

The Preliminary Study of Anthropogenic and Natural Drivers of Desertification in Drylands of South Punjab, Pakistan

Nausheen Mazhar^{1,3} Safdar Ali Shirazi²

¹Department of Geography, Lahore College for Women University, Lahore, Pakistan

²Department of Geography, University of the Punjab, Lahore, Pakistan

³Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK

*Email: nausheen.mazhar@lcwu.edu.pk

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Abstract: This study aims to investigate the perceptions of farmers residing in the drylands of south Punjab regarding the drivers of desertification mainly associated with meteorological and anthropogenic factors. Dataset of 399 respondents was collected using disproportionate stratified sampling technique from Bahawalpur, Rahim Yar Khan and Rajanpur districts. Pearson correlation and cross tabulation were performed to explore relation between variables. Simple Linear Regression (SLR) helped in investigating the association between natural and anthropogenic causes of desertification. The findings of this study indicate the significant variability in natural causes of desertification such as increasing temperature extremes, soil salinization and variation in rainfall patterns, while extensive land degradation, caused by anthropogenic factor, as leading to desertification in the study area. For Rajanpur, mean rainfall variation, supports the perception regarding major natural driver of desertification. Small-scale farmers were found to be most vulnerable to climatic extremes. SLR concluded that anthropogenic factors trigger or intensify the natural drivers of desertification in the study area. Useful insights are provided regarding the perceptions of the local farming community regarding causes of desertification as appropriate perception of a risk leads to fruitful adaptation measures.

Key words: Perceptions, climate extremes, desertification, drylands, land degradation.

Introduction

Across the globe, fragile ecosystems and their vulnerable population are affected most by desertification, with irreversible outcomes (Bisaro et al., 2014). Developing countries, especially in south Asia, rural population remains most exposed to the vagaries of extreme climate events (IPCC, 2014), while Deressa et al. (2009) reported the rural population of Pakistan as extremely vulnerable to climate change and its associated impacts. Fahad and Wang (2018) declare Pakistan to be one of the world's most vulnerable country to the extreme climatic events.

Understanding the perceptions of the farmers remain an essential element in anticipating any phenomenon operational in their region. Simelton et al. (2013) highlighted the significance of understanding the farmer's perceptions regarding rainfall fluctuations, by mentioning that perception of a problem is necessary for effective steps to be taken in future to adapt to it. The small-scale farmers in the drylands, paradoxically are the ones with low climate change awareness (Muller, 2014).

According to Simelton et al. (2013), the significance of relating and aligning farmer's perceptions with meteorological data, is increasing for areas where rainfall patterns are erratic and they are leading to dwindling agricultural productions. Similarly, in areas of Pakistan where the rainfall decadal variability is high (Mazhar et al., 2015) especially in semi-arid and

arid climatic zones, the need for mirroring farmer's perceptions with climatic data can be emphasized. Pakistan has a highly agrarian economy and variability in precipitation enhances its aridity, with almost 68% of its land receiving less than 250mm of annual rainfall (Siddiqui and Javid, 2019). Both social and environmental processes lead to desertification of a region, for example uncontrolled water usage, agricultural land exploitation, urbanization uncontrolled grazing practices, population growth and its associated pressures, deforestation, water depletion, soil erosion and salinization etc. (Abdi et al., 2013; D'Odorico et al., 2013; Martello, 2004).

One of the reasons identified as a barrier to successful implementation of UNCCD's desertification combating strategies, is lack of awareness about drivers of desertification (Giest, 2005). Although, according to Ayanlade et al. (2017), farmer's knowledge regarding climate change is insufficient for adaptation planning, while IPCC (2014) emphasizes the significance of local awareness in multi-stakeholder assessments. According to Simelton et al. (2013), indigenous knowledge of the locals helps in understanding the rainfall variability, whereas, Singh et al. (2016) regard the perceptions of people being exposed to risk, is the major barrier towards fruitful adaptation.

The studies regarding the perception of rural households regarding the driving forces behind desertification in the drylands of south Punjab, has remained a neglected area. A gap exists between

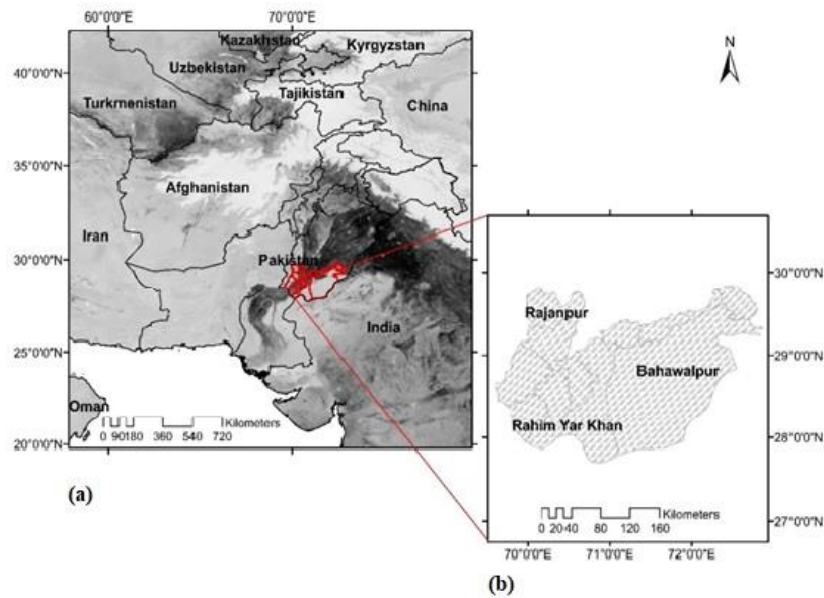


Fig. 1 (a) Map of Pakistan showing location of the study area (b) Shows three districts of south Punjab under study

scientific analysis of climate change and rural farmer's awareness (Ayanlade et al., 2017). Thus, present study aims bringing into light the perceptions of the farmers of the arid south Punjab, causing desertification in the region, and comparing perceptions with relevant data of meteorological variables. The study also aims to assess relationship between land holding as a variable and perceptions about the natural and anthropogenic causes of desertification by the respondents. It also explores, if the anthropogenic causes of desertification in the study area are associated with the natural factors of desertification.

Three districts of south Punjab, Pakistan, namely Bahawalpur, Rahim Yar Khan and Rajanpur, situated in the dryland region, form the study area (Fig. 1), covering a total area of 49, 029km² (GoP 1999a, 1999b, 2000). Coordinates of the districts under study are Bahawalpur: 29.3541°N, 71.6908° E, Rahim Yar Khan: 28.4211°N, 70.2986°E, Rajanpur: 29.1041°N, 70.33°E. These districts extend as dryland belt in south Punjab with a total population of 7,936,974 and more than 65% rural population in each district (GoP, 2017), highly dependent on agriculture and livestock herding. This high rural population percentage affirms the dependency, of the bulk of the district's population on agriculture. The expanse of desertification in the region will continue to aggravate the living conditions of this highly agrarian population.

Materials and Methods

Data were collected from the field survey which was conducted from February 2019 to July 2019. The questionnaire was pilot tested in 14 union councils in the study area during January 2019. The findings from the pilot survey allowed minor alterations to be made in the questionnaire. During this survey, 66 union councils located in three districts of study area were

surveyed to collect the primary data. Disproportionate stratified sampling technique was applied for the questionnaire survey, where three districts formed the first strata while three categories of desertification vulnerability zones based on the study by Mazhar et al., (2018), formed the sub-strata. Simple random sampling technique was used in each sub strata for final selection of the respondents.

The sample size for the questionnaire-based survey was determined using the Slovin's formula (equation 1) (Fikri et al., 2018; Indarti et al., 2017; Pawirosumarto et al., 2017), expressed as:

$$n = N / (1 + Ne^2) \quad (1)$$

where n is number of samples, N is total population and e is error (tolerance level 0.05). According to the provisional results of the 2017 census, total rural population of the study area is 7,936,974 (GoP, 2017), and by using the Slovin's formula the sample size calculated for this study was 399. Table 1 presents the number of union councils surveyed in each tehsil along with number of respondents.

Table 1 Number of respondents in surveyed Union Councils

District	Tehsil	No. of Union Councils surveyed	Total number of respondents
Bahawalpur	Bahawalpur tehsil	1	15
	Ahmadpur East	6	74
	Khairpur	2	8
	Tamewali	4	7
	Hasilpur	1	29
Rahim Yar Khan	Rahim Yar Khan tehsil	7	24
	Sadiqabad	10	10
	Liaquatpur	2	2
	Khanpur	1	1
Rajanpur	Rajanpur tehsil	14	64
	Jampur	14	57
	Rojhan	4	12

Meteorological data of the rainfall variables, minimum and maximum temperature and monthly means, were provided by Pakistan Meteorological Department for the districts of Bahawalpur, Rahim Yar Khan and D.G. Khan. The limitation of this study is insufficient meteorological data, since there was no meteorological observatory located in Rajanpur, therefore, nearby station D.G. Khan's data were used for Rajanpur. Ayanlade et al. (2017) also used the meteorological data from meteorological station available near the study area. D.G. Khan's observatory became operational in 2003, while, Rahim Yar Khan meteorological observatory was established in 2002. Although, Bahawalpur meteorological observatory had data since 1960 and to make comparison of all three districts data for the same years, analysis was run for the period of 2003-2017.

Statistical Package for Social Sciences (SPSS) 25 was used to find Pearson correlation between land holding, natural and anthropogenic drives of desertification. Singh et al. (2018) pointed out similar significant association between perception about water scarcity and landholding size. After obtaining the significant correlation, cross-tabulation was run between these variables. In order to explore the trends of temperature and rainfall, mean annual temperature, and average rainfall were graphically presented. Figures 6 and 7 also help relate the findings with the choice of main natural cause of desertification, as opted by the respondents. Simple Linear Regression (SLR) was applied in SPSS environment, to investigate, if anthropogenic drivers of desertification were triggering natural drivers in the study area. SLR is commonly used to explore the associations between variables (Lin et al., 2017; Vanleeuwen et al., 2013).

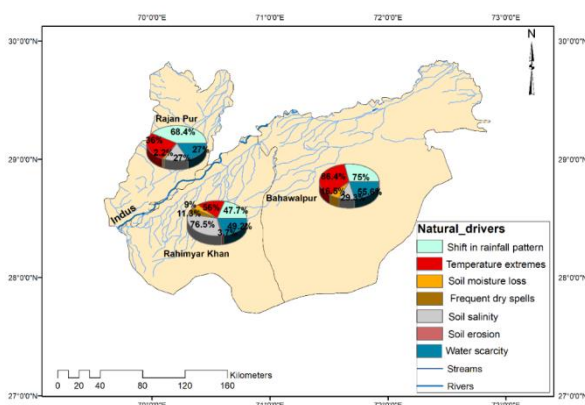


Fig. 2 Natural drivers of desertification.

Results and Discussion

Figure 2 presents interesting finding that all three districts ranked a different natural driver of desertification to be most influential in a particular district, i.e. increase in temperature ranked most significant natural driver in Bahawalpur, soil salinization in Rahim Yar Khan and variation in rainfall pattern in Rajanpur. Perceptions of rural

households regarding weather elated risks has been studied by many researchers (Fahad, 2018; Wolka, 2017). D'Odorico et al. (2013) also reported Indus basin in Pakistan to be suffering from salinity and the respondents from Rahim Yar Khan also mentioned the same to be the main driver of desertification in their district.

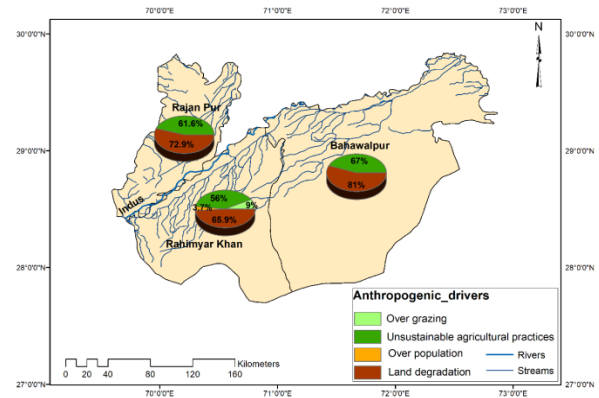


Fig. 3 Anthropogenic drivers of desertification.

The respondents from all three districts under study opted for land degradation, as the most significant anthropogenic cause of desertification in the region, followed by unsustainable agricultural practices. Katyal and Vlek (2000) also concluded that land degradation has proven strong links with human activities, as compared to natural variations in climate. The percentages in the slices of the pie graphs in Figures 2 and 3, represent percentage of respondents opting for a particular driver out of total 133 respondents: each respondent could choose as many drivers as he thought were in action in the region.

Landholding of the farmers appear to have a significant relationship with the farmer's choice of the main reasons of desertification, with Pearson's r value between land holding and mean of natural causes of desertification being 0.212, having a p value <0.05 , i.e. 0.01. Thus, two variables are significantly correlated. Similarly, land holding and mean of anthropogenic factors of desertification are also significantly correlated with Pearson's r of 0.149 and p value <0.05 , i.e. 0.003.

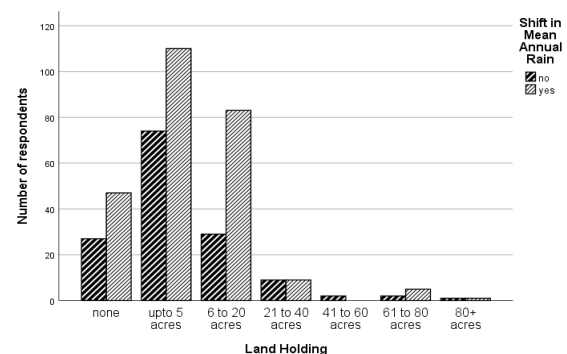


Fig. 4 Number of respondents on the basis of land holding opting for variation in mean annual rainfall as natural driver of desertification.

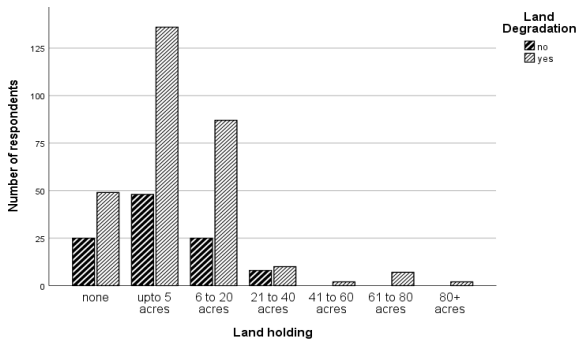


Fig. 5 Number of respondents on the basis of land holding opting for land degradation as anthropogenic driver of desertification.

Correlation between the variables of land holding and means of natural and anthropogenic causes of desertification were established. The cross-tabulation was then run in SPSS environment to explore, which land holding group opted for which factor of desertification to be in action in their region

Figures 4, 5 prepared using cross-tabulation, present the most influential natural and anthropogenic drivers of desertification in the region, which the small-scale farmers of up to 5 acres opted. Amongst natural causes most significant was variation in mean annual rainfall, followed by temperature extremes, soil salinity and water scarcity. The altered precipitation patterns and rising temperatures make various types of land use to suffer, more precisely agricultural sector (Lobell et al., 2011). Among anthropogenic causes of desertification, the most opted by small scale farmers was the driver land degradation. The analysis concludes that small scale farmers being more vulnerable to variabilities of climate, are more sensitive to variations in temperature, rainfall, soil salinization and land degradation. This finding is unlike Singh et al. (2018) who suggested, larger landholders opt for more variations in rainfall pattern.

It is difficult to segregate natural drivers of desertification from anthropogenic drivers, since in some cases the anthropogenic factors intensify and, in some cases, even result in the natural causes of desertification, while in other cases natural causes lead to certain anthropogenic drivers.

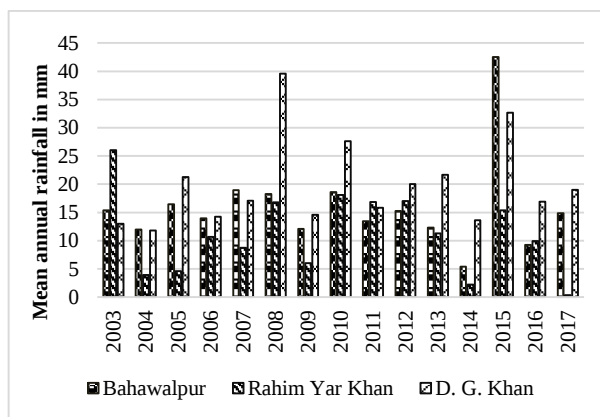


Fig. 6 Mean annual rainfall in mm in Bahawalpur, Rahim Yar Khan and Rajanpur districts during 2003-2017.

For example, water scarcity may be human induced as well, which might lead to land degradation. As pointed by Copeland et al., (2017) when the combination of extreme climate events and increase in land use co occur in drylands, it may lead to land degradation in hyper arid to sub humid areas.

The clustered bars present the mean annual rainfall for the three districts under study (Fig. 6). The bars present interesting finding that in 2015, Bahawalpur district received the highest mean annual rain among three districts i.e. 42.5 mm, while the least mean annual rainfall was received by Rahim Yar Khan, in 2017, i.e. 0.32mm for 14 years period of study.

While, mirroring the perception of the farming community in Rajanpur, that ranked variability in rainfall patterns as main natural driver of desertification in the region, similarly, D.G. Khan's mean annual rainfall shows maximum fluctuation from a minimum of 11.7mm in 2004 to a maximum of 39.56mm in 2008, but in 2015 the mean annual rainfall was 32.66mm (Fig. 6).

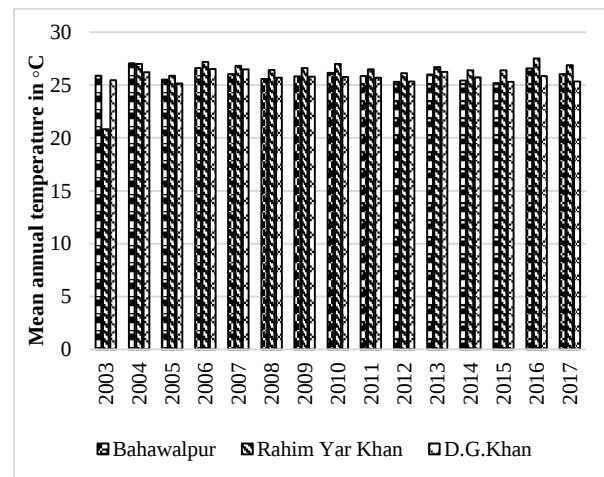


Fig. 7 Mean annual temperature in °C of Bahawalpur, Rahim Yar Khan and Rajanpur districts during 2003-2017.

A similar temperature trend for all three districts was recorded (Fig. 7). However, district Rahim Yar Khan experienced highest temperature fluctuation with a lowest of 20.82 °C in 2003 to a maximum of 27.5 °C in 2016, while for Bahawalpur and D. G. Khan (for Rajanpur) lowest temperature variations were observed.

In order to explore, if the anthropogenic drivers of desertification, aggravate or trigger the natural causes of desertification in the study area, simple linear regression was run with natural causes of desertification as dependent and anthropogenic causes as independent variables. The Pearson correlation coefficient of positive (0.342) between the two variables, with a significant level of 0.000 which is < 0.05 and thus accepting the alternative hypothesis that natural causes of desertification are associated with the anthropogenic factors triggering desertification.

The R^2 value of 0.117 means that 11.7% of the variance in the dependent variable of natural causes of desertification, can be explained by the anthropogenic driver of desertification, with a significance level of 0.000. The ANOVA table indicates that overall the regression, with these two variables is statistically significant at level of 0.000, which is less than our p value of 0.05, indicating that the SLR is a good fit for the data. The regression equation is: natural drivers of desertification=0.383 X + 0.180

The regression output concludes that a unit increase in the anthropogenic drivers of desertification leads to 0.383 times increase in the natural causes of desertification with a statistically significant p value 0.000. However, due to small value of R, the prediction of this SLR would not be much accurate. Thus, it clearly points towards the innate triggering power of the anthropogenic factors of desertification, that play role in triggering or intensifying the already present natural causes of desertification.

Conclusion

This study based on both primary and secondary collected data to investigate the perception of farmers in the rural drylands of south Punjab regarding the significant natural and anthropogenic drivers of desertification in the region and comparing the perceptions of the farming community with available meteorological data set. The study also explored, if anthropogenic drivers were triggering or intensifying the natural causes of desertification in the study area. The results indicated that the most significant natural driver of desertification was temperature extremes in Bahawalpur, soil salinization in Rahim Yar Khan and variation in rainfall patterns in Rajanpur, respectively. Whereas, for anthropogenic driver of desertification, most significant one, in all three districts was land degradation. The comparison of variability in rainfall patterns and temperature extremes as natural drivers, with meteorological data, also support the perception results and presents different dimensions. The study also proves a strong relation of land holding as a variable with perception regarding drivers of desertification. The findings affirm the perception that human causes of desertification lead to triggering or intensification of already existing natural drivers of desertification in the region. Therefore, proper land management practices, controlled urban expansion and restoration of degraded lands might lead to neutralizing the natural drivers of desertification, or at least may reduce their impact. The future studies are recommended to be focused on particular anthropogenic drivers responsible for severity of desertification in the region, so that policy makers can precisely work in the right direction towards controlling the main drivers of desertification and thus, intensifying this disaster in the drylands of south Punjab.

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