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ENVIRONMENTAL SUSTAINABILITY ANALYSIS OF SUB-NATIONAL AGRICULTURE IN PAKISTAN

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Abstract

This paper analyzes the environmental sustainability of sub-national agriculture in Pakistan based on indicators related to land use, crop production and protection practices. Quantitative information required to create environmental sustainability indices was collected from secondary sources, including, Economic Survey of Pakistan (2007-2012), Agricultural Census (2010), Agricultural Statistics of Pakistan (2009, 2011), Handbook of Pakistan Economy (2005) and Medium Term Development Framework (2005). The findings suggest that agriculture in Sindh and Punjab province lagged behind KPK and Balochistan in terms of environmental sustainability. The reasons for such trends in Punjab province were highly intense land use, the highest chemical use in terms of pesticides and chemical fertilizer. Contrary to this, Balochistan province performed better in the above indicators with an exception that it has the highest saline area in Pakistan. Sindh and KPK performed mix on selected indicators. Based on our findings, we recommend rational use of fertilizer and pesticides in Punjab and soil salinity control and crop zoning in Sindh. Whereas, we recommend cropping diversity in KPK and salinity control programs in some regions of Balochistan.

Keywords: *Environmental sustainability, Sustainable Agriculture, crop diversification, Pakistan.*

Introduction

Sustainability in agriculture sector is of utmost importance and can only be achieved through sustainable use of agricultural resources. The term ‘sustainable’ here means using the agricultural resources sensibly in such a way that they remain viable in present as well as in future (Fresco and Kroonenberg, 1992) so that future generations are not handicapped in their use because of over exploitation of the past. The notion of ‘sustainability’ has been the source of creating widespread consensus for its desirability as objective of agricultural development (Hansen, 1996).

With the advent of green revolution the crop productivity in Pakistan increased significantly mainly through using inorganic fertilizer and pesticides more intensively, the introduction of high yielding varieties and increased farm mechanization. The environmental problems caused by overuse of chemical inputs included land degradation and stalled agricultural productivity (Ahmed, 1994; Ali and Byerlee, 2002). Also the soil and water pollution has been caused by the excessive use of chemicals (Ahmed, 1994).

Materials and methods

The focus of this study was to assess the situation of environmental sustainability of agriculture at provincial level based on identified environmental indicators of success. The diversity in agriculture across all provinces lead us to conduct research at the provincial level (GOP, 2011). There are four provinces in Pakistan namely Punjab, Sindh, KPK (Khyber

Pakhtun Khwa) and Balochistan. The difference in agricultural infrastructure, environment, and diverse biophysical conditions have resulted in the development of whole different agricultural system in each province. The data for this paper related to environmental sustainability assessment was collected from secondary sources including government reports, Economic Survey of Pakistan (2007-2012), Agricultural Census (2010), Agricultural Statistics of Pakistan (2009, 2011), Handbook of Pakistan Economy (2005) and Medium Term Development Framework (2005).

Methods and Techniques

For the purpose of comparison the year 2005-06 was taken as base year similar to the standard adopted by the government of Pakistan (GOP, 2010). The data for all the indicators was analyzed from the year 2005-06 to 2010-11 or for the latest available data. This was because the last agricultural census in Pakistan, which provides comprehensive information on most of the agricultural variables, was carried out in 2010. The data analysis techniques were described in the following text.

Determination of Environmental Sustainability

The indicators can help in measurement and calibration of progress towards sustainable development goals (DiSano, 2001). There are multitude of indicators for the measurement of environmental sustainability depending on the availability of information and characteristics of the study area. However, the following indicators (table 1) were developed keeping in view the agricultural system in Pakistan, availability of the secondary data and regional level nature of the research (Rasul, 1999; DiSano, 2001; Rasul and Thapa, 2003; Zhen and Routray, 2003; Hatai and Sen, 2008; Hayati et al., 2011).

Table 1: Indicators of environmental sustainability

Indicators	Measurement
Agricultural land use intensity	Land use intensity = (Total cultivated area/ Total culturable area) * 100
Crop diversification	Crop diversification index
Extent of soil salinity	Percentage of total area under different soil salinity conditions
Use of fertilizers	Percentage of total farms using organic and inorganic fertilizers
Trend of inorganic fertilizer use	Fertilizer use (000 Nutrient tonnes)
Use of insecticides and pesticides	Percentage of total farms using insecticides and pesticides

The intensive use of chemical inputs has resulted in a lot of problems in Pakistan. A time series analysis of the use of chemical fertilizers and pesticides was done and conclusions were drawn based on the trends in chemical input uses. All the above indicators are self-explanatory except crop diversification index, which is explained below.

Crop Diversification Index

Crop diversification refers to a strategy to optimize the usage of agricultural land, water and other resources. Diversification may also be defined as the shift of agricultural production from low value crops to high value crops (Vyas, 1996 cited by (Bhattacharyya, 2008). There are various ways to measure the status of crop diversification. However, following method was used to calculate the crop diversification status in all four provinces of Pakistan. The Herfindahl Index (HFI) was calculated as following (Malik and Singh, 2002):

$$HFI = \sum_{i=1}^{n} Prop_i^2$$

HFI = Herfindahl Index, and $Prop_i = \frac{Area_i}{\sum_{i=1}^{n} Area_i}$

$Prop_i$ = Proportion of i^{th} crop, $Area_i$ = i^{th} crop area (hectare), $\sum_{i=1}^{n} Area_i$= Total cropped area (hectare), i = Number of crops (1,2,3,…n)

In order to calculate crop diversification an index was calculated directly from Herfindahl index and this is called Crop Diversification Index (CDI). $CDI = 1 - HFI$

The value of CDI varies from zero to one. The value of zero shows perfect specialization and as the value of CDI increases the level of crop diversification increases until it reaches one: which is perfect diversification. The CDI was calculated based on all crops including cereals, sugarcane, cotton, pulses, vegetables, fodder crops, and fruits.

Results and discussion

The environmental sustainability is an important component of agricultural sustainability. The very definition of sustainable agriculture requires the use of the resource base without environmental degradation (Firebaugh, 1990; Rasul and Thapa, 2003). It constitutes the use of natural resources for agricultural production without harming these resources and environment. The results are presented in the following discussion.

Agricultural Land Use Intensity

The appropriate use of land resources determines the sustainable use of it and land use intensity is a good measure for this. The higher land use intensity represents higher pressure on the farmland and thus lower environmental sustainability.

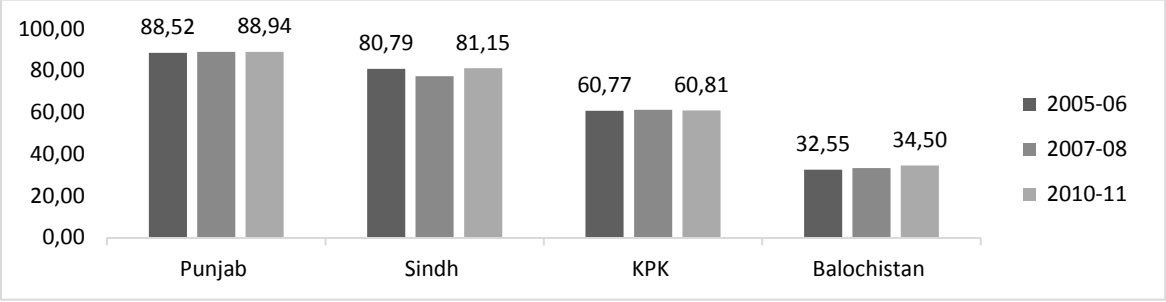

Figure 1: Land use intensity by province from 2005-06 to 2010-11

The land use intensity which measures the level of strain that its use puts on resources was highest in Punjab and lowest in Balochistan. The land use intensity was higher in Punjab and Sindh because of more favorable terrain and suitable growing conditions. The agriculture in these two provinces is mostly irrigated and presence of vast alluvial plains made it possible to use the land intensively (GOP, 2009). The presence of large irrigation network allows Punjab and Sindh to use more culturable land under cultivation. The KPK province was the third in the list because of difficult terrain due to hills and mountains. As expected, the Balochistan province had the least land use intensity due to a large area under deserts and limited irrigation infrastructure. The intense aridity and rugged topography only add up to pull down the agricultural land use in Balochistan (GOP, 2009).

Crop Diversification

A diversified farming system is more sustainable both for land and biodiversity. It also helps in maintaining the correct nutrient balance in soil.

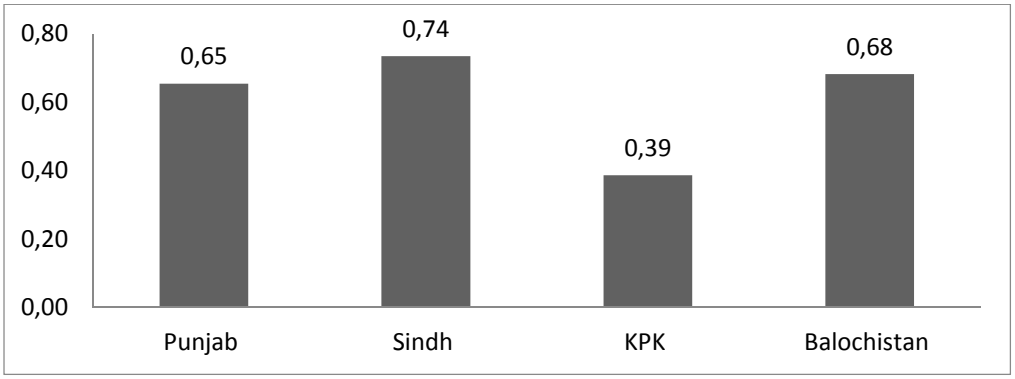

Figure 2: Crop diversification index for year 2010-11

The crop diversification status of the four provinces was presented in Figure 2. The low level of crop diversification status in KPK can be explained by the type of crops grown in KPK, more than 70 percent of the agricultural cropped area was covered by only wheat and maize crops (GOP, 2011). There was a significant difference of crop diversification status among KPK and all other provinces. Sindh province has more diversity in soil conditions and thus farmers have to sort towards cultivation of different crops according to biophysical conditions rather than concentrating on few crops, like was done in Punjab. Similarly, in Balochistan there was great diversity of crops grown (GOP, 2011).

Extent of Soil Salinity

The good status of the land resources is an indication of its appropriate use. Thus, the extent of soil salinity was taken an indicator for measuring the environmental sustainability of the agriculture in each province.

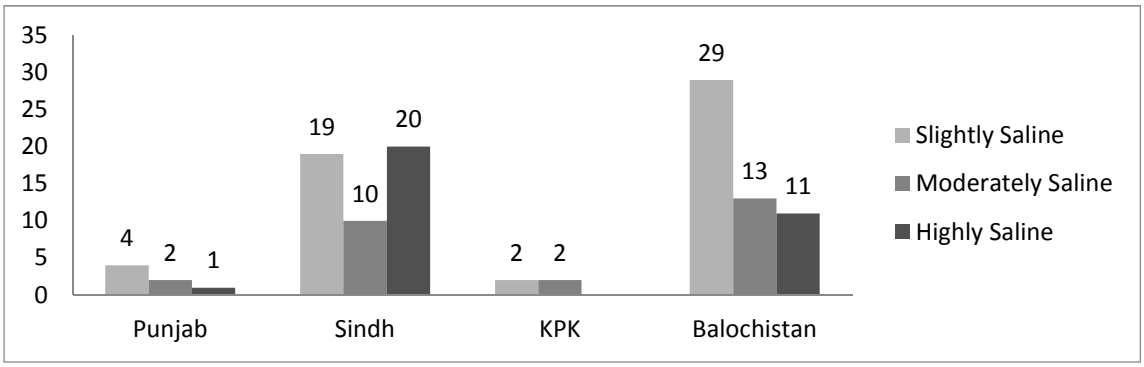

Figure 3: Surface salinity status by province for the period 2001-04

It can be deduced from the Figure 3 above that KPK was the least affected province from soil salinity problem. It was mostly because of different topographical conditions of KPK than that of other provinces. The crops grown in KPK and the lower irrigation water application along with soil nature combined together to result in lower soil salinity. The worst affected provinces were Sindh and Balochistan in terms of total percentage of agricultural area. In fact half of the soils affected by salinity were in Balochistan and Sindh province only (Khan et al., 2012).

Use of Fertilizer

In Pakistan the non-availability of organic fertilizers has forced farmers to use organic matter together with chemical fertilizers or in some cases organic matter alone. Thus, the use of organic matter was taken as an indicator for the willingness to use organic fertilizers.

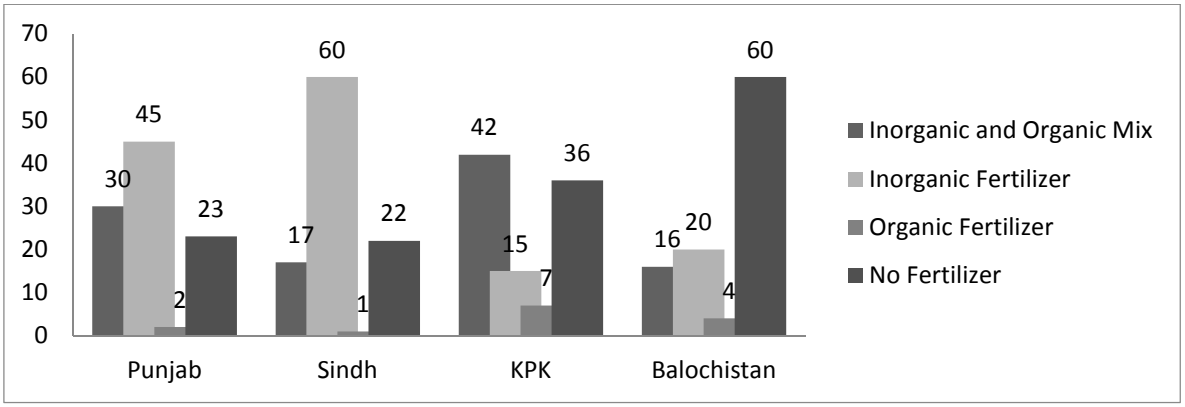

Figure 4: Percentage of total farms using fertilizers and manures in 2010

The use of organic manures was considered environmentally sustainable and KPK has the highest percentage of farms, 7 percent, using organic fertilizers only with no inorganic fertilizer use as shown in Figure 4. The low use of chemical fertilizer includes the non-availability and lack of proper know how about its usage (Khan, 2012). While, in Sindh and Punjab a majority of the farmers used inorganic fertilizers during the period under consideration. This was in-line with the high land use in these two provinces. In order to maintain such a high land use there was a need for an intensive use of chemical fertilizers.

Trend of Inorganic Fertilizer Use

The use of chemical fertilizers has proved to have many detrimental effects on environment. The trend of inorganic (chemical) fertilizer use gives an indication of the direction which agriculture is taking, whether towards or away from sustainability.

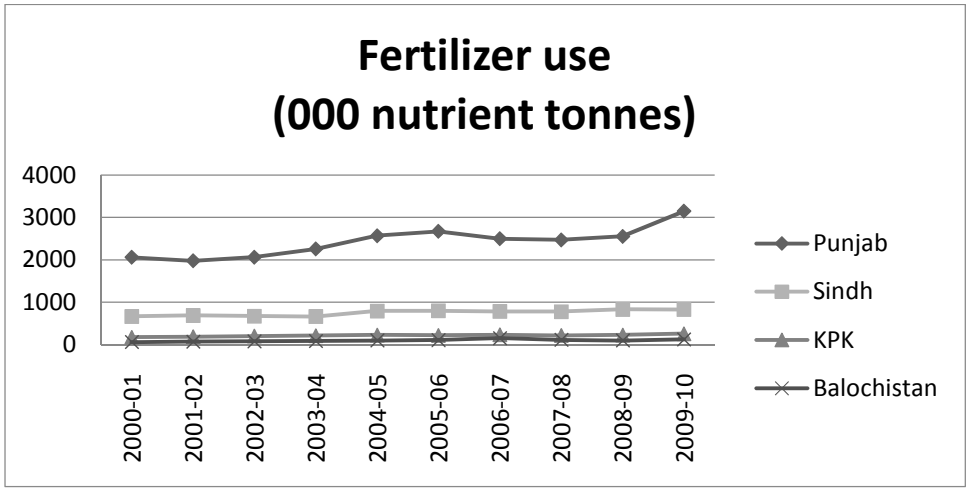

Figure 5: Trend of fertilizer consumption by province from 2000-01 to 2009-10

Although the cropped area in Punjab has not increased significantly during the period under consideration (GOP, 2011) the fertilizer use had shot up very quickly, indicating an upsurge in per hectare use of inorganic fertilizers. After Punjab, Sindh province had a smaller fertilizer use increase while KPK and Balochistan showed insignificant change in chemical fertilizer use. Thus, according to the trend in inorganic fertilizer use the order of environmental sustainability increases from Punjab to Sindh while KPK and Balochistan come in between these two provinces.

Use of Insecticides and Pesticides

The use of appropriate plant protection measures is necessary for good production. However, the nature of these measures determines the environmental sustainability of agriculture.

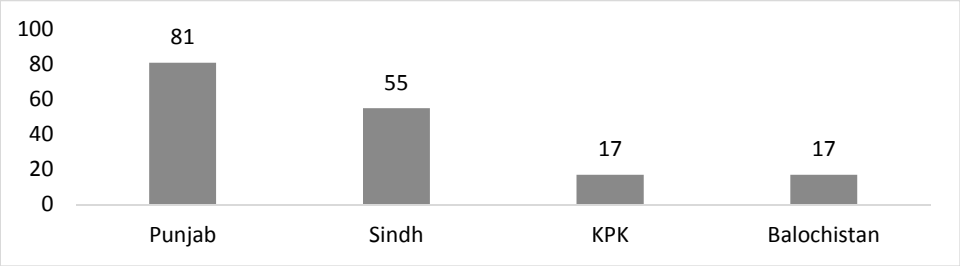

Figure 6: Percentage of total farms using insecticide, pesticide and herbicide in 2010

The use of chemicals as plant protection measures is harmful both for human health as well as to the environment (Carson, 1962; Jabbar and Mallick, 1994; Khan et al., 2011). Punjab province had the highest ratio of farms, 81% to be precise, under insecticide, pesticide and herbicide use as shown in Figure 6. Sindh province followed Punjab and had 55 percent of the farms using pesticides, insecticides and herbicides. This high level in both provinces was to maintain high level of land use as well as to control the high persistence of diseases. Thus, according to this criterion KPK and Balochistan rank highest on environmental sustainability, and also equally because these have same percentage farms, seventeen percent, under insecticide, pesticide and herbicide use. A study conducted in Balochistan also came with the same results about these chemicals; that the farmers in Balochistan use very low or no insecticides, pesticides and fungicides (Siddiqui et al., 2007).

Conclusion

The majority of farmers in all four provinces still use chemical fertilizers and pesticides indiscriminately, prefer the specialized cropping system, aspire to further intensify cropping and have large labor force in agriculture. The environmental sustainability of agriculture presented an altogether different picture across the four provinces. Punjab province had the highest land use intensity while Balochistan had exactly the opposite. Punjab province also had the highest chemical use in terms of total farms using insecticides, pesticides and herbicides as well as highest growth rate in chemical fertilizer use. These all four indicators had put the Punjab province as least sustainable in terms of environmental sustainability. Contrary to this, Balochistan had the lowest of all these four indicators along with lowest chemical fertilizer use placing it at the top of environmental sustainability among all four provinces. The other two provinces, Sindh and KPK, had mixed results in all indicators and came in between Punjab and Balochistan for environmental sustainability.

The contrasting results for environmental sustainability at the provincial level require province specific policies. In order to improve the environmental sustainability of agriculture in Punjab province there is need to diversify to more high value crops and encourage the use of organic fertilizers. For the improvement of environmental sustainability in Sindh province there is need to control soil salinity and over application of chemical fertilizer. The soil salinity control requires concerted efforts by the government to promote crops and varieties which are suitable to the arid biophysical condition of Sindh province. The biophysical conditions in KPK province are very suitable for fruits and vegetable cultivation and thus, there is need to promote their cultivation. In Balochistan and similar actions may be taken to control soil salinity as suggested for rain-fed agriculture in Sindh province. This study encourages the policy makers to embark on province specific policies for the achievement of sustainability based on diverse nature of biophysical conditions and agriculture across provinces.

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