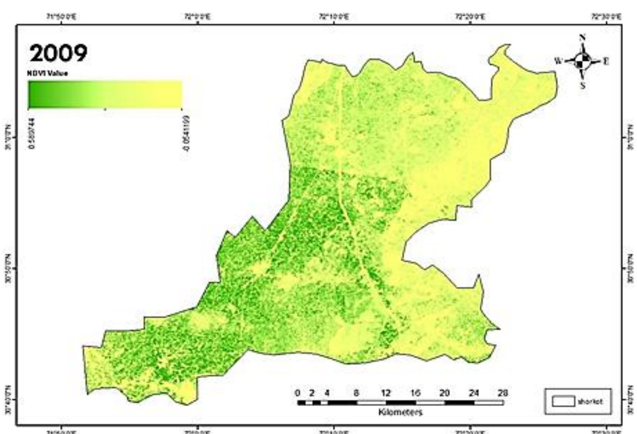


Figure 6: NDVI in study area 2009

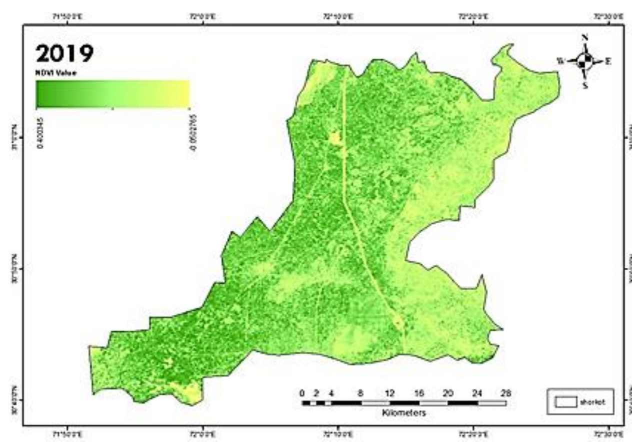


Figure 7: NDVI in study area 2019

In figure 6, the NDVI in 2009 demonstrated where the green color shows the vegetation cover, yellow color denotes the built-up and the barren land in the study area. Basically, as per normalized difference vegetation index value ranges +1 exhibit the healthy vegetal cover and -1 values used to display the built-up land and barren land. Similarly, in figure 7, the NDVI in 2019 demonstrated where the green color denotes the vegetation cover, yellow color is used to show built-up and barren land in study area. Figure 8 showed a comparison of the NDVI of the study area for the years 2009 and 2019. The main classes that have been shown were the vegetation cover (green color), and built-up and barren land in yellow color.

Normalized differenced water index (NDWI) to improve open water landscapes in the remotely sensed imageries of the study area. Figure 9 showed that NDWI results in 2009 the blue color shows the water bodies and the green color displays other area while according to the NDWI, water bodies value ranges at 0 and the land area is given the value at -1.

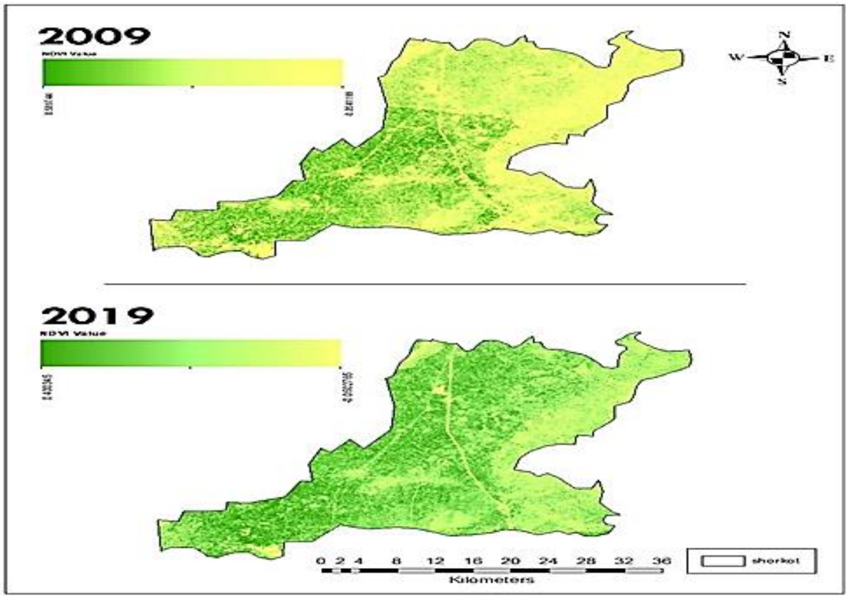
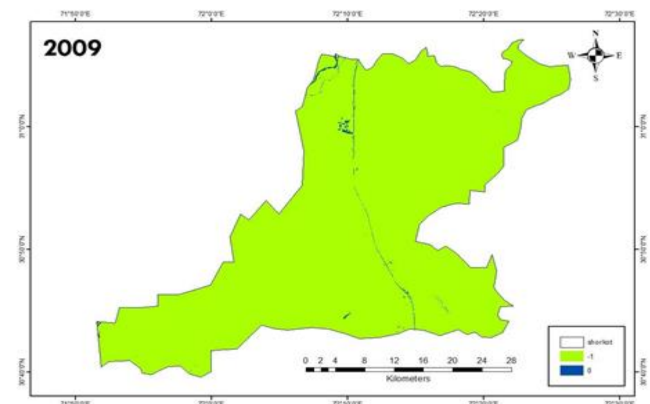


Figure 8: NDVI comparison in study area 2009-2019



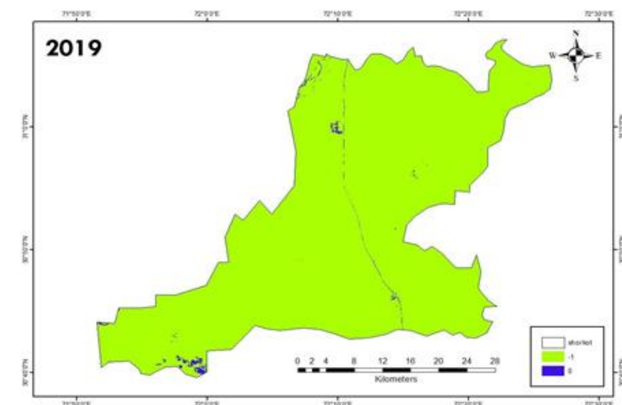


Figure 9: NDWI in study area 2009 **Figure 10: NDWI in study area 2019**

Figure 10 showed that NDWI 2019 where the blue color confirms the water bodies and green color demonstrates other area while according to the NDWI water bodies are usually valued at 0 and land area is centered at -1.

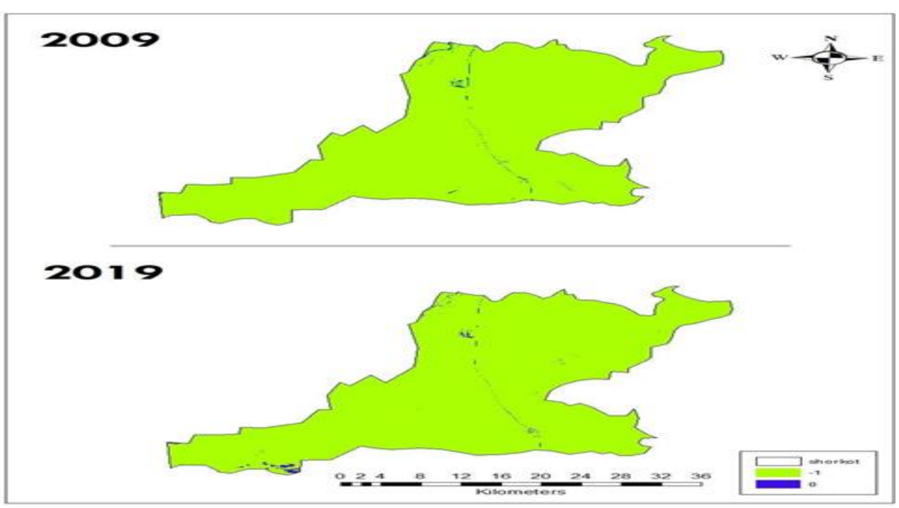


Figure 11: NDWI comparison in study area 2009-2019

Figure 11 demonstrated a comparison between NDWI 2009 and 2019. The blue color basically shows the water bodies and green color denotes the other area while as per the normalized differentiated water index, the water bodies are centered at 0 and land area is valued at -1. It was revealed that the water logging has been increased during the last 10 years in south west side of the study area.

Salinity Index (SI): The salinity index (SI) is the portion of the red bands to the nearest infrared (NIR) band was the entire amount of the red alteration in the NIR divided by the two. The salinity index was listed as follows. The formula used to examine the indicators of the salt and the soil vegetation is as follows;

$$SI = G \times R/B$$

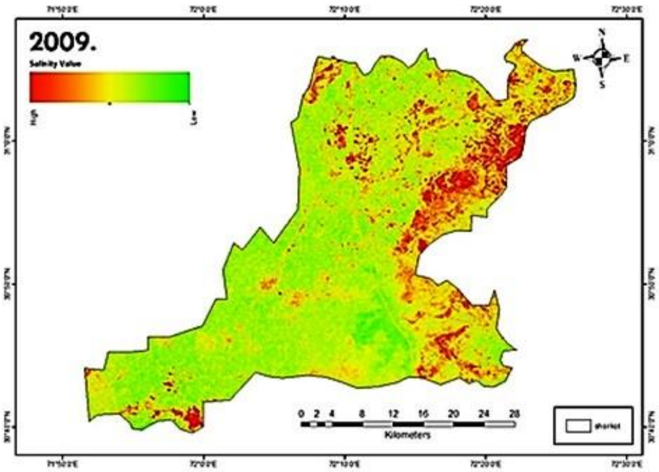


Figure 12: Salinity index in study area 2009

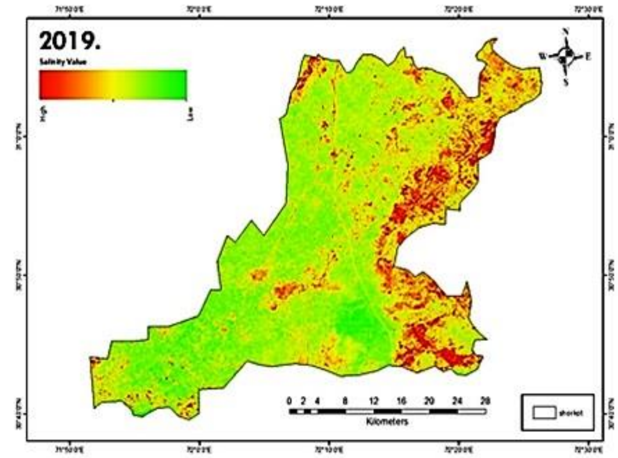
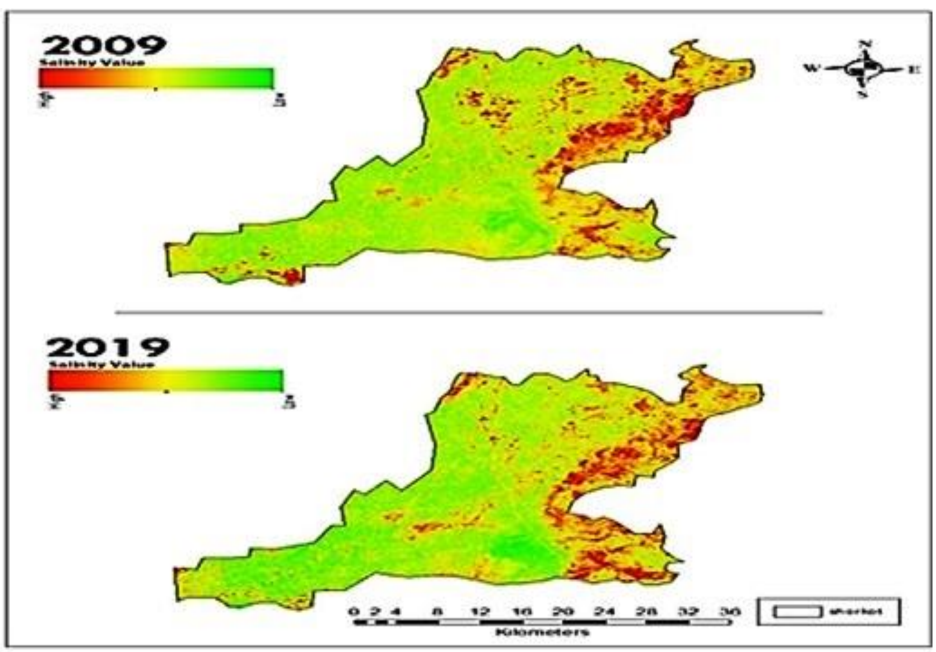


Figure 13: Salinity index in study area 2019



d

Figure 14: Salinity index comparison in study area 2009-2019

Figure 12 and figure 13 showed the salinity index in the study area during 2009 and 2019 while the figure 14 made a comparison of Salinity Index (SI) between 2009 and 2019. The areas in red color show the high absorption of the salinity as the color slope moves from red to green the absorption of salinity decreases. The areas which are situated in east and the north east to south east directions are typically more affected by salinity. The scattered areas which are located in the center and west sides were having less saline.

Classification of water logging and salinity: The classification of the water logging and salinity in 2009 and 2019 is based on the combination of the visual bands (5, 4, and 1) where the blue color denotes the water logging, light pink color demonstrates the other area and the red color shows the salinity which classified salinity index.

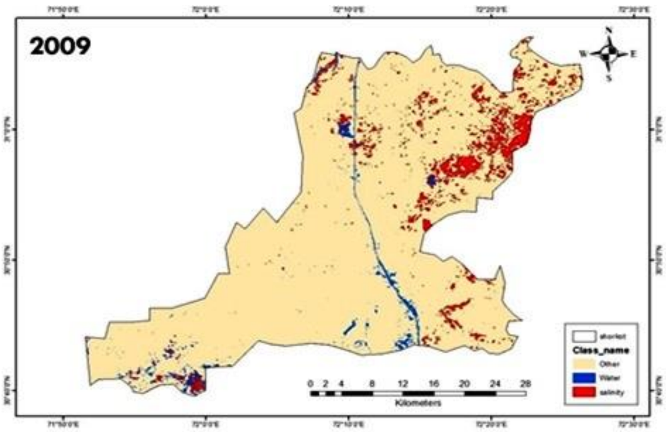


Figure 15: Classification of water logging & salinity in study area 2009

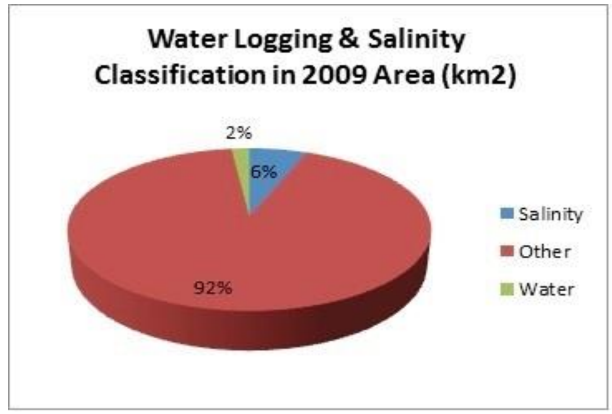


Figure 16: Classification of waterlogged & salinity in study area 2009

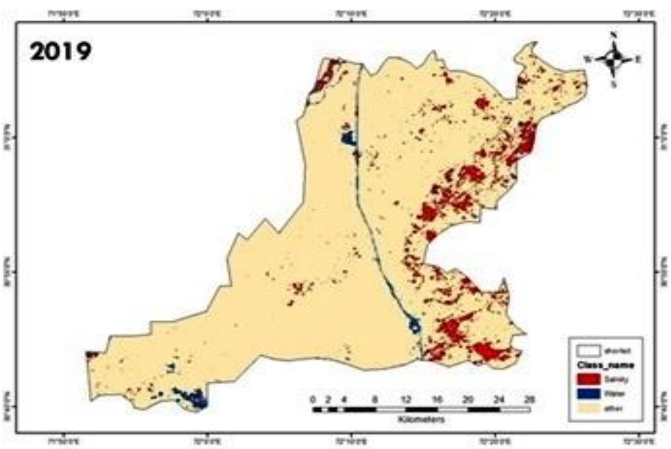


Figure 17: Classification of water logging & salinity in study area 2019

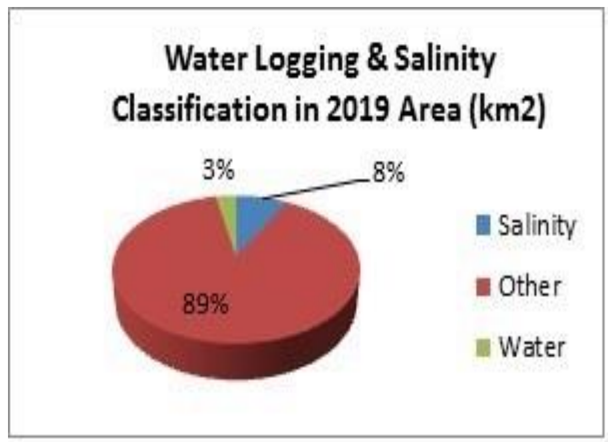


Figure 18: Classification of water logging & salinity in study area 2019

Figure 15 was generated from the classification area using the cumulate geometry tool which shows the ratios of water logging and salinity in the study area in 2009. Figure 16 depicted that blue color in the chart shows that 2% of the study area was facing the water logging, 6% of the total area of the study area was facing salinity and 92% of the study area represented other land use classes like built-up area and cultivated area etc.

Figure 17 showed the ratios of the water logging and salinity in study area in 2019 generated in the same way as figure 15 and figure 18 demonstrated the water logged and saline areas percentages in study area. Blue color shows that 3% percent of the area was facing water logging, 8% area was facing salinity and 89% of the study area represents other classes like built-up area, cultivated area and others.

Table 2: Water Logging and Salinity Classification in 2009 and 2019

Water Logging & Salinity in 2009		**Water Logging & Salinity in 2019**	
Class	**Area ($km2$)**	**Class**	**Area ($km2$)**
Salinity	74.89627	Salinity	75.51981
Water logging	20.03036	Water logging	23.2739
Other	1,150.073	Other	1,157.017

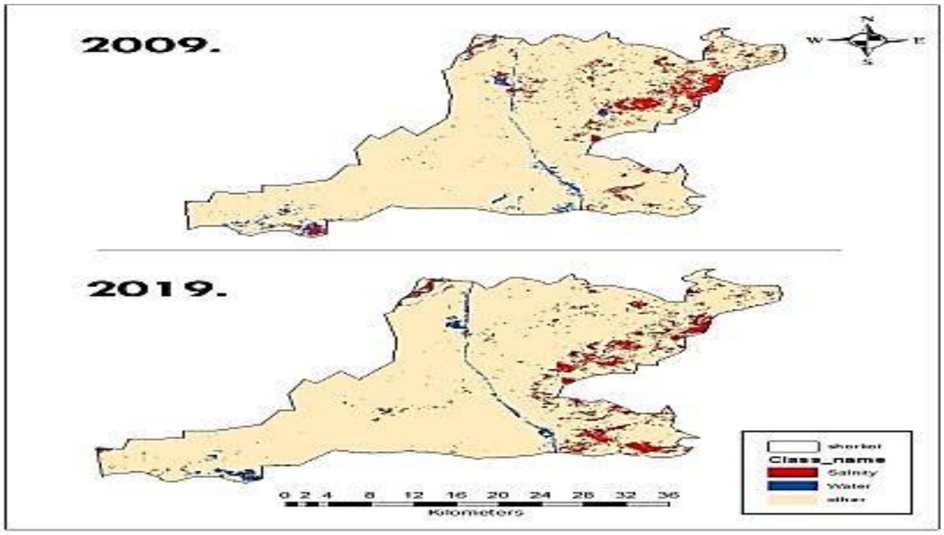


Figure 19: Classification of water logging and salinity in study area in 2009 and 2019

Table 2 and figure 19 represented a comparison classification of water logging and salinity in 2009 and 2019 based on the visual bands combination (5, 4, and 1). In 2009, the area under salinity was 74.89 km^2 which increased to 75.52 km^2 in 2019. Likewise, the area facing water logging issue was 20.03 km^2 in 2009 which increased to 23.27 km^2 in 2019. Other area where built-up was the main class also increased from 1,150 km^2 to 1,157 km^2. These results verified the gradual increase of water logging and salinity over time that could be dangerous for the crops production.

Table 3 represents the production per acre and the area of main crops i.e. sugarcane, wheat and rice in Shorkot for the years 2009 to 2019. The cultivated area shown in acres whereas the production per acre demonstrated in *Monds* (1 Mond= 40 kg). In 2009, the production of the wheat was 33 *Monds* per acre and the cultivable land was 182,250 acres that shown variations in area and production and decreased to 26 *Monds* per acre with a considerable decrease in cultivable land area of 167,340 acres in 2019. While the rice cultivable area steadily increased from 55,950 acres in 2009 to 58,500 acres in 2019. Similarly, the production is also slightly increased from 32 *Monds* (2009) to 33 *Monds* (2019) perhaps due to the issue of water logging and salinity along with other intervening factors i.e. traditional agricultural practices, pest and viral attacks and others. Additionally, the production and area of sugarcane increased over time as production rise from 550 *Monds* in 2009 to 900 *Monds* in 2019. Likewise, the cultivable area of sugarcane also upsurge from 48,450 acres in 2009 to 53,500 acres in 2019. The overall results show that the production of rice and wheat in Shorkot District Jhang is lower than that of sugarcane. The impact of the water logging and salinity is clearly visible in the area and production of these crops evidenced from the analysis of the remotely sensed data.

Table 3: Crop Production and Area in Tehsil Shorkot

Sr. No.	Year	Wheat Per Acre Production	Cultivable Land (Acres)	Rice Per Acre Production	Cultivable Land (Acres)	Sugarcane Per Acre Production	Cultivable Land (Acres)
1	2009	33	182,250	32	55,950	550	48,450
2	2010	34	184,580	33	54,940	575	49,270
3	2011	34	185,980	34	56,350	600	50,240
4	2012	33	163,460	34	56,900	600	49,550
5	2013	34	160,215	35	57,200	650	51,600
6	2014	34	175,250	35	57,730	700	52,250
7	2015	31	175,550	34	59,195	700	52,503
8	2016	35	179,990	32	60,250	650	52,350
9	2017	31	182,350	33	59,540	800	53,450
10	2018	29	166,500	35	60,450	900	61,350
11	2019	26	167,340	33	58,500	900	53,500

Source: Agriculture Department, Tehsil Shorkot, District Jhang (2019)

DISCUSSION

The results of the geospatial analysis indicate the impact of water logging and salinity on crop production in the study area. A GIS technique integrated in this study has clearly modified its impacts on crop production. In this study, water logging and salinity images were successfully used to estimate crop yields. This study demonstrates values (NDWI and SI) using remote sensing data and GIS methods to identify the effects of water logging and salinity on crop yields in tehsil Shorkot, District Jhang. The study examined the local distribution of crops such as wheat, sugarcane and rice in relation to crop production conditions, using remote sensing data from the study area to show the effect of irrigation and its status salinity in crop production. The results of this study clearly show that the use of RS and GIS techniques in tehsil Shorkot District Jhang from 2009 to 2019 has clearly demonstrated the water logging and salinity status and effects. First, the NDVI technique used to estimate vegetation cover in the target area. The NDVI values for 2009 were 0.400345 and for 2019 it is 0.589744. The findings revealed that the production of sugarcane, wheat and rice crops using water logging and salinity classification in tehsil Shorkot. The value indicates lower wheat and rice production than sugarcane production in Shorkot District Jhang. Find the yield of sugarcane, wheat and rice crops using GIS technique. Furthermore, the crops data obtained from the Agriculture Department is also verified these results that wheat and rice particularly facing reduction in yield and cultivable area.

Conclusion: Water logging and salinity are among the chief agricultural problems of the agrarian countries like Pakistan. The study assessed the impact of water logging and salinity on the agricultural crops production in tehsil Shorkot of district Jhang using spatiotemporal data. Various remote sensing indices (NDVI, NDWI & SI) were applied to monitor the impact of water logging and salinity on crops production and change in their land use patterns this is because of an accurate and reliable information at the strategy level is required to estimate production and achieve effective planning, especially in adverse conditions such as soil salinity and water logging. Findings suggest that the relative reduction in yield due to salinity in wheat and rice was to be higher than that of yield in sugarcane. The published data from Agricultural Department also verified the findings of the remotely sensed data. The results of the present research also highlight that the integration of GIS and remote sensing data can be a useful tool for monitoring the effects of salinity and water logging on crop production. This research will be useful for decision makers and, agriculturalists and land use planners to identify priority areas for implementing action plans on water logging and salinity stricken areas in Punjab and other provinces of Pakistan.

REFERENCES

El-Nashar, W.Y. (2013). The combined effect of water-logging and salinity on crops yield. OSR Journal of Agriculture and Veterinary Science, 6(4): 40-49.

Gandhi, G.M., S. Parthiban., N. Thummalu and A. Christy. (2015). NDVI: Vegetation change detection using remote sensing and GIS–A case study of Vellore District. Procedia Computer Science, 57: 1199-1210.

GoP. (2006). Agriculture Statistics of Pakistan. Government of Pakistan Ministry of Food, Agriculture and Livestock, Economic Wing, Islamabad.

Kaur, G., G. Singh, P.P. Motavalli, K.A Nelson, J.M. Orlowski, & B.R. Golden. (2020). Impacts and management strategies for crop production in waterlogged or flooded soils: A review. Agronomy Journal, 112(3): 1475-1501.

Khan, A.A. and M.S. Chaudary. (2003). Water logging and salinization: A serious threat for our agriculture. Pakistan Geographical Review, 58(1-2): 1-18.

Khan, A.A., Arshad, S., and Mohsin, M. (2014). Population Growth and Its Impact on Urban Expansion: A Case Study of Bahawalpur, Pakistan. Universal Journal of Geoscience, 2(8): 229-241.

Makhdum, M.S.A. and M. Ashfaq. (2008). An economic evaluation of negative impact of water-logging and salinity on wheat productivity. Soil & Environment, 27(1): 105-108.

Manik, S.M.N., G. Pengilley., G. Dean., B. Field., S. Shabala and M. Zhou. (2019). Soil and crop management practices to minimize the impact of waterlogging on crop productivity. Frontiers in Plant Science, 10: 140.

Mohsin, M. (2014). Urban Growth and Conversion of Farmland in Bahawalpur City, Pakistan: Causes, Rates and Remedies. LAMBERT Academic Publishing, Saarbrücken, Germany.

Mohsin, M., F., Jamal, A.A. Khan and F. Ajmal (2014). Transformation of fertile agricultural soil into housing schemes: A case of Bahawalpur city, Punjab, Pakistan. International Review of Social Sciences and Humanities, 6(2): 141-156.

Mohsin, M., A. Ghaffar., A.A. Khan and S.M. Malik. (2015). Linkage of water shortage and fruit orchards deterioration: A case study of Tehsil Fort Abbas, Bahawalnagar, Pakistan. Journal of Environmental and Agricultural Sciences, 5: 49-61.

Mohsin, M., and A.A. Khan (2017). Analysis of the determinants of agricultural land conversion (ALC) into housing colonies in Bahawalpur city, Pakistan. Pakistan Journal of Agricultural Sciences, 54(3): 725-430.

Qureshi, A.S., P.G. McCornick., M. Qadir and Z. Aslam. (2008). Managing salinity and waterlogging in the Indus Basin of Pakistan. Agricultural Water Management, 95(1): 1-10.

Sajid, M., M. Mobeen., T. Aziz., N. Kanwal., A. Rehman and M. Rauf. (2020). Impact of land use change on agriculture production of Multan District, (A Case Study). Science International (Lahore), 32(6): 705-710.

Sajid, M., M. Mohsin., M. Mobeen., A. Rehman., A. Rafique., M. Rauf and G. Ali. (2023). Spatio-Temporal Analysis of Land Use Change and its Driving Factors in Layyah, Punjab, Pakistan. The Nucleus, 60, (1-2): 15-23.

Sandhu, G.R. and R.H. Qureshi. (1986). Salt-affected soils of Pakistan and their utilization. Reclamation and Revegetation Research, 5: 105-113.

Singh, A. (2016). Hydrological problems of water resources in irrigated agriculture: A management perspective. Journal of Hydrology, 541: 1430-1440.

Syed, A., G. Sarwar., S.H. Shah and S. Muhamamd. (2021). Soil Salinity Research in 21st Century in Pakistan: Its Impact on Availability of Plant Nutrients, Growth and Yield of Crops. Communications in Soil Science and Plant Analysis, 52(3): 183-200.

USGS. (2021). NDVI, the Foundation for Remote Sensing Phenology. Remote Sensing Phenology. 2021. Retrieved from https://www.usgs.gov/core-science-systems/eros/phenology/science/ndvi-foundation-remote-sensing-phenology?qt-science_center_objects=0#qt-science_center_objects (10-4-23).

Yu, Q., Y. Shen., Q. Wang., X. Wang., L. Fan., Y. Wang., S. Zhang., Z. Liu and M. Zhang. (2019). Light deficiency and waterlogging affect chlorophyll metabolism and photosynthesis in Magnolia sinostellata. Trees, 33(1): 11-22.

Zeng, F., L. Shabala., M. Zhou., G. Zhang and S. Shabala. (2013). Barley responses to combined waterlogging and salinity stress: Separating effects of oxygen deprivation and elemental toxicity. Frontiers in Plant Science, 4: 313.

Ziad, M., S. Khalid., W. Shah., A. Naz and Z. Rehman. (2016). Impacts of water logging and salinity on crops Production of village Adina, District Swabi. ARPN Journal of Agricultural and Biological Science, 11(6): 217-222.