AGRICULTURE POLICIES AND CROPPING PATTERN IN PUNJAB PROVINCE OF PAKISTAN: ISSUES OF WATER AND ENVIRONMENT

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by

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CERTIFICATE

This is to certify that this thesis entitled: **"Agriculture Policies and Cropping Pattern in Punjab Province of Pakistan: Issues of Water and Environment".** submitted by Muhammad Ashfaq is accepted in its present form by the PIDE School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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LIST OF ABBREVIATIONS

CA	Cotton Area
CEC	Cotton Export Corporation
CWW	Canal Water Withdrawal
DRC	Domestic Resource Cost
ExpPrice	Export Price
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GOP	Government of Pakistan
IM Price	International Market Price
MP	Market Price
NPC	National Protection Coefficient
NWFP	North West Frontier Province
OECD	Organization for Economic Cooperation and Development
RA	Rice Area
REC	Rice Export Corporation
SROs	Statutory Regulatory Orders
SA	Sugarcane Area
SP	Support Price
USD	United states Dollar
WP	Water Prices

Abstract

Over the years, Pakistan has relied heavily on its agriculture sector. Agricultural produce not only meets the local demand but is also a source of foreign exchange earnings. However, the increasing water stress in the country begs the question of cropping choices. This study aims to evaluate agricultural policies' support in adopting the existing cropping pattern in Punjab with respect to three main crops i.e. rice, sugarcane and cotton. Along with this, the issues of water scarcity and environmental impacts of the existing cropping pattern has also been evaluated. For this purpose, time series secondary data has been collected from Agricultural Policy Reports from 1980-2014 issued by Agricultural Policy Institute (API). Descriptive statistics, regression models and the latent content analysis have been applied for the analysis of the data. The results indicate that the area of the crop, market price, labour employed, use of pesticides and fertilizers have positive impact on the production of rice, sugarcane and cotton while the area of competing crops have negative impacts on the production of these crop. The cropping choices of three crops (Rice, Sugarcane and Cotton) have shown an upward trend since 1980-2014. The cropping choices have been mainly motivated by market and support prices, except for a few years where natural disasters have played their part. Market price and support price show a positive relationship with area of that particular crop. Farmers' profitability has been evaluated and the results show that farmers are relatively better off in these crops' cultivation. Use of heavy pesticides and fertilizers damages environment very badly. A mention of gender division and female farm worker's well-being has also been assessed whose findings indicate gender insensitivity in the policy documents and no relief offered for the cost of different operations done by farm workers. The study recommends that Govt have to increase the market and support prices to increase the area of particular crops, authorities should devise and implement new water prices, Extension Programme are advised for the training of farmers to appropriate use of fertilizers and pesticides and wages should be given directly to the workers to ensure that all the employees (male and female) are getting paid for their work.

CHAPTER – I

INTRODUCTION

1.1 Background and Statement of the problem

Agriculture plays significant role in the economic development of Pakistan. Out of the Pakistan's total area of 79.6 million hectares, 21.2 million hectares are cultivated. About 80 percent of the total cultivated area is irrigated and Pakistan has the world's largest contiguous irrigation system. The agriculture sector contributes 20 percent to country's GDP. Punjab is the main agricultural province of Pakistan. There is about 57 percent of total cultivated land in Punjab which is 69 percent of the total cultivated area of Pakistan. Punjab significantly contribute to national agricultural economy by providing almost 83 percent to cotton, 97 percent of the Rice and 63 percent of the sugarcane to the national food production. Pakistan is among the top ten producers of cotton and sugarcane while holds 13th position in rice production. Major crops (Cotton, Rice and Sugarcane) contributes about 6.5 percent of country's GDP (Junejo, 2014).

Pakistan has diverse agro-ecological zones with potential to produce many crops. In the past, there were no severe water crisis. The current era is challenging for the agriculture economy of Pakistan because it has to come across the petition of the emergent population while facing water shortages at the same time. In the past, agriculture policies were focused on the output, input, taxation, subsidies, and trade protection issues ignoring the water challenges and environmental aspects. The adoption of the current cropping pattern may be the outcome of the past agricultural policies. The current cropping pattern has also been affected from water insecurity, which has implications for the environment. Therefore, it is important for Pakistan to reassess these policies to account for water shortages and adopting suitable cropping pattern.

Pakistan uses its scarce water resources to produce and export water-intensive crops, while at the same time importing less water-consuming crops, which are also critical for nation's food security (GOP, 2018). This lead to a potentially unhealthy and unsustainable situation where production and areas for production of rice, cotton and sugarcane have increased and the yield was lower as the world's average yield in 1994-97 (Ghaffar & Mustafa, 1997) while production and areas under oil seeds, pulses and legumes decreased or stayed stagnant. Given current global trends in irrigation investments (Turral et al., 2010; Ward, 2010) and competing demand from residential and industrial uses, it's near impossible to develop additional physical infrastructure to sustain its current cropping patterns. Contrary to global trends in virtual water (Tamea et al., 2014; Zhang et al., 2016), one wonders why policymakers seemingly promote such irrational cropping practices in a water-stressed country like Pakistan. Answer to this question needs a thorough analysis of agricultural and water policies that regulate the agriculture in Pakistan.

Pakistan is one of the energy deficit countries while facing food insecurity at the same time. The increasing energy and food demand can be met only if there is sufficient water in the available reservoirs (Iqbal, 2017). However, the two dams namely Tarbela and Mangla, which are the major water reservoirs of Pakistan are also losing their storage capacity which may further increase the status of being water-stressed of the country. Deterioration of the existing water storage and difficulties in carrying out replacement work and new storage facilities cause the country to waste water worth approximately USD 70 billion without giving any economic, social and environmental benefit (Iqbal, 2017).

1.2 Purpose of the study

The main purpose of this research is to analyze, 1980 and onward, agricultural policies in Punjab:

i. To understand the way, the policy support for rice, sugarcane and cotton that has resulted in the magnitude and pattern of their cultivation that we observe today.
ii. To evaluate the implications of such crop selection on environment and water resource problems and their nexus.

1.3 Hypotheses

The research is based on the following hypothesis:

i. Production of particular crop (Rice, Sugarcane and cotton) is positively affected by area under crop, pesticide and fertilizers used and labour employed.
ii. The area under competing crops (rice, Sugarcane) has negative impact on cotton area.
iii. Market and support lagged prices have positive impact on area of rice, sugarcane and cotton.
iv. Use of pesticides and fertilizers have negative impact on environment.

1.4 Organization of the study

The study is organized into five chapters. In chapter 1, introduction about the study, purpose of the study and hypotheses of the study are given. In chapter 2, relevant literature are presented. Data used and methodology developed for the study is given in chapter 3. Chapter 4, comprises on cropping pattern, water used and farmers' profitability and CO_2 emissions from fertilizers (Urea, DAP) and pesticides. Chapter 5 presents conclusion and policy recommendations based on the finding of the study.

CHAPTER – II
LITERATURE REVIEW

2.1 Introduction:

The cropping pattern depends on the agro-ecological characteristics in the country. However, the policy interventions may also change it, as found by Indira M, (2014) while analyzing the change in the cropping patterns due to the implementation of "National Agricultural Policy 2000" in India by comparing food and non-food crops. Cropping pattern is also sensitive to availability of water. According to David, (1997) agriculture is the major consumer of water. In Asia, nearly 84% of the total water used in agriculture and half of the irrigated land is fervent to engulfed Rice production. The average water withdrawal per hectare of irrigated land is around 8900 m^3 per year the average irrigation water usage efficacy is fewer than 40 percent in Asia. With less water availability, the country or region may not be able to produce more.

Agricultural policies affect the environment in many ways. Due to agriculture input policy intervention, the use of pesticide increases which resultantly have a negative impact on environment (OECD, 2010). In Pakistan, the use of pesticides increases overtime as evident from the increasing imports of pesticides.

2.2 Agricultural Policies and cropping pattern

During early Seventies, annual growth level in agriculture fallen to the historically lowest, output of the cotton, rice and sugarcane declined continuously due to unavailability of modern technologies, and government intervention in the market mechanism (Ghaffar & Mustafa, 1997). In 1980's, there had been predominantly focus on fresh technologies, efforts and reserves to increase the growth of major agricultural crops (Hanif & Khan, 2004). In early 1980s, the new Agricultural Policy asserted to stimulate agricultural sector by progressively tumbling the breach between native prices and corresponding boundary prices. An Agriculture Prices Commission was recognized in 1981 to instruct the Government in determining support prices. Consequently, these prices were augmented in a recent year and stirred closer to global prices in some cases (Burki, 2014).

Study of Rehman et al., (2015) revealed that shortages of irrigation water is one of the foremost problems in agriculture production. The accessibility of agriculture water is projected to decline from 72 percent to 62 percent during 1995-2020. The groundwater table has diminished by a factor of approximately 0.3 meter per year. According to Tahir & Khan, (2014), the amount of water supply is not consistent with the time array of the crop needs. The demand for water exceeds its supply in both regions and seasons due to increased agriculture activities and concentrated river flow. The Govt of Punjab started a new program in 2006 to retain a record for irrigation proclamations to advance irrigation management, increasing transparency and determine how much water consumers receive. According to Kijne, (2001), cropping pattern is important; as rice, cotton and sugarcane are highly water-consuming crops requiring proper water demand management.

Existing water storage capacity in Pakistan is declining. No new dam has been constructed since the accomplishment of Tarbela Dam in 1974 due to lack financial constraints and lack political consensus (Kijne, 2001).

In Pakistan, agriculture is more vulnerable against climatic change impacts. Numerous studies revealed that production of crops in Pakistan decreased due to less rainfall, high temperature. Mean intensification of temperature in Pakistan is greater than the expected global average (1.4 ◦C–3.7 ◦C) (Imran et al., 2018). Pakistan is listed among the top most ten climate vulnerable nations in the world in the Global Climate Menace Index (World Bank, 2014).

Majority of the farmers in Pakistan are still engaged in conventional agriculture. Conventional agricultural policies targeted mainly support prices and farm income. Policies impact farming practices generally by varying the relative costs and returns of expending resources in agriculture, or by imposing restrictions on output and input use (Kim, C 2001).

The past agricultural policies covered various areas to improve the agriculture sector, which also resultantly supported to stay with the current cropping pattern. For example, according to *seed act, 1976*, the purpose of the Punjab Seed Certification and registration department was the controlling of the quality of cotton seeds, seeds certification and crops field inspections of the registered varieties. This policy expanded cotton productivity during the 1980s and early 1990s, linked both to better seeds, also persistent to sustain agricultural growth which remained at 4.5 percent per annum during 1988–96*(Hasan, P. 1997).*

Similarly, in 1973, Government recognized Cotton Export Corporation (CEC) and Rice Export Corporation (REC). These corporations monopolized cotton exports and also regulated local sales. In early 1980s, the agricultural policy declared to promote agriculture sector by progressively reducing the gap between the domestic prices and their respective border prices

(Burki, 2014). As a results, Agricultural Prices Commission was established in 1981 and advises the government in setting support prices. Consequently, these prices have increased in recent years and enthused nearer to world prices in some cases *(Burki, 2014)*.

According to *Ordinance Cotton, (2002*), the Pakistan Cotton Standards Institute in Punjab was established to encourage quality control of cotton. The purpose of this institution was to institute cotton criterions and applaud measures to Provincial Govt for making contamination-free cotton, lay down the policy and Programme and implementation for training in arbitration, cotton classification and cotton fiber testing. As a result, in few years, Pakistan Cotton Standards Institute has been able to comprehend some achievements that are following:

a. The standards and grades for seed cotton and lint developed by Pakistan Cotton Standards Institute were approved by Government of Pakistan and declared to be the official standards.
b. Due to the implementation of the cotton standardization system and segregation of some better cotton types in selected ginneries, the Pakistan cottons was quoted in Cotlook price Index 'A' whereas formerly these were being declared only under Cotlook Price Index 'B' which has a price difference of 5 to 7 cents/lbs between the two indices.
c. Pakistan Cotton Standards Institute has established cotton fiber testing hubs at Multan, Vehari, Rahim Yar Khan, Sahiwal, Faisalabad, D.G. Khan, Bahawalpur (Punjab) & Karachi, Mirpur Khas, Sanghar *(Pakistan Cotton Standards Institute in Punjab)*

This is also worth mentioning to note that the provincial Government set acquisition prices for sugarcane in meetings with legislatures of both the sugar industry and farmer's administrations, based on endorsements from the Ministry of National Food Security and Research and the provincial ministries of agriculture, industry, and food (Shafiq, 2016). Resultantly, sugarcane estate was receptive to changes in own prices. However, without trade obstructions, sugarcane

supply cannot be augmented by increasing its support price because internal and world prices, since late 1980s, were equal. But, given the reasonable advantage and lower water chucks of sugarcane, a carefully premeditated price support for sugarcane which favors the former could increase sugarcane production and promote more efficient water use (Khalid, 2001).

Besides, in a recent years, total area under cotton crop declined and farmers are moving towards Sunflower as an alternative crop in southern Punjab while in central Punjab, farmers are growing maize and vegetables. Farmers use alternative crops of cotton because they can't bear the heavy losses due to pests (Express, 2019). Farmers are cultivating sorghum and soybean as an alternative crop of rice because these are less water consuming crops (Heinrich, 2013). Sweet sorghum is used as an alternative crop of sugarcane in Pakistan and worldwide (Viator, 2008). However, these alternative crops of cotton, rice and sugarcane are growing on small farms while large landholders are not practicing the alternative crops.

2.3 Agricultural policies and Environment

Agriculture places a serious burden on the environment in the process of providing humanity with food and fibers. It is the largest consumer of water and the main source of nitrate pollution of groundwater and surface water, as well as the principal source of ammonia pollution. It is a major contributor to the phosphate pollution of waterways and to the release of the powerful greenhouse gases (GHGs) methane and nitrous oxide into the atmosphere (FAO). Impact of Agriculture on the environment can be described in terms of a sequence of processes. The quantity of agricultural production is affected by the financial resources available to agriculture (both returns from the market and government support), the incentives and disincentives facing farming, and the kinds of management practices and technologies adopted by farmers. These practices and technologies impact on the productivity of the natural resources (soil) and purchased inputs

(fertilizers) used by farmers. Depending on the management and productivity of agriculture's use of resources and inputs this will affect the rate of depletion and degradation of soils and water; the flows of harmful emissions (nutrients) into soils, water, air and the atmosphere; and the quantity and quality of plant and animal resources (biodiversity and habitats) and landscape features (Parris, 2001).

Agricultural policies, including price and income supports, were not originally developed to affect environmental quality in any way. They included no explicit conservation objectives. Agricultural policies influence farming practices mainly by changing the relative costs and returns of using resources in agriculture, or by imposing direct restrictions on output and input use. In particular, agricultural policies influence farming activities through changes in the relative prices of inputs and outputs, Direct and indicate restrictions on the use of inputs and outputs. The main objectives of agricultural policy are to support farm incomes and ensure a stable and reasonably priced supply of food. These objectives are achieved through a complicated system of farm programs that insulate the farm sector from the market economy by artificially supporting the prices of certain commodities, and controlling their supply. Each mechanism employed to support commodity prices, farm incomes and control the supply goals has secondary, and unintentional, effects on environmental quality. As well as price supports, agricultural policies may include trade barriers, subsidies for inputs and direct payments to farmers (Kim, 2001).

2.4 Summary of Literature review

Summing, Pakistan is a water scarce country and the unfortunate agriculture policy interventions (particularly for rice, cotton and sugarcane) may further add to the water scarcity and environmental degradation in the country. There was no such study conducted in Punjab province of Pakistan so this study is trying to bridge this gap.

CHAPTER - III

DATA AND METHODOLOGY

3.1 Profiles of the Study Area

There is about 57 percent of total agricultural land in Punjab, which is 69 percent of total cropped area of Pakistan. Punjab contributes to major agricultural share to the economy by providing about 97 per cent of Rice, 83 per cent of cotton and 63 per cent of sugarcane to national food production (Pakistan economic survey, 2018).

In Pakistan, precipitation and river flows are the two most important sources of surface water used to meet the requirements of agriculture sector. About 60 per cent of water is received during the July to September monsoon. There is no or less rain water storage system in Pakistan and rainwater is rarely used for agriculture. The major source for irrigation is the Indus Basin Irrigation System (IBIS). The contribution of rainwater to crops in the Indus Basin Irrigation System is about 16.5 billion m^3, which is about 10 percent of the mean annual river flow. About 162 billion m^3 of surface water is provided by the western rivers (the Indus, Chenab and Jhelum) in an average year during the post-storage period, 6.4 percent less than the pre-storage period. Inconsistency in eastern river (the Beas, Ravi and Sutlej) flow was even higher than in the western rivers. The eastern rivers contribute about 10.7 billion m^3 of water to the Indus River system in an average year 77 per cent in the *Kharif* season after the construction of the Mangla and Tarbela storage dams (Akhtar, 2002). There is a canal system for agriculture in Punjab. The public irrigation system in the Punjab consists of 13 barrages, 2 siphons through major rivers, 12 link canals and 23 major canal systems over a cumulative length of 34,500 km. The whole irrigation system lies within the Indus Basin System. About 8.58 million hectares' area is covered by Indus Basin System (Irrigation System in Pakistan).

3.2 Nature of Data and Approach Used

The study involves desk-work to review and critically analyze provincial, district level laws, regulations, guidelines related to agricultural production of the three crops mentioned above, and compare them with present area, production and yield of crops. The required information was obtained through scholarly publication, openly available documents such as federal policies and government reports and other devices that regulate the agricultural affairs in the country. These data sources were thematically analyzed through clearly formulated set of questions and associated historical context. Memon and Thapa (2016), developed and successfully applied this methodology in their study of forest policies in Pakistan. Similar set of policy analysis criteria and indicators to understand the evolution of policy support for some crops on the cost of others contributing to increasing stress on water resources.

Content analysis pertinent to different forms of amorphous information, such as transcripts of semi and unstructured interviews .The data was analyzed using latent content analysis which refers to the scrutiny of documents and scripts that pursues to enumerate contents in terms of preset category and in an organized and replicable manner (Bryman, 2012). Awojobi & Adeokun (2012) used content analysis for Agricultural Issues in Nigeria.

The information was obtained from the following Agriculture policy documents.

a. The Punjab Cotton Control Ordinance, 1966 (XX of 1966)
b. The Punjab Rice (Restrictions on Cultivation) Ordinance, 1959
c. The Punjab Seed Corporation Act, 1976 (X Of 1976)
d. *Seed Act, 1976 As Amended Through Seed (Amendment) Act, 2015 Further Amended Through the Punjab Seed (Amendment) Act, 2017 (Proposed).*
e. National Water Policy 2018

f. Policy analysis documents from 1980-81 to 2014-15 by Agriculture Price Commission (APCom); Agriculture Policy Institute (API)

The policy analysis is according to following mechanism.

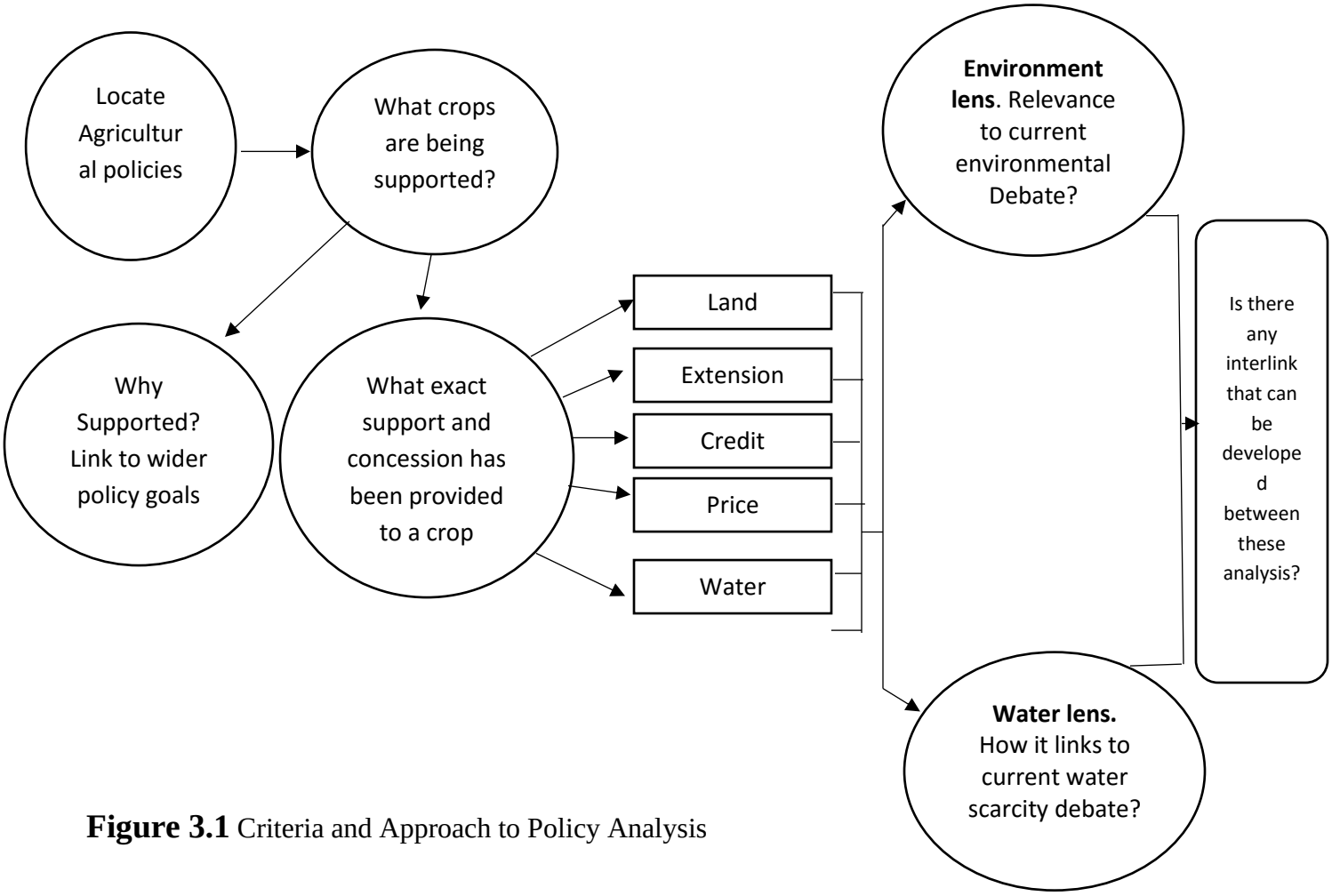


Figure 3.1 Criteria and Approach to Policy Analysis

3.3 Analytical tools

Three production functions were estimated for rice, cotton and sugarcane crops detailed as under:

3.3.1 Rice production function

$$PR=\beta_0 + \beta_1 RA + \beta_2 CA + \beta_3 MP(-1) + \beta_4 Pesticide + \beta_5 Urea + \beta_6 DAP + \beta_7 DAP^2 + \beta_8 Trend + \beta_9 labour + U_1 \quad \text{.....(1)}$$

PR= production of rice (million ton)

RA= area under rice ('000' acre)

CA= area under cotton ('000' acre)

MP (-1) = one-year lag market price of rice (Rs. /40kg)

Pesticide= pesticide used in rice crop (million ton). pesticide for rice is estimated from total amount of pesticide given (area under rice / total cropped area) * total amount of pesticide used (million ton)

Urea= urea fertilizer applied to rice crop (million ton)

DAP= Diammonium Phosphate fertilizer applied to rice crop (million ton)

DAP^2= square of variable DAP (million ton)

Trend = A proxy for technology

Labour = labour used in rice crop related operations (number per growing period)

U_1 = Error Term for rice regression model

The production of rice is affected by various factors such as area under rice and its competing crops, price, pesticides, fertilizer, labour and technology. The coefficient of area under rice is expected to be positive because bringing more area under rice will increase the production of rice.

3.3.2 Sugarcane production function

$$PS=\beta_0 + \beta_1 SA + \beta_2 CA + \beta_3 Pesticide + \beta_4 Urea + \beta_5 DAP + \beta_6 DAP^2 + \beta_7 Trend + \beta_8 labour + U_2 \quad \text{.....(2)}$$

PS= production of Sugarcane (million ton)

SA= area under sugarcane ('000' acre)

CA= area under cotton ('000' acre)

Pesticide= pesticide used in sugarcane crop (million ton). pesticide for sugarcane is estimated from total amount of pesticide given (area under sugarcane / total cropped area) * total amount of pesticide used (million ton)

Urea= urea fertilizer applied to sugarcane crop (million ton)

DAP= Diammonium Phosphate fertilizer applied to sugarcane crop (million ton)

DAP^2= square of variable DAP (million ton)

Trend = technology (numbers)

Labour = labour used in sugarcane crop related operations (number per growing period)

U_2= Error Term for Sugarcane regression model

The production of sugarcane is affected by various factors such as area under sugarcane and its competing crops, price, pesticides, fertilizer, labour and technology. The coefficient of area under sugarcane is expected to be positive because bringing more area under sugarcane will increase the production of sugarcane.

3.3.3 Cotton production function

$$PC=\beta_0 + \beta_1 CA + \beta_2 RA + \beta_3 SA + \beta_4 MP(-1) + \beta_5 Pesticide + \beta_6 Urea + \beta_7 DAP + \beta_8 DAP^2 + \beta_8 Trend + \beta_9\, labour + U_3 \quad \ldots\ldots (3)$$

PC= production of cotton (million ton)

CA= area under cotton (‘000’ acre)

RA= area under rice (‘000’ acre)

SA= area under sugarcane (‘000’ acre)

MP (-1) = one-year lag market price of cotton (Rs. / 40 kg)

Pesticide= pesticide used in cotton crop (million ton). pesticide for cotton is estimated from total amount of pesticide given (area under cotton / total cropped area) * total amount of pesticide used (million ton).

Urea= urea fertilizer applied to cotton crop (million ton)

DAP= Diammonium Phosphate fertilizer applied to cotton crop (million ton)

DAP^2= square of variable DAP (million ton)

Trend = technology (numbers)

Labour = labour used in cotton crop related operations (number per growing period)

U_3= Error Term for cotton regression model

The production of cotton is affected by various factors such as area under cotton and its competing crops, price, pesticides, fertilizer, labour and technology. The coefficient of area under cotton is expected to be positive because bringing more area under cotton will increase the production of rice.

Regression of Determinants of Area

The area under rice, sugarcane and cotton crop has been regressed with one-year lagged market and support price of particular crop. The results show that one-year lagged market and support prices of particular crop have positive impact on the area of that crop. If one year back market and support prices were higher than area will increase under that crop.

3.3.4 Rice Area Regression Analysis

$$RA=\beta_0 + \beta_1 ACC + \beta_2 NPC + \beta_3 CWW + \beta_4 lag\_MP + \beta_5 lag\_profit + \beta_6 lag\_IM\_prices + \beta_7 + E_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

RA = Rice area in '000' acres

ACC = Area of competing crop (Cotton area + Sugarcane area) in '000' acres

NPC = Nominal Protection Coefficient (ratio of Domestic prices and world prices)

CWW = Canal water withdrawal (Million acres)

MP=Market Price (Rs. Per 40 kg)

lag_profit = lag value of farmers profit of Rice

IM_prices= International Market Prices (Rs. Per 40 kg)

E_1 = Error Term for rice regression model

The area of rice is affected by various factors such as area under competing crops of rice (cotton and sugarcane), Nominal protection coefficient, canal water withdrawal, market price, profit and international market prices. The coefficient of area under rice is expected to be positive because bringing less area under competing crops will increase the area under rice.

3.3.5 Sugarcane Area Regression Analysis

$$SA=\beta_0 + \beta_1 ACC + \beta_2 lag\_NPC\_imports + \beta_3 lag\_NPC\_exports + \beta_4 PD + \beta_5 WP + E_2 \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

ACC = Area of competing crops(Cotton and Rice) '000' acres

SA = Sugarcane area ('000' acres)

lag_NPC_import = Lag of Nominal Protection Coefficient under imports (Domestic price/ Internationa price)

lag_NPC_export = Lag of Nominal Protection Coefficient under exports (Domestic price/ Internationa price)

PD = Price Difference (Market price – support price)

WP = Water Prices (Rs. Per acre)

E_2 = Error Term for Sugarcane regression model

The area of sugarcane is affected by various factors such as area under competing crops of sugarcane (cotton), Nominal protection coefficient under imports and under exports, price difference and water prices. The coefficient of area under sugarcane is expected to be positive because bringing less area under competing crops will increase the area under sugarcane.

3.3.6 Cotton Area Regression Analysis

$$CA=\beta_0 + \beta_1 RA\_ratio + \beta_2 SA + \beta_3 RSP_{(cotton)} + \beta_4 RSP_{(IRRi\_Rice)} + \beta_5 RSP_{(sugarcane)} + \beta_6 ExpPrice_{(cotton)} + \beta_7 DAP\_price + E_3 \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

CA= Cotton area ('000' acres)

RA_ratio = ratio of rice area(Basmati area ['000' acres)/ IRRI area ('000' acres)]

SA=Sugarcane area ('000' acres)

$RSP_{(cotton)}$ = real support price for cotton (Rs. /40 kg)

$RSP_{(Rice)}$ = real support price for rice (Rs. /40 kg)

$RSP_{(sugarcane)}$ = real support price for sugarcane (Rs. /40 kg)

$ExpPrice_{(cotton)}$ = export prices of cotton (Rs. /40 kg)

DAP_price= price of DAP (Rs per bag of 50 kg)

$\mathbf{E_3}$= Error Term for cotton regression model

The area of cotton is affected by various factors such as area under competing crops of cotton (rice, sugarcane), real support prices of cotton, rice and sugarcane, export prices of cotton, and fertilizers price as it uses more fertilizers. The coefficient of area under cotton is expected to be positive because bringing less area under competing crops will increase the area under cotton.

3.4 Estimation of water productivity and Economic efficiency

Economic Water productivity is a direct measure of efficient water usage by the farmers for the cultivation of crops. It is calculated by checking the water requirement of each crop and the water price for that particular crop. The value of Economic efficiency is taken from API documents 1980-2014. This will tell if the crop is water efficient and also if appropriate water price is paid for the crop or it is overpriced or underpriced. The efficiency of resource use is an important indicator for judging the comparative advantage of a nation in the production of certain crop. It is mostly estimated in the form of Nominal protection coefficient (NPC) and Domestic Resource cost (DRC). Nominal protection coefficient is the protection of local farmers by the Govt. if NPC>1, Govt will protect local farmers and vice versa. Domestic resource cost show either there is comparative profitability in local crop production or in the import of that crop. If DRC<1 then there is a comparative profitability in local production of that crop as compared to import of that crop and vice versa (Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)).

CHAPTER – IV

RESULTS AND DISCUSSIONS

4.1 RICE CROP ANALYSIS

4.1.1 Descriptive Statistics of Variables (1985-2014)

Average Area under rice production is 3400.73 thousand acres on which rice production is 2124.75 million ton on average Rs. 843.26 /40 kg and maximum production gone to 3119.30 million ton at Rs. 3150 / 40kg. In the same era cotton is cultivated on 5701.43 thousand acres and maximum area under cotton cultivation up to 8097 thousand acres. Total pesticides used in rice production is 6.02 million ton which goes up to maximum at 18.02 million ton. In the same manner Urea and DAP are 0.04 million tons and 0.02 million ton are used for production respectively with an average labour force of 2100206 for total rice area of 4326 thousand acres.

Table 4.1 Descriptive statistics of rice-related variables (1985-2014)

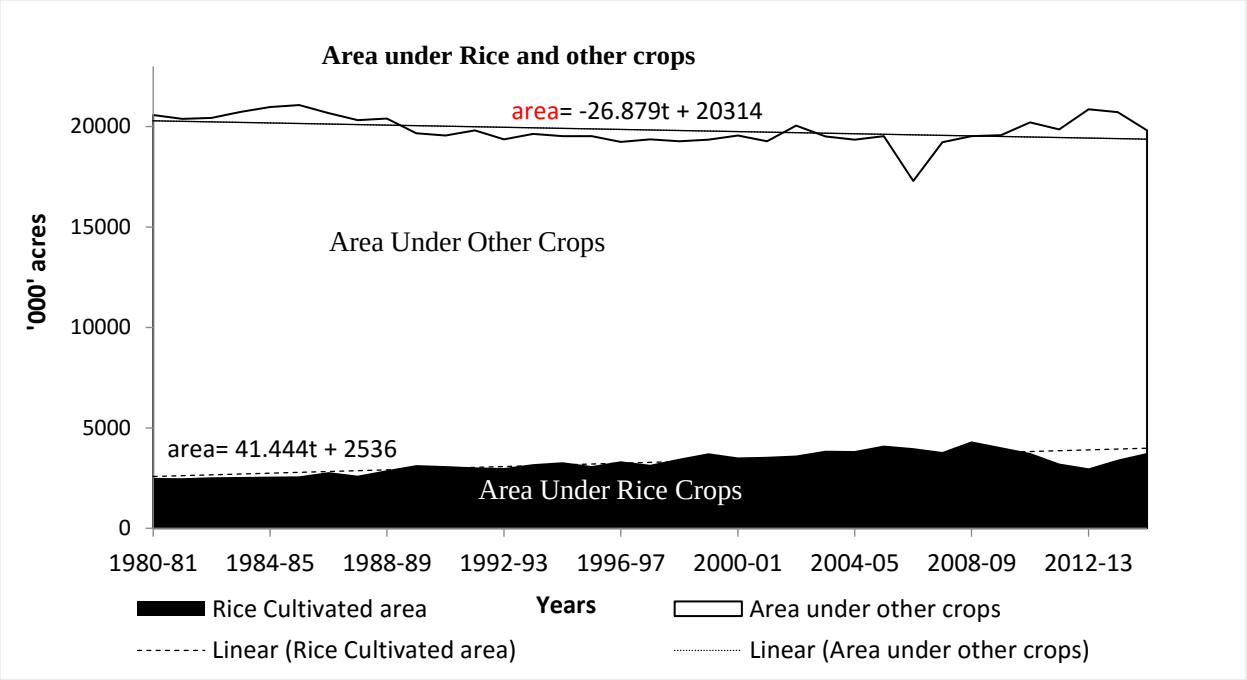
Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
Production of Rice (RP)	Million ton	30	2124.75	600.97	1324.4	3119.3
area under rice (RA)	'000' acres	30	3400.73	462.37	2590	4326
area under cotton (CA)	'000' acres	30	5701.43	666.8	4312	8097
lag market price [MP (-1)]	Rs. /40 kg	30	843.26	808.09	206	3150
Pesticide	million ton	30	6.02	4.18	1.24	18.02
Urea	million ton	30	0.04	0.01	0.02	0.07
DAP	million ton	30	0.02	0.01	0.01	0.03
Trend	Numbers	30	15.5	8.8	1	30
Labour	Numbers	30	2100206	767976.4	1047247	3432818

4.1.2 Variation in the Rice Area, Prices and Economic Efficiency

Rice, in terms of area planted, is the 3rd important crop of Pakistan after wheat and cotton. It occupies about 9 percent of the total cultivated area and contributes 16 percent of food grain production. The share of rice in the value added by the major crop is around 14 percent. A high-water delta crop, rice is primarily concentrated in Punjab and Sindh. Punjab is the foremost rice cultivating province with almost 61 percent rice area and concentrate on Basmati rice for export. Due to agro-climatic and soil conditions, Punjab is producing 100 percent of the Basmati rice in the country (Junejo, 2014).

A time-series analysis of the area under rice crop from 1980 to 2014 slight fluctuations overtime in in Punjab province of Pakistan (Figure 4.1).

Figure 4.1. Trends in the area under rice and other crops in Punjab during 1980-2014

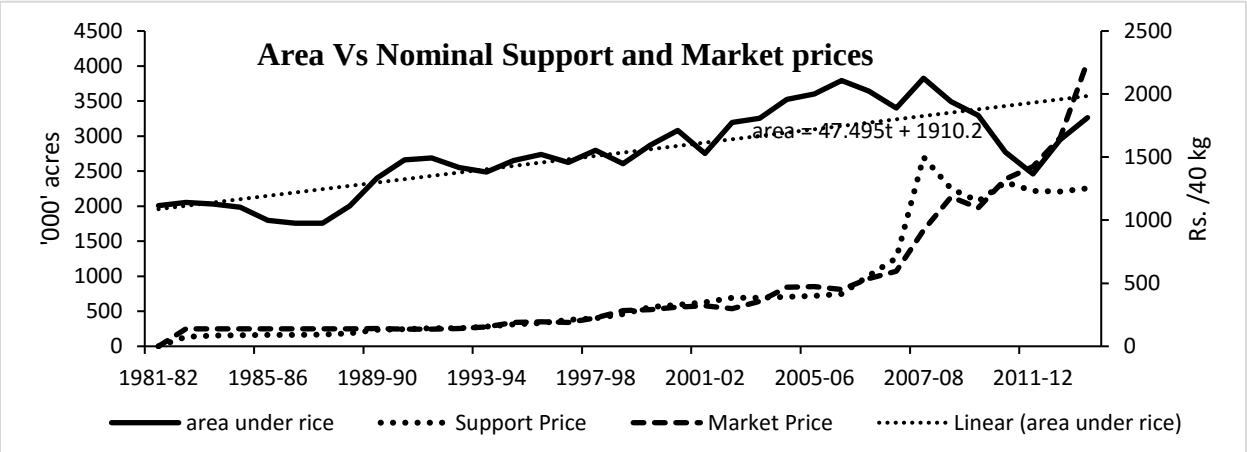


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

The area under rice remains the same from 1980 onward (Figure 4.1) and this may be attributed to the low government price support as evident from the values of NPC less than 1. However, in some years, the increase in the support prices pushed the farmers to bring more area under rice to earn more profit.

In 1985-86, area decreased slightly but in 1990-91 the area was increased. According to API policy Documents (1991-92), A support price of Rs. 143 per 40 kg was given to the farmers which is Rs. 13 higher than the previous year. When the government announced the higher support prices, farmers cultivated more land and area under rice crop was increased. In the same period, the area under cotton was also increased but the area under sugarcane cultivation was decreased. According to API policy analysis document, In 1989-90, the domestic price for Basmati rice was Rs. 136 per 40 kg while support price was Rs. 143 per 40 kg (API Policy document 1990-91), Farmers had the benefits in rice cultivation, so farmers brought more area under rice. In 1999-00, about 1.2 million acres under rice cultivation was increased. At the same time, the area under sugarcane crop was decreased to about 1 million acres. This shows that the area under rice increased due to decrease in the area of its competing crop (sugarcane).

Figure 4.2. Area Vs Nominal market and support prices of Rice Basmati and IRRI, 1980-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

From figure 4.2 and table 4.2 it can be seen that rice area is increased when one-year lagged market and support price of rice is increased.

Table 4.2 Regression results for factor influencing rice area in Punjab

Rice_area	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mp(-1)	0.49	0.28	-1.69	0.101	-1.07	0.09
sp (-1)	1.05	0.33	3.13	0.004	0.36	1.74
_cons	2421.06	118.12	20.50	0.000	2180.45	2661.66

ANOVA results for factor influencing rice area in Punjab

Source	SS	df	MS	Number of obs	=	35
Model	4860239.6	2	2430119.82	Prob > F	=	0.0004
Residual	7597411.9	32	237419.12	R-squared	=	0.3901
				Adj R-squared	=	0.3520
Total	12457651.5	34	366401.51	Root MSE	=	487.26

In 2011-12, the area under rice was lowest due to 2010-flood in Punjab. About 1.037 million acres of cultivated area was affected by this flood. After 2010 flood, when market price for rice was increased, the area under rice increased. Nominal market price was higher than nominal support prices. Farmers have received higher prices than Govt. announced prices which also impacted to increase the area under rice in that year.

4.1.3 Regression Analysis of Rice production function in Punjab

From regression table, it can be seen that when Rice area has positive impact on its production while its competing crop area has negative impact on its production. An increase in one-year lagged market price of rice will increase rice production. Based on the previous year prices, the farmers are motivated to increase the rice area/production. The other inputs such as pesticide and fertilizers also have positive impact on the rice production.

The analysis of variance (ANOVA) also shows that there is a statistically significant relationship between production of rice and inputs such as rice area, cotton area, one-year lagged market price, technology, labour employed, pesticide and fertilizers.

Table 4.3 Regression results of rice production function in Punjab

PR	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RA	0.23	0.25	0.92	0.37	-0.3	0.77
CA	-0.02	0.03	-0.48	0.64	-0.09	0.06
MP(-1)	0.18	0.09	-1.95	0.07	-0.38	0.01
Trend	48.27	12.64	3.82	0.00	21.91	74.64
Labour	0.002	0.002	0.89	0.38	0	0
Pesticide	0.01	0.01	1.33	0.20	-0.01	0.03
Urea	389.5	383975.8	1.00	0.33	-4159.9	1186
DAP	2560	7690	3.33	0.00	95800	4160
DAP^2	-5250	1360	-3.86	0.00	-8090	-2410
_cons	2819.47	878.54	3.21	0.00	986.87	4652.07

ANOVA results of Rice production function in Punjab

Source	SS	Df	MS	Number of obs = 30
Model	10353690	9	1150410	Prob > F = 0.0000
Residual	120246.5	20	6012.32	R-squared = 0.9885
				Adj R-squared = 0.9834
Total	10473937	29	361170.2	Root MSE = 77.54

4.1.4 Regression Analysis of Rice Area function in Punjab

Table 4.4 shows the change in dependent variable (Rice area) due to the change in explanatory variables (Area of competing crops, National protection coefficient, Total canal water withdrawal for Rice crop, market price, profit and international market prices). The regression results show that due to one thousand acres increase in area of competing crop will increase 0.19 thousand acres of rice area. As rice (Basmati and IRRI) is cultivated in those districts of Punjab where cotton and sugarcane is not cultivated from 1980-81 but from 2012-13, IRRI rice was cultivating in the districts of cotton. National protection coefficient of rice has positively significant. NPC >1 means Govt protect the local farmers which promote the rice cultivation on more area. Total canal water withdrawal has positive impact on rice area. Rice is more water consuming crop and higher amount of canal water availability promote to cultivate rice on more area. Profit is positively significant. Farmers got more profit then cultivate rice on more area. International market prices have very important role in rice area because total Basmati rice is cultivated in Punjab province and Basmati is exported. If farmers got higher international market prices, then they grow Basmati rice on more area and as a result rice area increased.

Table 4.4 Regression results of rice Area function in Punjab

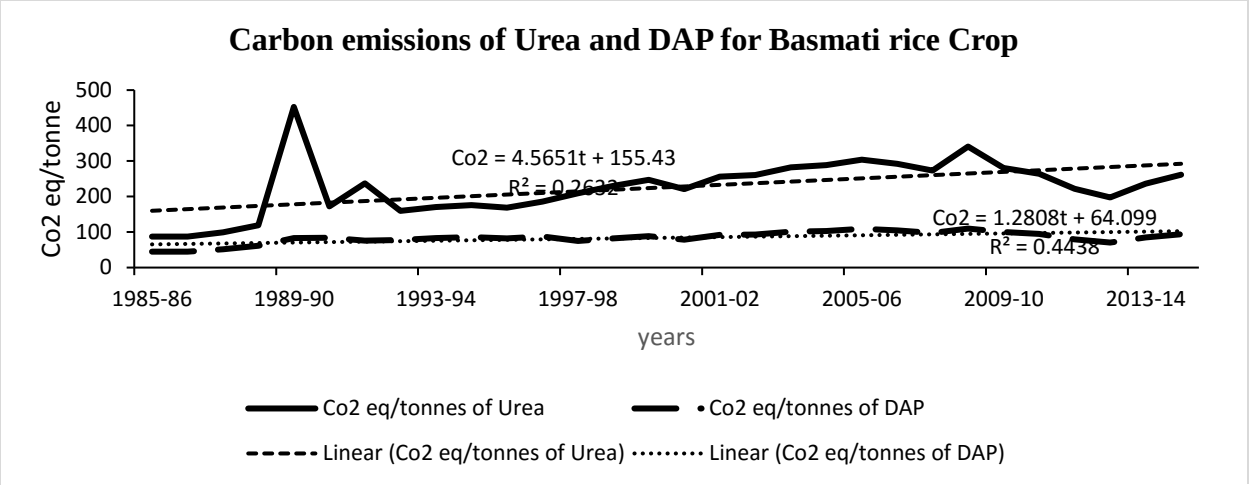
RA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ACC	.1953428	.0665782	2.93	0.008	.057268	.3334176
NPC	1030.486	473.315	2.18	0.040	48.89055	2012.081
CWW	72.9658	21.53385	3.39	0.003	28.30732	117.6243
MP(-1)	-.4617548	.1369059	-3.37	0.003	-.7456802	-.1778294
PROFIT(-1)	.6101709	.317486	1.92	0.068	-.0482548	1.268597
IM_PRICE(-1)	.4453371	.0971829	4.58	0.000	.2437921	.6468821
_cons	-1628.102	911.5281	-1.79	0.088	-3518.496	262.2915

R-squared = 0.7652 Adj R-squared = 0.6905

4.1.5 Carbon emissions from Fertilizers and pesticide use (1985-2014)

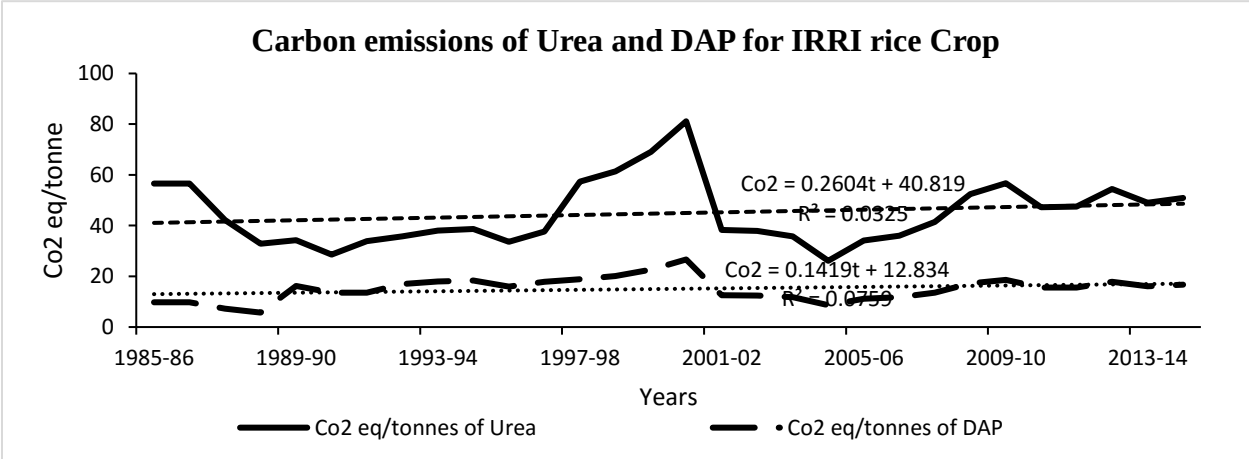
From figure 4.3 and 4.4 it can be seen that over the time if area under rice increases then higher amount of urea and DAP is applied and as a result there have been more Co_2 emissions from urea and DAP and environmental degradation increases.

Figure 4.3. Carbon emissions of Urea and DAP fertilizers for Basmati Rice



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

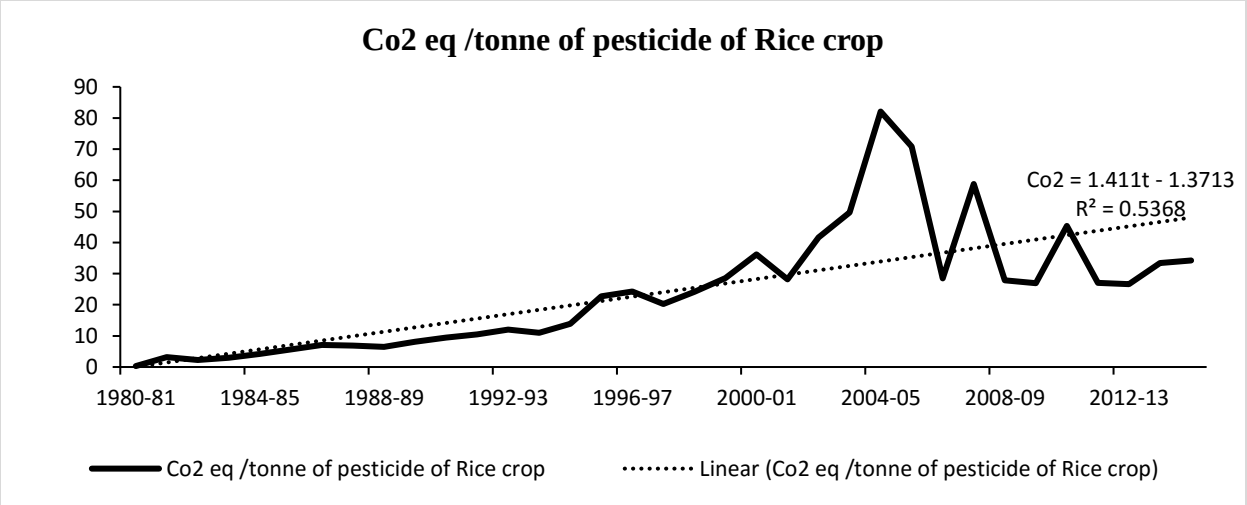
Figure 4.4. Carbon emissions of Urea and DAP fertilizers for IRRI Rice



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Over the time, when area under rice increases, more pesticides are applied and there is more Co_2 emissions from pesticides that damages the environment.

Figure 4.5. Carbon emissions from pesticide use



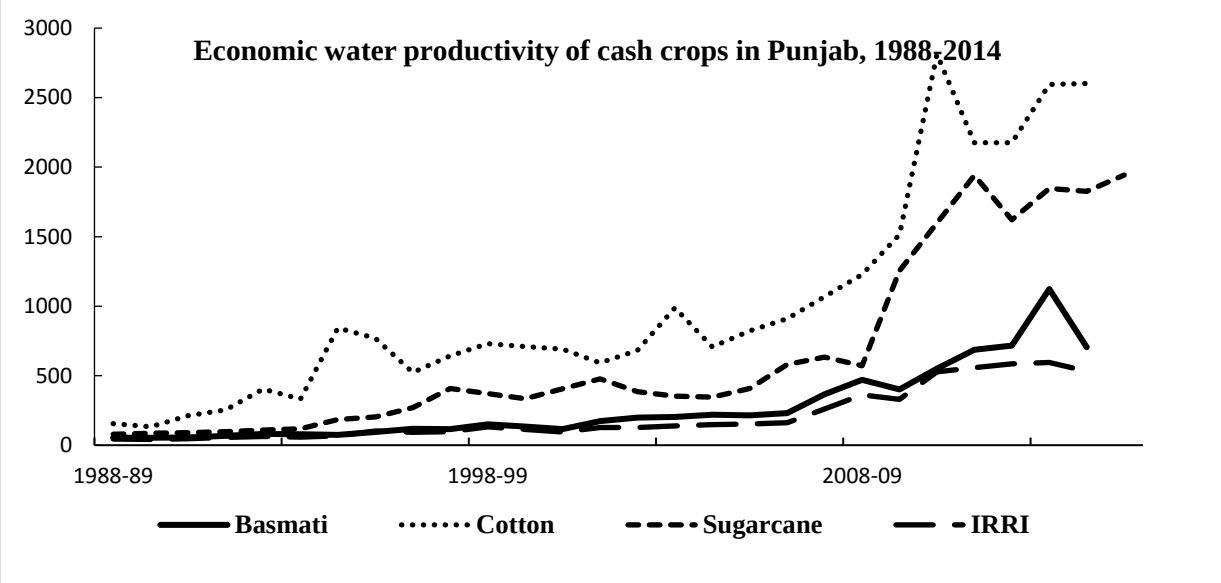
Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

4.1.6 Water use and Farmers Profitability

The choice of selecting a crop depends on the factors like costs, income and output-input ratio. Rice is one of the major crops sown in Kharif with competitive crop of cotton. The competing crop for sugarcane is rice in most of the growing areas. The economics of rice and competing crops has been analyzed in term of gross revenue per unit of water used. Figure 4.6, depicts that Basmati paddy crop is generating less revenue as compared to cotton and sugarcane in terms of per acre inch of water used. Maximum amount of water is used in rice fields and it generated less revenue per acre inch of water used.

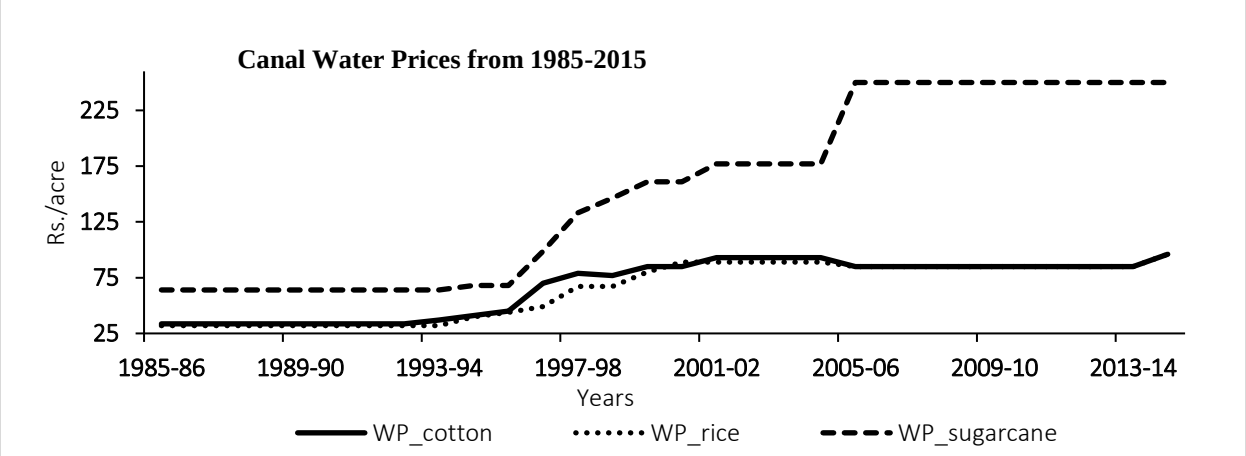
According to FAO, rice is 90-150 days crop and it require 17.71-27.56 inch per growing period of water. Rice consume more water as compared to cotton and sugarcane.

Figure 4.6. Comparison of the economic water productivity of cash crops in Punjab, 1988-2014



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Figure 4.7 Water prices for Rice, and competing crops, 1980-2015

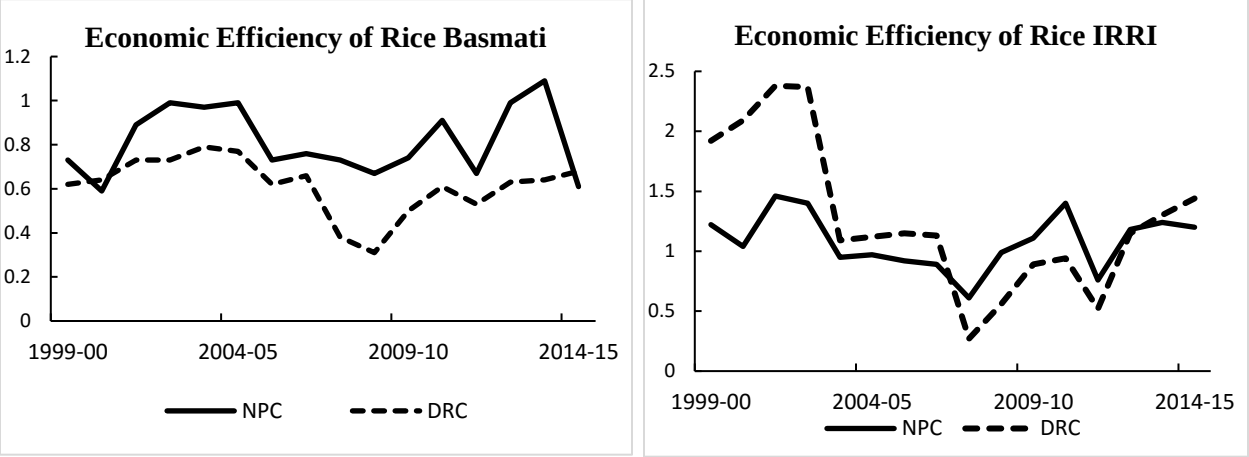


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Figure 4.8 depicts that the National protection coefficient of Basmati rice is less than one from 1999-00 to 2014-15 except 2013-14. NPC<1 means that the Govt does not protect the local farmers through the international prices. The Govt only protected local farmers in the year 2013-14 after 2010-flood in Punjab. In case of IRRI rice, NPC is greater than 1 expect for few years. Govt did not protect the IRRI growers.

Domestic resource cost (DRC) is less than one in Basmati rice from 1999-00 to 2014-15. There was comparative profitability in local production of IRRI rice in those years when DRC was less than one.

Figure 4.8. Economic efficiency of Rice, 1999-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

This section conclude that the cropping pattern of rice crop mainly administered by the support prices and market prices of rice crop and other competing crops of same season or due to climatic conditions that may alter the cropping pattern. The farmers adopt the minimum risk tactic and shifts between the crops of the same season to avoid the loss. Government price policies of rice have induced farmers to shift the cultivation to cash crops. Farmers also choose the

combination of crops that give them maximum income. As area under rice is increasing from 1980-81 to onward, Co_2 emissions also increases from fertilizers (urea and DAP) and pesticide use.

Water prices are under the flat rate system and Water as an environmental commodity has not such prices that determine the market of water for cultivation of rice. Rice use excessive amount of water and there is no market for water and farmers use more water while rice generated less revenue as per acre inch of water used as compared to cotton (Khan, 2007).

4.2 SUGARCANE CROP ANALYSIS

4.2.1 Descriptive Statistics of variables

Average Area under sugarcane production is 1592.7 thousand acres on which sugarcane production is 29639.7 million ton and maximum production gone to 43704 million ton. In the same era cotton is cultivated on 5701.43 thousand acres and maximum area under cotton cultivation up to 8097 thousand acres. Total pesticides used in sugarcane production is 2523.5 million ton which goes up to maximum at 6661.7 million ton. In the same manner Urea and DAP are 35.5 million tons and 16.6 million ton are used for production respectively with an average labour force of 987159 for total sugarcane area of 43704 thousand acres.

Table 4.5 Descriptive statistics of sugarcane-related variables (1985-2014)

Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
Production of Sugarcane (PS)	Million ton	30	29639.7	8334.4	16755	43704
area under Sugarcane (SA)	'000' acres	30	1592.7	236.3	1203	2040
area under cotton (CA)	'000' acres	30	5701.4	666.8	4312	8097
Trend	Numbers	30	15.5	8.8	1	30
Labour	Numbers	30	987159.1	376435.2	509409.8	1639627
Pesticide	million ton	30	2523.5	1657.2	541.2	6661.7
Urea	million ton	30	35.5	10.1	20.6	63.9
DAP	million ton	30	16.6	5.2	6.4	29.9
DAP^2	million ton	30	0.0003	0.0002	0	0.0009
Labour	Numbers	30	987159	376435.2	509409.8	1639627

4.2.2 Variation in the Sugarcane Area, Prices and Economic Efficiency

Pakistan is the fifth largest sugarcane producer in the world and 7th largest sugar producer at the global level. Sugarcane is the traditional crop of Pakistan. Because of its several uses it is well customary in the cropping pattern of the country as a major crop. It gives the raw material for manufacturing sugar primarily for domestic use. A vast mainstream of farmers is affianced in

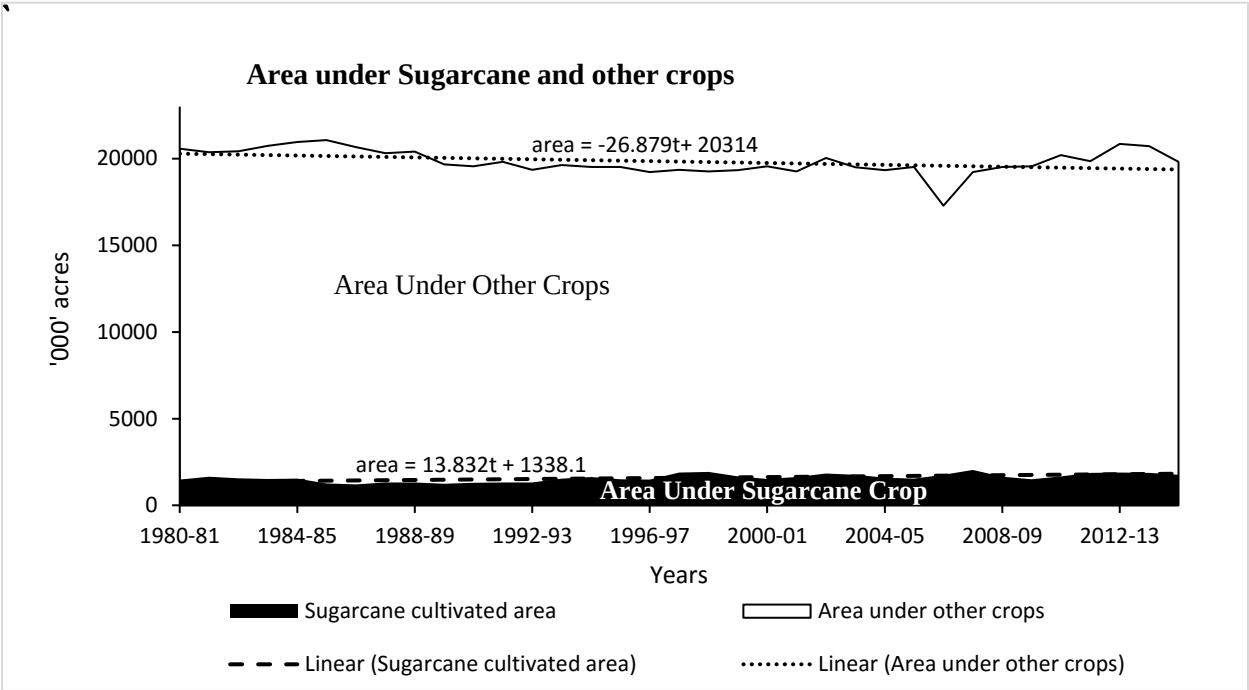
sugarcane farming and a substantial proportion of labor is employed at farm level and in the associated industries. In particular, it helps to save a lot of foreign exchange by providing indigenous sugar rather than imported in place of much needed foreign exchange. Punjab is the major sugarcane producing province contributing about 69 percent of its area and provides about 65 percent of the total sugarcane to country. Currently, there are 91 sugar mills in Pakistan out of which, 48 mills are in Punjab, 34 in Sindh and 9 in NWFP (Safdar, 2015).

A time-series analysis of the area under sugarcane is effectuating to understand the fluctuation in cropping area of sugarcane and reasons behind these fluctuations.

The graph (Figure 4.9) indicate that in 1981-82, sugarcane was cultivated in more area as compared to 1980-81. In February 1980, the government announced the national agricultural policy that emphasized on input and output prices and prices for fertilizers were reduced. The government eliminated the subsidy on pesticide and water charges were increased. The Agricultural price commission was established in 1981 to acclaim the support prices that would maintain the concern of the sugarcane growers against gratuitous fall in prices and stabilize the price. Due to the above reasons, the area under sugarcane crop was increased in 1981-82. In 1984-85 and 1985-86, the area under sugarcane crop was suddenly reduced from 1.5 million acres to 1.2 a million acres as cost of production for sugarcane was increased from Rs. 165.5 per ton to Rs. 179.25 per ton. As Pakistani farmers are profit-oriented and they cultivate such crops that give maximum income, when the cost of production for a crop increases, they shift towards another crop of the same season that give maximum profit. As a result, the area for such crop was decreased. After this, the trend for sugarcane area was stable for 1992-93. The next increase in the sugarcane area was seen in 1997-98. An indicative price of Rs. 35 per 40 kg was given to farmers by the government which was Rs. 11 per 40 kg was greater than the last year. The real indicative

prices were increased Rs. 5 per 40 kg. The farmers cultivated sugarcane on more land to get maximum benefit. After that in 1999-00, the area was decreased as the cost of production from Rs. 628 to Rs. 656 per ton.

Figure 4.9. Trends in the area under Sugarcane and other crops in Punjab during 1980-2014

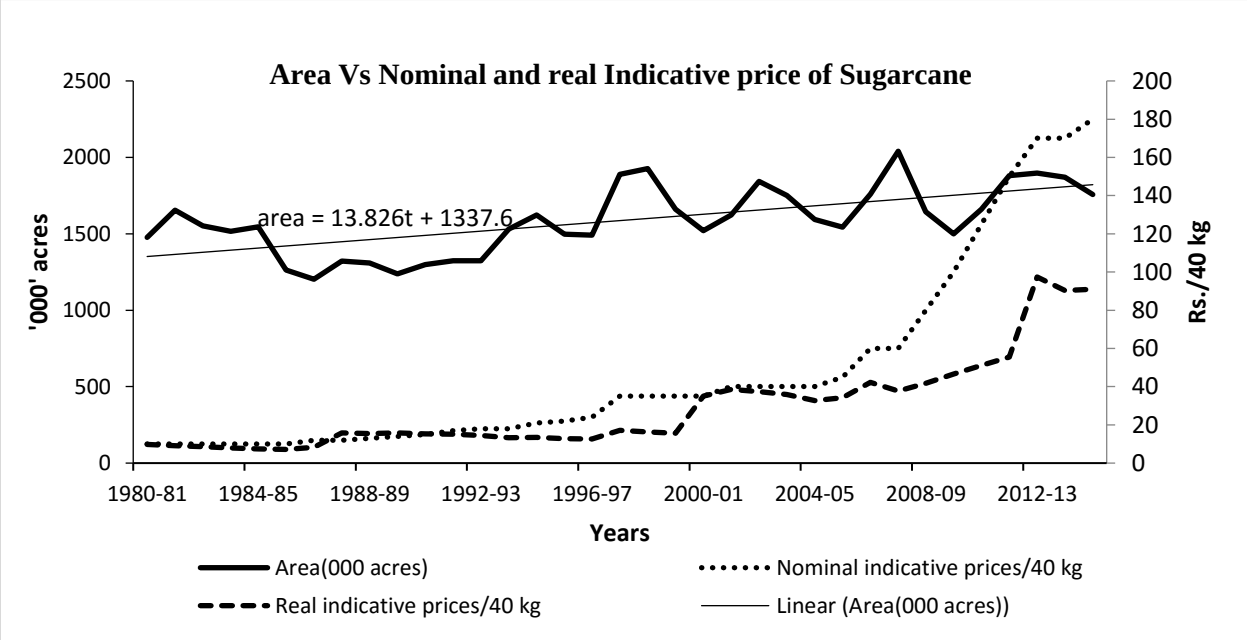


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Another increase in area was observed in 2002-03, as the cost of production was decreased from Rs. 810 per ton to 793 per ton and indicative price of Rs. 40 per 40 kg was given which was Rs. 5 per 40 kg greater than last year. In the next year, the cost of production was increased and the area was decreased under sugarcane production. The next peak in the graph is in 2007-08. The sugarcane area was increased from 1.7 million acres to 2.04 million acres as indicative price of Rs. 60 per 40 kg was given which was Rs. 15 per 40 kg greater than the last year. Sugarcane growers got extra Rs. 15 on per 40 kg and they shift to cultivate sugarcane on

more area. Indicative prices of Rs. 100 per 40 kg was given in 2009-10 which was Rs. 20 greater than the last year but in real terms, it was increased only Rs. 5 per 40 kg but the cost of production for sugarcane was increased from Rs. 1534 per ton to 1990 per ton and area was decreased. After 2009-10, slightly higher indicative prices were given to sugarcane growers and there was an increasing trend that can be seen in figure 9.

Figure 4.10. Area Vs Nominal and real indicative prices of Sugarcane, 1981-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

From figure 4.10 and table 4.5, it can be seen that sugarcane area is increased when one-year lagged market and support price of sugarcane is increased.

Table 4.6 regression results for factor influencing sugarcane area in Punjab

area	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
mp (-1)	0.705	0.050	0.14	0.889	-9.580	10.996
sp (-1)	5.013	5.257	0.95	0.347	-5.696	15.723
_cons	1430.761	52.9676	27.01	0.000	1322.869	1538.652

ANOVA results for factor influencing sugarcane area in Punjab

Source	SS	df	MS	Number of obs	=	35
Model	540526.503	2	270263.251	Prob > F	=	0.0017
Residual	1104930.24	32	34529.07	R-squared	=	0.3285
				Adj R-squared	=	0.2865
Total	1645456.74	34	48395.7866	Root MSE	=	185.82

Nominal and real indicative prices remained same from 1980-81 to 2005-06 and after that nominal indicative prices were increased from the prices that farmers got but there was fluctuation in area of sugarcane. As sugarcane is a three-year crop, area of sugarcane was not affected by the indicative prices.

4.2.3 Regression Analysis of Sugarcane production function in Punjab

From regression table, it can be seen that when sugarcane area is increased then sugarcane production is increased. when cotton area is increased then sugarcane production is decreased. An increase in one-year lagged market price of sugarcane increase sugarcane production. Application of higher amount of pesticide and fertilizers increase the production of sugarcane.

The analysis of variance ANOVA show that there is a statistically significant relationship between production of sugarcane and inputs such as cotton area, technology, labour employed, pesticide and fertilizers used in the production of rice.

Table 4.7 Regression results of Sugarcane production function in Punjab

PS	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
SA	7.52	3.76	2	0.06	-0.29	15.33
CA	-0.83	0.58	1.44	0.07	-0.37	2.04
Pesticide	0.17	0.28	0.61	0.55	-0.41	0.75
Urea	35.76	49.97	-0.72	0.48	-139.68	68.16
DAP	1010	9724	1.04	0.31	-101	303
DAP^2	-201.34	308.26	-0.65	0.52	-842.41	439.73
Trend	271.85	241.82	-1.12	0.07	-774.75	231.06
Labour	0.02	0.01	1.47	0.00	0.01	0.04
_cons	-3961.68	5045.38	-0.79	0.44	-14454.1	6530.76

ANOVA results of Sugarcane production function in Punjab

Source	SS	Df	MS	Number of obs = 30
Model	1973200000	8	246656168	Prob > F = 0.0000
Residual	41157240.3	21	1959868.6	R-squared = 0.9796
				Adj R-squared = 0.9718
Total	2014400000	29	69462296	Root MSE = 1400

4.2.4 Regression Analysis of Sugarcane Area function in Punjab

Table 4.4 shows the relationship of dependent variable (Sugarcane area) with independent variables (Nominal protection coefficient under imports and exports, price difference and water prices). The regression results show that due to one thousand acres increase in area under competing crop (cotton and rice), 0.001 thousand acres of sugarcane area is decreased. NPC is measured by dividing domestic market prices by international market prices and it measure the impact of output pricing policies without taking into contemplation the misrepresentation in input

markets. NPC under imports shows the positive relationship with the area of sugarcane. If NPC under imports increased by one unit, Govt protect the local farmers for the import of sugarcane and area of sugarcane increased by 954 thousand acres. NPC under exports shows a negative relationship with area of sugarcane. Govt not protected the local farmers for sugarcane cultivation for export purpose. Price difference (market prices – support prices) has negative impact on sugarcane area. Water prices shows positively significant impact on sugarcane area because the price of water is under flat rate system and farmers not pay the actual prices for sugarcane water.

Table 4.8 Regression results of Sugarcane Area function in Punjab

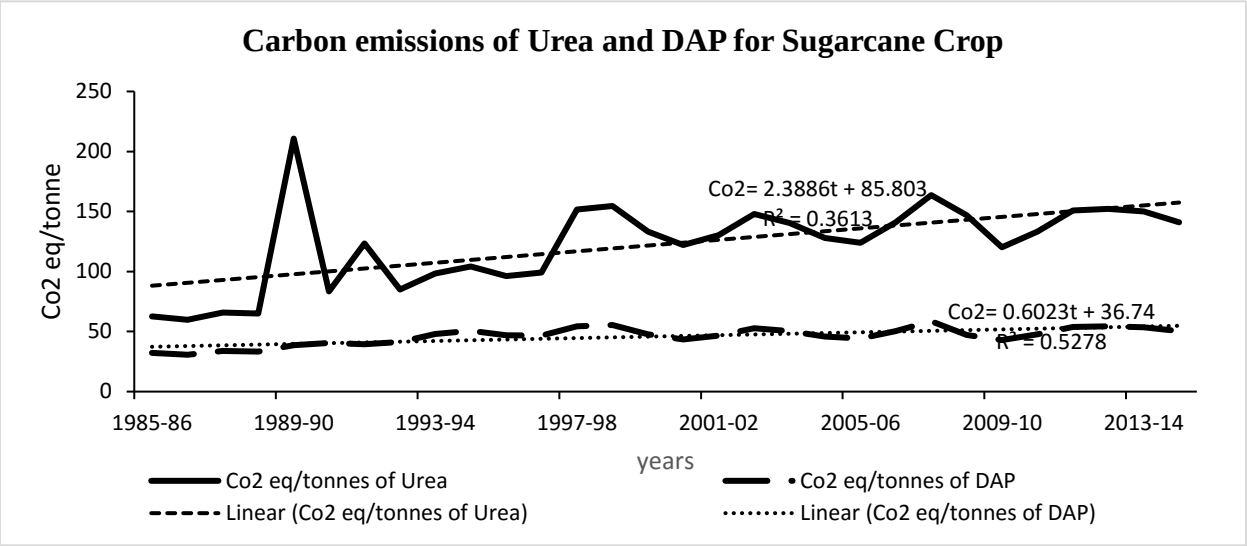
SA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ACC	-.0018793	.0333574	-0.06	0.956	-.0707256	.066967
NPC_imports(-1)	954.1984	393.2529	2.43	0.023	142.5643	1765.832
NPC_exports(-1)	-673.7763	256.6059	-2.63	0.015	-1203.385	-144.1677
PD	-6.879894	2.240163	-3.07	0.005	-11.50336	-2.256425
WP	6.387295	1.457994	4.38	0.000	3.378144	9.396446
_cons	1269.502	341.965	3.71	0.001	563.7207	1975.283

R-squared = 0.7527 Adj R-squared = 0.7012

4.2.5 Carbon emissions from Fertilizers and pesticide use (1985-2014)

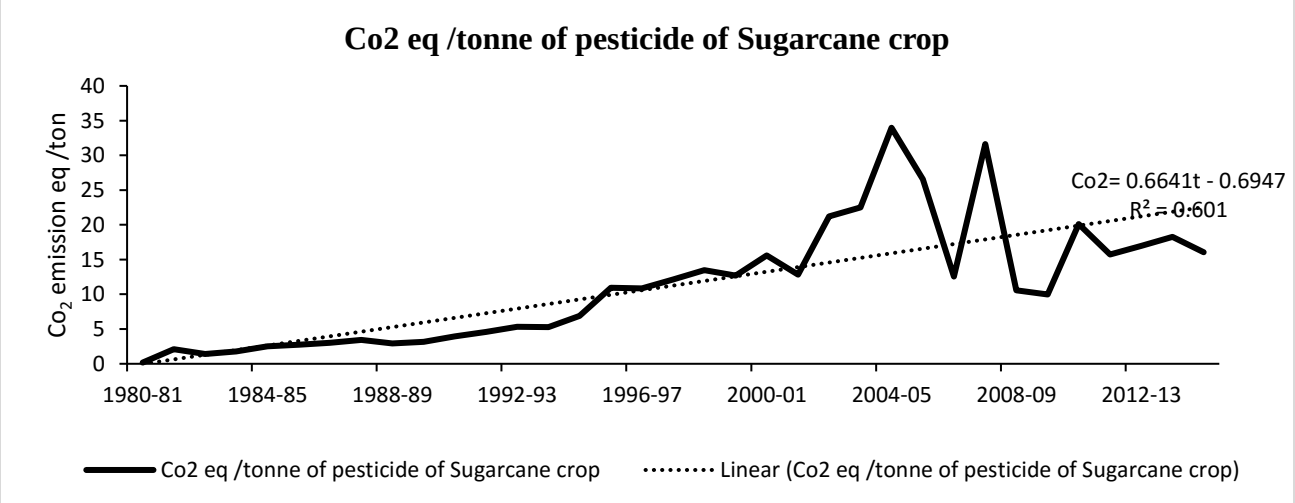
Trend of area under sugarcane crop is increasing from 1980 to onward. As area increases, farmers applied more fertilizers to get higher yields and there are more Co_2 emissions from Urea and DAP fertilizers.

Figure 4.11. Carbon emissions of Urea and DAP fertilizers for Sugarcane Crop



Area under sugarcane crop is increasing from 1980 and farmers applied higher amount of pesticides to sugarcane crop and as a result Co_2 emissions are increasing from use of higher amount of pesticides.

Figure 4.12. Carbon emissions from pesticide use

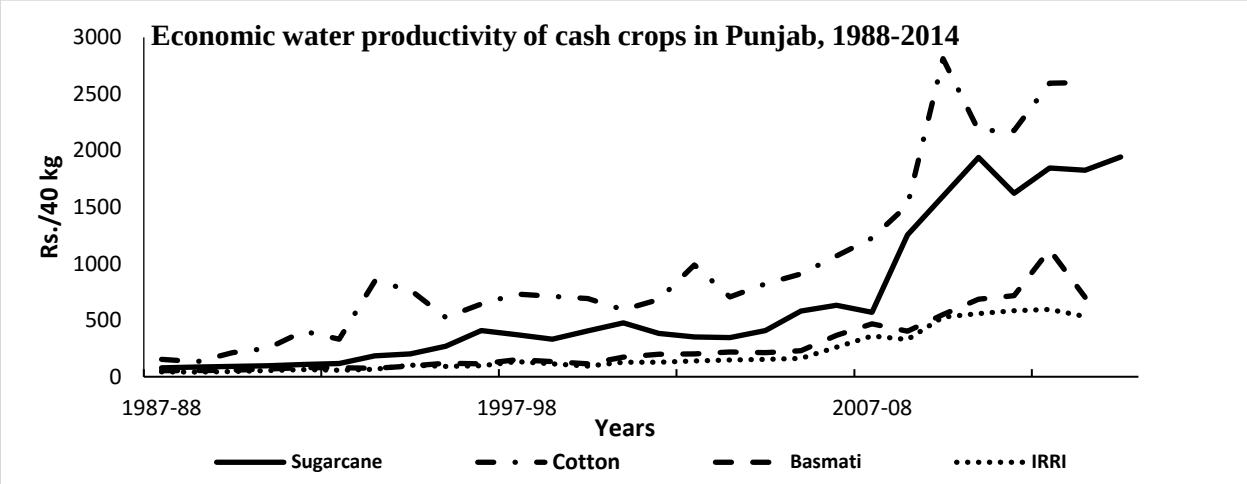


4.2.6 Water use and Farmers Profitability

Resource allocation among the competing enterprises is primarily governed by the economic consideration reflected in their gross cost, gross income and output to input ratios. Sugarcane is cultivated in the irrigated regions of the country and being an annual crop, it competes for land, water, and other farm resources. Economics of sugarcane and competing crop has been analyzed in terms of output prices received by growers and input prices that were paid by the growers. Analysis of an indicators of competitive economics is given in following figure.

From figure 4.13, it can be seen that sugarcane crop has been generated less revenue as compared to cotton and more as compared to Rice (Basmati and IRRI) in terms of per acre inch of water used. Maximum amount of water is used in sugarcane fields and it generated less revenue per acre inch of water used

Figure 4.13 Comparison of economic water productivity of cash crops in Punjab, 1987-2014

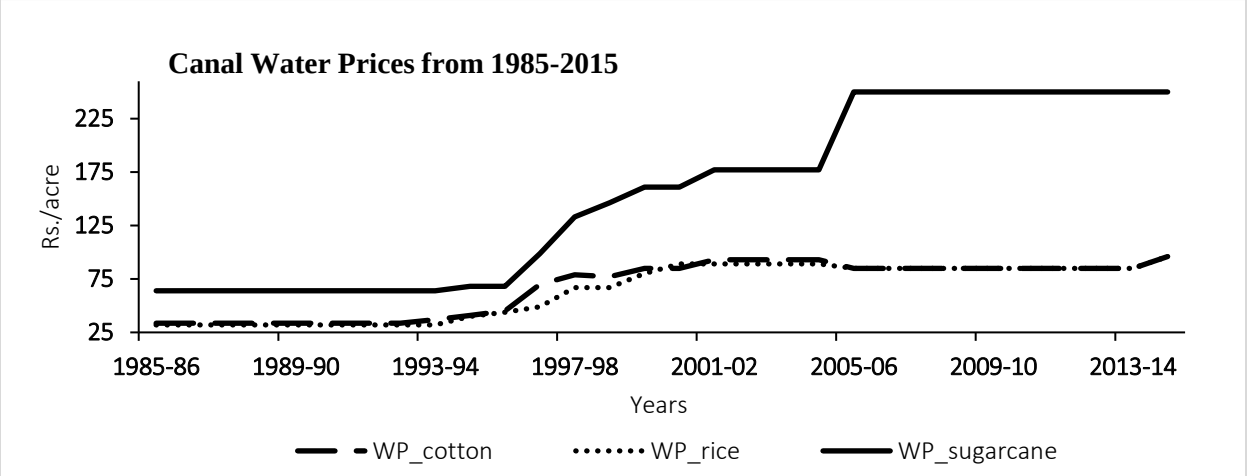


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

According to FAO, sugarcane is 270-365 days' crops and its requirements of water is 59.05-98.42 inch per total growing period. Price for water is fixed under the flat rate system as Rs.

64 in 1985-87 and Rs. 68 in 1994-95 and then increases to Rs. 133 in 1997-98. Water prices for sugarcane was increased to Rs. 250 per acre.

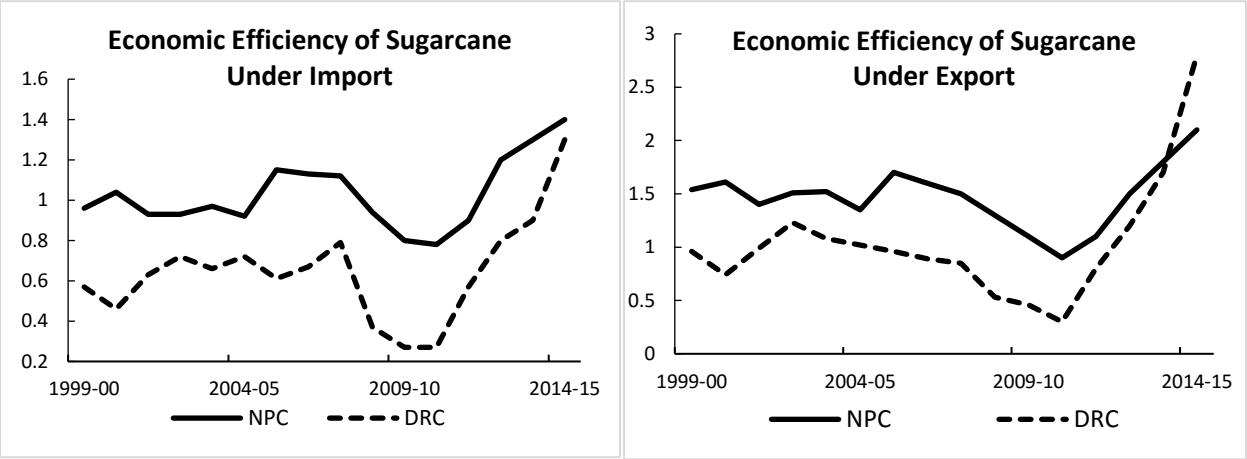
Figure 4.14. Water prices for Sugarcane, and competing crops, 1985-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

From figure 4.15, it can be seen that National protection coefficient under import of sugarcane is almost less than one. NPC<1 means Govt not protected local farmers. There is a comparative profitability in producing local cotton as imposed to imports while DRC is greater than one expects few years. There was comparative profitability in local production of IRRI rice in those years when DRC was less than one.

Figure 4.15. Economic efficiency of sugarcane, 1999-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

In the conclusion to this portion, it can be said that sugarcane crop is a water-intensive crop and if the cost of production (cost of water or other inputs) increases, farmer shifts to other competing crops that give the maximum income. The trend of sugarcane area from 2014 to onward is decreasing because sugarcane crop is a political crop. Sugarcane growers do not get the actual amount or they received less amount after a period of 3 to 4 months. Farmers switched to other crops due to these problems.

Water prices are under the flat rate system and Water as an environmental commodity has not such prices that determine the market of water for cultivation of sugarcane. sugarcane use higher amount of water and there is no market for water and farmers use more water while sugarcane generated less revenue as per acre inch of water used as compared to cotton and higher revenue as compared to rice sugarcane.

4.3 COTTON CROP ANALYSIS

4.3.1 Descriptive Statistics of variables

Average Area under cotton production is 5701.43 thousand acres on which cotton production is 8372.12 million ton on average Rs. 1017.03 /40 kg and maximum production gone to 11416.8 million ton at Rs. 4003 / 40kg. In the same era rice is cultivated on 3400.73 thousand acres and maximum area under rice cultivation up to 4326 thousand acres. Total pesticides used in cotton production is 8583.66 million ton which goes up to maximum at 26010.8 million ton. In the same manner Urea and DAP are 0.61 million tons and 0.22 million ton are used for production respectively with an average labour force of 3481098 for total cotton area of 8097 thousand acres.

Table 4.9 Descriptive statistics of Cotton-related variables (1985-2014)

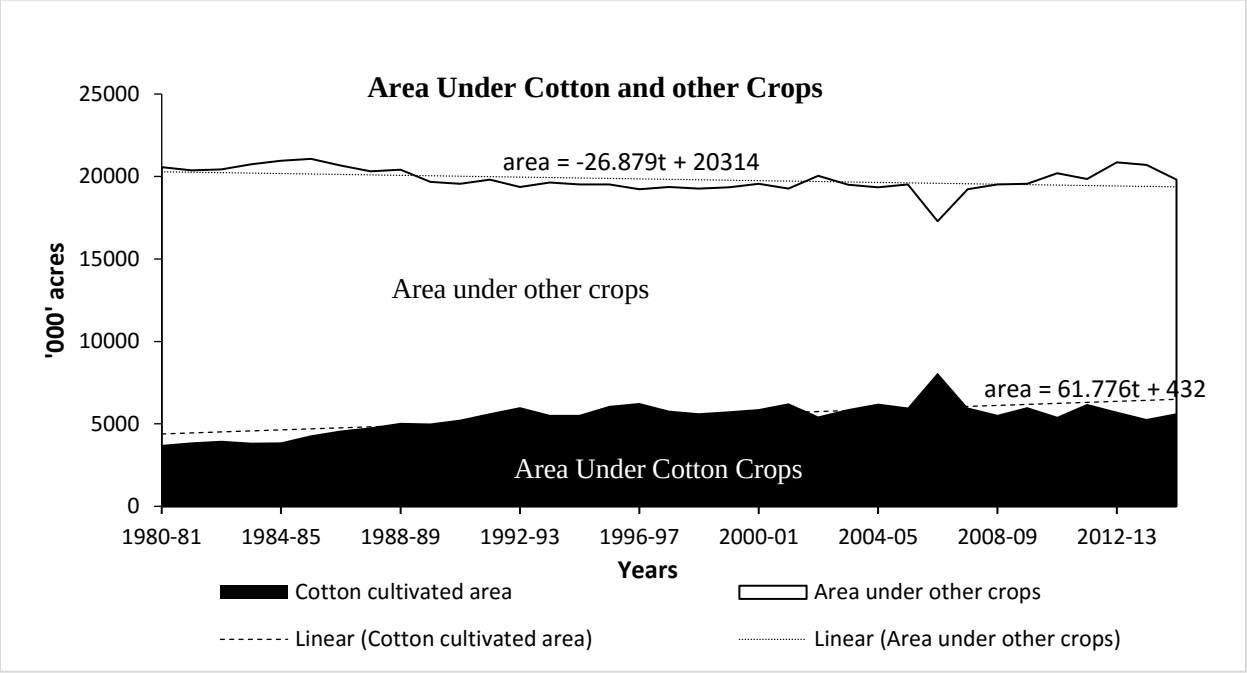
Variable	Unit	Obs	Mean	St Dev.	Min	Max
Production of Cotton (CP)	Million ton	30	8372.12	1448.42	5701.2	11416.8
area under cotton (CA)	'000' acres	30	5701.43	666.8	4312	8097
area under Rice (RA)	'000' acres	30	3400.73	462.37	2590	4326
Sugarcane area (SA)	'000' acres	30	1592.7	236.34	1203	2040
lag market price [MP(-1)]	Rs. /40 kg	30	1017.03	940.06	189	4003
Pesticide	million ton	30	8583.66	5818	1848.16	26010.8
Urea	million ton	30	0.61	0.22	0.32	1.15
DAP	million ton	30	0.22	0.05	0.15	0.37
DAP^2	million ton	30	0.05	0.02	0.02	0.13
Trend	Numbers	30	15.5	8.8	1	30
Labour	Numbers	30	3481098	1136078	1743524	5780975

4.3.2 Variation in Cotton Area, Price and Economic Efficiency

Pakistan is an agricultural country since independence and according to the Government of Pakistan, its contribution to country GDP is 18.5 per cent and 38.5 per cent of labor force is associated with this sector. The major crops (wheat, cotton, rice and sugarcane) contribute 21.9 per cent to value addition of agriculture and 4.06 per cent in country's GDP. Cotton is the major cash crop of Pakistan known as "white gold" and it contribute 4.5 per cent in agriculture value addition and 0.8 per cent in country's GDP. Pakistan is the 4th producer of cotton in the world with the average production of 1610 thousand metric ton (Nabi, 2012). Cotton is cultivated across two provinces of Pakistan; Punjab and Sindh but the Punjab province is leading in terms of cultivated area and production (Hina, A. et al,. 2013). Punjab is the main cotton producer accounting for 79 percent of its area and provides about 83 percent of cotton to country. The share of cotton in GDP is 2.4 percent. Productivity in both of the provinces is lower than probable regardless of the favorable soil characteristics and feasible environmental conditions (United States Department of America, 2017)(United States Department of America, 2017).

A time-series analysis of the area under cotton crop from 1980 to 2014 shows a few peaks and valleys in otherwise gradually increasing trend in the area in Punjab province of Pakistan.

Figure 4.16. Trends in the area under Cotton and other crops in Punjab during 1980-2014

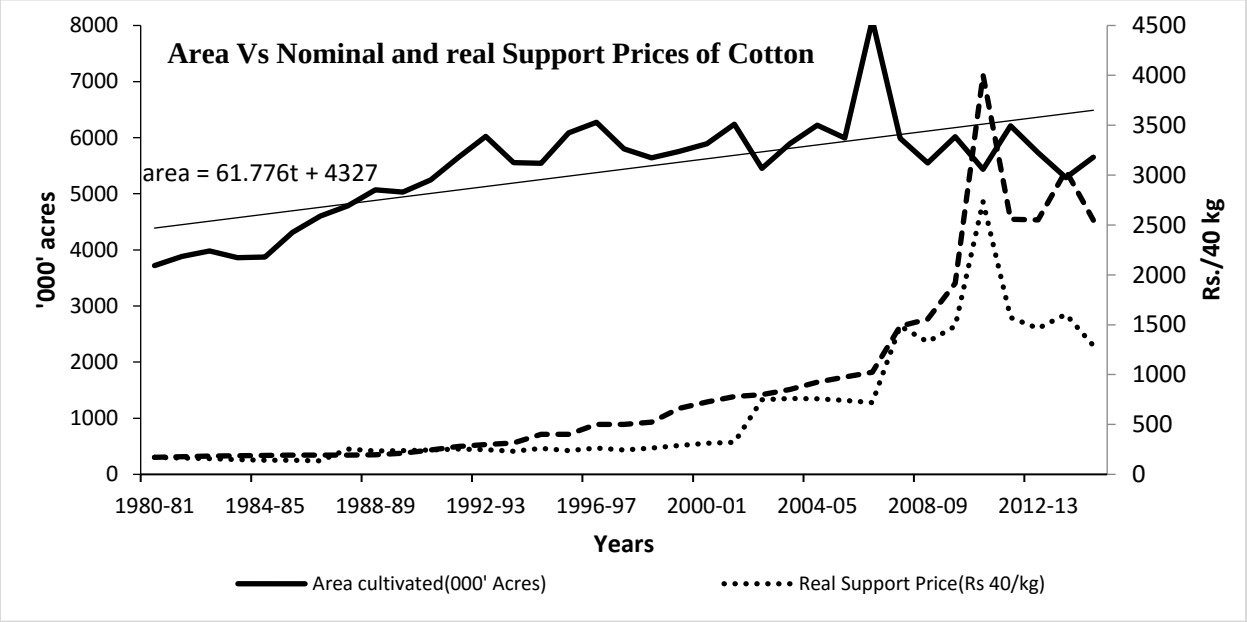


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Keeping in view the importance of cotton crop, both for farmers and industry, Government announced annually reviews the support prices for cotton. In the event of falling market prices to un-remunerative levels, the support price provides a guaranteed minimum price to safeguard the interest of producers. However, the announcement of support prices by assuring reasonable returns to the growers has induced them to invest in cotton production technology resulting in increased cotton production. The figure 1 shows that there is a gradual increase in area under the cotton crop but in 1992-93 the area under cotton crop was suddenly increased. According to the policy documents of Agriculture Price Commission (APCom), a support price of Rs. 300 per 40 kg was in 1991-92 which was Rs. 12 more than the previous year and farmers were shifted to cultivate cotton crop on more area. After that in 1993-94, the cotton area was decreased, as higher support price was announced but the problem is that the support prices was just announced instead

of implantation of announced support prices. Another sudden increase in area was perceived in 1996-97, the government announced a support price of Rs. 500 and farmers were shifted towards the cultivation of the cotton crop. After that, the area under cotton cultivation was gradually increasing. In 2002-03 the area was decreased. Market price and support price was the same at that time and farmers grow cotton on less area.

Figure 4.I7. Area Vs Nominal and real support prices of cotton, 1980-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

The area was suddenly increased to the highest level of 8.093 million acres in 2006-07. A support price of Rs. 1025 per 40 kg was given to farmers which is Rs. 50 higher than the last year. Farmers may shift towards cotton cultivation due to higher support prices or due to the subsidy given to farmers by the government to reduce the cost of inputs for cotton cultivation during this year. This sudden increase in the area may be due to the government's Programme of contamination-free cotton production that has shown success in certain areas of Punjab. The cotton area was decreased from 6.016 million acres to 5.435 million acres in 2011-12. This dire change

was ascribed to 2010 floods in Pakistan that heavily affected the agriculture sector. About one million acres of the cotton area was destroyed. This was also adversely affected the price figures. The reduced area was added to cotton competing crops like rice, sugarcane, wheat and sunflowers in the expectancy of better return to their investments.

From figure 4.17 and table 4.8, it can be seen that cotton area is increased when one-year lagged market and support price of sugarcane is increased.

Table 4.10. regression results for factor influencing cotton area in Punjab

area	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sp(-1)	1.060	1.047	-1.01	0.31	-3.193	1.072
mp(-1)	1.628	1.049	1.55	0.13	-0.509	3.765
_cons	5049.796	203.155	24.86	0.00	4635.981	5463.61

ANOVA results for factor influencing cotton area in Punjab

Source	SS	df	MS			
Model	5184297.2	2	2592148.6	Number of obs	=	35
Residual	22211469.8	32	694108.43	Prob > F	=	0.0349
				R-squared	=	0.1892
				Adj R-squared	=	0.1386
Total	27395767	34	805757.852	Root MSE	=	833.13

4.3.3 Regression Analysis of cotton production function in Punjab

From regression table, it can be seen that when cotton area is increased then cotton production is increased. When rice area and sugarcane area is increased then cotton production is decreased. An increase in one-year lagged market price increase cotton production. Application of higher amount of pesticide and fertilizers increase the production of cotton.

The analysis of variance ANOVA show that there is a statistically significant relationship between production of cotton and inputs such as cotton area, rice area, one-year lagged market price, technology, labour employed, pesticide and fertilizers used in the production of rice.

Table 4.11 Regression Results of cotton production function in Punjab

PC	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CA	1.94	0.88	2.2	0.04	0.1	3.78
RA	-0.73	1.13	-0.64	0.53	-3.1	1.64
SA	-4.45	1.8	-2.47	0.02	-8.21	-0.69
MP (-1)	0.34	0.76	0.45	0.66	-1.24	1.92
Pesticide	0.00095	0.00075	1.27	0.22	0.00061	0.0025
Urea	587.33	5506.64	0.11	0.92	-1038.2	1212.85
DAP	1017.1	7235.24	-1.4	0.08	-2512.8	5018.55
DAP2	-1889.1	1322.5	1.43	0.07	-8813.62	4631.8
Trend	342.99	224.02	1.53	0.04	-125.89	811.86
Labour	0	0	-1.24	0.23	0	0
_cons	1891.02	925.5	2.08	0.05	-118.87	3880.91

ANOVA Results of cotton production function in Punjab

Source	SS	Df	MS	Number of obs = 30
Model	37172137	10	3717214	Prob > F = 0.0194
Residual	23670428	19	1245812	R-squared = 0.6110
				Adj R-squared = 0.4062
Total	60842565	29	2098019	Root MSE = 1116.2

4.3.4 Regression Analysis of cotton production function in Punjab

Cotton area depends on ratio of rice area [Ratio of Basmati area ('000' acres) and IRRI area ('000' acres)]. In some districts of Punjab, cotton is cultivated on IRRI area. As Ratio of rice area (Basmati area/IRRI area) increases (Basmati area increases, IRRI area decreases and Decreased IRRI area goes to Cotton), Cotton area increases. Sugarcane area decreases and cotton area increases as cotton and sugarcane cultivated in same districts of Punjab. As Real Support prices of cotton increases, according to results, cotton area decreased. This is because as Govt. announce support price (Nominal Support price) but support price that Farmers get are lower so farmers cannot focus on the support prices. In Pakistan, most of farmers are traditional farmers and they do not focus on support prices while they are deciding to cultivate. Real support price of IRRI rice has negative relationship with area of cotton. As cotton is cultivated in some areas of IRRI rice in Punjab and when area of IRRI rice is increased, cotton area decreased. Real support prices of sugarcane have negative relationship with cotton area. As support prices of sugarcane increases, farmer shift to sugarcane cultivation. Export prices of cotton, if increases, farmers will grow cotton on more area. If prices of DAP fertilizer increases, then farmers decrease the cotton area but this is not significant. I take only DAP fertilizer in this model because DAP is given to cotton at the time of sowing and this fertilizer is necessary, no other fertilizer can be used in place of DAP. This is much more important fertilizer for cotton. _cons represent the constant, also referred to as the Y-intercept. In other words, this is the predicted value of the dependent variable (Cotton area) when all other variables are zero.

Table 4.12 Regression Results of cotton Area function in Punjab

CA	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RA_ratio	257.9036	55.29265	4.66	0.000	143.2337	372.5736
SA	-.8299473	.6498979	-1.28	0.215	-2.177753	.5178584
$RSP_{(cotton)}(-1)$	-2.651751	.756758	-3.50	0.002	-4.221171	-1.082331
$RSP_{(IRRI\_Rice)}(-1)$	-5.231176	1.525191	3.43	0.002	2.068123	8.394229
$RSP_{(sugarcane)}(-1)$	-25.75023	9.787006	-2.63	0.015	-46.04724	-5.453224
$ExpPrice_{(cotton)}(-1)$	1.594098	.4100398	3.89	0.001	.7437275	2.444468
DAP_price	-.0506623	.5102886	-0.10	0.922	-1.108936	1.007612
_cons	5429.36	811.0394	6.69	0.000	3747.367	7111.353

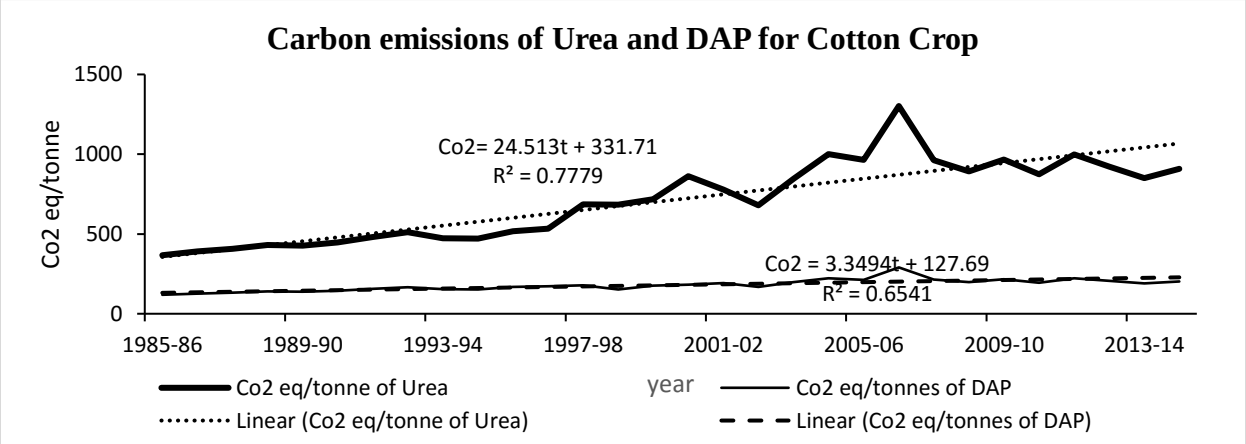
R-squared = 0.6803 Adj R-squared = 0.5786

As I am studying the cropping pattern, so I have focused on the real support prices because farmers made decision about the cultivation of any crop on the basis of prices that they have received (real prices) not those prices that Govt announced (nominal prices).

4.3.5 Carbon emissions from Fertilizers and pesticide use (1985-2014)

Over the time area under cotton crop increased, higher amount of fertilizers is used and trend of Co_2 emission is increasing i.e. environment is degrading over the time.

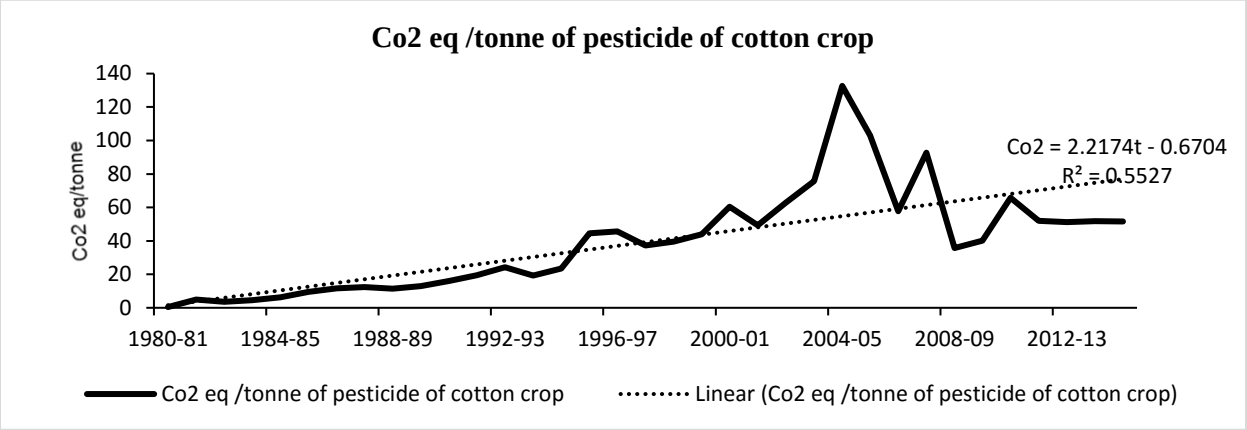
Figure 4.18. Carbon emissions of Urea and DAP for Cotton Crop



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

Over the time, if area under cotton crop increased then higher amount of pesticide is applied and there is higher Co_2 emissions from pesticide use and as a result environment is degraded more over the time.

Figure 4.19. Carbon emissions from pesticide use



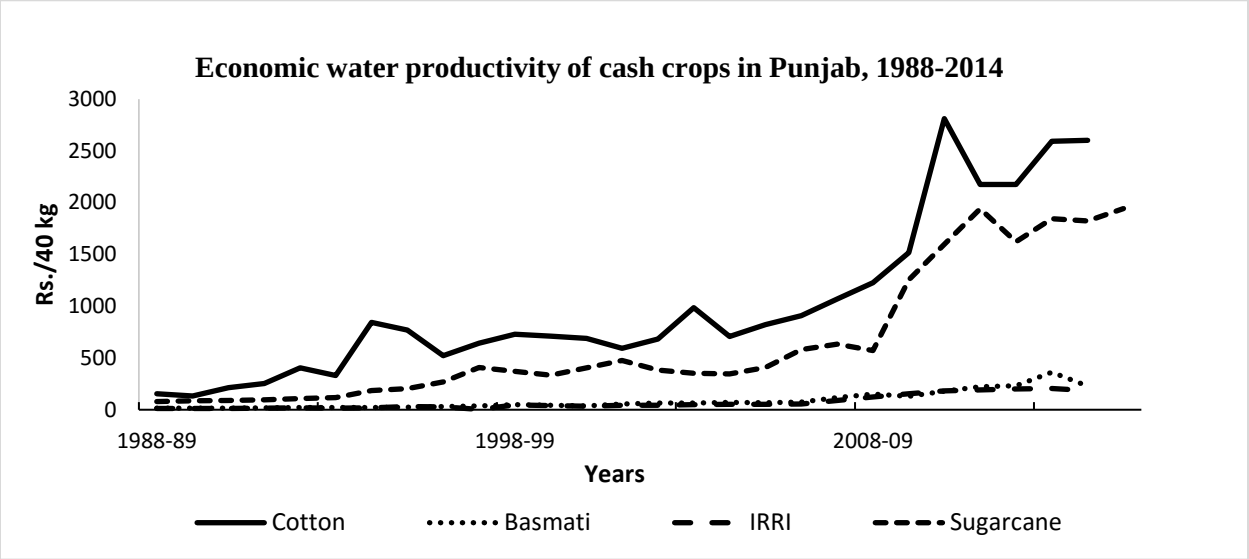
Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

4.3.6 Water use and Farmers Profitability

Farmer priorities and decisions regarding resource allocation among the competing crops are primarily governed by a number of economic considerations particularly focusing on gross cost, gross income and output-input ratio. These indicators provide useful insight into the pattern of resource used at farm level, both by individual as well as the whole farming community. Cotton competes with rice for land, water and other farm resources in the areas where cultivation of both the crop is feasible. Cotton also faces indirect competition from sugarcane, which occupies land throughout the year as annual crop.

The economics of cotton and competing crops has been analyzed in terms of output-input prices received and paid by growers and gross revenue per acre inch of water used. A graph of economic indicators for cotton and competing crops is given below.

Figure 4.20. Comparison of the economic water productivity of cash crops in Punjab, 1988-2014

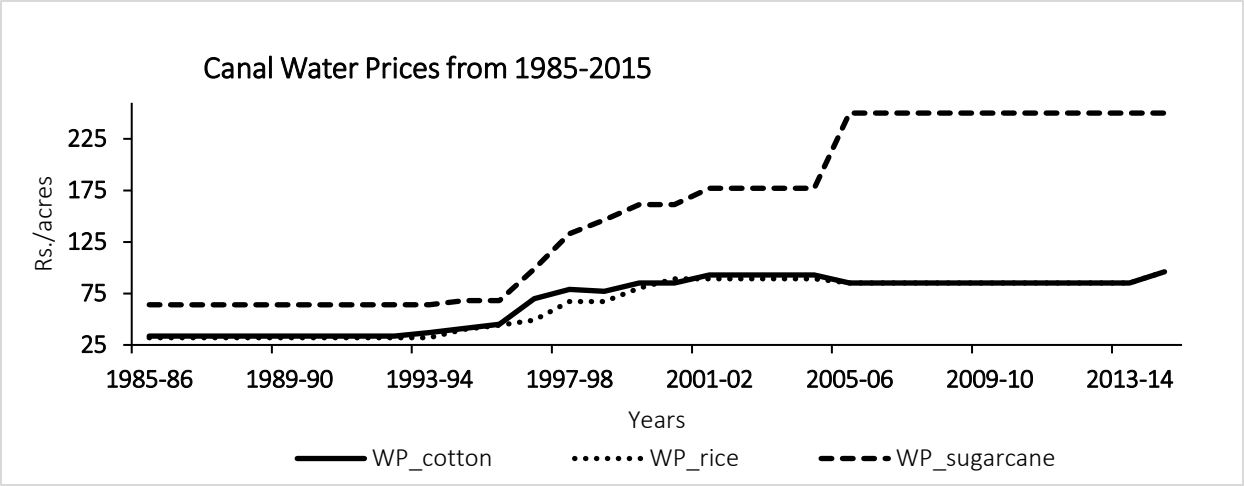


Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

From above figure it can be seen that cotton crop has successes to attain required return in terms of output-input ratio, and gross revenue per acre inch of water used as compared to cotton competing crops. Farmers are profit-oriented and they adopt only those crops that give maximum profit. From figure 2, it can be seen that in 2008-09, Gross revenue per purchased of input cost of cotton was at Rs. 1.2 while for Basmati, and IRRI was at Rs. 1.5 and Rs 1.4 respectively. Cotton remunerated better return in terms of gross revenue per acre inch of water used.

According to FAO, Cotton is 180-195 days' crops and it required 27.56-51.18 inch per growing period of water while prices for water was fixed from 1985-86 as Rs. 32 per acre per season to 1992-93. Water prices were fixed under the flat rate system and did not changed. The real value of price of water was decreasing. Cotton paid better return in terms of gross revenue per acre inch of water used.

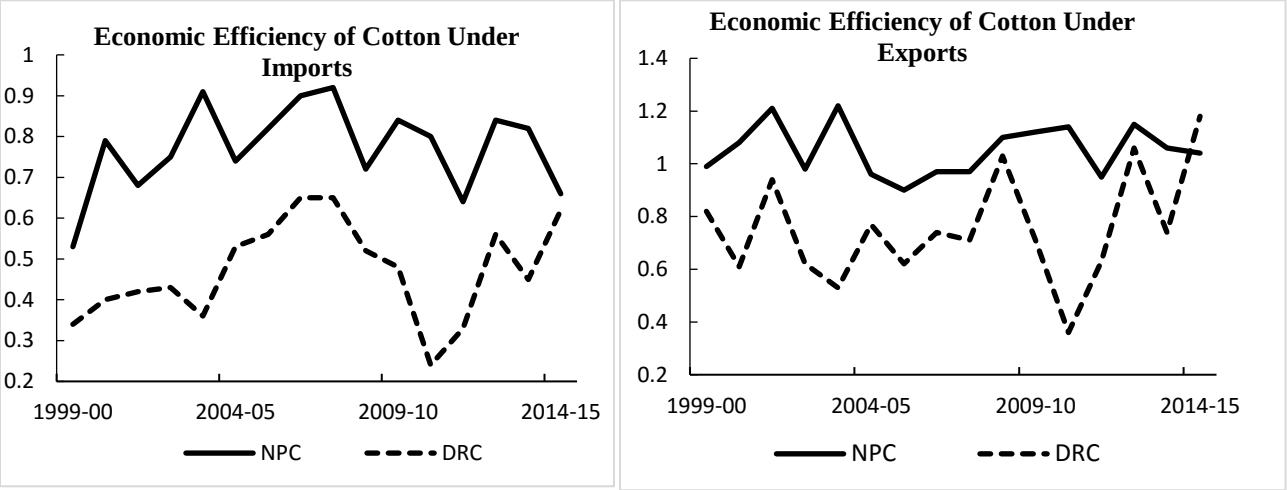
Figure 4.21. Water prices for cotton, and competing crops, 1980-2015



Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

The efficiency of resource use is an important indicator for judging the comparative advantage of a nation in the production of certain crop. It is mostly estimated in the form of Nominal protection coefficient (NPC) and Domestic Resource cost (DRC). NPC is measured by dividing domestic prices with world prices and measures the impact of output pricing policies without taking into consideration the distortion in input markets. The value of NPC under export scenario were either close to one or greater than one while under importing condition it must be less than one while DRC indicate the opportunity cost of domestic resource used per unit of value added in the production of a commodity. From figure 4.22, it can be seen that National protection coefficient under import of cotton is less than one. NPC<1 means Govt not protected local farmers. There is a comparative profitability in producing local cotton as imposed to imports while DRC is greater than one expects few years. There was comparative profitability in local production of IRRI rice in those years when DRC was less than one.

Figure 4.22. Economic efficiency of cotton, 1999-2015



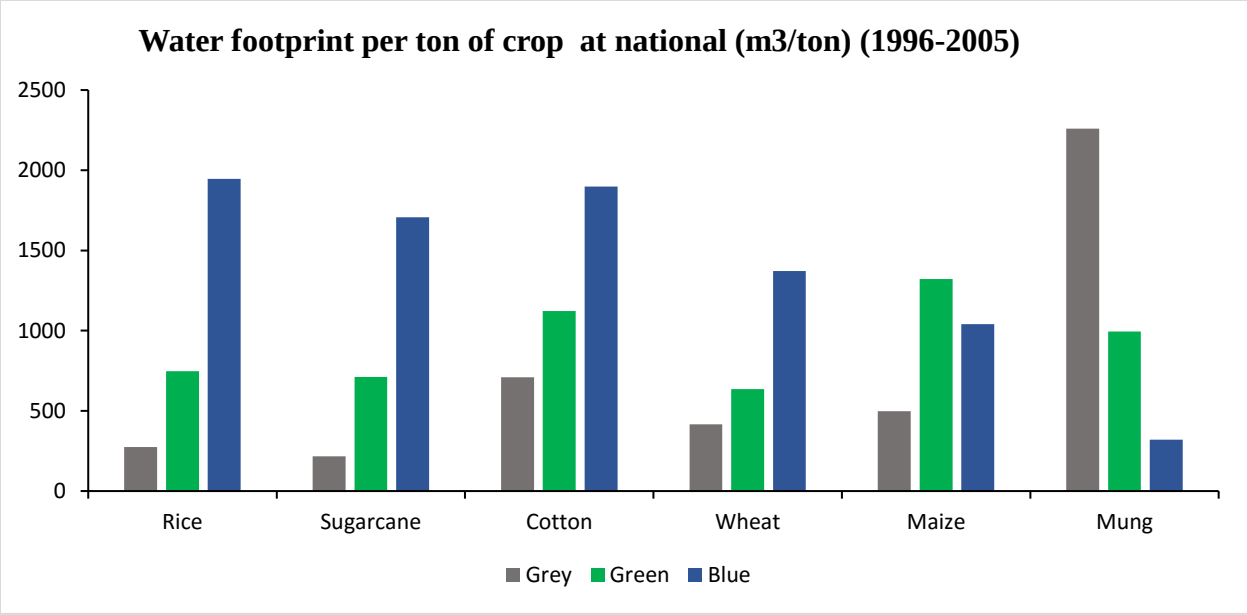
Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API)

In conclusion, it can be said that the area under cotton cultivation has been continuously on rising regardless of slight vacillations in the support prices. Farmers prefer cotton crop as it is a cash crop and have a domestic demand and judicious profit precincts in the comparison of other competing crops. There is nothing such crop that give such return to farmers for their investments. As cotton is a cash crop and it paid a better return, so farmers cultivate cotton crop on maximum area.

4.3.7 Water footprint per ton of crop at national and sub-national level (m^3/ton) (1996-2005)

Water footprint is a measure of humanity's appropriation of fresh water in volumes of water consumed and/or polluted. Blue water footprint is water that has been sourced from surface or groundwater resources and given to crops. Grey water footprint is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. While Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants (Hoekstra & Mekonnen, 2010). Rice is a more water consuming crop as compared to other crops (cotton and sugarcane). Blue water footprint for rice crop is higher than other crops. As cotton is a cash crop and there is a higher attack of pests on cotton and higher amount of pesticide is applied to cotton crop. So, grey water footprint is higher than other major crops (rice and sugarcane).

Figure 4.23. Water footprints of different crops



Source: Hoekstra & Mekonnen, (2010)

4.3.8 Average growing period and water requirement of major crops

Rice and wheat require same amount of water i.e. 21.65 inches per total growing period while cotton require higher amount of water 39.37 inches per total growing period (187 days) and sugarcane require 68.90 inches water per total growing period (317 days). Cotton, rice and sugarcane require higher amount of water as compared to other crops like wheat, maize and mung.

Table 4.13 Average growing period and water requirement of major crops of Punjab

Crop	average growing period (days)	Crop water need (inches/total growing period)
Cotton	187	39.37
Rice	120	21.65
Sugarcane	317	68.9
Wheat	135	21.65
Maize	152	25.59
Mung	110	22.01

Source: Brouwer & Heibloem, 1996

4.4 COST OF AGRICULTURAL OPERATIONS RECEIVED BY MALE AND FEMALE LABOUR AS A PERCENT OF TOTAL COST

Agriculture has always been a gender-neutral occupation. Since old days, both males and females have participated in this activity to earn a living for themselves. On the agricultural front, Punjab province has been the most progressive out of all. Being a family activity, women have contributed significantly in the agricultural activities (Kaur & Mavi, 2015).

In order to estimate the gender participation rate in Punjab agriculture, a set of agricultural report policies have been obtained from Agricultural Policy Institute (API). Time series data from 1985-2015 has been analysed to see the gender participation rate in Punjab through the ages. The data is then verified by various interviews conducted from farm owners in different districts of Punjab for the particular crops i.e. cotton, rice and sugarcane as shown in Table 4.7

Table 4.14 Gender participation in various crop cultivation related activities for particular crops

Gender	Farm Activities	Cost of operation as a per cent of total cost
Male	Land preparation, Seed bed preparation, Sowing, Field irrigation, Plant protection, Interculture, Harvesting, Loading trucks	Cotton = 66%
		Rice = 69%
		Sugarcane = 77%
Female	Stripping seeds, Seed transplantation, Sowing, Harvesting	Cotton = 34%
		Rice = 31%
		Sugarcane = 23%

Source: Policy Analysis documents (1980-2014) by Agricultural Price Commission (APCom); Agriculture Policy Institute, (API).

From the Table 4.11 it can be seen that over the years, nearly 69% of male farm workers have been associated with these crops whereas 31% of female farm workers have been associated with this field. These results have been generalized over the past 30 years so there exists a chance of difference between the average and actual values. Over the years, female participation rate has seen a gradual decrease in rice and sugarcane whereas it has seen a slight increase in cotton. In

case of these crops, females have majorly been active in sowing and harvesting of the crops whereas men are required for more laborious activities such as land preparation, seed bed preparation, truck loading etc. Sowing of rice, cotton picking and manual weeding are purely female activities while all other activities are either male dominated or in the form of 50-50 male-female participation.

Farm activities that include both male-female participation is performed in the form of groups per acre of cultivated land. The wages of these activities are given by the farm owners to the male head of the group, who further distributes them to the group members. There is no wage disparity between male and female farm workers by the farm owners, however, it is not certain if the group head distributes the wages in a fair manner to all the group members or not.

Another problem that exists for the female farm workers is the introduction of new technology in the form of mechanized cultivation and improved chemicals like herbicides. By the advance of machines in agriculture, all the labour-intensive work that was previously done by both males and females is now performed by machines run by male farm workers. These activities involve ploughing by tractors, fertilizer and pesticide spraying machines, harvesting machines and threshers etc. These machines have rendered females useless in these particular activities as the social setting of Punjab province does not appreciate a female farm worker as a machine operator.

Same is the case with herbicides. Earlier the females used to extract weeds from the cultivated fields and use them as fodder for animals and for selling them in the market. Due to better herbicides, anti-weed medicines have been introduced that retard the weed growth in the fields. Now the female farm workers are suffering an economic loss by losing the additional

income earned by weed sale in the markets as well as paying money to buy fodder for their cattle, which was previously free due to weed extraction from the fields.

All phases of agricultural activities from seed sowing to harvesting and processing of crops are intimately done by rural women. A decrease in water availability leads to poor crop production which ultimately affects women income stability (Mwinzi, 2014). As cropping pattern of agriculture is changing. Female labour are mostly affected due to change in cropping pattern of major crops. The declining usage of female labour inputs in agricultural operations (Duvvuru & Motkuri, 2013).

CHAPERT V

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

For many years, Pakistan has depended on its agriculture sector. Agricultural produce not only meet the local demand but it also a source of foreign earnings. The study was designed to find the cropping choices of farmers to rice, sugarcane and cotton in Punjab province of Pakistan. Along with farmer's profitability, water usage and environmental impacts of these three crops have also been evaluated. For this purpose, a time series analysis of three major crops has been done in this study. It is seen that the cropping pattern of rice, cotton and sugarcane has been on an increasing trend since past 30 years. Production and arable land under these crops fluctuated over the time. The results show that the area of the crop, market price, labour employed, use of pesticides and fertilizers have positive impact on the production of rice, sugarcane and cotton. Area of the three major crops is increased due to increase in market prices and support prices of that crop. Further, these crops are water intensive. The water prices have been set on the flat rate system, which fixes the price at a specific level. Sugarcane offers better revenues per acre-inch of inputs used than cotton and rice. The area of competing crop has negatively affected the area under these selected crops. The increasing trend in the cultivation of these water consuming crops also put pressure on the use of pesticides and fertilizers which also have negative impact on the environment. The government support (NPC) has positive impact on Rice, sugarcane and cotton area which evidence that the past price support policies shaped the current cropping pattern.

In Punjab, there are specific regions or districts allocated to each crop e.g. Gujranwala, Sialkot, Lahore are known as rice-wheat belt as both these crops are alternatively cultivated there.

The farmers belonging to these crops cultivate only these particular crops. Hence, we can conclude that in most cases, a farmer belonging to one particular crop will keep on cultivating it, regardless of other opportunities, till that crop becomes totally unprofitable. These cases are present where farmers consider the market prices of other competing crops before deciding upon a specific crop for cultivation on their land.

5.2 Policy Recommendations

Keeping in mind the purpose and findings of the research, following policy recommendations are suggested for the concerned government authorities:

- In order to increase the area of particular crops, Govt have to increase the market and support prices as area has been highly influenced by one year back market and support prices of that crop.
- Cotton crop has higher economic water productivity as compared to rice and sugarcane. The water prices have been stagnant since past two decades which has essentially made water a free commodity. Governmental agricultural authorities should devise and implement new water prices for each crop and the recovery of those water prices should be made compulsory by the concerned authorities. In this way, water conservation can be made effective.
- Production of particular crops has been highly prejudiced by high use of pesticides and fertilizers but heavy fertilizers and pesticides damages the environment. Extension programme are advised for the training of farmers to appropriate use of fertilizers and pesticides.
- The government policies have been gender insensitive throughout the years. Policies should be more gender inclusive and proper wages should be set for farm workers. Also, wages should be given directly to the workers rather than to the male head of group working on an area. In this way it can be ensured that all the employees are getting paid for their work.

- The female farm workers have suffered economically due to the introduction of new and improved technology, like farm machinery and chemicals. With the introduction of technology, government should also focus on relief programs for the female farm workers or they should be included in the mechanized farm work along with male farm workers. Also, they should be compensated for their economic loss by equal or alternative work opportunities.

5.3 Limitations of the Study

As the present study is limited in its selection of data source and variables choice, not every facet of inimitable singularity under reflection could be scrutinized. This leave space for future research where information avenues can be further explored and better understanding can be established regarding the issue around us.

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APPENDICES

Appendix A: Cost of operations of Rice as a per cent of total cost

Years	Total labour (male, female) cost	Male work cost	Male work cost as a % of total cost	Female work cost	Female work cost as a % of total cost
1985-86	814.7	541.47	66	273.23	34
1986-87	848.9	567.24	67	281.61	33
1987-88	872.8	596.715	68	276.075	32
1988-89	833.7	555.255	67	278.465	33
1989-90	1000.5	655.745	66	344.785	34
1990-91	1127.6	753.74	67	373.85	33
1991-92	1265.2	851.06	67	414.1	33
1992-93	1402.7	948.38	68	454.35	32
1993-94	1528.6	1010.27	66	518.36	34
1994-95	1719.4	1154.05	67	565.34	33
1995-96	1747.2	1174.81	67	572.34	33
1996-97	1948.9	1296.715	67	652.175	33
1997-98	2824.4	2010.215	71	814.135	29
1998-99	2960.6	2067.57	70	893.03	30
1999-00	3408.7	2345.65	69	1063.08	31
2000-01	3438.5	2393.555	70	1044.925	30
2001-02	3369.5	2416.96	72	952.52	28
2002-03	3672.2	2614.815	71	1057.375	29
2003-04	4301.6	3061.97	71	1239.63	29
2004-05	4499.3	3180.92	71	1318.4	29
2005-06	4626.2	3173.44	69	1452.73	31
2006-07	5078	3604.61	71	1473.41	29
2007-08	5319	3767.84	71	1551.14	29
2008-09	6750.3	4605.83	68	2144.46	32
2009-10	8410.3	5684.98	68	2725.36	32
2010-11	9571.9	6665.16	70	2906.73	30
2011-12	11663.4	8077.64	69	3585.8	31
2012-13	12981.9	9085.335	70	3896.545	30
2013-14	15237	10490.34	69	4746.62	31
2014-15	16503.5	11227.44	68	5276.065	32

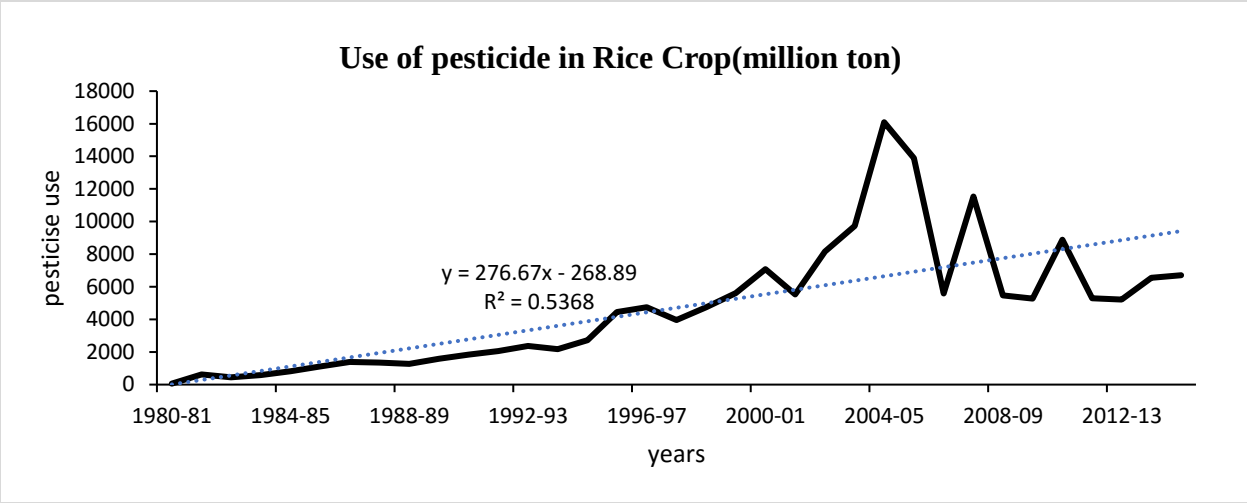
Appendix B: Cost of operations of sugarcane as a per cent of total cost

Years	Total labour (male, female) cost	Male work cost	Male work cost as a % of total cost	Female work cost	Female work cost as a % of total cost
1985-86	1752.0	1249.5	71	502.5	29
1986-87	1752.0	1249.5	71	502.5	29
1987-88	1597.4	1357.93	85	239.48	15
1988-89	1597.8	1358.27	85	239.48	15
1989-90	1743.4	1468.605	84	274.785	16
1990-91	1879.9	1573.345	84	306.535	16
1991-92	2054.3	1732.855	84	321.445	16
1992-93	2603.9	2160.42	83	443.44	17
1993-94	2428.4	1812.44	75	615.96	25
1994-95	2531.6	1885.595	74	645.995	26
1995-96	2885.1	2168.02	75	717.06	25
1996-97	3053.1	2304.21	75	748.85	25
1997-98	3323.4	2575.14	77	748.26	23
1998-99	3899.5	3000.69	77	898.8	23
1999-00	4448.2	3413.155	77	1035.055	23
2000-01	4670.3	3620.635	78	1049.695	22
2001-02	5033.9	3906.04	78	1127.82	22
2002-03	5562.1	4342.755	78	1219.305	22
2003-04	6041.9	4566.155	76	1475.735	24
2004-05	6465.6	4823.9	75	1641.68	25
2005-06	6805.0	5051.685	74	1753.345	26
2006-07	7730.6	5644.375	73	2086.255	27
2007-08	8996.0	6732.91	75	2263.12	25
2008-09	9505.5	7085.475	75	2419.985	25
2009-10	10840.7	8072.955	74	2767.695	26
2010-11	14000.9	10443.82	75	3557.03	25
2011-12	17161.1	12814.685	75	4346.365	25
2012-13	19306.3	14810.445	77	4495.865	23
2013-14	21038.4	16357.64	78	4680.74	22
2014-15	21790.0	17109.23	79	4680.74	21

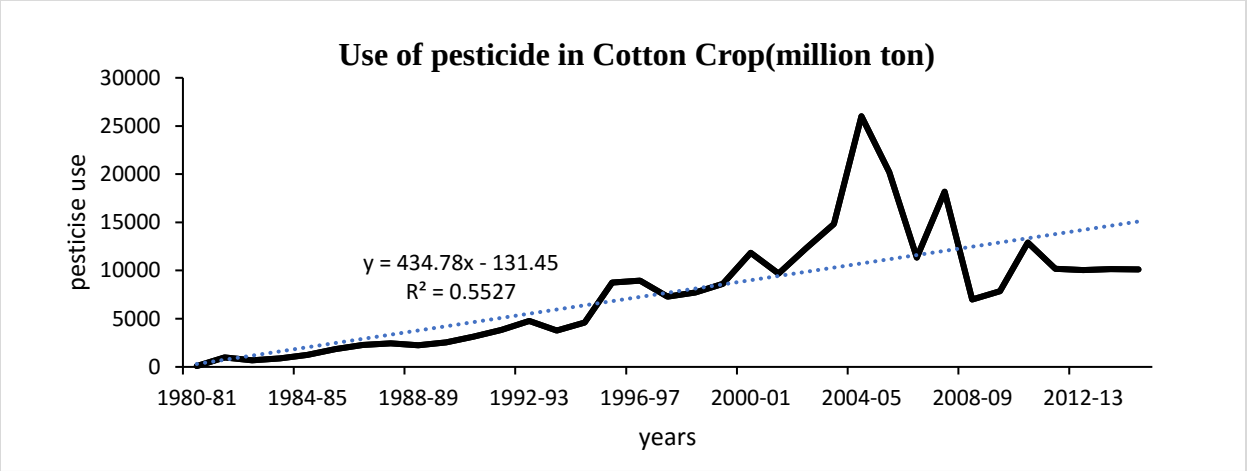
Appendix C: Cost of operations of Cotton as a per cent of total cost

Years	Total labour (male, female) cost	Male work cost	Male work cost as a % of total cost	Female work cost	Female work cost as a % of total cost
1985-86	1177	834	71	343	29
1986-87	1177	834	71	343	29
1987-88	1229	878	71	351	29
1988-89	1229	878	71	351	29
1989-90	1324	947	72	377	28
1990-91	1325	1065	80	260	20
1991-92	1664	1367	82	297	18
1992-93	2075	1480	71	596	29
1993-94	6067	1586	26	4481	74
1994-95	2607	1691	65	916	35
1995-96	2818	1752	62	1066	38
1996-97	2939	1870	64	1068	36
1997-98	3025	1969	65	1056	35
1998-99	3421	2691	79	731	21
1999-00	3995	2771	69	1224	31
2000-01	4157	2862	69	1294	31
2001-02	4427	3037	69	1390	31
2002-03	4767	3377	71	1390	29
2003-04	6414	4622	72	1792	28
2004-05	7163	5200	73	1962	27
2005-06	5832	3980	68	1852	32
2006-07	5909	4141	70	1768	30
2007-08	5868	3901	66	1967	34
2008-09	7074	4997	71	2077	29
2009-10	6613	4183	63	2430	37
2010-11	7463	4629	62	2834	38
2011-12	8483	5158	61	3325	39
2012-13	10323	5663	55	4660	45
2013-14	11421	5834	51	5588	49
2014-15	12299	6244	51	6055	49

Use of pesticide in Rice Crop (million ton)



Use of pesticide in Cotton Crop (million ton)



Use of pesticide in Sugarcane Crop (million ton)