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Salinity, livelihood and agricultural productivity: A case of Hafizabad District

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Abstract

Background: Soil salinity; concentration and or accumulation of salts may pose severe risk on soil productivity and in turn concerned population and farmers. Salt-influenced lands in Pakistan were spread over 6.63 million hectare which is diminishing the agrarian profitability. This study will explore the impact of salinity on livelihood of farmers in district Hafizabad.

Methods: Data of 192 small, medium and large farmers was collected from four randomly selected villages of salinity affected area of Hafizabad district of Punjab province of Pakistan using multistage probability sampling technique. SPSS version 21.0 was utilized to analyze the data for generating logical results.

Results: Farmers belonging to saline area communities were characterized on the basis of their education, experience, cultivated area, and method of irrigation and technological adoption for analyzing their livelihood typologies. Average yield of wheat was found to be 26mnds/acre, while marketable surplus was high for large farmers due to ownership of more area. Livelihood typologies were derived mainly from on-farm and off-farm income activities of the farmers. Agriculture farm earning in the saline area was estimated as Rs. 10 to 12 thousand per acre. Contribution of off-farm income in household cash flows was estimated in 79% of small, medium and large farmer as less than 15000 indicating the dependency status of the households.

Conclusion: Major livelihood source in Salt-affected soils was still agricultural cash inflows beside their contribution to the food basket of consumers. Farmers were in favour of provision of farming inputs on subsidized rates i.e. lime and gypsum as a poverty alleviation strategy in the area for positive promotion of sharing culture with public sector.

Introduction

Salinity is a major issue affecting farm productivity, environment and farmers livelihood all over the globe. Salinity originated due to decrease of freshwater spill out of stream, groundwater salinization and changes in soil salinity [1,2]. Salinity hazard prolonged in soil due to saline water application for irrigation purposes. Salinity has appeared to be an important parameter hindering crop production in Bangladesh [3]. Various agro ecological zones were becoming inefficient in farm production due to soil salinity [4].

Soil salinity is not only impacting agricultural efficiency [5,6,7] but also putting extensive pressure on livelihood strategies of farming communities. Salinity either soil or water adversely effect on individuals' expectation for everyday comforts, day by day life exercises and financial conditions [8,9,10,11]. The high intensity of salinity problem is not only pressurizing farm productivity but also effecting its livelihood strategies and efforts to combat the circumstances.

As per the Food and Agriculture Organization (FAO) in 2008 [12], more than 6 % of the world's land is influenced by either salinity or sodicity. More than 15 million hectares of land experienced decreased yields because of soil salinity in creating nations [13]. Soil salinity was one of the essential environmental problems constraining the improvement of farming in shoreline areas [14.15]. Salinity is the essential constraining element for farming advancement in seaside locale. The value of Salinity over 0.7 dS m^{-1} extremely undermine the ordinary development and growth of crops [16]. The impacts of more salinity in soil on yields may also be summarized in the form of osmotic influences of soil arrangements, changing physical properties of soil and the capacity of specific particles [15].

Salinity possess main threat to food production and food security [17,18] due to its impacts on yield of crop and also reduce the utilization of past uncultivated areas. Above 800 million hectares of crop lands are salt affected globally and are either saline or sodic in nature and comprised of above 6% of the global landscape [12]. The global focus of mitigating salinity is diverting from costly land treatments and amelioration of saline soils towards selection and breeding improving salinity tolerance in crop genotypes being economical and efficient alternative strategy [19]. Global research focus is generally shifting towards Improving tolerance against salinity in wheat and rice crops as global population landscape is changing quickly than the agricultural lands [12].

Soil salinity is severe problem of saline communities threatening sustainable yield of agricultural crops. The estimated salt affected area is about 6.63 m ha in Pakistan [20]. The remedial strategies for saline communities might be the removal of excessive soluble salts and root zone sodium exchange ion [21,22]. The economic utilization of moderate type salt-affected lands might be the cultivation of salt tolerant crop varieties and optimum utilization of plant nutrients, especially nitrogen fertilizer [22,23]. Saline soils can be cultivated by improving farmer's management practices [24]. Calcium intake can support in increasing efficiency of nitrogen and ultimately growth of plant along with sodium exclusion by root zone exposed to NaCl salt stress [25].

Salinity profile of Hafizabad

Pakistan is comprised of geographical area of 80.0 million hectares and having one of the world best canal irrigation system spread over 62,400 km longitude originating from Indus plain [26]. The irrigated plains of Pakistan spread over an area of 19.43 million hectares. The salinity landscape is situated mainly in this plain [27]. In Pakistan, sat is affecting about 6.30 million hectares, while saline landscape is 1.89 hectares, permeable saline sodic are 1.85 million hectares resistant saline-sodicare 1.02 million hectares and sodic are 0.028 million hectares [25] which limit crop production [28].

Hafizabad district population was 832,980 heads, with urban periphery population of 26.73%. mostly Punjabi language (98.7%) is spoken [29]. Salinity is a foremost problem in district Hafizabad which limits the growth and production of crops and also adversely effects the livelihood of farmers. Hafizabad district is characterized as medium level salinity and trace elements contamination. TDS in Hafizabad were found as 946.50mg/L [30]. Application of wheat straw and nitrogen in rice crop in an experiment at Hafizabad district were found to be economical in improving soil health [31] while application of a dose of 150% nitrogen is most effective technique for fodder production in the area [32].

Methods

Punjab is Pakistan's densely populated province and rank second in area. It has an area of 205,344 sq. km (79284 square miles) and a population exceeding 196.7 million. Punjab has the largest economy in Pakistan which contributes most in national gross domestic product (GDP). Punjab province has 36 districts and four regions which are named as Southern, Northern, Central and Western region [33]. Pakistan was divided into four regions on the basis of salinity infestation. Multistage sampling technique was used to select one region located in Punjab. Hafizabad was selected in Punjab province due to high salinity profile of the area.

Hafizabad district was located in central Punjab and was a known producer of rice, wheat and other agricultural crops. According to federal bureau of statistics, the production of wheat in year 2008-09 was 464.8 thousand tones and production of rice in 2008-09 was 245.9 thousand tones. Presence high salinity limits agricultural production in the area. Therefore, selected region was true representative of saline areas for data collection to measure the effects of salinity on livelihood of local farmers. Total area of Hafizabad district is 2,367 sq. km. and has two tehsils, namely Hafizabad and Pindi-Bhattian. At second sampling stage, Pindi Bbhattian Tehsil was selected due to more salt affected lands. At third sampling stage, KotNakka and Bhobhra union councils were selected randomly from Pindi Bhattian tehsil for data collection. At forth stage, two villages were selected from each union council for data collection. The villages selected from Kot Nakka were Sharbagha and

kot Murad. Two villages selected from Bhora UC were Par Lakhan and Bhobhra villages (Table 1).

Categories of farmers	Kot nakka (u.c1)		Bhobra (u.c2)	
	Kot Murad (v1)	Sharbagha (v2)	Bhobra (v3)	Par lakhan (v4)
Small	16	16	16	16
Medium	16	16	16	16
Large	16	16	16	16
Total	48	48	48	48

Table 1: Distribution of respondents' category wise from selected villages of Hafizabad.

Farmers of these villages were further distributed into small, medium and large farmers on the basis of farm sizes (land holding).Small farmers owned (0 -12.5 acres), medium farmers (12.5- 25.0 acers), large farmers (Above 25 acres) of land. Sixteen farmers of each category from each village were selected randomly. Total number of respondents from each village thus becomes forty-eight. Total sample studied was comprised of 192 farmers.

Questionnaire was developed to investigate the impact of salinity on concern variables by collecting data from selected villages. Statistical package for Social Sciences (SPSS) version 21.0 was used to analyze the data. By using the descriptive statistics, Box plotting and frequency distribution, means and standard deviation of the variables were calculated. Variables of the study were education, farming experience, Rabi crop production, Kharif crop production, irrigation source, transportation, Rabi crop sale, Kharif crop sale, wheat crop production, rice crop production, on farm earning, off-farm earning etc.

Figure 1: Map of Hafizabad district of Punjab.

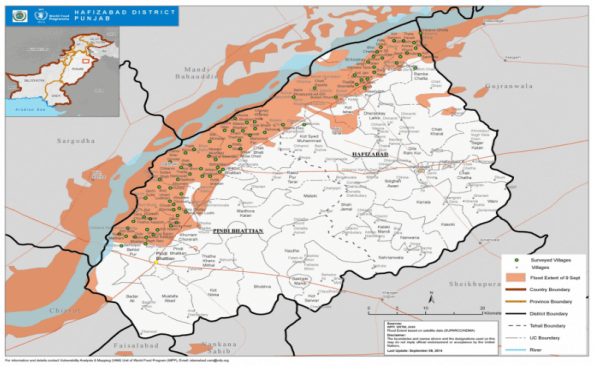

Figure 2: Salinity Map of District Hafizabad.

Results

Farmers characterization in Saline Environment

The farming communities of Hafizabad can be characterized as a host of socioeconomic and biophysical constraints along with diversity in livelihood typologies. The area is in transition stage of their livelihood transformation from farm income sources to off-farm earnings.

a. Education:

Education plays an important role in adopting new innovations and technological interventions. Results revealed that common education in the area was matric (10 year of schooling). Majority of the respondents are literate to the level of matric in all farm categories. Education up till matric or below is common feature in agricultural household in saline environment of Hafizabad district. In small and medium farmer, middle level education is common, while in large farmer, either illiteracy or high level of education is noticed (Fig 3).

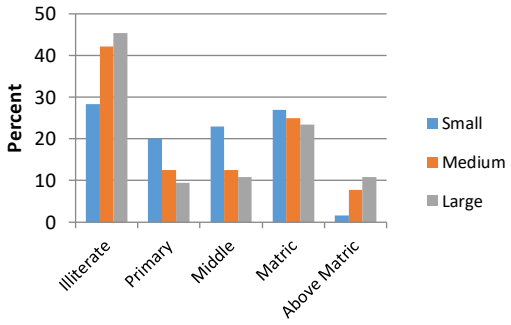

Figure 3: Education status of selected respondents.

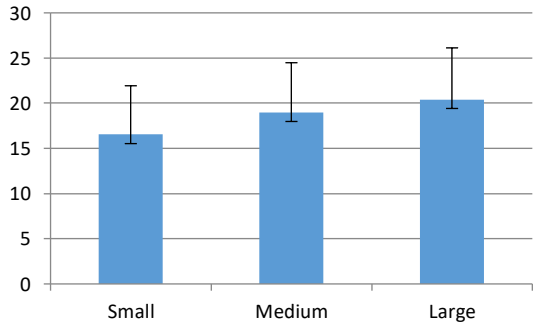

Figure 4: Farming experience of selected respondents.

b. Experience:

Results expressed that majority of the farmers have experience of 10-20 years (Fig 4). The large farmers were more experienced as compared to small and medium farmers.

c. Cultivated area and method of irrigation

Possession of farm area is an important indicator of farmer wealth and physical asset. Data revealed that 97

percent of the large farmers and 75 percent of medium farmers has own cultivated area of above 9 acres, while 53.5 percent of small farmers has the cultivated area in range of 6 to 9 acres (Fig 5). Standard deviation of cultivated area owned by large farmers was very high indicating variability in holding /maintaining cultivated area. Irrigation source causes salinity to change in the saline areas. In Hafizabad area, 39.1 percent of large farmers, 46.9 percent of medium and small farmers used the irrigation source of tube well and canal at present (Fig 6).

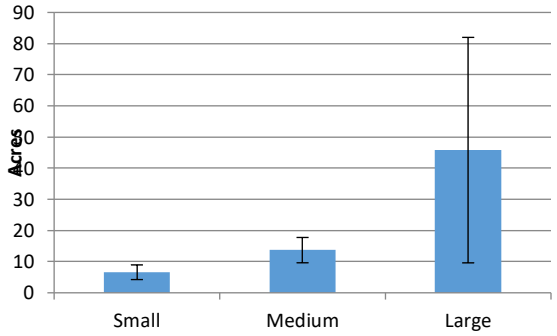

Figure 5: Cultivated area by farm categories.

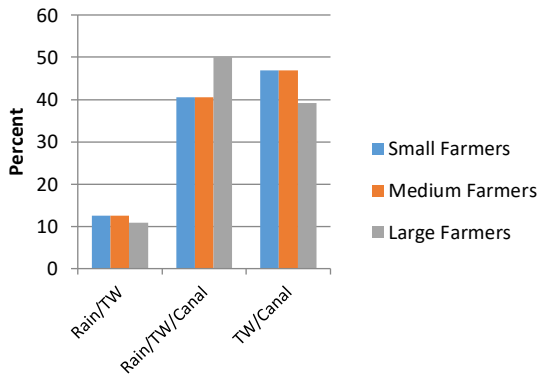

Figure 6: Irrigation sources by categories and sources.

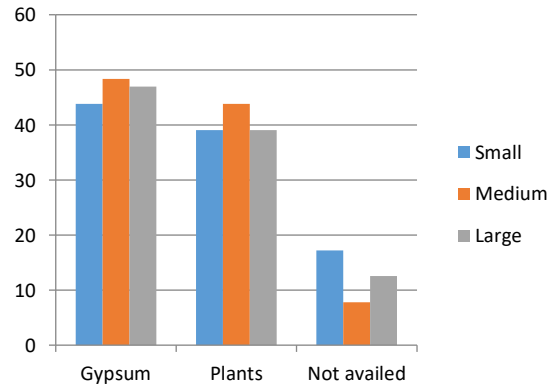

Figure 7: Farmers benefited from different activities of the Biosaline project.

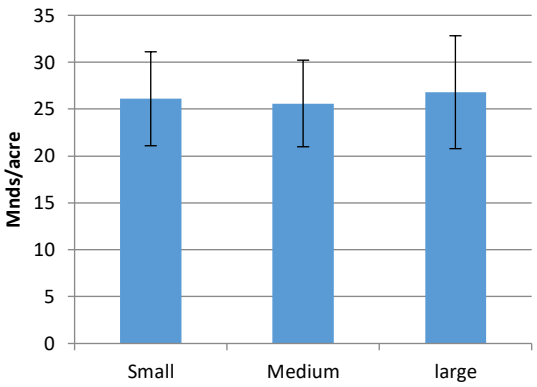

Figure 8: Productivity of wheat under saline environment.

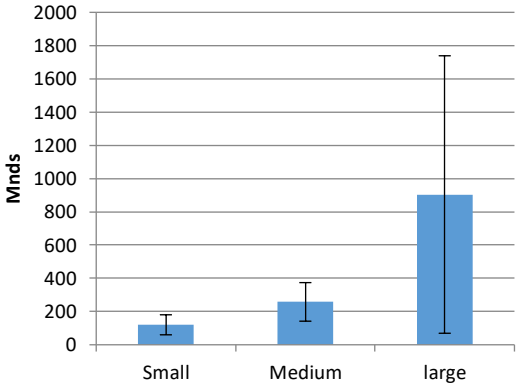

Figure 9: Farm category wise marketable surplus in saline environment.

d. Technological adoptions

On an average 87 percent of the farmers reported benefiting from the project activities. Large, medium and small farmers comprising of 46.9, 48.4 and 43.8 percent respectively reported benefiting Bio-saline project in the form of gypsum as a salinity controlling agent. Similarly nearly 40 percent of the farmers availed plants from the project as a reclamation activity (Fig.7). The data indicated that approximately same ratio of small, medium and large farmers benefited from the project without any discrepancy normally reported in other projects.

Productivity and marketable surplus

Productivity of wheat in saline environment is almost same among small, medium and large farmers (Fig 8). Average yield of wheat in saline was noticed as 26.10 ± 5.01, 25.60 ± 4.62 and 26.8 ± 6.02 obtained by small, medium and large farmers respectively (Fig 8). The marketable surplus of small, medium and large farmers was notices as 120.07 ± 60.24, 258± 116 and 904 ± 834.7 respectively. The marketable surplus was very high in case of large farmers along with more standard deviation (Fig 9).

Livelihood typologies

Farmers of saline affected areas of Hafizabad are mainly deriving their livelihood from farm and off-farm resource utilization. The farm income was mainly contributed by wheat and rice crop. Farm income was found to be in the bracket of 10-12 thousand per acre as 80 percent of farmers fall in this category (Fig10). Average income derived from farm resources were reported by small, medium and large farm was approximately same while standard deviation of large farmers was high indicating their vulnerability (Fig11).

Off-farm income in the saline areas were mainly earned by the farmers by working as casual labour, whose standard deviation is very high indicating their vulnerability and high risk. The off-farm earning of medium and large farmers were almost same i.e, 8140 and 8000 respectively while standard deviation is very high indicating its unstable behaviour (Table 2).

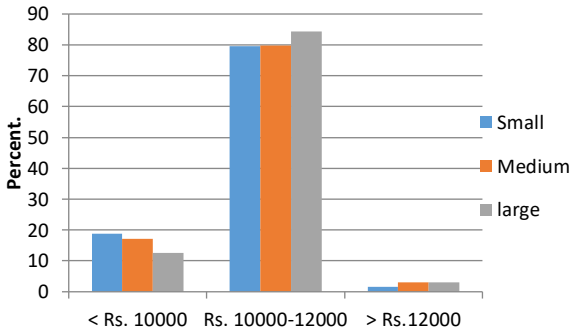

Figure 10: Farm Income contribution on the basis of farm and income size.

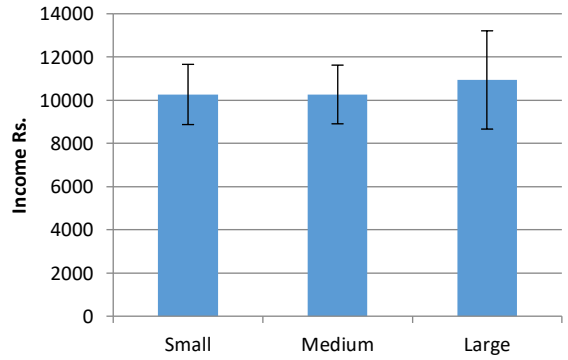

Figure 11: Average onfarm income in saline environment.

Category of farmers	< Rs 15000	Rs 15000-30000	>Rs 30000	Mean & S.D (Rs.)
Small	79.7	10.9	9	6437 ± 13819
Medium	68.8	28.1	3.1	8140 ± 12655
Large	81.3	7.8	10.9	8000± 20750

Table 2: Monthly off-farm income contribution farm category wise and farm wise.

Discussion

Socioeconomic characterization of saline communities may support in localized technological solutions based on farmer's knowledge. Education and experience of farming community facilitate farmer in adoption process of technological interventions for improving productivity and earning livelihood from efficient use of local resources.

Education and farm experience determine the farmer's attitude to control salinity [22]. Education is the primary tool for growth and development of an economy, its social welfare and ensuring human rights. The farmers of Hafizabad saline area were mostly illiterate (Fig 3). Trend of education is more among small farmers but higher education is limited due to resource constraint. Formal education helps in controlling excessive irrigation and in turn salinity [34]. Even drinking water salinity may effect children educational achievements [35]. Small farmer were evolving solutions based on their education and experience. Experience plays a vital role in farming work, research and task. Experienced farmers mitigate salinity more effectively than others. Experience plays important role in improving efficiency of farming but experience coupled with technology is more effective. Less experienced small farmers mostly engaged in off farm activities to compensate income loss as compared to medium and small famers. Farmers having more farming experience are capable of producing better results to cater salinity. Large farmers have more variability in maintaining area under cultivation. Farmers of saline areas mostly use Canal and tubewell water for irrigation of their cultivated area. Excessive irrigation may also cause salinity [34].

Water sector strategy of Government of Pakistan includes salinity control among its five elements and in 2017-18, and amount of Rs. 36.78 billion were allocated for water sector projects in Pakistan [36]. Government is also investing in the area to control salinity. Biosaline project was initiated in the area with several salinity control interventions. Major activities of the Biosaline project in the target area were provision of Gypsum and plants for reclamation of the infected soils [37]. The project activities were proved to be effective in the treatment of salinity in the area [38].

Land income or earning capability represents the relationship of farm household with land in one end and fertility on the other end. More income from agricultural land is an indicator of strong bonding of agricultural household with land and high land productivity. Salinity intrusion adversely affects farm income [39]. Average land earning from agriculture sector per acre was found to be in range of Rs. 10-12 thousand per acre in the saline areas (Fig 10). Poor farmer with less income could not able to invest in controlling salinity and earning of saline fields is about three times lesser as compared to irrigated plains of Punjab.

Wheat productivity in saline area is around 26 mounds per acre (2.6 t ha^{-1}) while in Egypt maximum yield obtained was 3.1 t ha^{-1} [40] and large farmers contribute more marketable surplus due to greater land holdings.

Contribution of off-farm income in rural agricultural household economy represents the dependency of farm household and its livelihood strategy. Off farm income significantly reduce poverty [41].

The livelihood typologies derived by farm household may be applied for saline agriculture characterization, analysis and modeling [42.43]. Many studies focused on these livelihood typologies [44]. Saline farming communities of Hafizabad district of Punjab, majority of small, medium and large farmers earn less than fifteen thousand rupee monthly from off-farm sources (Table-2) and its standard deviation is very high indicating vulnerability and risk in off-farm earnings.

The study was planned to analyzed the livelihood strategies of farming community of Salinity affected areas of Pakistan. Primary data was collected from 192 respondents of salinity affected district of Hafizabad. Socio-economic profile of saline communities indicated the human and physical capital of farmers. On human capital side, mostly the farmers are illiterate but equipped with farming experience while only large farmers are enriched with physical resource of cultivated area and irrigation by tube wells and canals. Majority of farmers adopted new technologies through government interventions. Wheat productivity is almost same among all categories of farmers but the large farmers has more marketable surplus due to more land holding. Livelihood of farmers in saline environment mostly depends upon on-farm and off-farm income. Eight percent of the farmers earn between Rs. 10-12 thousand per acre from on-farm resources and Rs. 15 thousand from off-farm sector. Off-farm income is more vulnerable than on-farm income. Effect of salinity is three fold on-farm income. The saline communities are marginally surviving and need immediate government intervention for increasing income through employment generation in the area.

It is therefore recommended that Salt-affected soils should be kept under cultivation to meet the food requirements of country. Socio-economic status of salt-affected communities could be uplifted with the provision of subsidized farming inputs.

Conflict of interest

The authors declare that they have no competing interests.

Author Contributions

Arshad Mahmood Malik: Conceived the idea, prepared workplan, supervise the research work, write up. Guidance at every step

Hafiz Muhammad Tayyab: Conceived the idea, data collection, analysis and write up

Muhammad Arshadullah: write up and guidance at every step

Muhammad Talha Bilal: write up and guidance at every step

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