CLUSTER DEVELOPMENT BASED AGRICULTURE TRANSFORMATION PLAN

VISION-2025

Basmati Rice Cluster Feasibility and Transformation Study

Planning Commission of Pakistan, Ministry of Planning, Development & Special Initiatives

February 2020

FOREWORD

In many developed and developing countries, the cluster-based development approach has become the basis for the transformation of various sectors of the economy including the agriculture sector. This approach not only improves efficiency of development efforts by enhancing stakeholders' synergistic collaboration to resolve issues in the value chain in their local contexts, but also helps to gather resources from large number of small investors into the desirable size needed for the cluster development. I congratulate the Centre for Agriculture and Bioscience International (CABI) and its team to undertake this study on **Feasibility Analysis for Cluster Development Based Agriculture Transformation.** An important aspect of the study is the estimation of resources and infrastructure required to implement various interventions along the value chain for the development of clusters of large number of agriculture commodities. The methodology used in the study can also be applied as a guide in evaluating various investment options put forward to the Planning Commission of Pakistan for various sectors, especially where regional variation is important in the project design.

Muhammad Jehanzeb Khan,
Deputy Chairman
Planning Commission of Pakistan
Ministry of Planning Development and Special Initiatives
Government of Pakistan.

FOREWORD

To improve enhance Pakistan's competitiveness in the agriculture sector in national and international markets, the need to evaluate the value chain of agricultural commodities in the regional contexts in which these are produced, marketed, processed and traded was long felt. The Planning Commission of Pakistan was pleased to sponsor this study on the **Feasibility Analysis for Cluster Development Based Agriculture Transformation** to fill this gap**.** The study aims to cover a large number of agriculture commodities spread in various clusters throughout the country.

I truly hope that the policies, strategies, and interventions suggested in this report will facilitate the federal and provincial governments to chalk out and implement plans for cluster-based transformation of the agriculture sector.

Zafar Hasan,
Secretary,
Ministry of Planning Development and Special Initiatives
Government of Pakistan

FOREWORD

This is part of the series of studies on 33 agriculture commodities undertaken for the purpose of preparing a cluster-based transformation plan based on the regional realities in the entire value chain including production, processing, value addition, and marketing. I congratulate the whole team of the project especially the Team Lead, Dr. Mubarik Ali to undertake and successfully complete this monumental study. We are thankful to all commodity specialists who have contributed to this assignment. The CABI Project officers Mr. Yasar Saleem Khan and Ms. Aqsa Yasin deserve appreciation. I truly believe that this study will serve as a basis to make and implement plans for cluster-based agriculture transformation. I hope you will enjoy reading the study and it can help you making your investment decisions along the value chain of various agriculture commodities.

Dr. Babar Ehsan
Bajwa
Regional Director
CAB International

FOREWORD

This report is part of the series of studies on 33 agriculture commodities to prepare the agriculture transformation plan by incorporating regional realities at the cluster level. In the report, the clusters of various commodities are identified and characterized, and viable investment options along the value chain of each cluster are proposed. For this purpose, the study team has analysed macro data, reviewed the literature, and made extensive consultation with stakeholders along the value chain. Foreign and local internationally reputed consultants, Dr. Derek Byerlee and Dr. Kijiro. Otsuka and national consultant Mr. Sohail Moghal were also engaged to understand the cluster-based development approach and conduct cluster-based feasibility analysis. An MS-EXCEL based Model was developed which was validated by our national consultants. Separate viabilities for individual technologies and products suggested in each commodity are also estimated. This humongous task would not have been possible to complete without the excellent cooperation and facilities provide by CABI, the hard work of commodity specialists and our research team especially Mr. Yasar Saleem Khan and Aqsa Yasin. The true reward of our hard work is the implementation of the proposed policies, strategies and interventions to develop agriculture commodity clusters in the country.

Dr. Mubarik Ali
Team Leader
Cluster Development Based
Agriculture Transformation Plan-
Vision 2020 Project
Planning Commission of Pakistan
and
CAB International

ACKNOWLEDGEMENT

It is not possible to mention the names of all those who collaborated with us in completing this report, but my foremost gratitude goes to numerous stakeholders along the value chain who generously shared the information about barley production, marketing, trade and value chain. Without their support, this report would not have reached to the level of present quality.

My sincere thanks go to **Planning Commission of Pakistan** for this initiative and especially financial assistance to complete the project activities. Here I am especially thankful to **Dr. Muhammad Azeem Khan** (Ex-Member, Food Security and Climate Change, Planning Commission of Pakistan), **Dr. Aamir Arshad** (Chief Agriculture, Planning Commission of Pakistan), **Mr. Muhammad Akram Khan** (Project Director; CDBAT project) and other CDBAT project team member **Mr. Muhammad Arif** (Research Associate) and **Dr. Habib Gul** (Research Associate) for successful coordination and support for the project.

I am also grateful to **Centre for Agriculture and Bioscience International** (CABI) and its Regional Director for Central and West Asia, Dr. Babar Ehsan Bajwa and CABI team especially Mr. Yasar Saleem Khan for selecting me as commodity specialist for this task and offering outstanding cooperation, support and advice during all the stages of this project. However, the research team takes the responsibility of any shortcoming left in the report.

Dr. Ikram Saeed
Senior Author

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DISCLAIMER

This report is prepared by using the data from various published and unpublished sources and that obtained during the consultations with stakeholders. The research team took utmost care to arrive at the figures to be used, but is not responsible for any variation of the data in this report than those reported in other sources. Moreover, the views expressed in this report are purely of the authors and do not reflect the official views of the Planning Commission of Pakistan, Ministry of Planning Development and Reforms or the Centre for Agriculture and Bioscience International (CABI).

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AAG	Ali Akbar Group
ACIAR	Australian Collaboration for International Research
ADP	Annual Development Plan
BCR	Benefit Cost Ratio
CBOs	Community Based Organizations
CPEC	China Pakistan Economic Corridor
CO	Community Organization
DAP	Di Ammonium Phosphate
DSR	Dry Seeded Rice
FFA	Free Fatty Acid
EFL	Engro Fertilizers Limited
FFC	Fauji Fertilizers Company, Limited
FFS	Farmer Field School
FTA	Free Trade Agreement
FEG	Farmer Enterprise Group
GAP	Good Agriculture Practices
GI	Geographical Identification
GDP	Gross Domestic Products
Global Gap	Global Good Agri. Practices
GoP	Government of Pakistan
GMOs	Genetically Modified Organisms
ha	Hectare(s)
HACCP	Hazard Analysis and Critical Control Points
HYVs	High Yielding Varieties
ISO	International Standard Organization
IPM	Integrated Pest Management
IPO	Initial Public Offering
IRR	Internal Rate of Return
IRRI	International Rice Research Institute, Philippines
KSK	Kala Shah Kaku, Sheikhupura
Kg	Kilogram

MRL	Minimum Resistance Limits
MNFSAR	Ministry of National Food Security and Research
MUSD	Million US Dollar
NARC	National Agriculture Research Council
NGOs	Non-Governmental Organizations
NPV/W	Net Present Value/Worth
NRSP	National Rural Support Program
OPV	Open pollinated Variety
PARC	Pakistan Agriculture Research Council, Islamabad
PCSIR	Pakistan Council for Scientific and Industrial Research, Islamabad
PSDP	Public Sector Development Plans
PKR	Pakistani Rupee
PTA	Preferred Trade Agreement
QRC	Quality Review Committee
R&D	Research & Development
RRI	Rice Research Institute
REAP	Rice Exporters Association of Pakistan
SoPs	Standard Operating Procedures
SPS	Sanitary and Phyto-Sanitary
SWOT	Strengths, Weaknesses, Opportunities, Threats
TCP	Trading Corporation of Pakistan
TDAP	Trading Development Authority of Pakistan
TRIPS	Trade Related Aspects of Intellectual Property Rights
USA	United States of America
USD	United States Dollar (i.e., one $ equal to Pak-Rupee 135 for this study)

EXECUTIVE SUMMARY

Rice is grown in all provinces of Pakistan but fine quality basmati rice varieties exhibiting special features of elongated grain, fragrance and light delicious taste are popular from the Pak-Punjab '*Kalar*' tract. Basmati rice enjoys an economic significance in the economy of Pakistan by contributing 3.1% towards its total agricultural value addition and 0.6% in the national GDP. According to the latest available statistics, the annual growth trend in area, production and per ha yield of basmati rice during 2000-17 in Punjab are (-) 0.54, 0.60 and 1.14 % respectively.

Despite significant improvement in yield during the 2000s, Pakistan has lost the competitiveness edge in basmati as indicated by its plummeting shares in total basmati export from 46% in 2006 to less than 10% in 2017, which was conveniently picked up by its competitor India. Pakistani basmati exports also declined by 45% in absolute term during the period. This declining competitiveness is due to number of factors that favoured India than Pakistan during the period including stronger technological innovations which gave higher productivity growth in basmati that have more elongated kernel size without aroma, lower production costs due to high input subsidies, aggressive marketing tactics which enabled to earn high prices to Indian basmati without aroma and showcasing of cooked dishes like "Biriyani" instead of "*Murgh Pulao*" etc.

In view of the above scenarios, the present project is developed to explore the technological and economic opportunities for investment in the basmati rice value chain in Pakistan with the goal of improving its competitiveness. Focus group consultation meetings/discussions were arranged to gather field information from diversified stakeholders engaged in basmati paddy production, marketing, and processing viz., farmers, commission agents, traders, processors, and development partners in public and private sector. Based on the final basmati product processed, two clusters for basmati rice are defined in this study: i) *Katcha* (polished) rice-Cluster-I supplying white rice with its central district of Sheikhupura; and ii) Parboiled (*Saila*) rice-Cluster-II supplying parboiled rice with central district of Hafizabad. While Super Basmati and Basmati-386 are the major varieties cultivated in Cluster-1, Kainat basmati is the dominant variety in Cluster-II each have relatively different management practices and passes through different processing process.

Six interventions are suggested in the focal districts and feasibility of these interventions is estimated. These are: i) gradual shifting to mechanical rice transplanting which is needed for increasing plant population and long awaited productivity enhancement issue of the area; ii) diffusion and adoption of high yielding varieties in the area which is required to replace the varieties like basmati-386, Supra, Supri, etc.; iii) introducing improved crop management practices as large gap between average and progressive farmers' yield and associated variations in crop management practices can be noticed across farms; iv) shifting to rice combine harvesters which are essentially needed to control harvest and post-harvest losses in milling and address the problem of burning of rice straw; v) introduction of paddy drying at farm level in order to improve the quality of paddy and its by-products; vi) introduction of rice bran oil in cluster-I and increasing production of parboiled/*Saila* rice in cluster-II to diversify rice value chain as well as addressing increasing demand of *Saila* rice in Pakistan and abroad.

The economic feasibility analysis shows that, from stakeholders' perspectives, the total gross revenue from the Basmati Up-gradation Plan in the focal points of both clusters (i.e., Sheikhupura and Hafizabad) would be US$105.9 million during the 5th year of the plan. From development project perspective, it will require an investment of US$73.8 million in a 5-years project both by the public and private sectors. The public sector investments shall address the areas like strengthening of basmati rice research and extension services, arranging farmer's training programs towards adoption of improved crop management practices, providing capacity building training to all value chain stakeholders to efficiently manage the value chain, organizing Farmer's Entrepreneur Group (FEG) with collection centres, building cluster-based infrastructure, strengthening international linkages, and offering concessional loans all of which will cost to the government about 26% of the total investment which will be US$26.4 million. The remaining 74% of the total investment of US$47.4 million will be brought by the private sector which will be mainly required for mechanization of transplanting & drying, extraction of bran oil and modernization of *Saila* process. We believe that private sector can be attracted for these investments with the proposed incentives structure by the government and highlighting the expected potential benefits of the interventions.

The additional operation cost (undiscounted) due to the improvement in the value chain would be US$52.2 million and net cash flow after (undiscounted) deducting all associated operational costs and investment at the focal points of both the clusters would be US$68.1 million during the 5th year of the project. The Internal Rate of Returns (IRR) of the whole basmati rice Up-gradation Plan in the focal points of both clusters was estimated at 28% thus clearly indicating an economically viable project. In addition to economic returns, the Up-gradation Plan will add to the foreign exchange earning worth of US$157 million during the last year of the Plan. These investments will also generate thousands of skilled and unskilled jobs along the value chain nodes including respective industrial zones, mostly in rural areas. It must be noted that the proposed Upgradation Plan is only for the central points of each cluster, which covers only 40% of the total basmati clusters and 30% of the whole basmati growing areas. The targeted Plan will have tremendous spill over effects within and outside of each cluster. Thus, the above impact is very conservatively estimated. The summary of cluster-level information and economic impacts of basmati Up-gradation Plan of each cluster are presented in the Summary Sheet given below.

The main pillars of the basmati rice Up-gradation Plan are: the capacity building of all stakeholders in the value chain management, development of cluster-based infrastructure, reforms in R&D system, mechanization and diversification of the value chain and strengthening of international interaction and collaboration. Among these, we give highest priority to the capacity building of stakeholders and reforms in basmati R&D.

Summary Sheet

Information	B.-*Katcha*	B.-*Saila*	Overall
Area of the cluster (ha)	472.77	203.55	676320
Production of the cluster (tonne)	832.93	406.98	1239910
Yield of the cluster (kg/ha)	1761.8	2042.9	1833.3
Area of cluster focal point (ha)	158,230	104,410	262,640.0
Production of the focal point (tonnes)	289,840	213,300	503,140.0
Yield of the focal point (tonnes/ha)	23.48	21.4	44.8
Yield increase -mechanization in planting (tonnes/ha)	0.29	0.32	0.6
Added production from mechanized planting (tonnes)	11503.65	8466	19,969.5
Additional value due to mechanized planting (Mil. US$)	4.34	4	7.9
Additional production due to improved varieties (tonnes)	10736.74	27,090.6	37,827.3
Additional production value - improved varieties (M. US$)	4.05	11.5	15.6
Additional production – Improved management practice (tonnes)	21473.49	22,575	44,049.0
Additional production value – improved practices (M.US$)	8.10	10	17.7
Production saved- reduced PH losses (tonnes)	22430.59	18,168.75	40,599.3
Additional production value – reduced PH losses (M.US$)	8.46	12.72	21.2
Added value of production from improved quality (M.US$)	15.57	14	29.8
Additional value from bran oil (M.US$)	0.52	5.6	6.1
Number of transplanter required	2172	1433	**3,605**
Harvester required	814.6	537.5	**1,352.1**
Dryer required	348.1	241.7	**589.7**
Processing unit required for rice bran oil	3.0		3.0
Investments (M.US$)			
Investment on strengthening Basmati research	1.852	1.852	3.704
Investments on mechanical transplanter	13.033	8.600	21.633
Farmers training for good practices	0.484	0.361	0.845
Investment on driers	6.265	4.350	10.615
Investment on combined rice harvester	15.477	10.213	25.690
Investment on new installing *Saila* rice plant		1.107	1.107
Investment on bran oil extraction	0.202		0.202
Organizing FEGs with collection centres	1.500	1.000	2.500
Strengthening international links	0.500	0.500	1.000
Government loans	3.847	2.670	6.517
Total Investment	43.2	30.7	73.8
Public sector investment	15.2	11.2	26.4
Private sector investment	28.0	19.4	47.4
Economic Analysis (M.US$)			
Enhanced production - (exportable)(tonnes)	66144	76300	142,445
Increased production at international prices	72.8	83.9	156.7
Gross revenue from all Interventions	48.6	57.3	105.9
Total operational costs of the Interventions	22.0	30.1	52.2

Net cash flow from all interventions	26.58	27.13	53.71
NPV (M.US$)	6.6	9.5	16.1
Internal Rate of Return (%)	23.7%	32.8%	28%

1. INTRODUCTION

1.1. Basmati - a high quality rice

The origin of word basmati can be traced to the word “vasmati” meaning soil recognized by its fragrance (Akram, 2009). The Hindi world “Bas” was derived from the Prakit word “VAS” and has a Sanskrit root --- “Vasay” (meaning Aroma) while “mati” originated from “Mayup”, (ingrained from the origin). In common usage “Vas” is pronounced as “Bas”, and while combining “Vas and Mayup”, the later changed to “mati”, thus the word “basmati” emerged (Gupta, 1995; Ahuja *et al*., 1995; Singh and Singh, 2009). Later on, the definition of basmati was changed to include other fine long-grain qualities even without aroma, which is the definition considered throughout in this study, although sometime we distinguish between aromatic and non-aromatic basmati.

The name ‘basmati’ is traditionally associated with its geographical origin (Bligh, 2000). It is generally accepted that good quality basmati rice is characterized by extra-long super fine slender grains with chalky endosperm and a shape comparable with a Turkish dagger; pleasant and exquisite aroma, sweet taste, dry, fluffy and soft texture when cooked, delicate curvature, low amylose, medium-low gelatinization temperature, 1.5 to 2-fold lengthwise elongation with least breadth-wise swelling on cooking and tenderness of cooked rice (Siddiq *et al*., 1997). Because of all these attributes, basmati rice commands a premium price in the world market (Bhattacharjee *et al*., 2002).

1.2. National scenario

Currently, basmati rice in Pakistan accounts for 3.1 percent of total agricultural value added, 9.0 percent of the crop sector GDP, and 0.6 percent of national GDP. In the past five years, the total basmati rice production in the country varied from 1.867 to 3.467 million tonnes vis-à-vis domestic consumption staying at 1.0 million tonnes (Government of the Punjab, 2018b; Government of Pakistan, 2018).

In Pakistan during 2016-17, basmati rice was cultivated on 1.45 million ha producing a total of 2.74 million tonnes of cleaned rice and giving 1.89 tonne/ha yield. During 2001-16, the area under basmati rice experienced a negative growth in the country, while production and per ha yield had a positive trend at annual growth rates of (-)0.31, 1.31 and 1.61 percent, respectively, (Table 1).

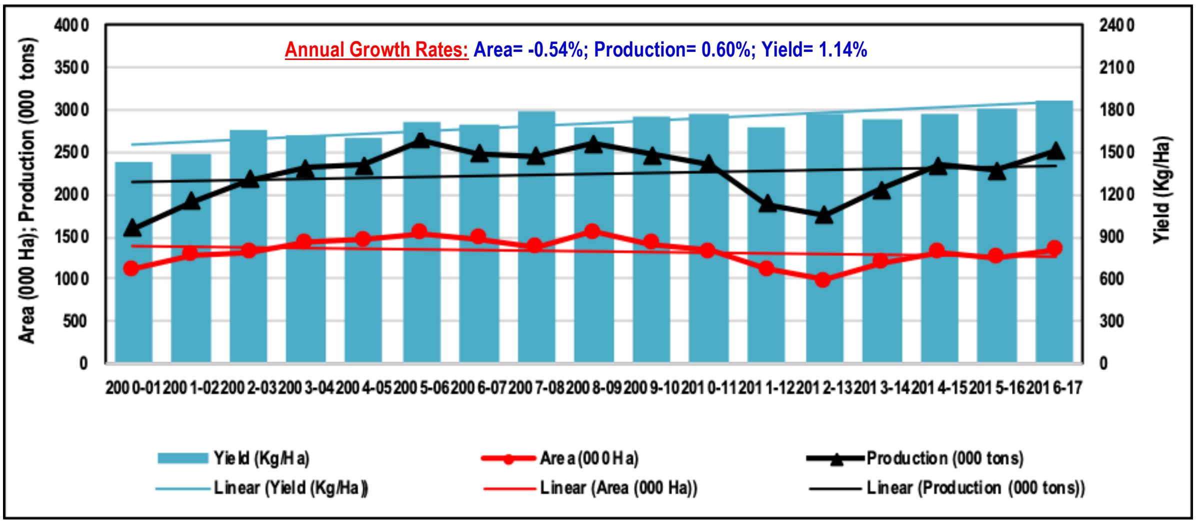
Table 1: Basmati Rice Area Production and Yield in Punjab and Pakistan, during 2000-16

Years	Punjab			Pakistan		
	Area (000 Ha)	Production (000 t)	Yield (Kg/Ha)	Area (000 ha)	Production (000 t)	Yield (Kgs/ha)
2000-01	1114	1601	1438	1158	1701	1468
2001-02	1294	1914	1479	1332	1999	1501
2002-03	1317	2176	1652	1377	2304	1673
2003-04	1426	2309	1619	1521	2522	1659
2004-05	1467	2348	1601	1558	2555	1639
2005-06	1535	2642	1721	1659	2920	1761
2006-07	1474	2494	1691	1589	2736	1721
2007-08	1377	2453	1781	1467	2643	1801
2008-09	1548	2602	1680	1697	2901	1710
2009-10	1414	2475	1751	1543	2732	1770
2010-11	1334	2365	1773	1413	2445	1731
2011-12	1121	1889	1685	1241	2124	1711
2012-13	995	1758	1767	1057	1867	1766
2013-14	1193	2057	1725	1298	2268	1748
2014-15	1320	2337	1770	1424	2548	1789
2015-16	1254	2279	1817	1359	3466	2551
2016-17	1353	2524	1866	1454	2740	1885
Growth rate (%)	(-) 0.54	0.6	1.14	-0.31	1.31	1.61

Source: Government of Pakistan, 2018a.

Over 92% of basmati rice production in the country comes from Punjab. In Punjab, the area fluctuated between 0.95 million ha in 2012 to 1.55 million ha in 2008, while production varied between 1.76 to 2.6 million tonnes during the period. Overall during 2000-2016, the basmati area in Punjab declined at a rate of 0.54% per annum, while yield and production increased at the respective rate of 1.14% and 0.6% per annum. Both area and production experienced a serious dip from 2011 to 2013 which was subsequently recovered (Figure 1).

Figure 1: Trends of basmati rice area, production and yield in Punjab, Pakistan, 2001-2017



Source: Various Issues of Punjab Development Statistics, 2008, 2012, 2017

In Punjab, during 2016-17, basmati (aromatic and non-aromatic) varieties are cultivated nearly on 77% of total rice area planted, while their share in total rice production is around 73%. Remaining 23% area and 28% of the total production goes to course-grain varieties (Government of Pakistan, 2018). More than 7 basmati varieties are grown in the province, of which Super Basmati (aromatic) and Kainat (non-aromatic) are the two dominant varieties occupying over 69.2% and 28.3% of total basmati area, respectively (Table 8). In the recently conducted field survey, Super Basmati followed by Kainat and Basmati-386 (aromatic) are found to be dominant varieties collectively planted at 95% of total basmati rice area during 2017 (Bashir *et al*., 2018).

Considerable changes in basmati varietal mix spread can be seen during 2010s. An overtime substitution of Super Basmati[1] with Kainat-1121/PS-2[2] has taken place in the rice-wheat

[1]The line was evolved through hybridization of Basmati-320 and line 10486. Since its approval in 1996 for general cultivation, it gained popularity among rice growers for its longer grain, aroma, and better cooking quality. The variety also gained attention of its quality among international buyers (*Bashir et al*., 2018).

[2]Indian Pusa-1121 variety, recognized in Pakistan as PK-*1121 (*or Kainat*)*, was evolved through the process of hybridization over a long breeding process in Indian Agricultural Research Institute (IARI). The variety is known for its extraordinary kernel (grain) length, which can be as much as 8.2 millimeters (0.32 inches) for a single grain, the longest ever known released rice cultivar in the world. It has very high kernel elongation ratio ranging from 2 to 2.5, i.e. length of cooked to uncooked kernel. When cooked, the rice does not turn sticky, possesses minimum breadth-wise expansion with intermediate alkali-spreading value and amylose content. It was leased for commercial cultivation in *kharif* season of 2003 (see Annexure-1 for its pedigree). By 2007, the variety was rapidly popularized among Indian farming community, as Pusa-1121 is photo-sensitive, requires less water, matures early and yields 4.5-5.0 tonnes per ha as compared to 2.5 tonnes per ha for traditional tall basmati.

The percent area occupied by other varieties is quite low, highlighting a need to explore reasons for this. Similar observation was made by Bashir *at al*., 2018.

Table 2: Trends (%) in area under different basmati varieties in rice-wheat belt of Punjab

Varieties	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
	--- (Percent area under different basmati varieties) ---						
Super Basmati	93.53	92.95	90.65	83.17	78.02	71.12	69.25
Kainat-1121/PS-2	2.34	0.60	3.10	14.55	19.59	27.33	28.28
Basmati-385	1.25	0.96	0.40	1.11	0.89	0.80	0.67
Basmati-2000	0.00	0.06	0.07	0.00	1.22	0.74	0.51
Basmati Karnal	0.00	1.93	0.00	0.35	0.28	0.00	0.00
Basmati-370	0.00	0.06	0.00	0.12	0.00	0.00	0.00
Basmati Shaheen	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Other Basmati	2.89	3.37	5.79	0.70	0.00	0.00	1.29

Source: Government of the Punjab (Crop Reporting Services Department), Lahore (2018c).

In Pakistan, the ‘Kainat’ variety was imported in around 2006 and officially released in 2013. Because it is high yielding and fetch about similar or sometime even better farm gate prices as Supper Basmati or Basmati 386, its adoption is rapid. The variety is non-aromatic but very much suitable for parboiling processes. Therefore, the parboiling facilities have mushroomed in the region. Currently parboiled plants are operating in the basmati growing region of ‘*Kalar*’ in Punjab. In parboiling process or preparing *Saila* rice, paddy is soaked in water for a certain time period and afterward dried and then milled. In this way, the starch inside paddy grain is gelatinized, and after removal of outer paddy layer, the rice grain appeared yellow in colour, which can be darkened according to the requirement. In the process, however, the bran losses its oil quality thus cannot be processed into bran oil suitable for human consumption but it may be used for other industrial by-products. The parboiled rice grain is relatively harder than the non-parboiled rice and upon cooking; there are little chances of grain burst. Any rice can be milled with this process, basmati or non-basmati rice (Choudhary, 2016), but in India and Pakistan, it is most popularly done with basmati long-grain non-aromatic rice like Kainat in Pakistan and Pusa in India due to high consumers’ demand. Detailed parboiling processes are explained in Annexure-2.

Parboiled rice is favoured by consumers and chefs who desire an extra fluffy and separately cooked rice, and presently very popular amongst the commercial caterings to prepare salty rice dishes as ‘*Biryani*’ as well as sweet rice dishes as ‘*Zardah*/*Mutanjan*’ at the occasion of marriage parties and other festivals. The popular dishes of rice are “boiled rice”, “*Zardah*”, “*Pulao*” and “*Biryani*” that are relished almost universally.

However, basmati aroma is still favoured mainly by Indian-Pakistani-Turkish-Middle Eastern communities living in Europe. Currently, however, international demand is changing towards non-aromatic but still long grain varieties that remain separated after cooking with milky whitish colour. This resulted in falling demand for Pakistani basmati in favour of the Indian fine *Saila*/steamed rice[3] of Kainat, Pusa series of basmati.

1.3. Global Scenario

Basmati rice is traditionally grown in the Himalayan foothill regions of India and Pakistan. Pakistan had been enjoying an edge over India in the production and export of traditional basmati rice with respect to quality traits like aroma. However, certain technological innovations, policy support, international environment, change in consumers' behaviour, and market drive by Indian traders ruined this edge and shifted the trade tide in favour of India.

This shift started with the development and release of a series of 'Pusa' type varieties by Indian researchers. Initially, Pusa-1121 was released in 2003 which shifted the yield frontier from 3.0 t/ha to 3.6 t/ha. The gain was further strengthened with the release of Pusa-1509 in 2010 which further enhanced the farm-level yield to 4.25 t/ha. This not only reduced the market price of basmati rice for traders but also improved the profit of the farmers, thus creating win-win situation for both parties (Table 3). These benefits provide the quick drive for adoption of these varieties.

Table 3: Impact of the release of new Agny varieties on farmers income

Variety	Average Yield (t/ha)	Average Market price (IRP/t)	Gross Income (IRP/ha)	Cost of cultivation (IRP/ha)	Net Return (IRP/ha)
Basmati-386/CSR-30	2.37	28000	66360	47000	19360
Pusa-112	3.62	25250	91405	48000	43405
Pusa-1509	4.25	23000	97750	45000	52750

Source: Estimated by authors from the average yield, market price, and cultivation cost taken from Bashir, et al. (2018) and Grover, et al. (2014)

As noted in Footnote 2, Pusa varieties are good for par-boiling, efficient par-boiling technologies were developed in India. However, these developments with Pusa varieties would have been meaningless if Indian traders would not have adopted pro-active commercial strategy. The Pusa-varieties gave completely a new product to traders to sell. It has much longer kernel (grain) length than traditional basmati varieties, but has little aroma especially after parboiling. Indian traders through product promotion strategies, such as food stalls, propaganda campaign, etc., convinced the Middle East consumers that aroma is not so important especially when par-boiled rice is cooked which gives completely a new attractive look to the dish. In addition, the catering industry of India introduced internationally a new variety of dishes called 'Biryani' (instead of '*Murgh Pulao'* from aromatic basmati varieties)

[3] In Steaming Process, steam passes through paddy grains, and upon drying paddy husk is removed. The rice grain inside remain white, however, its surface become harder and upon cooking, the grains do not burst (Choudhary, 2016).

where aroma even if originally present in rice grain is lost during cooking under the impact of heavy use of other spices.

Some policy factors also favoured Indian traders which are: i) Availability of highly subsidized inputs (i.e. fertilizers, pesticides, custom-hiring of sowing and harvesting machines) gave market edge to Indian farmers and traders *vis-à-vis* Pakistan where inputs are relatively less subsidized. ii) Although, India banned the export of non-basmati rice in April 2008 through September 2011, but Indian traders continue exporting Pusa rice as basmati under the nose of Indian customs. iii) Indian Government also withdrew Minimum Export Price (MEP) regulation from basmati rice, which allows Indian traders to play around with the market as it suits them.

International political environment also favoured Indian traders. Not affected by USA sanction under the Food *vs* Oil Program, India could export food grains to Iran. On the other hand, Pakistan's trade was routed through the Bank of New York, which was suspended by the US-Government. Hence, Pakistan was deprived of its niche Iranian rice market. In addition, Iranian Government also offered other facilities to India[4] during sanction period.

On the other hand, Pakistan could not respond quickly to the changing basmati environment internationally. First of all, there was no counter strategy to nullify the Indian propaganda on aroma and traders could not convince the Middle East consumer that aroma is in fact the most important element in basmati rice dishes. Secondly, its research system could not develop parallel to 'Pusa' varieties of its own which can compete with Indian varieties. Although some seed companies brought the seed of Pusa varieties from India and was able to get it released officially with the name of PK1121 (commonly known as Kianat) in 2013, but it was too late. India by then moved to higher Pusa varieties and Pakistan remains behind in technological front. On top of it, the Indian government support to farmers through input subsidies, especially free electricity for tube wells, is generally higher than in Pakistan. Aslam (2016) reported that 49% untapped productivity gaps in Pakistan can be attributed to poor research (12%) and weak agricultural advisory services (37%). In addition, the export of Pakistani basmati rice has been impacted by leaf blight, bearish trade practices, and inefficient market conditions (ADB, 2018). The Chairman of REAP pointed out that Indian basmati industry is more organized in approaching international market. Lack of support from the Pakistani government to establish brand image is also a factor in losing the competitiveness.

In the current scenario, Pakistan is losing trade war in basmati rice with India, as is evident from the export growth trends. It should be noted that in the drive to gain basmati share, India has expanded the basmati market from US$1.1 billion in 2006 to US$4.58 billion in 2013 (Table 4). India not only has captured the additional expanded market but also encroached upon Pakistani share thus the later not only lost its relative share to India but also could not maintain its absolute level of export both in quantity as well as in value (Table 4).

Table 4: Export of basmati from India and Pakistan during 2001-2017

[4] Iran has decided to open a direct route with India to import basmati rice from the country [*http://www.business-standard.com/article/markets/basmati-rice-exports-to-iran-via-dubai-soar-115111001536_1 .html*].

Year	Quantities (000 tonnes)			Values (Million US$)			Value share (%)		Quantity share (%)	
	World	Pakistan	India	World	Pakistan	India	Pakistan	India	Pakistan	India
2001	1262.1	410.4	851.7	671.5	197.4	474.1	32.5	67.5	29.4	70.6
2002	1150.5	483.8	666.7	644.1	252.2	391.9	42.1	57.9	39.2	60.8
2003	1303.5	593.3	710.2	740.7	315.2	425.5	45.5	54.5	42.6	57.4
2004	1427.6	656.1	771.5	803.7	360.9	442.8	46.0	54.0	44.9	55.1
2005	1905.0	742.0	1163.0	1052.9	423.6	629.3	39.0	61.0	40.2	59.8
2006	1816.8	771.1	1045.7	1094.0	474.5	619.5	42.4	57.6	43.4	56.6
2007	2034.0	850.6	1183.4	1900.0	826.2	1073.8	41.8	58.2	43.5	56.5
2008	2480.8	924.4	1556.4	3079.5	1,018.80	2,060.7	37.3	62.7	33.1	66.9
2009	3049.1	1032.3	2016.8	3175.6	878.3	2,297.3	33.9	66.1	27.7	72.3
2010	3541.3	1170.6	2370.7	3457.3	966.2	2,491.1	33.1	66.9	27.9	72.1
2011	4131.5	953.3	3178.2	4076	853.7	3,222.3	23.1	76.9	20.9	79.1
2012	4133.9	674.0	3459.9	4255.7	691.6	3,564.1	16.3	83.7	16.3	83.7
2013	4424.8	667.5	3757.3	5642.1	775.8	4,866.3	15.1	84.9	13.8	86.2
2014	4225.7	523.4	3702.3	5121	602.9	4,518.1	12.4	87.6	11.8	88.2
2015	4525.8	480.0	4045.8	3931.6	453.6	3,478.0	10.6	89.4	11.5	88.5
2016	4454.5	469.3	3985.2	3669.8	453.2	3,216.6	10.5	89.5	12.3	87.7
2017	4481.8	425.0	4056.8	4579.5	410.1	4,169.4	9.5	90.5	9.0	91.0

Source: Government of Pakistan, 2018 (Various Issues).
India: Download from India Ag Export Authority: http://apeda.gov.in/apedawebsite/ on 22-05-2019

Pakistani export values reported in terms of Rupees were converted into US$ using the respective year exchange rate. The exchange rate data was taken from FAOSTAT on 22-05-2019.

While Indian export of basmati increased from 1.04 million tonnes in 2006 to 4.06 million tonnes in 2017, Pakistani basmati export plummeted from 0.7 tonnes to 0.42 tonnes in the corresponding period, which is about 45% decline in 11 years. The Pakistani share in export of basmati quantities declines from over 42% in 2006 to less than 10% in 2017. Similar trends can be seen in the foreign exchange earnings from basmati rice during the period.

Since 2008, Pakistan has lost its basmati share in all major Middle East basmati markets, as well as UK, and USA markets (Table 5).

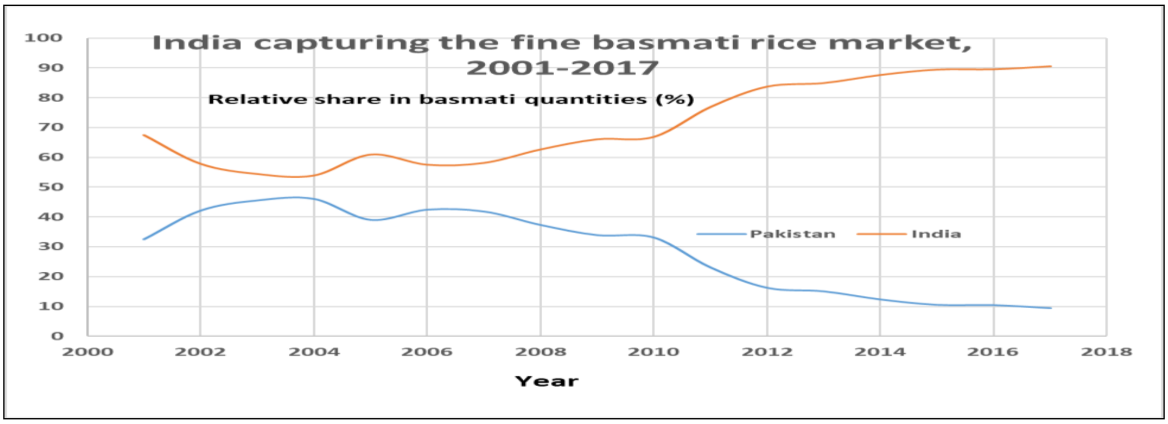
Table 5: Country level share of India in total basmati export market during 2008-2017

Years	Saudi Arabia	UAE	Yemen	Iran	Kuwait	Qatar	USA	UK
2008-09	86.6	71.7	44.6	38.2	89.1	18.3	73.9	67.7
2009-10	87.9	72.6	48.8	66.1	91.8	9.6	59.1	39.5
2010-11	89.4	70.2	53.3	75.5	94.5	12.6	73.9	52.6
2011-12	92.1	79.1	60.7	82.3	97.0	24.2	86.9	77.4
2012-13	91.9	65.3	77.6	96.2	97.8	75.6	81.7	82.9
2013-14	93.2	49.5	71.4	99.6	96.4	60.0	81.1	71.7
2014-15	95.8	71.8	82.5	99.8	97.8	87.5	81.8	79.7
2015-16	95.9	85.0	72.9	99.3	99.8	72.2	84.7	88.5
2016-17	96.6	80.8	79.6	99.4	98.6	86.3	85.8	100.0

*The remaining share in each country in a year goes to Pakistan

Overall, Pakistan has lost basmati share in international market from almost 46% in 2006 to less than 10% in 2017. The decline started more rapidly in 2010 when India consolidated its impact of innovation by releasing Pusa-1509 variety (Figure 2).

Figure 2: Plummeting trend of Pakistani basmati export share as compared to India



Source: Drawn from the data in Table 4

Total Pakistani rice export has been fluctuating between 3.4-4.2 million tonnes during 2017 (Table 6), but the proportion of basmati rice to non-basmati rice in total rice export quantities has declined from 31% to 12% during the period. Similarly, the total value of Pakistani rice export had touched to US$2 billion, but the share of basmati in the value of total basmati rice export has declined from US$953 million to US$525 million, i.e., from 46% to 26% of the total export in the corresponding period. In total, the export of rice from Pakistan is confronting with a seriously crisis situation during 2010s (Table 2). This continued discouraging position led to piling up of the carry-over stocks and falling domestic basmati prices within the country. The government had to provide financial support to farmers and traders costing billions of Rupees to partially compensate the losses during 2016.

Table 6: Export trend of rice from Pakistan during 2010 -2018

Year	Quantities (000 Tonnes)			Values (Million US$)			Average price (US$/tonne)	
	Basmati	Non-Basmati	Total	Basmati	Non-basmati	Total	Basmati	Non-basmati
2010-11	1138	2564	3702	953	1138	2091	837	444
2011-12	965	2756	3721	841	1237	2078	872	449
2012-13	630	2859	3489	627	1211	1838	995	424
2013-14	734	2628	3362	846	1052	1898	1153	400
2014-15	677	3055	3731	682	1167	1849	1007	382
2015-16	503	3759	4262	455	1405	1860	905	374
2016-17	480	3105	3585	427	1181	1607	888	380
2017-18	501	3522	4024	525	1476	2001	1047	419

Source: Quality review Committee (QRC) & Trade Development Authority of Pakistan (TDAP)

The major importers of Pakistani rice overseas are: a) Gulf & Middle East for white basmati rice; b) European countries brown basmati rice c) Asia & Africa for single polish basmati rice; d) Asia and Africa for double polish basmati rice. On average, *Saila* to '*Katcha*' rice export ratio is 20:80 amongst the Gulf and Middle East countries. The specific importing countries of Pak-basmati are UAE, UK, Belgium, Oman and Saudi Arabia (Table 7). Pakistani basmati fetches highest price in UAE, Oman, and Saudi Arabia.

Table 7: Top basmati rice importing countries from Pakistan during 2017-2018

Country	Quantities (000 tonne)			Values (000 US$)			Average price (US$/ton)	
	Basmati	Non-Basmati	Total	Basmati	Non-Basmati	Total	Basmati	Non-Basmati
UAE	74.86	109.68	184.538	89.4	42.3	131.6	1194	385
UK	66.93	2.81	69.733	64.3	2.3	66.6	961	834
Belgium	46.59	5.48	52.068	49.6	4.3	53.9	1064	794
Oman	32.80	38.39	71.198	37.8	26.9	64.6	1178	699
Saudi Arabia	28.04	56.70	84.744	31.2	35.2	66.4	1113	621
Italy	27.57	6.70	34.268	28.2	4.9	33.1	1024	733

Source: Quality review Committee (QRC) & Trade Development Authority of Pakistan (TDAP)

The above macro-level analysis suggests that Pakistan is fast losing its basmati competitiveness in its international markets. To remain competitive, Pakistan must put the whole value chain of basmati in order. The Planning Commission of Pakistan initiated this study to identify various constraints, suggest appropriate interventions and evaluate their feasibility at various segments of the value chain. As situation may be different in various basmati clusters, the analysis will be conducted at basmati cluster levels. Based on this analysis, an upgradation plan for each cluster will be suggested to improve the competitiveness of basmati rice.

2. GOAL AND PURPOSE

The overall goal of this project is to contribute to the 'Cluster Development Based Agriculture Transformation Plan -V2025'. The specific objectives are spelled out as under:

i. To identify the major clusters of basmati rice production in Punjab, Pakistan

ii. To characterize each cluster and conduct a diagnosis and SWOT of the basmati rice value chain in each cluster

iii. To identify technological, institutional, infrastructure and policy gaps in each cluster

iv. Assess the potential of basmati rice production in each basmati rice producing cluster

v. Suggest technological, institutional, infrastructure and policy interventions to achieve the cluster potentials

vi. Conduct economic and social feasibility of the suggested interventions

vii. Make suggestions and prepare an upgradation plan to improve the competitiveness of the basmati rice sector in Pakistan.

3. METHODOLOGY

The required primary and secondary information pertaining to the characteristics, gap, potential and needed interventions were gathered during August through October of 2018 through a wide-ranging consultation with stakeholders along the value chain in *Kalar* tract, collect and synthesize macro-data, and conduct an intensive but not exhaustive literature review as follows:

3.1. Macro-Data from Secondary Data:

Desired macro data (i.e., quantitative and qualitative) were collected from various published and unpublished reports, books and periodicals of government and non-government organizations, and web portals and internet search on basmati rice value chain (See the details of data source from reference list presented at the end of this document**.**

3.2. Stakeholders Consultations:

Primary information (i.e., quantitative and qualitative) were collected through formal and informal survey means by following the purposive sampling technique (i.e., non-probability sampling) including personal meetings, consultations, key informant interviews, surveys and focus group discussions, emails, telephonic conversation by using structured and unstructured (open-end) questionnaires (See a list of stakeholders consulted in Annexure-3).

3.3. Literature Review:

The literature gathered and synthesized to understand and comprehend the relevant and significant knowledge, issues and opportunities. Literature review will assist in recognition of gaps between known and unknowns. The literature review will also guide us to identify and design the interventions to bridge the gap and upgrade the basmati rice cluster development. (See succinct findings in targeted areas in the literature review section).

Following generic and current updated parameters and indicators were used in collecting the data:

a. Local and Global context of basmati rice cluster sectors;

b. Production potentials and review of basmati rice cluster sectors;

c. Cost of production, best practices, seedlings/transplanting, harvesting and threshing, post-harvest processing of basmati paddy including drying, de-husking, from growers, commission agents, processors, traders, catering service providers, etc.;

d. Branding, marketing/trading and processing information from traders, wholesalers, retailers, exporters, and processors;

e. Issues and constraints relating to production, harvesting/threshing, drying, processing, marketing, shellers, trading, and storing were gathered from all respective stakeholders;

f. Information on parameters required for undertaking feasibility study including financial, costs, investment, prices, conversion factors, etc., and

g. Recommendations and benchmarks based on local and global standards employed in this study depending upon the nature of clientele ship and situation in the cluster,

The author used the data set generated to identify and characterize the basmati rice clusters, conduct SWOT analysis, describe the value chain, identify gaps and opportunities, suggest interventions, and set values for various parameters used in feasibility analysis. The investments required for various interventions and associated costs were quantified, and expected benefits of each intervention were also estimated. The Net Present Value (NPV) and Internal Rate of Return (IRR) of the whole package of interventions to upgrade the identified clusters were worked out. Basmati Rice Cluster Transformation Plan is also formulated which identified the useful signals in each cluster for updating and scaling up the whole value chain of basmati rice on sustainable ground. The Basmati Upgradation Plan is initially designed for the focal point of each basmati cluster. However, we believe that the Plan will generate forward and backward spill over effects to the surrounding districts and regions of the focal point. Mainly these spills over effects will open up the additional income and employment opportunities through boosting productivity of land, labour and capital resources across the value chain and benefit all stakeholders including farmers, commission agents, processors, service providers, traders, consumers, etc.

4. LITERATURE REVIEW & STAKEHOLDERS' DISCUSSIONS

The purpose of literature review and consultations are to: a) identify important variables that influence the sector; b) development of the hypotheses/research questions; c) finding the testability and replicability of the findings of the current research; e) not running the risk of "reinventing the wheel" and avoid wasting of efforts on trying to rediscover something that is already known; and f) the relevance and significance of the problem identified as perceived by the scientific community. These guidelines were followed in keeping ourselves on track. The significant areas reviewed and presented as follows:

4.1. Direct Seeded or Dry Seeded Rice (SDR)

Hasnain (2017) and Akhtar *et al*., (2018) noticed that in compliance to address the problems like drudgery, high production cost, low quality, low cropping intensity and above all water and labour scarcity during peak crop season of rice crop seedlings transplanting, the interest in DSR cultivation technology has resurged. The sowing of dry seeds into dry or moist, non-puddled soil has many advantages over traditional transplanting and is a principal method of rice growing in many parts of the world including Philippines, Vietnam, Thailand, Korea, America, Japan and the sub-Saharan Africa. The study discussed the advantages of DSR technology, i.e., 15-30 percent saving in water and 40 percent in labour cost, low input use, reduced tillage and efficient utilization of nutrients at proper placement and time. Mechanized direct seeded transplanting may further lead to resource use efficiency and sustainable agriculture. This indicates that direct seeded rice farmers are technically more efficient as compared to conventional farmers. Shaheen *et al*. (2017) also supported above findings of DSR method of paddy cultivation in rice-wheat cropping zone - II of Punjab, Pakistan. They revealed that direct seeded rice farmers are technically more efficient as compared to conventional method of rice planting farmers (i.e., rice cultivation through puddling method). On the other hand, technical efficiency model results revealed that overall technical inefficiency turned to be 14 percent at the aggregate level comprising of 15 percent at conventional rice farms and 13 percent at direct seeded rice farms. But this study did not explain the limitations of the DSR methods across and within the soil types, different ecologies and pest infestation levels.

In Pakistan traditional DSR is reported on limited areas across southern part of Punjab and still warrants a big challenge for both research and extension wings of the agriculture department for its standardization, popularization and adaptation. The author of this report observed that Rice Research Institute (RRI), Kala Shah Kaku (KSK) has also introduced the DSR technology in different parts of the Punjab. But, the diffusion process is very slow due to number of reasons, especially lack of expertise on the part of farmers, unsuitability of hard/clayey soil type zones (mostly in '*Kalar*' tract) and the danger of dense weed infestation. Therefore, DSR technology got less reception in the *Kalar* tract. However, visiting and talking with the people in number of villages of Narang Mandi, Muridke, Malikay, Kamoke, Eimanabad, Wazirabad, Daska, Nowshera Virkan, Ali Pur Chatta areas of Union Councils, we found that mechanized transplanting under wet situation may currently have more scope, if all the operations before crop establishment, like nursery raising, land levelling, puddling, irrigation, and transplanting are done through an expert service providing company.

4.2. By-products of Paddy and Rice

Rice milling is a major agribusiness industry in Pakistan especially in Punjab and Sind provinces. Generally milled rice is consumed as staple food in some regions of Pakistan. Sagar and Ashraf (1986) noted that rice products are fairly high value commodities but currently its industrial use is limited. Major rice milling by-products are husk, bran or brown rice, and rice germ. The study emphasizes to improve the range of rice industrial products which can enhance their uses in several foods, feed and pharmaceutical products, thus reduce production cost of the whole value chin. Improving milling cost of rice can also enhance the competitiveness of the whole rice industry (see Annexure-4 for the list of rice products). The concepts and definitions as well as classifications are spelled out in the annexure for reference as well as standardization employed in the business circle of rice/paddy products' transaction in domestic and international trading. The same concepts have been used for interpretation in the present project report.

In the stakeholders' discussions, they pointed out that some potential companies in basmati rice processing can improve its value chain. For example, Matco Foods Limited, which is Karachi based leading basmati rice exporting company for over 50 years across 60 countries in the world, is in the process of expanding its operations into new rice products, such as rice glucose, and rice protein at its own plant through seeking and adopting the Chinese technology. Similarly, rice bran oil, which is considered most healthy edible oil and already being produced in large quantities in China, India, and Vietnam, is also being marketed in Pakistan although economic viability of its local production is not yet clear. In this report, the feasibility of bran oil extraction will be explored.

4.3. Integrated Weed Management

Farooq *et al*. (2017) pointed out that weeds' infestation reduces per ha yield and quality of the paddy produce due to adulteration of weed seeds in the produce. Although the paddy yield normally drops in the range of 15-20 percent, but in extreme cases, total crop failure may happen. The competition between weeds and rice depends on: i) relative growth stages of rice and weed; ii) nature of stand establishment (paddy cultivation method by adopting seedling transplanting versus direct seeded rice); iii) density of plant population; iv) variety type; and v) moisture and nutrients availability.

Controlling weeds with just through chemical gives the weeds a chance to adapt to that chemical. Integrated weed management practices in rice includes proper land preparation, water management, hand hoeing, crop rotation, and herbicides as a last resort. In Pakistan, where rice seedlings are transplanted into puddled soil, the competition at the initial stage while crop establishment is in progress is minimal than in the DSR fields.

Conclusions: In the basmati rice clusters, the most commonly weed management operations in vogue are land preparations through puddling method, where good water management practices and relatively less quantity of herbicide applications are successfully practiced. The growers are having the expertise in running these practices since long from their forefathers. Moreover, these practices seem to be feasible and successful, especially in *Kalar* tract. On the basis of this logic and widely adopted practices of rice cultivation through employing puddling method, this project focus on mechanization of the practice to improve its efficiency. The economic and cost feasibility of mechanized transplanting in both the basmati rice clusters have been prepared with these assumptions.

4.4. Coordination with R&D Organizations

In Pakistan, the research and development funds for rice crop are not very significant and its priorities are not even spelled out in visionary strategic development documents of National as well as provincial like Pakistan Vision 2025 and Punjab Growth Strategy 2018/Punjab Agriculture Policy 2018, though rice export is the second major exportable commodity after cotton. As reported in ADB (2018), only couples of exclusive basmati rice projects have been funded out of the development funds like agricultural endowment funds of PARC, Islamabad, which provided only a meagre amount. Generally, Pakistan invest very low (only 0.17 percent of its agriculture GDP) on R&D as compared to their competitor alleys like Bangladesh, China, India and Nepal (Ali et. al. 2018).

In view to overcome the shortcomings of R&D funds, Pakistan always look for and explore the local as well as international R&D partners. For example, since independence, Pakistan has been member of Consultative Group of International Agricultural Research (CGIAR), especially International Rice Research Institute (IRRI), Philippines. The technical assistance from IRRI in the areas of breeding through germplasm sharing and capacity building had been an integral part of the rice research system in the country. The development in the rice production up to this point is an evidence of IRRI technical support to Pakistan during the last 50 years or so.

In a relatively recent development, Pakistan has entered a new partnership agreement with Chinese government; name the 'China Pakistan Economic Corridor' (CPEC). It has multiple areas of mutual cooperation in terms of financial, capital, technical, capacity building, communication, infrastructural networking, etc. Chinese companies have already been engaged in development of hybrid paddy and wheat seeds in Pakistan. The Chinese researchers of Sinochem Group Agriculture Division and Yuan Longping High-Tech Agriculture Co. are already engaged, in partnership, with Pakistan's public and private research institutions (e.g., Guard Agriculture Research Services Pvt. Ltd.), and running pilot projects at 200 sites to develop hybrid rice varieties.

The Pakistani and Chinese governments have jointly identified a couple of areas for cooperation in agriculture. China has promised to build agriculture demonstration centres across Pakistan and supply seeds and machinery to Pakistani farmers. So far infrastructure projects were a priority in CPEC, but recent government has given priority to include agriculture related projects in CPEC like building farm-to-market road networks that will connect with storage, packaging and processing units. Unlike other infrastructure projects which are mostly taken up by the private sector, the agriculture infrastructure development projects in CPEC is waiting for the long-term state funding. Some of the reservations were also reported in the literature about the implications of CPEC agreement, for example:

“--- CPEC could work for Pakistani agriculture or it could be a disaster ---‘’, as said Nazish Afraz, a Professor of Economics and Public Policy Researcher at the Lahore University of Management Sciences. “--- None of the potential gains under CPEC are automatic, though, and there is a sense that China much more prepared than Pakistan ---”. “--- We should not just become a market for Chinese goods completely---‘’ as said by the Federal Secretary of Food Security and Research, Mr. Mekan. He further added that the government was “late” in setting advantageous conditions for the country’s farmers and businesses. (November 14, 2018 and December 5, 2018: FacebookGoogle+LinkedInTwitter: Chinese help in agriculture).

4.5. Trading Opportunities

The Chairman of Rice Exporters Association of Pakistan said that Iran is a nation of rice eaters with an average consumption of 46 kg per capita. They are very fond of Pakistani super basmati rice due to its taste, aroma, length, and cooking ability. Pakistani premium rice export potential can be materialized on sustainable footings, if Iranian government access to super basmati rice is facilitated through appropriate trade measures and technical barriers may be removed by offering lower duty regime on the imports of Pakistani rice in Iran under Preferred Trade Agreement (PTA). Further, the REAP Chairman suggested that *Pakistan may move forward from PTA to a Free Trade Agreement (FTA) preferably an effective zero import duty regime on both sides*. The implementation of PTA between two neighbouring countries was effective since 2006 and the current volume of bilateral trade between the two countries is not true reflective against its potential. As a result of reforms in trade policy, it will be instrumental for agriculturally enriched Pakistan to launch bilateral trade relationship with Petroleum enriched Iran. Unfortunately, however, most trading is done through other countries by adopting sometime illegal means. There is a real potential that both countries may increase bilateral trade volume up to 5 billion USD, if just the problem of transferring money through banking channel is addressed. The authority in REAP is fully in favour of opening Iranian bank in Pakistan which will ensure sustainable trade between private business partners as well as governments of both Islamic nations. On these lines, “The Bank Melli Iran” is interested to open branch in Lahore. Under the bank arrangements like ‘Currency Swap Agreement’, the representative of REAP assured that all rice exporters will be routing necessary transactions in their own currencies by legal means. (April 3rd, 2018; Facebook+Google+LinkedIn+Twitter).

The author of this report learned from the traders and processors of basmati rice that Pakistani rice and its by-products are in high demand, and enjoying the status of niche market in exporting of brown rice amongst the quality cautious consumers across the European Union countries as well as in Middle East-Gulf and America.

5. CLUSTER IDENTIFICATION AND CHARACTERIZATION

5.1. Geographical Identification of Clusters

In Punjab, basmati paddy crop is cultivated in almost all the 36 districts of Punjab, except in barani (un-irrigated) districts (Annexure-5). However, it is highly concentrated in *Kalar* tract comprising of seven districts, namely Sheikhupura, Sialkot, Gujrat, Hafizabad, Gujranwala, Nankana Sahib and Narowal (Figure 5). The *Kalar* tract of Punjab-Pak is popular in producing quality basmati rice among the rice producing areas of the world, and contribute about 50% of the total basmati rice area and production in Pakistan. The tract is classified into two clusters based on the distinct basmati variety grown and final processing through which each variety passes through:

i) *Katcha* rice (Cluster-I) - This cluster consists of Sheikhupura, Sialkot, Gujranwala, Narowal and Gujrat districts of Punjab with Sheikhupura as its focal point. The total area of the cluster is 473 thousand ha supplying a total production of 833 thousand tonnes, which is about one third of the total basmati rice area and production in the country. Variably, over ninety percent of the production in this cluster is comprised of Supper Basmati and Basmati-386 which is mainly processed for polished (or *Katcha)* rice. The tehsil of Muridke of district Sheikhupura is the focal point of the cluster that contributes 158.2 thousand ha and 289.8 thousand tonnes of *Katcha* rice, which is about one third of the total cluster area and production. The focal district has not only highest area but also highest per ha yield in the cluster (Table 6)

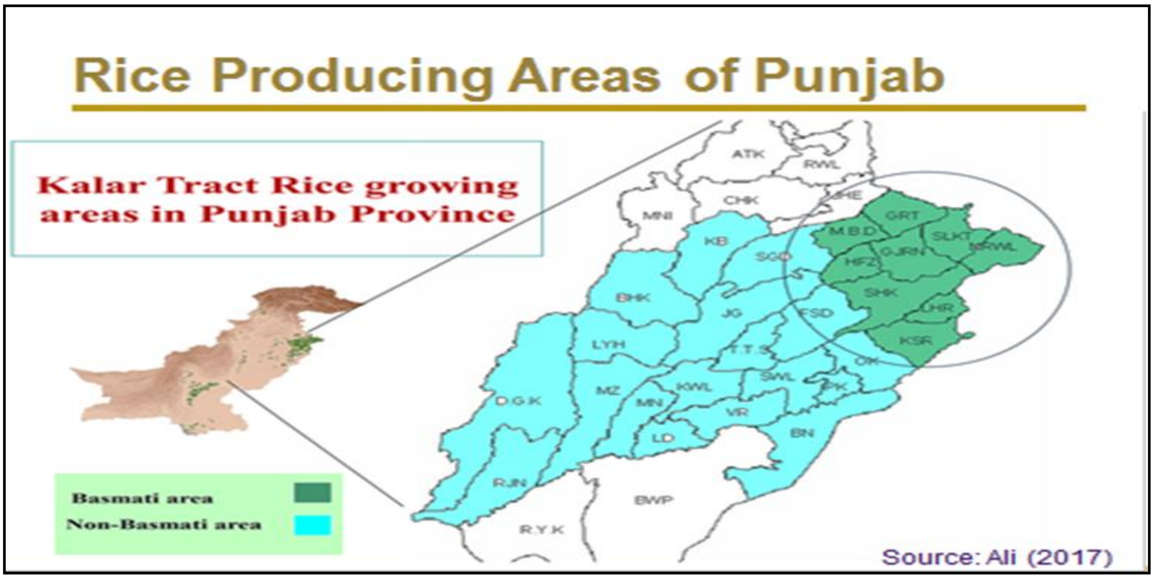
ii) *Saila* (*Pucca*) rice (Cluster- II) - This cluster consists of Hafizabad and Nankana Sahib districts of Punjab with Hafizabad as its focal point. The total area of the cluster is 204 thousand ha supplying a total production of 407 thousand tonnes, which is about 14% of the total basmati rice area and production in the country. About 75% percent of the production in this cluster is comprised of PK-1121 variety, which is mainly processed for parboiled/*Saila* (or *Pucca)* rice. The focal point of the cluster is Sheikhupura district that contributes 104.4 thousand ha and 213.3 thousand tonnes of *Pucca* rice, which is more than one half of the total cluster area and production. The focal point of the cluster has not only highest acreage under basmati rice cultivation but also highest yield among the two districts of the cluster (Table 8).

Table 8: Area, production, and yield of major basmati rice growing districts of Punjab during 2016-17

District	Area (000 Ha)	Production (000 Tonnes)	Yield (Kg /Ha)
Cluster-I (Katcha rice)			
Sheikhupura	158.23	289.84	1831.8
Sialkot	114.93	205.66	1789.4
Gujranwala	101.98	184.35	1807.7
Narowal	63.94	105.5	1650.0
Gujrat	33.69	47.58	1412.3
Total cluster	472.77	832.93	1761.8
Cluster-II (*Pucca* rice)			
Hafiz Abad	104.41	213.3	2042.9
Nankana Sahib	99.14	193.68	1953.6
Total cluster	203.55	406.98	1999.4
Total Punjab	1352.8	2524.4	1866
Total Pakistan	1454	2740	1885

Rice occupies about 35% of the total annual cropped area in both clusters; however, it is a major crop during the *Kharif* season as it occupies about 90% of the total cropped area in the season in both clusters. The basmati to non-basmati ratio in the total rice area is 70:30 percent. Fodder occupies another 7-8% of the total *kharif* cropped area (Government of the Punjab, 2016a).

Figure 3: Map of Basmati Rice Targeted Clusters



5.2. Comparison of Cluster Characteristics

Both the clusters have socioeconomically, biologically and physically comparative advantage to cultivate basmati rice. The ecology has intrinsic natural unique character that gives fragrance and pleasant taste to basmati, especially while cooking. These characteristics are popular throughout the world and fetches premium price, and has been especially demanded amongst the consumers of Asia, Gulf, Middle East, Europe, etc., especially among the consumers in these countries belong to Indian and Pakistani origins.

The *Kalar* tract of Pak-Punjab situated in between two rivers including Ravi and Chenab called *doaba* belt. These districts are operating under the public advisory services of adaptive and general extension departments. However, the role of private extension advisory services, especially of pesticide companies to provide plant protection coverage, in both the cluster is on the rise. The knowledge and approach of the public sector extension service is confined to the farm-level and very limited to address the issues of the farming and allied community which is under paradigm shift to meet the global challenges of agrarian economy. The comprehensive comparison between Cluster-I and II are presented in Table 9. The key aspects covered in characterization are: varieties planted, crop husbandry, R&D infrastructure, export, supply chain, certification of international standards, socioeconomic networking, marketing practices, socioeconomic networking, etc. of Cluster-I and Cluster-II

Table 9: Characteristics and Comparison of Clusters

Salient Features	Cluster-I	Cluster-II
Product	"*Katcha chawal*" of Basmati Rice Brown-white (single polished and double polished/silky) Basmati Rice	"*Pucca chawal*" of Basmati Rice Parboiled ('*Saila*') - Steamed rice of Basmati Rice
Districts	Sheikhupura, Sialkot, Gujranwala, Narowala	*Hafizabad*, Nankana Sahib
Rice Zone	**'*Kalar*' tract of Punjab**	**'*Kalar*' tract of Punjab**
District area by variety	**Sheikhupura**: Super Basmati=83%; Bas-386=15%; Others=02% **Sialkot:** Super Basmati=70%; Bas-386=25%; Others=05% **Gujranwala:** Super Basmati=36%; Bas-386=57%; Others=07% **Narowal:** Super Basmati=90%; Bas-386=05%; Others=05%	**Hafizabad:** PK-1121=85%; Super Basmati=08%; Others=07% **Nankana Sahib**: PK-1121=70%; Super Basmati=20%; Others=10%
Area of the cluster (000 ha)	472.77	203.55
Production of the cluster (000 tonnes)	832.93	406.98
Yield of the cluster (clean rice-kg/ha)	1761.8	1999.4
Focal point district/tehsil/ Mouza	Sheikhupura/Muridke	Hafizabad/Pindi Bhattian
Area of the focal point: (000 ha)	158.23	104.41
Production of the focal point: (000 tonnes)	289.84	213.30

Salient Features	Cluster-I	Cluster-II
Yield of the focal point: (clean rice-kg/ha)	1831.8	2042.9
Percentage of the basmati rice area to total cropped area during the year in the cluster (basmati area/total cropped area)	25	22
Geographical and Environmental Factors	Mix of Clayey and Loamy texture soils.	Mostly Clayey with patches of Loamy texture and saline soils.
	Flat plain, the broad strip of land between Ravi and Chenab rivers	Flat plain, the broad strip of land between Ravi and Chenab rivers
	30° 10° N	30° 10° N
	Relatively semi-dry climate with hot and humid summers and cold winters.	Sub-humid climate with hot and humid summers and cold winters.
	Good quality surface and subsoil water for canal and tube well irrigations, respectively.	Good quality but in some area's brackish poor-quality groundwater for tube well irrigations.
	High costs of pumping due to ever increasing energy rates.	High costs of pumping due to ever increasing energy rates.
	Average rainfall 400 mm to 700 mm per annum mostly during the months of Monsoon, June through August.	Average rainfall 300 mm to 500 mm per annum mostly during the months of Monsoon, June through August.
	Day Temperature rises up to 42°C during earlier stage of crop season (Summer)	Day Temperature rises up to 45°C during earlier stage of crop season (Summer).
	In winter it drops to 08-20°C during later stage of crop season.	In winter it drops to 10-22°C during later stage of crop season.
	Wind, rain falls and hail storms may occur during summer months.	Wind, rain falls and hail storms may occur during summer months
	Strong winds blowing during September and November months causes lodging, especially in Super basmati fields. (see in Annex Figure 1)	Strong winds blowing between September and November months sometimes causes damages to paddy crop.
	Fog converted to Smog that occurs during the winter season mainly during the months of late October to early January.	Fog converted to Smog that occurs during the winter season mainly during the months of late October to early January.
	The density of smog depends upon the intensity of pollution and level of humidity present in the air.	The density of smog depends upon the intensity of pollution and level of humidity present in the air.
	Mostly dry but rare spell of rain comes during panicle emergence and harvesting of crop, September through December.	Mostly dry but rare spell of rain comes during panicle emergence and harvesting of crop, September through December.

Salient Features	Cluster-I	Cluster-II
	Basmati Rice varieties are moderately photosensitive.	Basmati Rice varieties are moderately photosensitive.
Rice Growers	Small holding size (<05 acres), medium (05-12.5 acres), large (> 12.5 acres)	Small holding size (<10 acres), medium (11-30 acres), large (> 30 acres)
	Most of farmers under matric and can understand new methods and techniques of good practices including: judicious use of chemicals i.e., fertilizers, pesticides/ weedicides.	Most of the farmers are matriculate --- Partly follow and afford new methods and techniques of good practices including: judicious use of chemicals i.e., fertilizers, pesticides/ weedicides.
	Many Paddy growers' associations (CBOs/Coops) are inactive except few NGOs, (potentially Engro Pvt. Ltd.) covering smaller part of basmati rice ecology in order to help farmers to pool input and output resources by farmers' groups.	Most Paddy growers' associations (CBOs/Coops), inactive except National Rural Support Program (NRSP) covering smaller part of *Saila* rice ecology --- guiding and supporting farmers in crop husbandry management, and post-harvest handling including marketing and processing.
	Small farmers' family members engage in routine farming chores.	Family members of small farmers do many chores by themselves like animal care, watering to the paddy fields.
	Transplanting is done by hired labour, while harvesting and threshing of paddy is performed on rental/hiring services of wheat combine harvesters.	Transplanting of seedlings, harvesting and threshing performed through hired casual labour as well as on custom hired service of rice combine harvester (See in Annex Figure 2)
Product Features	Basmati *'Katcha Chawal'* prepared from fine popular varieties: Super Basmati (average yield of paddy 2.5-3.0 tonne/ha); Bas-386 (average yield of paddy 3.0-3.5 tonne/ha), and other insignificant varieties grown including Basmati-385, Super Kernel, Basmati-515, Kissan, Punjab, Chenab, etc. have higher yield potential than Bas-386.	Current dominant grown fine variety, basmati was PK-1121 ('Kainat') --- with an average yield of paddy 3.4-3.7 tonne/ha. PK-1121 variety is exhibiting the height to the tune of 120 cm. The grain size of this variety is larger than for all reported basmati varieties in the rice belt.
	Grain (Kernel) size, appearance and shape affect towards greater market acceptability: Grain size of all above mentioned basmati rice varieties varied between 6.5 to 8 mm.	The grain size is extra-long measuring >8 mm. It has high degree of grain elongation after cooking in comparison to basmati and non-basmati rice.

Salient Features	Cluster-I	Cluster-II
	The milling recovery varied from 62 to 72 percent depending upon the moisture content of the dried paddy	Parboiled Rice is hard that has gone through a steam-pressure process before milling. It is soaked, steamed, dried, and then milled to remove the outer hull.
Variety Features	Indigenous blood: crosses between Basmati-320 and line 10486.	PK-1121 '(Kainat'), fine rice variety borrowed foreign germplasm, mainly used for preparing parboiled ('*Saila*') rice because of their elongated grain size especially after cooking with measuring ranges from 16 mm to 18 mm
	The maturity periods of various varieties are: 95 days for Basmati-515, 100 days for Bas-386, 105 days for Punjab Basmati, and 110 days for Super Basmati, and Chenab Basmati. On average farmers maintain 55,000 to 65,000 plant population per acre against the recommended level of 120,000 plants/acre	Kainat variety seedlings transplanted up to mid of July and matures mid-November to last week of November. The maturity period is 110 days. Plant Population density status is similar to that of the other all types of paddy cultivation.
Nursery and Transplanting of Seedlings	Most growers raise their own paddy nursery seedlings at their own farms and it is self-maintained	Majority of farmers prefer to raise nursery and plant fine Kainat paddy through dry-bed method.
	Only 5-10 percent farmers are using certified seed from Punjab Seed Corporation, private seed dealers and research station.	Farmers' seed source of 'Kainat' variety is from the research station as well as from the Punjab Seed Corporation.
	The importance of timely sowing of nursery and the transplanting age of seedlings is very important to achieve higher paddy yield in all rice varieties.	Same practices observed as of Cluster-I for raising nursery and transplanting of seedlings.
Inputs/Management Practices	Normally, 7-9 ploughings (@ Rs.2000 per plow and planking) including dry and wet (puddling) practiced before transplanting the paddy seedlings.	Normally, 8-10 dry ploughings (@ Rs. 1500 per plow) practiced before transplanting paddy seedlings.
	On average, 1.5 bag of Urea/acre (Rs.1700/bag) and one bag of DAP/acre (Rs.3600/bag) is applied split in two doses with basal dose of 0.5 bag of Urea and one bag of DAP.	On average total 2 bags of Urea/acre (Rs.1700/bag) and one bag of DAP/ acre (Rs.3600/bag) is applied in two doses with basal dose as one bag of Urea/acre and one bag of DAP/acre.

Salient Features	Cluster-I	Cluster-II
	The second dose of only one bag of urea was applied before emergence of flowers.	The second dose of only one bag of urea was applied before emergence of flowers.
	In '*Kalar*' tract, mostly granular as well as liquid pesticides are used against the pests at different stages of crop growth.	Granular and liquid pesticides are applied to control pests at different stages of paddy crop growth.
	On average, cost of all pest control including weeds ranged from Rs.4500 to Rs.5500 per acre.	On average, cost to control all pests including weeds ranged from Rs.6000 to Rs.6500 per acre.
Harvesting and Threshing	The traditional way of manual harvesting and threshing is totally wiped out. Presently, almost all the farmers are harvesting and threshing the basmati paddy crop mechanically by employing either mostly with wheat combine or few by rice combine harvesters on rental charges of Rs.2500-3000 per acre (takes 30-40 minutes) and Rs.4500-5000 per acre (takes 1.2 hour), respectively.	The paddy harvested and threshed with wheat combine harvesters is exhibiting high moisture contents (i.e., up to 34 percent) vis-à-vis rice combine harvester exhibiting relatively low moisture contents due to inbuilt in fan to separate grain from inert material (i.e., <34 percent). (See both machines in Annex Figure, 2&3.)
Drying/Packaging/ Transportation	Mostly, farmers transport the paddy direct to the markets in trolley without drying and packing except few who used sacks.	Drying, packing and transportation operations are not different. Currently, Rs.50-60 per 65-Kg bag of paddy incurred for drying. It includes labour charges for sun drying may be by two times with some intervals as well as for packing and un-packing paddy in a bag.
	Commission agents/'*Pharias*' or wholesalers or Sheller owners also buy paddy directly from farmers, mostly from farm gate, and transport either by trolley or Mazda (@Rs.150/40-kg)	
Wholesaler/Retailer	Commission agents exploit the situation and condition of paddy received at their purchase centers by offering low prices due to presence of high moisture contents, green paddy grains and pieces of paddy straw ('*Kundi*'). (See in Annex Figure 4.)	Contractors or wholesalers buy the product from farmers as they have connections with the commission agents in the market. The price is offered to the farmers based on the quality, form and location of the rice product.
	The commission agents often charge 1-7 percent of the total revenue computed against the paddy received from the growers	

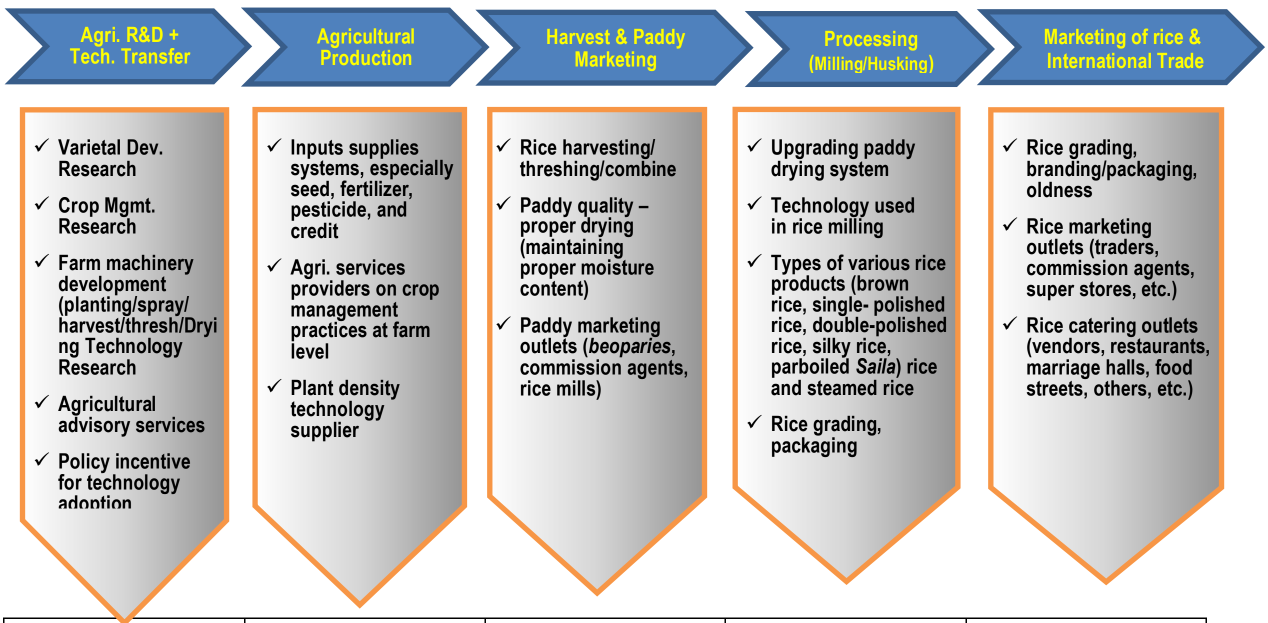
Salient Features	Cluster-I	Cluster-II
	depending upon the extent of the loan received by the growers during the crop season for meeting purchased inputs expenses. In addition, they deduct one Kg paddy out of 40 kg on account of '*palidhari*' as a labour charges for loading/ unloading, etc. of paddy.	
	The quality judgment criterion is not standardized in case of paddy trading, so the range of purchases and sales are varied from one lot to another within and across the market locations.	The auction in the wholesale market is generally based on the variety, and deductions are made based on moisture content, presence of inert material and green grains.
	This situation is favourable for the commission agents/ traders/ retailers due to non-existence of legitimate rules of marketing about the permissible limits of moisture contents of paddy or rice at the points of entry/ exit from farmers through rice Sheller mill processors, and later on to consumers.	Thus, exact grading is not determined for the paddy products except purity of variety.
Technological Innovations & Infrastructure Development	Some commission agents have already started using mechanical dryers	Parboiled - '*Saila*' rice become rancid upon storage for longer period --- discover safe technology to maintain or improve the quality of the commodity.
	Many farmers are already using Direct Seeded Rice (DSR) technology in paddy cultivation.	Quick development of Kainat varietal series, although this is a reactive action in response to Indian researchers' pro-active action of releasing superior Kainat varieties (Pusa series) with almost 26 percent higher yielder as well as elongated kernel size after cooking, thus fetching higher price in international market
Export/ domestic marketing	Relative annual basmati rice exports share of Pakistan declined significantly vis-à-vis increased share of India.	Parboiled ('*Saila*')/steamed rice demand is rapidly increasing in the domestic and international market ---- especially in Gulf, Iran and Middle East.
Certification	Mandatory quarantine requirements of importing as well as exporting countries of food safety standards and traceability	Similar to Cluster-I requirements and bottlenecks of Food safety standards and traceability traits

Salient Features	Cluster-I	Cluster-II
	fulfilled under the prevalent agreements (HACCP, SPS, TRIPS, etc.)	including HACCP, SPS, TRIPS, etc. fulfilled.
Socioeconomic networking/Gender involvement	In some cases, females of family or hired labour engaged in transplanting of paddy seedlings, harvesting paddy straw to feed their livestock, and looked after postharvest care including storage, etc.	In heavy chores of rice cultivation, the women participation is low, but higher in decision making for sale and retention paddy products for seed and household's consumption uses.
Source: Feedback from different stakeholders blended with Secondary sources surveyed **Note:** Please see Annexure 3 discusses the Basic Concepts and Classification of Paddy and Rice By- products.		

5.3. Value Chain Analysis of Clusters

A number of stakeholders are engaged along the value chain of basmati rice products in both the clusters, as elicited in the schematic flow chart in Figure 6. Its' processes are starting from agricultural R&D as well as technology transfer activities of public and private institutions through the phases of agricultural production, harvest and paddy marketing, processing and ends at domestic and international trading. During the consultation meetings and focused group discussions with the stakeholders along the value chain in the targeted basmati rice clusters, some of the key findings are discussed in this section.

Figure 4: Basmati rice value chain



Implementing Agency	Implementing Agency	Implementing Agency	Implementing Agency	Implementing Agency
• Provincial and Federal Agri.	• Punjab Agriculture Department	• Farm Machineary	• Rice sheller mills, Rice Traders	• Rice sheller mills, Rice Traders, Packaging and

Research System • Private Agencies like Engro, Guard pvt. Ltd. And Provincial Agricultural Extension Departments (Field, Farm Machinary, etc.), NGOs-NRSP	• Rental hiring service providers, • Pesticide companies, e.g., Bayer, Syngenta, etc.), Fertilizer companies, i.e., Fatima Fertilezer Company, Fouji Foundation and Pakarab Fertilizer Company • Several private seed Compnies • Zarai Tarqyati Bank • Increasingly short laor for transplanting • Few mechanical transplanting services are emerging	Service Providers, • Farming Community, Commission Agents, • Rice sheller owners and rice traders		Branding, like Engro and Guard and other REAP members, TDAP, TCP

Source: Figure Adapted from Bashir *et al*. (2018)

5.4. R&D in Basmati Rice Production

Basmati crop cultivation in Punjab was not much popular than other states of un-divided India. The varietal improvement of basmati rice was initiated in 1926 at Kala Shah Kaku, Muridke through pure line selection from available indigenous cultivars of paddy. The first rice variety, Kangni-27, was released from Rice Research Station, KSK for cultivation in 1927. In 1933, the world-famous rice variety, “basmati-370” was selected from the local selected land races and approved for cultivation on extensive area of rice growing regions of un-divided India. Basmati-370 proved to be the most valuable traditional quality rice which became a standard variety for export quality led to a manifest boom in export of India and Pakistan even after independence of Pakistan (Bashir *et al*., 2018). This variety enjoyed maximum popularity among the domestic and international consumers mainly due to sweet taste and pleasant aroma. After this variety some other successful basmati varieties were released like basmati-385 (in 1985), Super Basmati (in 1996), Bas-386 (in 2014), etc.

Recently released basmati varieties, Kissan, Chenab and Punjab, by RRI, Kala Shah Kaku are not getting diffused among the rice growers due to the lack of the traits they expect, i.e., something additional to the traits in super basmati variety. Moreover, Pakistani breeders are still emphasizing on developing aromatic basmati varieties unlike Indian's emphasizing on non-aromatic high yielding with elongated kernel size rice varieties like Pusa series (Kainat type). A promising basmati variety generation gap exists after Super Basmati --- which warrant to introduce improved germplasm viz., both open pollinated variety (OPV) and Hybrid. Recently, the Rice Research Institute (RRI), KSK seeks the approval of its research agenda from its board, comprising of representative members from farmers associations, REAP, seed, pesticide, and fertilizer companies, and academia like agricultural universities. The impact of this needs to be seen in the near future. Some other institutional reforms will be required like introducing output oriented specialized extension fast approval of varietal release and diffusion of promising basmati rice varieties.

There are many emerging and unresolved issues that need to be resolved through research t keep basmati competitive in national and international markets, such as: a) Further improvement in basmati varieties to meet international demand (e.g., improved version of PK-1121 competitive to Indian Pusa series); b) Discover safe technology to maintain the quality of rice after parboiling (e.g., to control *Saila* rancid in storage); e) Promotion and training of Integrated Pest Management (IPM) techniques or use of organic pesticides, especially to control weeds; e) to promote mechanization of production processes; f) diversification of basmati value chain. .

5.5. Research and Development Organizations

There are several institutions in the public sector in the provincial agricultural research as well as federal agricultural research arms of the Ministry of Science and Technology, Pakistan Atomic Energy Commission, Pakistan Agricultural Research Council working for the improvement of the basmati rice value chain. In addition, some state-of-the-art private sector companies, like Guard Pvt. Ltd. as well as Engro EXIMP, a subsidiary of Engro Corporation, are supplying quality rice seed and manufacturing rice products.

Recently the National Rural Support Program (NRSP) has launched a unique development project in *Saila* rice zone (Cluster-II) of Punjab to mobilize farmers through establishing community-based organizations for the purpose of setting community-based marketing, processing and trading facilities. In this process, the resources are pooled for accomplishing the above-mentioned activities in order to gain maximum profit share by the farmers. These community organizations are also linked with provincial agricultural research and extension services for advisory services. These organizations can be used as catalyst in improving the whole value chain of rice basmati clusters.

Several internationally accredited quality certification laboratories, like PCSIR under Ministry of Science and Technology, NIBGE under the aegis of Pakistan Atomic Energy Commission, Grain Testing Lab. at Karachi, PARC under Ministry of Food Security and Research have been established in the country.

5.6. Input Supply System

Input supply chain system well established throughout the 'Kalar' tract and is operated by the private sector. There is no serious shortage of rental service providers of tractor driven plowing and wheat combine harvesters. The availability of the services of rice combine harvesters is also increasing fast as it considerably lessens the paddy losses as well as save rice straw which is either fed to the animals are sold to the traders of paper industry. The achievement of desired plant population in paddy fields is another important rice production issue. Commonly paddy fields are maintaining 55 to 60 thousand plant population per acre against the recommended level of 120 thousand of plant density. As already discussed, this issue may be easily managed by the service providers through introducing the mechanical rice transplanter of China or Korean made technology, as evidenced in the fields of Ali Pur Chatta Union Council of District Gujranwala. Moreover, an alternate technology of DSR method of paddy cultivation may be popularized in loamy soil type area, especially in Cluster-II basmati rice belt. Normally for the first one and a half month after transplanting seedlings, farmers irrigate to paddy fields twice a week with light doses for proper plant establishment and suppression of weeds' germination depending upon the soil type and incidence of rain falls. The interval of irrigations may be weekly up to tasselling and grain formation stage and later on stopped depending upon the weather and soil conditions.

Fauji Fertilizers Co. (FFC), Engro Fertilizers Limited (EFL), Ali Akbar Group (AAG), Jafar Brothers Limited, Fatima Fertilizer Company, Syngenta, Bayer Crop Science are the main crop input (chemicals and seed) suppliers and all of these have well established dealership and distributor network system across the Punjab especially in basmati rice belt. Seed is mostly supplied by the Punjab Seed Corporation Pvt. Ltd., & Seed Council, and on small scale quality basmati rice seed is also supplied by the RRI, KSK as a breeder seed, truthful labeling seed and foundation seed for popularization as well as growers’ feedback. Seasonal, short term interest free loans are also disbursed by the scheduled banks for purchased inputs including seed and fertilizer. Commonly, farmers are using below average and imbalance fertilizer input levels, therefore, it impacts negatively, equally on output productivity and quality, except few progressive growers. Input and output quality monitoring system is not well established in Pakistan and its situation is better in Punjab than other provinces. The public institutions performance and Standard Operating Procedures (SoPs) are same in both clusters.

In '*Kalar*' tract, mostly granular as well as liquid pesticides are applied to protect the pest attacks at different stages of paddy crop growth. For example, the granular pesticides were used to control rice leaf folder, stem borers, grasshoppers (i.e., green and red), and liquid pesticides spraying to control green leafhoppers, aphids and Jassid on rice crop. On average, farmers are spending to control all pests including weeds ranged from Rs.4500 to Rs.5500 per acre (Inayatullah *et al*., 1986; Field Survey Information, August-October, 2018). Serious lapses observed in public agriculture sector, especially plant protection department, because the pesticide companies are aggressively selling their products to maximize their profits. It is very common problem noticed on the farmers’ fields pertaining to non-judicious use of micro and macro nutrients, pest control measures and insufficient pest management strategies. Since, farmers' practice like reckless use of pesticide due to lack of pest scouting awareness & non-declaration of minimum resistance limits (MRL) - defence against residual effects of pesticides on the living organisms, as well as, lack of government prudent monitoring system to check the quality of inputs and outputs at right time, form and location. As per author’s field observations, farmers had adopted the behaviour of overusing of pesticides even without monitoring of pest load; farmers are used to apply pesticide as a precautionary measure to avoid severe pest losses on fine basmati paddy crop, especially the productivity of super basmati crop. It is general opinion that the allied departments like Plant Protection and

Agricultural Extension are not pro-actively addressing these issues as compared to the pesticide private companies may be due to their business opportunities by selling their products. The crop husbandry practices are not much different across the basmati clusters except, plant protection, weed control and frequency of irrigations. The Cluster-II area of Kainat variety belt is relatively drier and exhibits separate flora and fauna. It requires more care of frequent irrigations to snub weeds germination as well as paddy plant establishment. Some more weedicide application performed than Cluster-I paddy crops.

The strategic solutions may be opted by the government to resolve above mentioned issues by creating awareness, tax rebates/ interest free loan provisions on imported farm machinery like rice transplanter, rice combine harvesters and dryers. Since, these farm machinery/equipment and technology require lumpy investment to procure as well as launching of skill development programs in line acquaintance about the intervention of technology in order to earn maximum benefits at all nodes of value addition players through satisfying the needs of the ultimate stakeholders/producers.

5.7. Harvesting

The traditional way of manual harvesting and threshing has totally vanished. Presently, 80% of the farmers are harvesting and threshing the basmati paddy crop mechanically by employing wheat combine harvesters (using both for wheat and rice crops) with rental charges of Rs.2500 -3000 per acre (takes 30-40 minutes). More than 80 percent farmers are using this machine in both basmati rice clusters. The paddy straw harvested with wheat combine is not much useful, especially for feeding to the animals, and the field is left with longer stubbles. Recently, upgraded rice combine harvester (Kubota) has been introduced, designed by the Korean/Chinese technology for paddy harvesting and threshing. Its rental charges are Rs.4500-5000 per acre (takes 1.2 hour). Presently, Kubota combines are covering about 15-20 percent harvested area of paddy crop. The paddy straw harvested with Kubota machine has many advantages like: relative green paddy can be used for animal feeding; short stubbles in the field enables easy ploughing for next crop; saving more than 60% harvest losses thus giving 6-7 maunds higher production per acre compared to paddy harvesting by wheat combine harvester; avoiding health effects of smog due to rice straw burning in cold winter season in metropolitan cities of rice belt and Lahore. It suggests alternates to straw burning and support allied agro-industrial.

5.8. Paddy Marketing

The commission agents ('*Arthi*') and wholesale merchants do keep accounts of their paddy transactions with loose record about type of varieties purchased and sold but no moisture contents record exhibited at this point of time. This was commonly observed that commission agents exploit the situation and condition of paddy received at their purchase centers by offering low prices due to presence of high moisture contents, green paddy grains and pieces of paddy straw ('*kundi*') (See in Annex Figure-4). This situation is favourable for the commission agents/traders/retailers due to non-existence of legitimate rules of marketing about the permissible limits of moisture contents of paddy or rice at the points of entry/ exit from farmers through rice Sheller/Mills, and later on to consumers. The quality judgment criterion is not standardized in case of paddy trading, so the price range offered for the transactions of paddy produce are varied from one paddy lot to another within and across the market locations depending upon the seller's status (i.e., socioeconomic, inputs purchased on cash or credit, and political influence). The paddy prices are low immediately after harvesting season, increasing gradually as the supply decrease with the passage of time. Thus, the paddy price increased from Rs.100 to 300 per maund after harvesting season over, depending upon the type of basmati varieties and its' demand and supply situation. Though the moisture content of paddy --- a factor for price determination and the chances of aflatoxin infestation increases if dumped in heaps and not aerated appropriately. The auction in the wholesale market is generally based on the variety, and deductions are made based on moisture contents, presence of inert material and green grains. The price is offered to the farmers based on the quality, form and location of the rice product.

The traders, wholesalers–sheller owners buy the paddy directly from the farmers. The commission agents often charge 1-7 percent of the total value of paddy received from the growers. In addition, they deduct one-kilogram paddy per 40-kg on account of '*Palidhari*' as a labour charges for loading/unloading and weighing services, etc. of paddy. The growers who do not take loan from the '*Arthi*' pay commission or *Arhat* @ 1-2 percent of the value of produce sold, which increases from 3 to 7 percent, if some money is borrowed from the *Arthi*. On average, the Paddy growers/*Arthi*/Sheller Owners/Wholesaler/Retailers purchased paddy of different basmati varieties during the season as: Super Fine (banned): Rs.900-1050; Supri (Banned): Rs.1100-1300; Basmati-386: Rs.1100-1300, Super basmati: Rs.1500-2000; The basmati rice wholesale prices of major varieties recorded during survey period in September-October, 2018 are as follows: Basmati-386: Rs.2100-2300, Super Basmati: Rs.3600-4000.

Supply chain of basmati paddy exhibited numerous inbuilt constraints throughout its flow from the farmers' field to the rice processing mills including high moisture content prone to aflatoxin, farmers' exploitation by commission agents lead to offering low paddy rates, mixing of inferior basmati rice varieties of Basmati-386, Supri, etc. in Super basmati especially by Sheller mill owners as well as basmati traders.

The strategic post-harvest solutions need to be followed by taking care of efficient harvest and quick disposal of quality products of paddy and its by-products including *Katcha* and *Saila* rice commodities by using marketing intelligence and interconnected structure of regional and inter-regional nodes of markets. Since, farm machinery like rice combine harvester may be employed to save harvest losses and additional contribution by saving rice straw that would generate higher value additional towards the kitty of all stakeholders involved. The farmers will gain relatively better share out in the form of marketing margins by less harvest losses plus additional wheat straw for the animals besides reduction in the cost of production.

5.9. Processing (Milling/Husking)

Based on the processing capacities of rice sheller plants, the processors could be categories broadly into three categories like small, medium and large sized processors. These processing plants are located in the close proximity of the basmati paddy growing areas of *Kalar* tract and in the surrounding districts of Punjab province. These processors as well as commission agents buy the paddy and mostly sun drying depending upon the condition of weather and its immediate purpose like storing for future de-husking or directly process for rice recovery.

Paddy and its product buyers could be categorized as: i) commission agents/brokers (*Pharia*) and rice sheller owners who directly buy paddy from the farmers; ii) domestic and international traders who buy head and broken products of rice etc.; iii) oil extraction mills, feed mills and pharmaceutical companies, etc. who buy rice bran/powder buyers, iv) packing material manufacturers who buy husk (thooh) as a source of energy who use it as filler to save from shocks; rice sheller owners also use the husk in burning for paddy drying and brick kiln owners for making bricks, etc.

The prices of paddy and its main products, especially rice are low at the commencement of the season, increasing gradually as the supply shrinks against demand as well as on aging of *Katcha* rice, but aging parameter is not counted in case of '*Saila*'. The price of PK-1121 (Kainat) used in *Saila* was Rs.1700-2300 per 40 kg during early season of crop harvest. While the wholesale price of its parboiled was Rs.5000-5700 per 40 kg during early October, 2018. The price of *Sail*a is normally more by Rs.250-300 per 40 Kg than '*Katcha* rice'.

The exact grading is not determined for the paddy and rice products except purity of variety, moisture content, head rice and broken categories of rice. The supply chain limitations of paddy of 'Kainat' (PK-1121) are similar as explained in Cluster-I, but inbuilt bottlenecks of its processed products (Parboiled/ steamed) include rancid of stored grain---aging lead to rejection by the consumers, resultantly reducing its demand and price.

Processing through passing the phases of drying, storing and milling to recover quality products of *Katcha* and *Saila* rice each have distinct channels to pass through in value addition phases. In the process, the importance of efficient technology of mechanical dryers as well as rice sheller mounted with upgraded *Saila* rice making plants are necessary to yield quality products to meet consumers' demand and as fetch good price.

REAP representative said that the process for quality finished rice starts from paddy procurement. The paddy is procured and dried and then kept under silos for effective storages. It is then cleaned, husked, polished, graded and then packed for exports. The value-addition of rice ranges from 100 percent to 140 percent. The paddy of basmati is procured at $450/ metric tonne while it is exported at around $1000 PMT. Parboiled and steamed is exported at around $1200 PMT. (Web portal information, December, 2018).

5.10. International Trade and Quality

As noted earlier, the relative annual basmati rice export share of Pakistani basmati rice is declining significantly vis-a-vis increased share of India. The demand is increasingly shifting toward '*Saila Chawal*' rice internationally more particularly in the Middle Eastern consumers as well as locally especially among the commercial catering service providers ('*Pakwans*').

Mandatory quarantine requirements of importing countries pertaining to food safety standards, traceability traits, HACCP, SPS, TRIPS, etc., are becoming increasing one of the major obstacles in entering into free markets for both *Katcha* rice from Cluster-I and *Saila* rice from Cluster-II. Only few Pakistani companies are liable to meet the desired standards. The quality-control responsibility for rice trading from government to government is on the shoulders of Trading Corporation of Pakistan (TCP). The quality issues in trading with the private parties is dealt by the Rice Exporters Association of Pakistan (REAP). The quality control issue between private parties of importing and exporting country may sometime leads to mistrust. The quality issues in rice, like aflatoxin infestation, residual effects of pesticides/weedicides, etc. may be resolved through quality-based contract with farmers' organization, giving more responsibility to REAP, and linking export with internationally accredited laboratories in the country.

Transportation network is reasonably satisfactory due to good cargo facilities of vessels/trucks by road and bogies by railways, ships by sea from Karachi/Gwadar --- more improvements are in progress upon the completion of CPEC project --- from the rice processing zone to the consumers' regions locally as well as overseas (via dry ports within country and to the Karachi port).

Several brand names in export of rice have been stablished brand in packing of 1, 2, 5 and 10 kg. However, majority of companies are trading as non-branded product in bulk lots. The branded products are earning better reputation as well as higher price than the non-branded products.

The major constraints being faced among the rice exporters that hinder free trading are complex procedural formalities including rules and regulation especially for food safety measures varied for different importing countries, and import/export duty charges, etc. To overcome these constraints, Standard Operating Procedures (SOPs) be designed for assurance of quality control mechanism acceptable globally.

Aggressive strategies and advertising propaganda are lacking by the responsible organizations of Pakistan for trading rice products especially, basmati rice export. Thus, the country needs artifact export lead polices, mobilizing of commercial attaches posted abroad, revisiting REAP and TDAP joint efforts in boosting export orders and searching of new export markets especially for basmati rice and its by-products to regain its share in the basmati export market. Moreover, this exercise must support to break the negative inertia created globally by Indian exporters.

On top of all, like the Indians, there is an urgent need of adopting the aggressive promotional campaign of Pakistani brands especially in *Saila* of Kainat for rapid reception amongst the end users through different means like launching international food contests in food street galas, rice catering outlets-vendors, restaurants, marriage halls, food streets and others. This type of efforts will definitely promote the basmati rice products' marketing domestically as well as globally to fetch value addition for the kitties of all stakeholders starting from farmer to consumers.

5.11. SWOT Analysis

5.11.1. Overview

The SWOT analysis was carried out with the focus group discussions housed in *Kalar* tract basmati rice producing clusters. The findings were synthesized through employing the grounding theory of qualitative and quantitative approaches. A list of potential questions was used for staying on track. Each targeted question was completed through querying and keeps on pondering until reaching at exhaustive point from the respective stakeholder in terms of strength, weakness, opportunity and threat pertaining to the aspects of basmati rice value chain. The detailed proceedings of the discussion are presenting in the following section.

5.11.2. SWOT Analysis for the Clusters

Both of the basmati rice clusters have their unique strengths, weaknesses, opportunities and threats, the details are illustrated in Table 11. The salient features of these clusters are suitable ecological mainly due to enabling sun light, temperature, natural precipitation, sweet ground water, irrigation network through canals and tube wells, soil types, farmers' expertise gained from past generations, physical location of the crop area near to roads, markets, processing mills, etc. Some major threats came up in the SWOT analysis are: i) rice straw burning leading to environmental pollution triggers smog problem during winter, ii) lodging in Super Basmati in Cluster-I due to imbalance use of nutrients and pest attacks, iii) overuse of pesticide lead to added costs and residual effects, iv) stagnant or even declining total factor productivity due to lack of organic matter as well as other micronutrients, v) problem of aflatoxin manifested due to green crop harvests, vi) declining export trend of Pak. basmati rice due to change in consumers' demand, un-competitiveness due to low productivity; changing consumers' taste preferences and convenience of catering service providers, vii) lack of sufficient R&D funds as well as laxity in the release quality basmati varieties/seeds superior than Super basmati, viii) inefficient processing of rice sheller mills as well as for preparing *Saila* rice, etc.

Table 8: SWOT Analysis of Basmati Rice Value Chain in Pakistan

Areas	Strengths	Weaknesses	Opportunities	Threats
Environment/Climate Change	• Clayey (Heavy) and *maira* (Loamy) soil texture, hot and humid climate, and mildly & well drained lands in both clusters "*Katcha Chawal*" (Brown-white-single/double polished/ silky Rice) and "*Pucca Chawal*" (*Saila* (parboiled)-steamed rice). • Suitable for Basmati rice cultivation. • Sufficient canal & suitable Tube well irrigation supplies	• Drought and floods cause biotic and abiotic stresses, encourage different types of pest attacks and pathogen infestation incidents leading to significant productivity losses	• Climate change induces to productivity gain of rice by increasing the temperature, as a result of global warming. • Occurrences of floods bring new area under rice crop.	• Heavy monsoon rain falls occasionally cause floods leading severe damages to the rice crop (i.e., at early/late stages of growth and maturity. • High moisture content in the air and presence of green seeds in the harvested paddy trigger Aflatoxin infestation. • Loss of biodiversity due to over-utilization of harmful chemicals.

Areas	Strengths	Weaknesses	Opportunities	Threats
				• Add in environmental pollution due to pesticide use, it further degrades soil and water bodies when chemicals leached down. • Paddy straw burning cause environmental pollution - develop the problem of smog in winter.
Inputs Supplies	• Easy accessibility to reliable input supply system including fertilizer and pesticide/ herbicide through many National/ Multinational Companies. • Healthy competition exists among chemical firms to supply and promote their respective products to control pest and weeds infestation problems erupts from time and again. • Insured inputs supply from the tobacco companies due to contract farming	• Non-availability of quality basmati rice seed, lot of mixing noticed of fine varieties by the private vendors except few companies. • Rice growers' knowledge not updated about the quality and brand of appropriate inputs. • Lack of on time availability of quality inputs at control prices including, fertilizer, pesticide/ herbicide, zinc and other important micronutrients. • Declining soil productivity observed over time mainly due to depletion of organic matter along with other	• Already established soil testing labs in the rice growing areas of Punjab can play a major role in providing their services on affordable payment basis, via matching the input use vis-à-vis with the present soil nutrient condition status prevailed. • In the surrounding areas of basmati rice crop, burgeoning trend of poultry & dairy farms observed to feed increasing rural and urban population---resulted to up scaling the biogas plants (energy) and its byproducts including slurry/ manure applied for arresting the declining organic matter in the fields as well as supply of bio-gas for	• Shortage of irrigation water at the critical stages of crop growth count a lot towards reduction in crop yield. • Use of adulterated or expired pesticides creates inefficiency towards inputs output impacts as well as cause harmful effects on soil, output and water bodies. • Injudicious use of chemicals especially residual effects of pesticides and nitrates are becoming major threat to supply clean water and survival of biodiversity and on top of the health of mankind

Areas	Strengths	Weaknesses	Opportunities	Threats
		micro and macro nutrients. • Limited availability of certified, quality, and pure improved fine rice varieties seed/seedlings (e.g., Super, PK-1121, Kissan, Punjab and Chenab Basmati).	household energy consumption. • Introduction of mechanization in farm operations like plowing, seedling transplanting, harvesting and threshing. • Developed backward linkages like, Agro-industry farm equipment and chemical manufacturing promoted. • Seed Act 2015- obligated to Agri. Departments to establish and promote certified seed, seedlings/ nurseries, and gain an opportunity by running its entrepreneurship through declaring industry status i.e., tantamount to cluster develop.	
Cluster Interactions	• Large number of farmers present in both clusters (i.e., "*katcha*" and "*Pucca*") but where the associations (especially NRSP) present get good services from the private infrastructure and pool their resources to fetch good returns. • Informal credit facility available for the purchased inputs to the needy growers from the commission	• Small and marginal farmers are frustrated due to misusing of their membership facilities like purchased input on credit by the influential and large farmers. • Most farmers' associations are inactive. • Lack of interaction observed between the farmers, '*Arthi*'/commissio	• More awareness and empowerment training warranted about the institutions who look after the interest of all farmers especially the deprived ones. • More need-based trainings from the resource professionals of all stakeholders engaged in good production practices, post-harvest management, marketing	• Lack of trust between stakeholders --- damages to the institutional transparency in mutual business deals. • Lack of harmony, communication and integration amongst the stakeholders of basmati rice value chain actors.

Areas	Strengths	Weaknesses	Opportunities	Threats
	agents though at higher interest rates.	n agents, paddy processors and traders, and even between farmers, researchers and extension workers. • Each stakeholder tries to conceal the facts from others.	intelligence, trading and matching the quality with the consumers' demands.	
Production Management Practices	• Enjoys local comparative advantage in cultivation of Basmati rice. • Farmers exhibiting age old generation expertise and knowledge for production of paddy crop. • Fairly good services of plant protection advisory services and processing facilities available in rice belt from private sector. • Occasionally govt. support schemes in collaboration with potential donors placed for paddy maximization through outreach demonstrations and media manifested	• Ecologically Suitable of any other major crop cultivation in *kharif* season -- non-profitable except some vegetables. • Lack of knowledge about the application and possible impacts of using micro/macro nutrients especially zinc, boron and potash on the quality of grain kernel and productivity of paddy. • Less knowledge about the importance of using balanced fertilizer doses in paddy production – status manifested through observing frequent lodging of super basmati crop on maturity. • Absence of laws/ penalty/ standard operating procedures	• Extension of quality lab. Testing facilities warranted on no profit no loss basis for soil, water, quality testing of paddy products as well as chemical brands. • Rice cultivation areas' soil productivity of Punjab especially '*kalar*' tract is declining steadily--- design tailored farmers' trainings on maintaining long-term soil fertility management through adopting various crop rotations with the perspective of weed control, nitrogen fixation and organic matter building. • Awareness trainings management about the paddy related farm machinery use, maintenance and safety and acquisition on affordable prices through provision of tax holidays or subsidy system.	• Health hazard problems occurred to the chemical users and hefty cost have to bear by the consumers due to imbalance and heavy doses of pesticides applied on paddy crop. • Heavy windy rainfalls at the early and maturity stage of crop growth increase the risk and uncertainty to harvest good crop.

Areas	Strengths	Weaknesses	Opportunities	Threats
		(SOPs) about plantation of banned varieties, planting/ harvesting and moisture content-based pricing mechanism of paddy products	• Scope of higher yield Potential existed through abridging gap.	
Transportation	• Mostly appropriate farm to market road network present. • Tractor mounted Trollies used for transportation from farm to market. • No quality damage reported during transport.	• High diesel cost makes the transportation freight higher leading to reduce farmers' profit margin. • No feasible alternate transport works except tractor mounted trolley due to condition of road's network from field to nearby markets.	• A lot of scope available to improve the mode of haulage through packing paddy in sacks instead of carriage in, open lot, trolley in order to reduce losses while transportation.	• Uncertain/ risks of road accidents of trolley mounted tractors numerous—prone to death or sever injuries
Marketing	• Marketing and paddy procurement system well established in the vicinity of rice belt mainly through the regularized commission agents ('*Arthi*') and/or brokers ('*Pharia*'). • Large number of buyers and sellers of paddy and products in a market. • Farmers' loyalty often observed to sell their paddy produce from where one sought the loan to purchase necessary inputs including seed, fertilizer, pesticides,	• Significant gaps observed in offering of paddy products' prices among different commission agents/ brokers at different nearby markets for the same variety and grade of paddy. • Auctioning in the wholesale market with visual inspection of the paddy lots without gauging moisture content with moisture meter. • Farmer exploitation by commission	• An effective marketing laws provision demanded to implement in letter and spirit --- reduce the farmers' exploitation in the hands of '*Arthi*' • Scope of marketing information system promotion present through inking the agreement with electronic media including Cell phone companies. • Financial support by the commission agent to the paddy growers may be effective and instrumental to maintain quality harvest through	• Increased free entry of paddy growers in the market increase the competition at the cost of higher rejection rate of many marginal paddy products' growers, and their produce may fetch very low prices not even meeting cost of production. • Low receipt of marginal paddy prices leads to malpractices by the farmers as well as traders through mixing the rejected non-descript varieties

Areas	Strengths	Weaknesses	Opportunities	Threats
	fuel/ electricity bills, etc.	agents, who sought advance loans to purchase inputs via deducting high commission charges (i.e., upto 7% against produce value) as well as offering low prices against the produce. Moreover, these farmers also bounded, ethically, to sell their produce to the same '*Arthi*'.	entering into contract agreement (including buyback and input supply through technical supervision) with the growers.	with the similar superior quality rice products. • Illegal trading or smuggling a major threat through the neighboring country borders especially Iran & Afghanistan in the absence of materializing the advance orders.
Trade/Export	• Fine quality basmati rice with special characteristics like aroma, slender kernel and elongated grain size after cooking always fetch premium price locally as well as globally. • Quality/nutritious conscious consumers may like to pick from the available shelves of diverse rice products including '*Katcha Chawal*' of brown, white and silky rice & '*Pucca Chawal*'/ parboiled ('*Saila*') and steamed rice. • Consumers in low income brackets may enjoy the quality, nutritious dietary dishes with pleasant fragrance through picking low priced out of the available multiple	• Rising costs of production due to continuous up surging of factors of production including: high inflation, rupee's devaluation, rising gasoline, electricity agro-chemicals prices and labour charges. • Food safety and traceability standards of importing countries (i.e., Aflatoxin presence, SPS, HACCP, Global GAP, EuroGAP, TRIPS, etc.) especially Europe and Japan --- major obstacles to enter into high-valued global markets. • Presently, numerous rice	• Up gradation of existing quality labs to conduct desired tests as well as setting up of new labs meeting the standards of internationally accredited and approved labs. • Introduce more high value added and internationally registered patented/branded rice products for earning maximum revenue through local sale proceeds and foreign exchange, e.g., bran oil, baby foods, animal, poultry & fish, feeds and cosmetics. • Upgrading the rice shelling mills exhibiting technically and economically efficient operations in order to compete	• Sharp declining trading trend of Pakistani basmati rice in international markets mainly due to loosing trade competitiveness especially with the introduction of more cost-effective high yielding Indian fine rice variety of Pusa series ('Kainat') as well as aggressive marketing tactics adopted by the Indian traders. • High cost of investment on establishing accredited labs of international standards, and lack of awareness amongst the stakeholders, especially paddy

Areas	Strengths	Weaknesses	Opportunities	Threats
	range kernel sizes of broken basmati rice products viz., 3/4, 2/4, 1/4 depending upon consumers' affordability levels. • Pakistani rice traders including public and private companies exhibit trading potential of marketing/ exporting the quality paddy seed of fine and coarse varieties locally as well as globally	shelling machines installed in the rice belt but mostly running under capacity, and economically as well as technically inefficient due to obsolete processing mills	and meet international standards	growers, traders, processing mill owners, etc. • Lack of stringent quality control measures and its legitimacy effective for the trading commodities in consonance between the trading partners locally and globally.
Processing	• Well established age-old easy access to paddy processing (de-husking mills) facility in the rice belt of Punjab. • Abundant supply of modern rice Sheller/mills and processes plants in the rice growing belt.	• Notably large number of rice mills in the area in low operating inefficiency due to using obsolete technology of rice polishing as well as traditional modes of par-boiling and steamed facilities. • The rice recovery rate was severely damaged at harvesting stage due to using old wheat combines for rice harvesting resulting in higher broken rice ratios to head rice while processing rice by the mills.	• Up gradation and/ or replacement of milling technology, especially for parboiled and steamed processing plants mainly because of its high demand locally and internationally. • Sustainable demand for quality rice may be assured through up scaling more efficient milling technology in line with global SoPs, SPS and other WTO quality compliances, branding, patenting for fetching higher prices	• Quality processing of Pakistani basmati rice products of parboiled and steamed rice is fetching low revenue as compared to Indian products due to known and unknown reasons --- in depth analysis is wanted to unveil critical causes. • Basmati rice producers' earning share is relatively low than all of the stakeholders involved in the value addition chain of rice processing industry

6. CHALLENGES FACED BY BASMATI RICE CLUSTER

6.1. Fast Loosing Competitiveness

As noted earlier, the major threat to the basmati rice clusters, especially to *Katcha* Rice-Cluster-I production, is the stiff competition with India in traditional international markets. The changing consumers' behaviour from aromatic basmati towards long-grain non-aromatic basmati has resulted to plummet the export of aromatic basmati rice from Pakistan. These developments in aromatic rice may completely wipe out *Katcha*-Basmati Cluster-I, if serious efforts are not made to improve its competitiveness. The cluster has inherent disadvantage as its yield is relatively lower when compared to the non-aromatic basmati rice while it fetches almost same or even lower price than the *Pucca* rice. When compared with Indian, overall performance of Indian basmati varieties is relatively better as it gives about 53% higher yield than that of currently grown basmati varieties in the Pakistani Punjab (Bashir *et al*., 2018; Grover *et al*., 2014; Government of the Punjab, 2017). According to the farmers, Super Basmati is also gradually losing its yield potential.

The *Pucca*-Rice Cluster-II production also faces tough competition with India in international market. For the last two decades India has been ahead of Pakistan in releasing better yielding non-aromatic basmati rice. The latest comparison shows that the Pusa varieties like Basmati-1509 yields about 26% higher at average farmers' field than Pakistani PK-1121 (Kainat) variety. Overall, India has developed better parboiling technologies, while in Pakistan the efficiency of the technology is mixed. According to farmers, the PK-1121 is also gradually becoming vulnerable to many diseases.

To become competitive in basmati rice, Pakistan has to resolve technological, institutional, and economic issues in modern technology dissemination and adoption, improve the value chain management, diversify the rice-based manufactured product, and encourage an offensive drive to introduce its branded products. Some of the technology and institutional issue are further elaborated in the following sections.

6.2. Shortage of Planting Labour

In rice production, nursery raising and its transplantation is one of the most labourious and one of the major variable cost items. The period for this activity is June-Jul --- the hottest months of the year. Because of the good non-farm employment opportunities available in the area, the prevailing hot season and high hot-humid condition of the paddy field, the shortage of planting labour has increased wages and production costs. This increasing cost, unless resolved through technological innovation, may further deteriorate the competitiveness of rice production in Pakistan.

6.3. Improved Management Practices

In both basmati rice clusters, achieving fast diffusion of improved management practices is a big challenge because of considerable variations in soils, quality of surface and ground water available and socioeconomic profile of the farming community in the area. Moreover, supply-driven, bureaucratic, and top-down orientation of the extension system in the Punjab makes it difficult to bring a change in the existing practices and diffuse optimal agriculture management practices to farmers (Ali et al., 2018). A large number of demonstration plots which are planned and implemented by farmers' organization but supervised by experts would be required to promote optimal crop management practices under different socioeconomic conditions in each cluster.

6.4. Shifting to Kubota Type Rice Combine Harvesters

Too much manual paddy handling creates problems both in quality and quantity (NAPHIRE, 1997). Harvesting and its related handling operations are significant points in the post-production sequence because grain losses can be incurred (Samson and Duff, 1973).

The gradual shifting from manual to mechanized paddy harvesting in the rice-wheat area of Punjab dates back to the introduction of Basmati-385 when it had significantly higher yield compared to Basmati-370. The shortage of harvesting labour emerged as a major problem. The introduction of wheat combine-harvesters for paddy harvesting rescued the farmers, despite paddy and straw losses at harvesting and increased percentage of broken rice at milling. Secondly, the farmers have to either burn paddy straw and left-over stubbles in the field or utilize disc plows for preparing their fields for wheat plantation. The burning of rice in the field also created smog problem causing pulmonary diseases. The introduction of wheat straw chopper has provided another alternate. Despite these disadvantages, the shifting to mechanical harvesting was fast.

Recently, however, with the increasing concerns on the environmental impact of agriculture production, especially with smog, and high cost of the existing wheat combined harvester used in basmati, in terms of high broken percentage, changing basmati rice harvesting and threshing method has become essential as well as a challenge for basmati stakeholders and policy makers.

6.5. Aflatoxin Issue in Basmati Rice

The aflatoxin (AFs) contamination in domestic as well as export-quality grains is an important public health concern. Rice is highly vulnerable to fungal contamination owing to its cultivation in extremely wet field and harvesting in warm and sometime humid season (Sales and Yoshizawa, 2005). Delays in drying, incomplete drying, or uneven drying of harvested rice will result in quality and quantity losses, including yellowing and discoloration, reduced milling yields, loss of seed germination and vigor, and damage caused by insects that are more active at high moisture contents (IRRI, 2009).

The first warning shot about aflatoxin was heard in early 2006 when European Union rejected the rice consignments due to high AFs contamination (Saeed, 2006). Later, several studies found positive aflatoxin in various types of rice samples and AF-B1 the most frequently occurring contamination in Pakistan (Reddy and Waliyar, 2012, Firdous *et al*., 2012, Asghar *et al*. 2014 and Mukhtar, Farooq, and Manzoor, 2016). Due to improving awareness among advance country and urban consumers, this situation may cause a serious threat to the rice sector especially for its export.

6.6. Diversification of Processed products

Pakistan until recently has concentrated only on basmati aromatic (*Katcha)* rice. However, with tough competition with India, the single commodity value chain will not work. To become competitive, Pakistan has to diversify its basmati-based value chain product. Rice bran oil presents one such opportunity. This is also necessary because India is already extracting and exporting rice barn oil which has given an additional competitive advantage to the value chain stakeholders.

Rice seed or the paddy kernel is covered with two layers: bran (the inner layer) and husk (the outer layer) (Figure 8). Paddy becomes rice only when the two layers are removed properly through milling. During milling, first brown rice is extracted by removing the husk from paddy, leaving the bran layer intact around the kernel --- this process is called “husking”. In the second step, the bran layer is removed by polishing machines that rub the gains together under pressure --- this process is called “milling”. The output is a polished white kernel or fine rice, which is ready for cooking (Patil, 2011; TDAP 2010). In general, the term rice milling implies both husking and milling.

Figure 5: From paddy grain to rice bran to rice bran oil

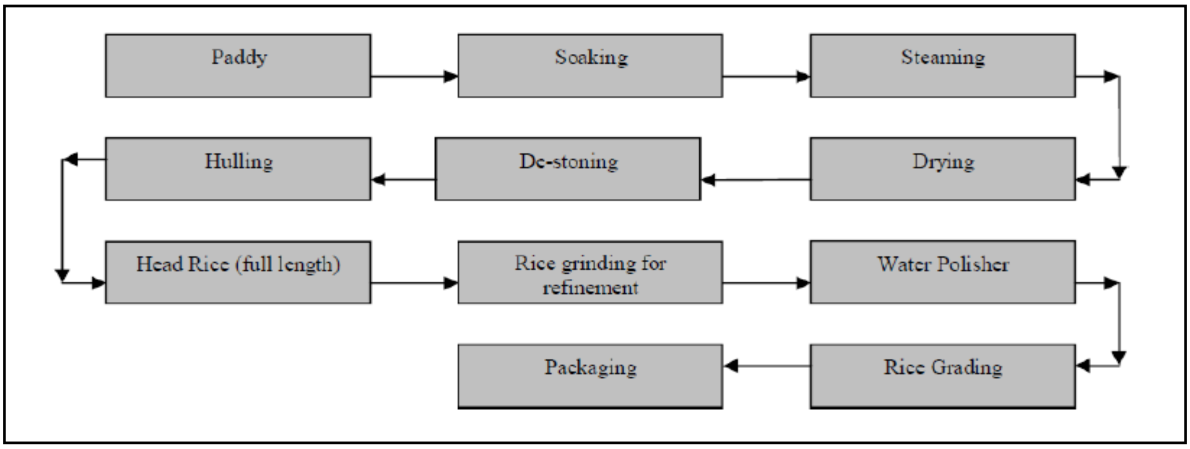
Pakistan has a great challenge to indigenize this technology; otherwise, the country will further loose its competitiveness with India in basmati value chain. Bran oil extracting machinery is costly for Pakistan as India is one of the leading countries in rice bran oil technology. Its’ per litter cost is close to sunflower oil. Thus, currently bran oil extraction can be commercially viable if it fetches as high price as sunflower oil. However, by indigenizing the technology, the cost can be decreased significantly (for costs details of bran oil, See Annexure-6). Rice bran oil can also be blended with other oils in many countries including India (The Express Tribune, 20th August 2014) https://tribune.com.pk/story/750936/innovative-concepts-setting-up-pakistans-first-rice-bran-oil-plant/

6.7. Low Efficiency in Parboiled/*Saila* Rice Production Technology

Parboiling means is precooking of rice within the husk. Parboiling makes rice easier to process by hand, improves its nutritional profile and changes it texture. Removing the bran layer manually is easier if the rice is parboiled, however, somewhat more difficult to process mechanically. The bran of parboiled rice is somewhat oily, and tend to clog machinery. Most parboiled rice is milled in the same way as white rice. Parboiling rice drives nutrients, especially thiamine, from bran into the grain, making it 80% nutritionally similar to brown rice. The starches in parboiled rice become gelatinized, making it harder and glassier than other rice. Parboiled rice takes more time to cook, and the cooked rice is firmer and less sticky (Sindh Board of Investment, 2010).

Realizing several advantages of parboiled rice, India has mastered not only in its processing but also in marketing. As noted earlier, India used this product not only to expand basmati rice market, but also to encroach on Pakistani basmati share. Pakistan came late in the par-boiled rice technology and feel threat to further loose basmati market unless it gets mastery in parboiling technology and marketing of parboiled rice. The efficiency of processing paddy into *Saila* in terms of the quality of the produce and ratio of broken rice is low compared to India --- converging into higher milling costs. In addition to the yield gap between Indian and Pakistani in non-aromatic varieties, the gap in the efficiency in parboiling cost must also be closed.

Figure 6: Parboiled/*Saila* Rice Making Process



7. CLUSTER DEVELOPMENT POTENTIALS

7.1. Dissemination of High Yielding Varieties

RRI, Kala Shah Kaku has released three varieties in 2016 for general cultivation namely: Kissan Basmati, Punjab Basmati and Chenab Basmati. These varieties, as claimed by the institute, are better yielding as compared with Basmati Super. Moreover, they are early maturing and have better head rice recovery and grain length as compared to Basmati Super. Kissan Basmati has better average and cooked grain length than Super Basmati and PS-2. Punjab Basmati being short stature and stiff stem is resistant to lodging. Chenab Basmati is moderately susceptible to Bacterial Leaf Blight (BLB), Paddy Blast (PB) and Stem Rot. On the other hand, NIAB, Faisalabad has also released two basmati varieties during the last 10 years. These varieties have performed better in paddy yield in NURYT than earlier cultivated varieties, and are 2-week early maturing as compared with Basmati Super. The variety is also cold tolerant and can be planted in high altitudes. NIAB Basmati 2016 is also suitable for *Kallar* tract. Noor Basmati is extra-long and early maturing as compared with Basmati Super and other field varieties (Bashir *et al*., 2018).

The BLB, Paddy blast, stem borer, etc. are the major threat for Basmati rice. At present, some mildly susceptible BLB resistant varieties are available. As per demand of REAP (Rice exporters Association of Pakistan), PS-2 fine extra-long grain rice without significant aroma has been approved in the recent Punjab Seed Council meeting held in 2018 with a new name of PK-1121. Rice exporters did not wait for release of new variety and brought Indian extra-long grain varieties to meet the demand for extra-long-grain. Recently Kainat-1509 and Kainat-1401 brought from India are at adaptability stage at the farmer's fields (Bashir *et al*., 2018).

These efforts in developing and adapting new basmati varieties, both aromatic and non-aromatic, are commendable. Although, generally, it is claimed that the new varieties are higher yielding as compared with Super Basmati. However, these varieties could not get popularity among the farmer as Super Basmati is still the major basmati variety cultivated in *Kallar* tract. Although, PK-1121 has been recently officially approved, but it has been already adopted by majority of farmers in *Pucca*-Basmati Cluster-II. However, we believe that if new available approved varieties are properly pushed through a campaign, the average yield in Cluster-I can be increased by 10%, while 20% in Cluster-II. Higher anticipated potential in Cluster-II is because of the higher gap between the experiment and average yield of Kainat type long-grain (non-aromatic) varieties.

7.2. Shifting to Mechanical Rice Transplanting

At present, basmati rice is mainly transplanted manually. The desired plant population for basmati rice is nearly 200 thousand. In a recently conducted survey, the average plant population was found ranging between 124 to 148 thousands per ha compared to the recommended level of 250,000 plants per ha.

Technologies are already available for mechanical planting. Several versions of Chinese, Japanese and even locally developed transplanters are available in the market. It must be noted the mechanical trans-planter as such is not successful unless the whole package including nursery and field preparation, irrigation, and transplanting are promoted as a package. The Agricultural Mechanization Research Institute (AMRI) Multan, Agricultural Engineering Faculties and Departments in Agricultural Universities, and Agricultural Engineering Institute of PARC are already trying to popularizing the use of mechanical rice transplanting (Farooq *et al*., 2001).

Recently, few progressive farmers imported Chinese rice transplanters and have successfully used it for rice transplanting in on a large area in Hafizabad district. They have established success stories and some service providers have also now involved in the diffusion of mechanical transplanting package in basmati rice farming communities.

The mechanical transplanting, as reported by few farming communities who have adopted this technology, can save more than 82 percent labour and increase plant population by nearly 18 percent compared to manual transplanting (Bashir *et al*., 2018). It can be anticipated that application of other inputs according to plant population shall certainly contribute in increasing paddy yield in the area. Hence, it can be easily assumed that mechanical transplanting can increase existing yield by at least 15%.

7.3. Improving Rice Crop Management Practices

Significant yield gap of about 50% is observed between progressive and average farmers both operating in similar localities (Punjab Agriculture Sector Plan, 2015). Earlier studies, especially in rice in the 1990s, suggested that variation in the quality of farmers' natural resources base could cause part of the yield gap (saline or waterlogged land, for example, or poor-quality water and substandard seeds), but a significant portion can be attributed to poor management practices, indicating weaknesses in access to institutions such as information and input-supply markets (Ali and Flinn, 1989 and Ali, 1995).

Farmers are cultivating rice since decades, however, when new technologies like varieties, chemicals, management practices, etc. are introduced, their knowledge about latest development in production technologies need to be upgraded on regular basis for sustained productivity growth along with conserving agricultural resource (Ali and Byerlee, 1991). According to the extension workers in each cluster, the farming community is already being educated on the updated knowledge about day-to-day developments in crop farming through electronic and print media along with demonstrating various technologies through workshops/seminars/demonstration plots/farmers' field days of the departments of agricultural extension, agricultural advisory services, etc. However, results are not very effective, as it is mostly supply driven (Ali et al., 2018). If advisory service is made more target and result oriented, this can significantly improve the farm management practices and harness yield potential. However, acknowledging the slow institutional change, we assume that only 5% increase in yield is possible through improved management practices.

7.4. Introduction of Kubota Paddy Combine Harvesters

Currently almost 80 percent of paddy harvesting is done by using combine harvesters initially designed for wheat, which results in grain shattering and a fairly high proportion of rice loss at milling stage in the form of broken rice, particularly in *Katcha* rice. Moreover, the basmati rice straw is lost in the field.

The introduction of combine rice i harvesters (called Kabota) by some progressive has created a great opportunity to address these issues. At present, this intervention is at infancy stage. To diffuse this technology at a faster rate so that the entire paddy area can be served with Kabota within five years span;, however, it will require certain incentives. But once adopted, it can save at least 15% of the harvesting losses. This will not only result in saving farmers' loss of paddy due to shattering and rice straw in the field, but also address environmental issues plus easy land preparation for the cultivation of following wheat crop.

7.5. Addressing Aflatoxin Issue by Introducing Paddy Dryers

Keeping the paddy moisture-content between 14-20% and its temperature below 15^{o}C are the key to keep aflatoxin at bay and this activity needs to be done before rice grain reaches in the hands of rice millers. However, paddy is harvested in Punjab during October and November with ambient temperature is relatively low and relative humidity is fairly high, both of which induces aflatoxin infestation. Moreover, farmers and traders prefer to sell wet rather than dried paddy due to lack of their access on drying infrastructure. Some traders consider drying as expensive and non-profitable business, although the claim needs to be proven (Swaskita, 2012).

In rice shellers, paddy is normally sun dried before husking. The problems of using sun-drying floor are: i) needs more space, while land is becoming limited; ii) fully depends upon weather condition, therefore, the frequency of hot-sunny days is low during wet and cold seasons; iii) causes a higher loss due to animal and other disturbances; and, iv) results in low quality of grain due to sudden rains, dust and other foreign materials contamination (Nugraha *et al*., 2007; Swastika and Sutrisno, 2010).

However, new opportunities have emerged with the invention of solar drier. The use of mechanical drying systems offers so many advantages over sun-drying like maintenance of paddy quality, safe drying during rains and at night, increased capacity, easy control of drying parameters and the potential for saving on labour cost. The solar drying can be provided to Basmati Farmers Entrepreneur Groups (FEGs) at union council level, so that when paddy comes from the field, it can be dried before it is delivered to traders or rice sheller owners. This can not only improve the quality of rice, reduce post-harvest losses but also minimize farmers' exploitation due to arbitrary hand-felt method of moisture measurement by traders. There is considerable scope for improving farmers' returns by introducing paddy solar dryers to farmers as they have to face price cut from 9 to 13 Rs./kg (which can be saved) if fungal infestation is detected in their produce (Bashir *et al.*, 2018). The benefits, constraints, and pre-conditions for introducing solar driers are elaborated in Table 12.

Table 9: An Overview of Economic Benefits, Pre-Conditions, and Constraints of Mechanical Drying

Sr. No.	Economic Benefit	Pre-Condition	Constraints
1.	Increase market value of (better quality) paddy	• Existing and significant price differentiation for different quality levels, must compensate for drying cost-plus weight reduction occurring during market access	• Little differentiation of quality in the markets • Little implementation of standards
2.	Secure income from minimizing weather risks	• Significant discount for spoilt or wet paddy	• Need to sell immediately after harvest • Discount do not cover drying cost
3.	Increase income from being able to process more grain in a given time	• Possibility of buying additional wet paddy	• Limited working capital

Source: Rice Knowledge Bank, IRRI, Philippines[5].

Studies conducted in Thailand and Cambodia showed that the cost of drying in both countries is equivalent to 4% of total paddy production cost. All the dryers that were successfully commercialized in Vietnam have drying cost <5% of the paddy value. Case studies in other Asian countries indicate that mechanical dryers with cost higher than 5% of the paddy value cannot be introduced successfully (Rice Knowledge Bank, IRRI, Philippines). In feasibility study carried out in Indonesia by Swastika (2012) revealed that the use of mechanical dryers proved to be highly profitable compared to sun-drying at the floor. Paddy drying at farm level using mobile paddy dryers is becoming gradually popular in India.

We assume here that the farmers will receive 20% higher paddy price after solar drying. Seven percent of this premium will be due to the reduction in moisture content from an average of 25% to 18%, while 10% premium will go due to improvement in quality such as reduction in aflatoxin and broken percentage. With these assumptions, farmers will receive additional revenue of US$21.6 million in Cluster-I and 19.0 million in Cluster-II.

7.6. Improved Processing

Diversifying the range of basmati products like brown rice, single and double polished/silky rice, and *Saila*/steamed rice can help Pakistan to gain its share in international market as these products have high potential demand in national and international markets. For example, Pakistan's foods industrial sector, Matco Foods (Pvt.) Limited, Karachi has recently opened

[5] [http://www.knowledgebank.irri.org/step-by-step-production/postharvest/drying/economic-aspects-f-drying]

up new avenues by diversifying the by-products of basmati rice through its operations and now producing rice glucose and rice protein that are mostly used in pharmaceutical, confectionery, juice and other such finished food products. The company has recently raised Rs.757 million with total issuing of over 29 million ordinary shares. Since rice glucose is not extracted from genetically modified (GM) food, it has huge demand in industrialized countries where health-conscious consumers prefer it over glucose that is extracted from GM food. Currently, Matco exports 75 percent of its rice glucose production to international markets where it is priced at around $11,000 per tonne against a price range of just $400-500 per tonne in the domestic market. Hopefully, future market trends are expecting to be rising bullishly, if export policies and quality issues will be addressed appropriately.

7.7. Introduction of Rice Bran Oil Expellers

Rice bran is the thin layer between hull and white rice produced from the paddy during milling (Figure-3). Rice bran is high in vitamins and nutrients, while its oil lowers cholesterol in healthy, moderately hyper-cholesterolemic individuals. According to American Heart Association, rice bran oil is the healthiest edible oil in the world.

Rice bran oil expelling relies on high quality rice bran oil expellers and its state-of-the-art technology is available with India – though expensive. During oil extraction, rice bran is put into the feeder of expeller. As the screw worm transports rice bran forward, the space becomes smaller and smaller, thus squeezing rice bran oil out. The extracted bran oil seeps out though a small opening in the bottom of the squeezing barrel, where rice bran oil cake cannot pass through, thus, separating rice bran oil from oil cake. At present, two imported brands namely Seasons Rice Bran Oil and King Bran Oil are marketed in Pakistan. Keeping in view the interest of certain class of consumers, there are chances of popularizing it on the lines of Canolive and Corn Oil in Pakistan.

Our estimates show that sufficient quantities of raw material, i.e. rice bran, is available in the area and at least two such units can be installed in Cluster-I. These plants can produce over 447 tonnes of rice bran oil to arrest the target of about 900 tonnes of rice bran product. If properly popularized, these supplies of bran oil can be domestically consumed which can give a big relief to the edible oil import in the country and save huge foreign exchange. Some of these supplies can also be exported which can earn foreign exchange earnings. However, for this proper financial and technical support to the private sector would be needed. One technical issue is that the bran must be used in oil extraction within few hours after it is produced during rice milling, otherwise oil quality in it gets deteriorates. However, there are several technologies available to preserve the bran for several weeks with simple technologies like heating and using chemicals.

7.8. Improving Parboiled/*Saila* Processing Technology

As noted earlier, the demand for parboiled/*Saila* rice in Pakistan and abroad is increasing due to its widespread uses in various dishes served in hotels, restaurants, marriage halls and the vendors. The price for *Saila* rice is also higher than the *Katcha* rice in domestic and international markets. The reason reported is relatively easiness in cooking compared to

Katcha rice. According to the cooking experts, while cooking *Katcha* rice, the quantity of water used should be according to the age of rice, whereas such problem does not exist with *Saila* rice. After cooking, the *Pucca* rice looks more separated and longer thus attractive. On production side, the soaking, heating and drying methods in *Katcha* rice are old fashioned and carried out manually before selling it for milling. Moreover, farm yield of *Saila* (Kainat) rice is higher than the old aromatic basmati rice.

These changes in market and technology have created significant potential for all stakeholders along the basmati value chain for increasing the proportion of *Saila* rice and upgrading the *Saila* processing technologies. Our consultation with stakeholders suggests that currently about 60% of Kainat produce in Cluster-II is utilized in *Saila* processing, which can be increased to at least 80% to utilize almost all the *Kainat* production in the cluster. It means the focal point of Cluster-II (just district Hafiz Abad) has the potential of producing additional of over 64 thousand tonnes of *Saila.*

The continued increasing demand for *Saila* in the Middle East and within the country suggests that additional supply can be absorbed in the national and international market. The upgradation of *Saila* processing technology shall reduce *Saila* rice manufacturing cost, which is currently expensive compared to *katcha* rice. Moreover, incentives in establishing *Saila* manufacturing plants shall help the private sector to not only meet the national and international demands but also to compete with India in the Moiddle East. Raising the proportion of *Saila* rice to 80% in Cluster-II will generate additional revenue to the processor to the tune of US$9.68 million assuming it fetches higher price of US$148 per tonne compared to the *katcha* rice.

8. CLUSTER UPGRADATION PLAN, POLICIES, AND STRATEGIES

8.1. Plan

After reviewing the constraints and potentials of basmati clusters, targets are fixed with the consultation of stakeholders: The purpose of whole exercise is to develop a research-based cluster development plan for basmati rice to achieve the targets presented in the following Table.

Table 13: Targets of Basmati Rice Cluster Plan

1.	**"*Katcha*" Basmati Rice-Cluster-I**: Increase yields by 10% from the current base to over the five-year period through improved varieties. **"*Saila*"- Parboiled/ Steamed Rice – Cluster -II**: Increase yields by 20% from the current base to over five years through improved varieties.
2.	Increase in yield by 15% through the introduction of mechanical transplanter on 50% of the area in both clusters
3.	Increasing yield by 5% in Cluster-I and 12% in Cluster-II through improve management practices.
4.	Reducing harvest and post-harvest losses by 62% (from 13% to 5% in both Clusters) through appropriate harvesting and drying technologies.
5.	Improving quality of the product by introducing proper drier at the farm/service providers/market level to yield aflatoxin and dumping free product that can add about 25% price in the original price of paddy in both the clusters.
6.	Utilization of most of the rice bran in brain oil manufacturing in Cluster-I through incentivizing oil expeller.
7.	Increasing processing of *Saila* rice and its proportion as compared to the *katcha* rice to meet the international rising demand of the former.

8.2. Policy Reforms

The policy makers must realize that direct income subsidy to farmers, like the one in 2016, which cost billions of Rupees, will not improve the competitiveness of basmati rice production. It must be stopped and the money should be channeled towards reforming institutions, improving infrastructure, building capacities of the stakeholders for the purpose of improving competitiveness of the sector. Any support must have clear target towards this goal and must be continuously evaluated.

Firstly, there shall be clear long-term vision of the government about the basmati sector which clearly sets policies and targets with respect to the type of basmati rice and its byproducts including *Saila*, brown rice, rice bran oil, etc., the country should go in the future. The status of the sector vis-à-vis industry must be clarified.

Secondly, basmati trade policies shall follow the long-term vision about the sector and be proactive in view of the changes in international market. Efficient and possibly duty free trade pacts with importing basmati rice countries, especially with Iran and Middle Eastern countries shall actively be negotiated. Negotiation shall be made with Iran to convert Preferred Trade Agreements (PTA) into Free Trade Agreement (FTA). Alternate more efficient banking arrangements will be negotiated with Iran so that the trade is not affected by the American sanctions. New basmati rice markets in Europe, Far East and North America shall be explored.

Thirdly, the R&D system shall be reformed to make it more responsive to resolve the issue along the whole value chain. The private sector shall be encouraged to get engaged in varietal development, especially in basmati hybrid where any innovation can be protected. The public sector research institute shall move towards those issues which currently private sector is not addressing, like developing efficient high-yielding *Saila* varieties that can compete with India in productivity and quality, develop SOPs for efficient management practices to improve productivity and sustainability, and provide cheap machinery models and SOPs for bran oil manufacturing, efficient SOPs for *Saila* manufacturing, etc. The approval of varietal development shall be made transparent and efficient. The system will be made financially and administratively autonomous from the bureaucratic control and snags.

Fourthly, support shall be provided to organize Farmers Entrepreneur Groups (FEG) which shall become the focal points for basmati upgradation Plan. The groups will become a key in ensuring quality to millers and traders thus induce quality and price-based contract farming with commission agents, traders and processors.

Fifthly, the public sector especially Ministry of Commerce will work with the private sector, like REAP, in analysing the changing market demand trends in basmati rice and its quality requirements in national and international markets and disseminate these to various stakeholders like traders, mill owners, and FEGs.

Finally, any upgradation plan for basmati rice would require huge operational costs in terms of additional inputs, machinery, technical skills, etc. that has to be borne by the stakeholders themselves and usually not accounted in development plan. In the proposed upgradation plan, financial system will be made to supply the loans to meet additional operating costs to farmers, traders, processors, and other stakeholders along the value chain.

8.3. Formulation of FEGs

- At each union council level, Farmers Entrepreneur Groups will be organized with the help of NGOs like NRSP who have main focus on social mobilization.
- Basic infrastructure like shed for collection point, room for storage and drying will be built by the government although land will be provided by the FEGs.
- Management of the collection center will be through a hired manager by the FEGs through consensus but initially paid by the government.
- All incentives and capacity building training would be channeled through FEGs.

- The members of the groups will be trained as demanded by the majority of FEGs. They can pick any or all of the training modules including good agricultural practices, IPM on pest especially weed management, setting up demonstration fields for variety testing and good agricultural practices, mechanical drying of paddy, mechanical transplanting, etc. These modules will be developed by the specially hired experts for this purpose.

- The FEGs will also be given priority on specialized loans for the purpose of promoting mechanization of the rice value chain.

- The groups will be encouraged to start quality- and fixed price-based contract with rice mills and traders. The main responsibility of FEGs would be to ensure quality.

8.4. Reforming the R&D System

To reform the research basmati research system, US$ 1.85 million has been allocated, for each cluster, to address issues related to Cluster-I and Cluster-II. This fund will be allocated on output-oriented research project in each cluster. For the sustainability of any development effort, the provincial and federal R&D system will be reformed on the following lines:

- From the total R&D funds, special funds will be confined to enhance research collaboration between international universities and rice related research organizations, like International Rice Research Institute (IRRI), Australian Collaboration for International Research (ACIAR), etc. for sharing advanced germplasm/nurseries and collaborative research on strategic basmati rice issues.

- Unfreezing and redirecting the cess funds for creating its Research Endowment Funds for financing rice research activities in Pakistan. Some of the funds will go to FEGs to conduct the group level activities, like seed and seedling production, training of farmers, etc.

- The Commodity Board on basmati rice will be given more autonomy to decide and monitor the research conducted in Rice Research Institute Kala Shah Kaku, NIBGE, etc.

- The extension wing of Agriculture Department will be made more responsive to the needs of the farmers, traders and processors. New dedicated and professionally sound staff will be hired to implement the Plan. They will set up demonstration and conduct training as per demand of the FEGs and trade and processors associations. The quality and outcome of the training and advisory services will be monitored by the stakeholders.

- Detailed and practical modules will be developed for the capacity building of farmers for good agriculture practices like: i) testing the latest released basmati rice varieties and other management practices on their own farm; ii) mechanical rice transplanting for achieving recommended plant population; iii) periodic use of laser land levelers for saving water and better pegging of better nursery plants during mechanical transplanting; v) proper decomposition of Farm Yard Manure; vi) use of balanced dozes of fertilizers; and vii) application of Integrated Pest Management, especially weed management practices. These modules will be implemented as per demand of FEGs through the private sector.

- Collaboration with local and international rice related organizations and universities will be improved. International and local consultants will be engaged in conducting trainings of the extension staff and researchers on strategic issues like bran oil production, research on bacterial leaf, maintaining the quality of basmati rice during production, drying, and processing, etc.

- Competition among researchers, extension agents and development partners will be held for their best contribution in identifying and resolving the issues along the value chain.

8.5. Enhancing Adoption of Recently Released Basmati Varieties

During the field visit, it has been observed that a critical mass of seed dealers (mostly also dealing with rice weedicides and insecticides) is present in both Cluster-I and Clusters-II. These seed-cum-insecticide dealers can be purposefully engaged for providing certified seed of latest released basmati rice varieties. However, in the backup, a well supervised and fully certified system of seed production, grading and packaging system will be established. For this purpose, the following measures will be taken:

- FEGs will select progressive farmers within the group for producing certified seed of latest approved varieties under the direct supervision of scientists at Kala Shah Kaku, NIAB, NIBGE and PARC as well as member farmers within the FEGs.

- The FEGs will be linked with the service providers of mechanical rice transplanting in the area for supplying certified nurseries of latest released varieties to other farmers in the rice belt of Punjab.

- Establishing nursery production centers which produce certified seed nursery on scientific grounds within each FEGs and supply it to farmers on subsidized rate.

- Providing financial support to FEGs in engaging certified seed production and the service providers of mechanical rice transplanting in the area. Financial incentives will also be provided to the scientists extending their supervisory services in producing certified seed.

- Provision of nursery of certified seed at subsidized rate during project period in order to achieve early spread of modern basmati rice varieties on farmers' fields.

- FEG member farmers will be trained for certified seed production and nursery raising.

8.6. Yield Improvement by Better Crop Management Practices

To bridge the 50% yield gap between farmers and experiment station, following measures will be taken:

- The skills of farmers and other stakeholders in the value chain will be continuously updated on new emerging methods of cultivation. Incentives will be provided to FEGs establish demonstration plots by the selected members of farmers in the group under the guidance of experts of Agriculture Department and Universities on the issues the group consider to be important. However, the FEGs will be made aware of the new cultivation methods and their anticipated impact on yield and costs, such as DSR, mechanical transplanting, optimum use of fertilizer, proper decomposition of manure and its use, etc.

- The key staff of Extension Wings of Agriculture Department will be trained on the DSR and mechanical rice transplanting for achieving recommended plant population, efficient decomposition and use of farm yard manure, application of balanced dozes of fertilizers; and application of recommended doses of plant protection chemicals. This staff will train the selected members of FEGs on these issues as per their demand.

- Training of farmers and service providers on FEG demanded issues on modern methods of rice cultivation.

8.7. Mechanization of Basmati Value Chain

Several opportunities exist to mechanize the basmati value chain which will be actively pursued through the FEGs and the private sector. The increased operating costs of these machines will also be facilitated by providing soft loans. Following specific strategies will be adopted to mechanize the basmati value chain in each cluster.

8.7.1. Mechanical Transplanting

- Mechanical transplanting can significantly improve productivity by bringing optimum plant population. Keeping in view the rising demand and interest of the farmers for having mechanical rice transplanters, the interest free loans worth of about US$3.5 and US$2.3 million are assigned for Sheikhupura and Hafizabad clusters staggered over the four-year period. A total of 79 and 52 mechanical transplanters will be subsidized in Cluster-I and Cluster-II, respectively. These transplanters will be preferably given to the members of FEGs or to the nearby service providers in the focal point.

8.7.2. Mechanical Rice Harvester (Kubota)

- As noted earlier, the mechanical rice harvesters can significantly reduce the harvesting losses and mitigate environmental pollution. Providing financial support to the agricultural service providers of Kubota combined harvester by offering interest-free loans by the ZTBL and other commercial banks in the area. The total number of harvesters needed for the focal point of Clusters-I and Cluster-II would be 158 and 40, respectively. The total interest free loans needed for this purpose would be US$11.7 and US$ 2.9 million respectively for Cluster-I and Cluster-II staggered on for four-year period. These harvesters would be preferably provided to the FEGs and its costs and benefits would be shared proportionate to the investment by the members. The nearby service provided to each cluster can also apply.

- To popularize the Kubota-rice combine harvester, the paper industry would be engaged for ensuring better prices for the extra available rice straw.

8.7.3. Introduction of Paddy Dryers at Farm Level

- The provincial wing of Agricultural Research and some innovative technological services providers will be engaged to single-out the most successful dryer suitable to our agro-ecological conditions and within the economic access of the farming community in the area.

- Based on the recommendation, various types of dryers (e.g. mobile dryers, solar bubble dryers, solar dryers etc.) already used in various countries in Asia will be introduced in the focal point of both the clusters.

- A total of 290 driers in Cluster-I and 235 driers in Cluster-II would be sponsored in the cluster focal points of each cluster costing US$12.9 million and US$10.4 million in respective cluster. These driers would preferably be provided to the FEGs where return would be proportionately shared according to the investment made by the members of the group. Each farmer will be charged for the services rendered to him/her.

8.8. Diversification of Rice Value Chain

Diversification of rice value chain, especially in Cluster-I is very important due to the declining demand for the main product, i.e., aromatic polished rice. As discussed earlier, several opportunities may be explored, but strategies to promote rice bran oil are discussed and *Saila* rice is discussed.

8.8.1. Introduction of Rice Bran Oil Extraction Unit

Installation of Rice Bran Oil Extraction unit is an intervention not being picked by the private sector in Pakistan despite considerable quantities of rice bran is produced/available in the Cluster-I. Moreover, India is successfully producing rice bran oil and exporting to the world; so why not Pakistan? Following strategies are proposed here to install rice bran oil mills and promote its use in the country:

- The government will provide interest free loans on four-year maturity basis to install two rice bran oil mills,

- The import of all machinery used in bran oil production will be duty free.

- The rice mills will be given special tax incentives to install rice bran politicization plan to stabilize the oil quality for several months.
- Farmers Entrepreneur Groups will be given priority for such loans.
- Side-by-side research will be outsourced to indigenize the bran oil extraction technology by reverse engineering or making small sized units.
- The bran oil will be promoted among consumers through media campaign.

8.8.2. Upgrading Parboiled/*Saila* Rice Production Technology

Keeping in view the rising prospects of marketing of parboiled basmati rice in domestic and international front, there is a strong felt need to upgrade existing parboiled paddy preparation technology in the Cluster-II where varieties suitable for parboiling are already grown.

- The production increasing intervention of Kainat in Cluster-II will provide increased raw material for *Saila* making.
- As parboiled paddy production requires only three operations, i.e. soaking, steaming and drying, the paddy drying intervention above will be dovetailed with *Saila* making. The mobile paddy dryers will be introduced for *Saila* paddy manufacturing afterwards.
- Interest free loans on four year-terms will be offered to set up the new *Saila* plant in Cluster-II.
- Special incentives will be provided to export *Saila* to Middle East to enable the traders to compete with India.
- *Saila* consumption will also be promoted to consumers in domestic market.

8.9. Strengthening International Linkages

Pakistan lost the international basmati market mainly because of its poor international links and lack of analysis of the international trends. The country has to pay a great cost for this. To avoid this happening in the future, following strategies are suggested:

- A Market Research Cell will be established at REAP that will continuously analyse the international trends in basmati rice markets in major basmati importing countries, including total quantities imported, quality, prices, domestic production and prices of basmati in Pakistan and India, technological development in the basmati sector (production, processing, trade, etc.) in both India and Pakistan. The cell will also forecast the market situation for short and long-run. These trends will be regularly and timely communicated to the traders, research station, FEGs and advisory will be issued for necessary action to all stakeholders along the value chain.

- Competition among traders will be held and awards will be given to best performing trader groups.
- Study tours will be organized to explore new potential market and devise strategies to explore these markets.
- Organize rice cooked dishes gala amongst international buyers of basmati rice.
- Branding of basmati produce will be encouraged through TDAP and REAP.
- Some international exhibition in the rice-wheat belt of Pakistan for the basmati rice importers of the world with due arrangements for field visits and visits of the rice processing mills for the trust building on quality.

9. FEASIBILITY ANALYSIS OF UPGRADATION PLAN

In line of the above strategies, various interventions are designed to improve the competitiveness of each cluster's products. Consequent upon the field survey of the *Kalar* tract are consultations with stakeholders --- farmers, commission agents (*Arthi*), processors/rice mill owners, traders and public & private institutions --- we conclude that there is discernable potential available for overall improvement in the performance of both clusters in myriad ways. Based on this field work, six interventions are suggested in each cluster that warrants improvements to boost efficiency of basmati rice value chain. These interventions are:

1. Yield Improvement by Diffusion of Modern High-yielding Varieties
2. Gradual Shifting from Manual to Machine Transplanting
3. Yield Improvement by Better Crop Management Practices
4. : Introduction of Rice Combine Harvesters
5. Addressing Moisture/Aflatoxin Issues by Introducing Dryers at Farm and Market Levels
6. (a) Oil Extraction from Rice Bran - *Katcha* Chawal Cluster-I and

6 (b) Improvement in Parboiled/*Saila*-Rice Making Cluster-II

In this section, these suggested interventions along with their underlying assumptions are explained. Their impacts on productivity enhancement, gross revenues, increase in costs, net returns, and investment requires are estimated. Then Internal Rate of Return (IRR) and Net Present Value (NPV) of the whole package of intervention are quantified. We also explained these parameters for the Key Product Intervention, which is bran oil in this case, at the end of this section.

9.1. Baseline Status or Prevailing Situation

9.1.1. *Katcha Chawal* Cluster-I: Benchmark

At present during 2016-17, basmati rice mainly aromatic is produced on 158.23 thousand ha which supply nearly 290 thousand tonnes of basmati paddy in the focal district, Sheikhupura of Cluster-I. The annual yield growth is estimated (based on recent past 17 years) to the extent of 1.14 percent. It is worth noting that price of paddy as well as clean rice in the Cluster-I was calculated as weighted price (i.e., based on the weightage allotted to super basmati equal to 70 percent and basmati-386 equal to 30 percent). Without any intervention, assuming the existing growth rate in yield, the expected production shall reach to the level of 306.76 thousand tonnes worth valuing to the tune of US$115.77 million at the farm gate prices (i.e., @ 377.38 USD/t) during the 5th year of the project as benchmark level. The expected production of clean rice from the basmati paddy would yield 199.40 thousand tonnes (@ 65%

recovery rate of clean rice from paddy) valuing worth 172.43 million USD at wholesale level (i.e., price @ 864.76 USD/t) on 5th year of the project life (Table 10).

Table 10: Benchmark Status of the *Katcha Chawal* Cluster-I in Sheikhupura District

Sr. #	Items	Inputs	Year-2	Year-3	Year-4	Year-5
1.	Area under cultivation in focal point (ha)	158,230				
2.	Total production in the focal point area (tonnes)	289,840				
3.	Baseline yield (tonnes/ha)	1.83	1.87	1.90	1.92	1.94
4.	Annual yield growth without intervention (%)	1.14%				
5.	Annual expected production (tonnes)		296,472	299,864	303,294	306,764
6.	Farm gate price of basmati paddy (US$/t)	377.38				
7.	Total value of basmati paddy (Million US$)		111.88	113.16	114.46	115.77
8.	Existing clean rice-paddy ratio (%)	65.0%				
9.	Annual expected production of clean rice (tonnes)		192,707	194,911	197,141	199,397
10.	Price of clean rice at wholesale level (US$/t)	864.76				
11.	Annual expected value of rice (Million US$)		166.65	168.55	170.48	172.43

9.1.2. Pucca/Saila Chawal Cluster-*II: Benchmark*

The benchmark information about focal district, Hafizabad, in Cluster-II exhibits 104.41 thousand ha of land under basmati rice cultivation that produced 213.30 thousand tonnes of clean rice (i.e., yield @ 2.04 t/ha) during 2016-17 year. The annual yield growth is estimated as 1.14 percent (based on recent past 17 years). The expected production level of paddy will reach to the level of 225.755 thousand tonnes worth valuing to the tune of 96.21 million USD at the farm gate prices (i.e., price @426.19 USD/t) on arresting 5th year of the project without any intervention. The expected production of clean rice from basmati paddy will recover to the tune of 158.028 thousand tonnes (i.e., @ 70% recovery rate of clean rice) that become by valuing worth 150.50 million USD at wholesale level (i.e., price @ 925.38 USD/t) by arresting on 5th year of the project life (Table 11).

Table 11: Benchmark Status of the *Pucca Chawal* Cluster-II in Hafizabad District

Sr. #	Items	Inputs	Year-2	Year-3	Year-4	Year-5
1.	Area under cultivation in focal point (ha)	104,410				
2.	Total production in the focal point area (tonnes)	213,300				
3.	Baseline yield (tonnes/ha)	2.04	2.09	2.11	2.14	2.16
4.	Annual yield growth without intervention (%)	1.14%				
5.	Annual expected paddy production (tonnes)		218,181	220,677	223,201	225,755
6.	Farm gate price of basmati paddy (US$/t)	426.19				

Sr. #	Items	Inputs	Year-2	Year-3	Year-4	Year-5
7.	Total value of basmati paddy Million US$)		92.99	94.05	95.13	96.21
8.	Existing clean rice-paddy ratio (%)	70.0%				
9.	Annual expected production of clean rice (tonnes)		152,726	154,474	156,241	158,028
10.	Price of clean rice at wholesale level (US$/t)	952.38				
11.	Annual expected value of rice (Million US$)		145.45	147.12	148.80	150.50

Intervention-1: Gradual Shifting from Manual to Machine Transplanting

On average farmers are maintaining 55-65 thousand plant populations against the recommended level of 120 thousand plant populations per acre. Low paddy plant population may overcome by adopting different modes including the Direct Seedling Rice (DSR) and mechanical transplanting. Recently, Rice Research Institute, Kala Shah Kaku, Muridke has demonstrated DSR plantation on 8000 acres in the selected districts including Narowal, Gujranwala, Sheikhupura, Sialkot, Khanewal and Lahore. The impact of this effort is not wide spread due to several reasons viz., variation in soil type, water availability, varying outcomes of the practice in different ecologies, technical know-how, etc. On the other hand, a successful introduction of mechanical rice planter (Chinese/Korean make) through a private service provider, without any government support, is already in practice on 2000 acres to maintain the desired number of plant population density per unit land in *village* Verpal Chatta of Ali Pur Chatta Union Council of Gujranwala District. The service providers are managing nursery raising in required trays by themselves which are ready to transplant in field by rice transplanter. This technology is more acceptable and popular among the rice growers where it is tested and made known to them, but all other farm operations remain unchanged. The available machine has manual calibration to adjust the plant population density as desired i.e., up to 120,000 seedlings per acre. Moreover, currently there is serious labour shortage at the peak season of rice seedlings transplantation. Therefore, under this situation, the introduction of rice transplanter as an intervention that may be feasible and widely accepted by the growers of the area. The feasibility of mechanical rice planter is estimated in Annexure-7.

9.1.3. *Katcha Chawal* Cluster-I

In the feasibility analysis, it is assumed that the introduction of mechanical transplanter would increase the per ha yield by 15 percent on the adopters' farm at the end of 5th year of project span and onwards. The gradual increase in yield of 3.75 percent of incremental rate per annum is fixed starting from 2nd year through 5th year. In five years starting from 2nd year, quarter of the total rice area will be planted by mechanical transplanters which would be phased out with the incremental rate of 6.25 percent annually. As a result of adoption of mechanized transplanting intervention, an additional production of 115.04 thousand tonnes of paddy would be expected amounting to US$4.34 million at farm gate prices on the 5th year of the project (Table 12).

Table 12: Yearly Returns of Mechanical Transplanting in *Katcha Chawal* Cluster-I

Sr. #	Items	Inputs	Incremental	Year-2	Year-3	Year-4	Year-5
1.	Percent area to be covered by transplanting	25%	6.25%	6.25%	12.50%	18.75%	25.00%
2.	Yield improved by mechanized transp.(t/ha)	15%	3.75%	3.75%	7.50%	11.25%	15.00%
3.	Actual yield ↑ by improved plant pop. (t/ha)			0.07	0.14	0.22	0.29
4.	Added prod. by mechanized transplant (tonnes)			695	2811	6398	11504
5.	Value of addit. Paddy at farm gate (Mill US$)			0.26	1.06	2.41	4.34

9.1.4. Parboiled/*Saila Chawal* Cluster-II

The intervention of introducing mechanical transplanters is also suggested in this cluster due to same nature of issue, such as, low plant population density per ha, unavailability of labour at the time of transplanting, etc. In the feasibility analysis of Table 14b for Cluster-II, similar extent of yield increases and adoption rate is assumed as in Cluster-I. As a result of adoption of mechanized transplanting intervention, an additional production of 84.66 thousand tonnes of PK-1121 (Kainat) paddy (added Yield @ 0.32 t/ha) would be of expected value US$3.61 million at farm gate prices on the 5th year of the project (Table 13).

Table 13: Yearly Returns of Mechanical Transplanting in *Pucca Chawal* Cluster-II

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Percent area to be covered by transplanting	25%	6.25%		6.25%	12.50%	18.75%	25.00%
2.	Yield improved by mechanized transp.(t/ha)	15%	3.75%		3.75%	7.50%	11.25%	15.00%
3.	Actual yield ↑ by improved plant pop. (t/ha)				0.08	0.16	0.24	0.32
4.	Added prod. by mechanized transplant (tonnes)				511	2069	4708	8466
5.	Value of additional paddy at farm gate (Mill US$)				0.218	0.882	2.007	3.608

9.2. Intervention-2: Diffusion of Modern High-yielding Varieties

As discussed earlier, a large number of recently released presumably high-yielding varieties both for Cluster-I and Cluster-II are available, but they are not being adopted mainly because of unawareness of the farmers. These varieties will be promoted through demonstration fields conducted by the member farmers of FEGs under the supervision of the professionals from RRI, Kala Shah Kaku and Universities. The seed production and nurseries for transplantation will also be arranged by the FEGs.

9.2.1. *Katcha Chawal* Cluster-I

The modern high-yielding varieties like Kissan basmati, Chenab, Punjab and Basmati-515 are already approved but not adopted by the farmers. The varietal degeneration process of Super Basmati (the Queen of basmati rice varieties) is reported to be quite high resulting in shrinking and deforming the size of kernel, losing uniformity and stability in plant height and yield. Rice researchers/bio-technologists of public (RRI, KSK, Muridke) and private institutions (Guard Agricultural Research & Services Pvt. Ltd, Raiwind Rd., Lahore) are diligently engaged to release, very soon, the promising varieties superior to super basmati, especially hybrid. In the light of above discussion and assumptions, the feasibility study was carried out in *Kalar* tract with the special interest to boost productivity of basmati rice through promoting "improved high yielding basmati rice varieties" as an intervention in the focal district, Sheikhupura.

It is assumed here that the intervention would add 7 percent per annum productivity gain on maturity of project (i.e., on and after 5th year of project life) with 1.8 percent annual incremental rate from 2nd year to arrest 5th year of project life span. The seven percent gain in productivity would yield 0.14 tonne/ha of basmati paddy in 5th year. It was assumed that 50 percent area of the focal district would be covered in the intervention with the incremental rate of 12.5 percent per annum effective from 2nd year through to 5th year of the project span.

As a result of diffusion of HYV of basmati rice intervention, an additional production of 10.737 thousand tonnes of paddy would be expected amounting to US$ 4.05 million at farm gate prices on the 5th year of the project. The interim production and its revenue results of 2nd through 4th year may be viewed from the Table 17. Such additional production can easily be absorbed in domestic market.

Table 14: Yearly Returns from Diffusion of HYV in *Katcha Chawal* Cluster-I

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Area replaced by modern basmati HYV (%)	50%	12.5%		12.5%	25.0%	37.5%	50.0%
2.	Increase in yield due to HYVs (t/ha)				0.03	0.07	0.10	0.14
3.	Yield increase due to basmati HYV (%)	7%	1.8%		1.75%	3.50%	5.25%	7.00%
4.	Additional prod. due to diffusion of HYVs (tonnes)				649	2624	5971	10737

5.	Value of add. paddy due to HYVs (Mill US$)				0.24	0.99	2.25	4.05

9.2.2. Parboiled/*Saila Chawal* Cluster-II

Under the prevalent situation of emerging global and national trend of enhancing consumers' demand for *Saila* rice, the present feasibility study is prepared to boost Kainat production by exploiting the upcoming HYV potential.

It is assumed that improved high yielding varieties of Kainat series will bring 20 percent productivity gain on maturity of project i.e., on 5th year of project life with an annual incremental rate of 5 percent contribution staring from the 2nd year up to 5th year (i.e., 0.43 tonnes/ha). To achieve 20 percent productivity gain in 5 years of project life on account of diffusion of HYV, 60 percent paddy area of the focal district will be covered in four phases with 15 percent per annum increment staring from the 2nd year of the project. As a result, an additional production of paddy will be fetched to the tune of 27.091 thousand tonnes (i.e., an additional yield @ 0.43 t/ha) valuing worth US$11.55 million on the 5th year of the project. The intervening production and its revenue results of 2nd through 4th year may be viewed from Table 15.

Table 15: Yearly Returns from Diffusion of HYV in *Pucca Chawal* Cluster-II

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Area replaced by modern basmati HYV (%)	60%	15.0%		15.00%	30.00%	45.00%	60.00%
2.	Increase in yield due to HYVs (t/ha)				0.10	0.21	0.32	0.43
3.	Yield increase due to basmati HYV (%)	20%	5.0%		5.00%	10.00%	15.00%	20.00%
4.	Additional prod. due to diffusion of HYVs (tonnes)				1636	6620	15066	27091
5.	Value of add. paddy due to HYVs (Mill US$)				0.70	2.82	6.42	11.55

9.3. Intervention-3: Yield Improvement by Better Crop Management Practices

It is assumed that with an improvement in farm management practices like optimal use and timing of inputs, proper weed control, etc. would add 7 percent in the yield with an annual phasing of 1.75 percent effective from 2nd year through to 5th year in Cluster-I. This assumption is set on conservative estimates, since it includes the farmers' acceptable level of input use practices adopted after yearlong experiences as well as knowledge gained through agricultural extension advisory services including seed, fertilizer, irrigations, pesticides, weedicide harvesting & threshing, etc.

9.3.1. *Katcha Chawal* Cluster-I

The advisory services will be provided by specially hired and trained extension worker for this purpose. About 106 additional professional extension workers in Cluster-I would be required to render these services in the focal targeted sites of each cluster. Thus, additional production of paddy to the tune of 21.473 thousand tonnes would be expected worth US$ 8.10 million at farm gate prices on the 5th year of the project. The interim additional production and its additional revenue results of 2nd year through 5th year may be viewed from the Table 16.

Table 16: Yearly Returns from Yield Improvement by Better Crop Management in *Katcha Chawal* Cluster-I

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Yield improvement by better crop mgmt. (%)	7%	1.75%		1.75%	3.50%	5.25%	7.00%
2.	Yield increase by better crop mgmt. (t/ha)				0.03	0.07	0.10	0.14
3.	Additional paddy production by enhanced yield (tonnes)				5188	10495	15923	21473
4.	Value of addition paddy due to yield improvement (Million US$)				1.96	3.96	6.01	8.10

9.3.2. Parboiled/*Saila* Rice Cluster-II

Here 70 additional dedicated professionals will be hired and trained to conduct the advisory services. This will add into the productivity by 0.22 t/ha of Kainat basmati rice at the end of 5th year of project life. Thus, an additional production of 22.8 thousand tonnes of paddy would be expected amounting to US$ 9.62 million at farm gate prices on the 5th year of the project. The year to year gain in additional production and its additional revenues effective from 2nd year through to 5th year of the project due to employing improved management practices may be viewed from the Table 17.

Table 17: Yearly Returns from Yield Improvement by Better Crop Management in *Pucca Chawal* Cluster-II

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Yield improvement by better crop mgmt. (%)	10%	2.50%		2.50%	5.00%	7.50%	10.00%
2.	Yield increase by better crop mgmt. (tonne/ha)				0.05	0.11	0.16	0.22
3.	Add. paddy prod. by enhanced yield (tonnes)				5455	11034	16740	22575
4.	Value of additional paddy (Million US$)				2.32	4.70	7.13	9.62

9.4. Intervention-4: Introduction of Rice Combine Harvesters

It is observed that currently Kubota is used only on 15-20 percent of paddy cultivated area. Its rental charges are Rs.4500-5000 per acre (takes 1.2 hour). The paddy straw harvested with Kubota can be used for animal feeding, cut the stubbles at ground-level with little left-over stubbles in the field to be burned. It also yields 81 -114 kg more production per ha by saving losses, as well as, contributes towards lowering moisture contents than that of wheat combine harvester due to its superior technology mounted with air fans for separating grain from rice straw. Combine harvesters also damages to the kernel of the rice through developing cracks in it and grain breaks on rice processing but with Kubota less cracks developed. However, Kubota is not as efficient, in comparison, as combined wheat harvester when paddy crop is lodged. This deficiency must be kept in mind while evaluating its feasibility as an intervention. A care is needed while giving recommendation as well as interpretation of the results pertaining to the performance of this technology. The economic feasibility of rice combined harvester is estimated in Annexure-8.

Based on the information gathered from the service providers of wheat and rice harvesting machines, on average, 500 ha could be harvested by the Kubota type rice combine harvesters. The service charge for the Kubota machine is assumed to be 33% higher than that in wheat combined harvester.

9.4.1. *Katcha Chawal* Cluster-I

It is assumed that 13 percent post-harvest losses during wheat combine harvesting shall be reduced to 5 percent at farm level after introducing Kubota rice combine harvester, making net-effect of 8 percent phased out into four years with an annual increment rate of 2 percent starting from 2nd year through 5th year of the project. We also assume that rice combine harvester will be fully adopted in each cluster area in the project period (phased out with 20 percent per annum incremental rate on the completion of 5 year's span of the project). Two pronged benefits on adoption of rice combine harvester will be in the form of saving paddy straw worth 7.53 million USD, and additional paddy of 22.43 thousand tonnes (i.e., worth of 8.46 million USD) making the total revenue of US$ 16 million towards 5th year of the project. The annual details are portrayed in Table 21 pertaining of economic and feasibility analysis.

Table 18: Yearly Returns from Diffusion of Rice Combine Harvesters in *Katcha Chawal* Cluster-I

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Current losses by harvesting rice with wheat combine harvesters (%)	13%						
2.	Losses by rice harvesting with Kubota rice combine harvesters (%)	5%	8%		2.00%	4.00%	6.00%	8.00%
3.	% rice area currently harvested by using combine harvesting method	20%						

4.	% rice area shifted to Kubota rice combine harvesting (%)	100%	80%		20.00%	40.00%	60.00%	80.00%
5.	Additional paddy achieved by reducing harvesting losses at the farm level (tonnes)				1212	5053	11937	22431
6.	Value of additional paddy achieved (Mill. $)				0.46	1.91	4.50	8.46
7.	Value of paddy straw got @ $60/ha (Mill. $)	60			1.88	3.77	5.65	7.53
8.	Total benefit to farming community by shifting to Kubota rice harvesting (Million $)				2.34	5.68	10.15	15.99

9.4.2. Parboiled/*Saila* Rice Cluster-II

Similar assumptions are applicable as in Cluster-I made in terms of saving in harvest losses an adoption speed of the machine. The value of paddy straw saved would be worth US$ 4.97 million, and saving of harvest losses would be worth of US$18.17 thousand tonnes worth of US$ 7.74 million fetching total benefit as 12.71 million USD during the 5th year of the project (Table 19).

Table 19: Yearly Returns from Diffusion of Rice Combine Harvesters in *Pucca Chawal* Cluster-I

Sr. #	Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
1.	Current losses by harvesting rice with wheat combine harvesters (%)	13%						
2.	Losses by rice harvesting with Kubota rice combine harvesters (%)	5%	8%		2.00%	4.00%	6.00%	8.00%
3.	% rice area currently harvested by using combine harvesting method	20%						
4.	% rice area shifted to Kubota rice combine harvesting (%)	100%	80%		20.00%	40.00%	60.00%	80.00%
5.	Additional paddy achieved by reducing harvesting losses at the farm level (tonnes)				903	3846	9350	18169
6.	Value of additional paddy achieved (Mill. $)				0.38	1.64	3.98	7.74
7.	Value of paddy straw got @ $60/ha (Mill. $)	60			1.24	2.49	3.73	4.97
8.	Total benefit to farming community by shifting to Kubota rice harvesting (Million $)				1.62	4.13	7.71	12.71

9.5. Intervention-5: Introducing Dryers at Farm and Market Levels

The drying losses are varied from 3 to 15 percent depending upon the available moisture contents after paddy harvest. Most of the Sheller owners have their own mechanical drying facilities (See Annex Figure-5) but they prefer sun drying except when labour is short, and bad weather conditions including wet, fogy/smoggy season. On average, Rs.50-250 is incurred to dry 65 kg paddy depending upon the level of moisture content and mode of drying either sun drying or mechanical drying. The economic feasibility of mechanical rice drier is estimated in Annexure-9.

9.5.1. *Katcha Chawal* Cluster-I

Currently, about 20 percent basmati paddy already dried through mechanical driers and the target is drying of 90 percent paddy by employing mechanical dryer making annual adoption rate of 18 percent per annum from 2nd year through 5th year of the project. In total 290 dryers would be needed to remaining 70 percent paddy in the focal district. These driers will be supplied to FEGs on subsidized rate. In this way, 261.04 thousand tonnes of paddy shall be dried by 5th year considering 9.3 conversion factor. In the drying process of paddy, and an additional value added in the farm gate price (460 US$/t) of basmati paddy was by 83 US$/t that finally arrived at 543 US$/tonne. As a result of introduction of mechanical dryer in the area, the expected additional value of paddy from improved quality would be 1.79, 6.81, 10.89 and 15.57 million USD from 2nd year though 5th year of the project (Table 20).

Table 20: Yearly Returns from Introducing Dryers in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Percent of product currently dried	20%					
Target %age of practicing paddy drying	90%	18%	18%	35%	53%	70%
Conversion factor of paddy drying (W to D)	10 to 9.3	7%				
Actual production needs to be solar dried (tonnes)			53,238	112,296	180,350	261,036
Dried Production (tonnes) – after 7% cut			49,511	104,436	167,725	242,764
New higher price due to better paddy quality and lower moisture (USD/tonne) – 26+57= 83	460	83				
Value of add. paddy of improved quality produced in the cluster (Mill US$)			**1.79**	**6.81**	**10.89**	**15.57**

9.5.2. Parboiled/*Saila* Rice Cluster-II

Similar assumption regarding current output being dried through mechanical drier and conversion factor, and additional price to be fetched after drying are made here as in Cluster-I. Additional 235 dryers (with the capacity of 1000 tonnes of paddy drying during the paddy crop season) would be required in four phases to dry additional paddy of the targeted focal district. As a result, additional dried paddy would be 196.64 thousand tonnes on the 5th year of the project that would be phased out into four-year span of the project starting from the 2nd year through to 5th year. As a result of drying, new higher price 520 USD/tonne will be realized due to improvement in quality of paddy with a drying premium of price of 94 USD/tonne at farm gate prices. Hence, the value-added paddy shall fetch additional value to the tune of 1.49, 5.76, 9.52 and 14.25 million USD from 2nd year through to 5th year, respectively.

Table 21: Yearly Returns from Introducing Dryers in *Pucca Chawal* Cluster-II of Hafizabad District

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
% of product currently dried	20%					
Target %age of practicing paddy drying	90%	18%	18%	35%	53%	70%
Conversion factor of paddy drying (W to D)	10 to 9.3	1.25				
Dried paddy production (tonnes)			36,893	79,502	131,371	196,638
New higher price due to better paddy quality	520	64+30=94				
Value of add. paddy of improved quality produced in the cluster (Mill US$)			**1.49**	**5.76**	**9.52**	**14.25**

9.6. Intervention-6a: Introducing Rice Bran - *Katcha Chawal* Cluster-I

In several countries like Japan, a major proportion of edible oil comes from this source. In some other South-East-Asian countries like, Burma, Thailand, India, Nepal, and republic of Korea, the rice bran oil is more commonly used. In Pakistan, until today it is not yet widely used, but additional supply of bran oil through this intervention can either be promoted within the country or can be exported. This intervention is applicable to Cluster-I only because bran oil quality may deteriorate during parboiling/steaming process of *Saila.* The detailed feasibility of bran oil extraction is explained in Annexure-6.

9.6.1. *Katcha Chawal* Cluster-I

It is assumed that currently there is no bran oil extracted from the rice bran in Cluster-I of the targeted focal district. It is suggested from the 2nd year onwards, the rice bran oil will be assumed to extract oil from 20 percent paddy with an annual increment rate reaching 80 percent on the 5th year of the project. Since, the recovery rate of rice bran from the basmati paddy is 1.5 percent (Bashir *et al*., 2018), the rice bran production would be collected from the total production (i.e., existing production without intervention as well as additional production gained by employing all the interventions). At the rate of 1.5% of bran production from the paddy milled, it was estimated that the rice bran amounting to 4,475 tonnes shall be available from the available paddy in the 5th year of the project. Total number of bran oil extraction machines required would be 3. It is assumed that each unit will collect rice bran from 10 rice mills each will install bran palletization machine which will make pallets of bran and thus stabilize the quality of oil content in it. It is assumed that rice bran contains 20 percent oil contents, resultantly; the enhanced production of bran oil would be extracted to the tune of 895 tonnes in the 5th year of the project (Sagar and Ashraf, 1986). The intervention of bran oil extraction would be contributing to the extent of US$ 0.52 million (sold at US$1630/ t) in the 5th year as a gain from bran oil. The other details in this respect may be seen in Table 22.

Table 22: Yearly Returns from Rice Bran Oil Extraction in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Current %age of bran converted to bran oil	0%					
Target %age of bran conversion into bran oil	80.0%	20.00%	20.0%	40.0%	60.0%	80.0%
Qty. of rice bran produced for oil extraction	1.5%		3,651	3,850	4,122	4,475
Conversion rate of oil from rice bran	10%					
Quantity of rice bran oil produced (tonnes)			369	391	417	447
Expected value of bran oil @ US$1630/t (Million US$)	1629.60		**0.43**	**0.46**	**0.49**	**0.52**

9.7. Intervention-6b: Improvement in Parboiled/*Saila*-Rice Making Cluster-II

As noted earlier, the current dominant grown fine variety of basmati rice in Cluster-II is PK-1121 (‘Kainat') which is mainly used for preparing *Pucca Chawal* or *Saila* because of its elongated grain size especially after cooking with measuring ranges from 16 mm to 18 mm. Some other non-registered varieties like Basmati-519 may also be used for preparing *Saila*. Parboiled rice is rough that has gone through a steam-pressure process before milling. It is soaked, steamed, dried, and then milled to remove the outer hull. This procedure gelatinizes the starch in the grain, and is adopted at the mill in order to harden the grain, resulting into less breakage (yielding 3.2 kg/40 kg more head rice than steamed rice), thus ensuring a firmer, more separate grain (Bashir *et al*., 2018).

Parboiled rice is favoured by consumers and chefs who desire extra fluffy and separate cooked rice. The '*Saila*' of this variety is very popular amongst locals and overseas traders and consumers. The Pakistani commercial cooks ('*Pakwans*') are totally using basmati rice '*Saila*' and steamed products for preparing *Biryani* and sweet dishes ('*Zardah/Muttangan*') due to number of good reasons especially, *Saila* yields better performance after cooking, as said by the consumers and '*Pakwans*' the quantity of serving plates increased than that of non-*Saila* ('*Kaccha Chawal*') product, good show casing of '*Pakwans*', no breakage of cooked rice grains as well as convenience of '*Pakwans*'.

With the increasing demand of *Saila* in the Middle Eastern countries and within country, absorption of additional supply of *Saila* generated through this intervention will not be an issue. However, it may reduce the market for *Katcha* rice.

9.7.1. Parboiled/*Saila* Rice Cluster-II

During field visit, it was observed that currently 50 percent of Kainat basmati variety is used for making *Saila* rice. In order to achieve the targeted level (i.e., 80 percent of *Saila* making), an additional 30 percent Kainat paddy need to be brought under *Saila* making OR it would be 30 percent with annual increments as 7.50 percent staring from 2nd year through to 5th year of the project. After intervention, total expected production of *Saila* rice of Kainat would be 63.432 thousand tonnes in the 5th year of the project. The wholesale price premium of *Saila* rice is 148.15 US$/t higher than *Katcha* Kainat rice, making additional 5.56 million USD on 5th year of the project life. For other years, please see the Table 23 below.

Table 23: Yearly Returns from Making *Saila* Rice in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-1	Year-2	Year-3	Year-4	Year-5
Current status of making *Saila* rice from Kainat basmati (%)	50.0%						
Target percentage of preparing *Saila* rice from Kainat basmati (%)	80.0%						
Net-increase in *Saila* rice conversion (%)	30.0%	7.50%		7.50%	15.00%	22.50%	30.00%
Enhanced production of *Saila* basmati rice (tonnes)				11,901	25,646	42,378	63,432
Premium price of *Saila* rice compared to *Katcha Chawal* ($/t)	148.15						
Expected additional value from increased *Saila* basmati rice production (Million US$)				**1.04**	**2.25**	**3.71**	**5.56**

9.8. Total Summary of Benefits from Introduced Interventions

9.8.1. *Katcha Chawal* Cluster-I

The yearly benefits stream from the six introduced interventions in focal point of Sheikhupura district in Cluster-I are summarized in Table 27. It can be observed that the total benefits from the six introduced interventions shall be worth of US$ 48.59 million by the 5th project year.

Table 24: Yearly Expected Gross Returns from *Katcha Chawal* Interventions in Cluster-I (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Intervention-1: Shifting to mech. Transplanting	0.26	1.06	2.41	4.34
Intervention-2: Diffusion of HYVs	0.24	0.99	2.25	4.05
Intervention-3: Improved management practice	1.96	3.96	6.01	8.10
Intervention-4: Adoption of rice combine harvester	1.83	3.81	6.01	8.46
Intervention-5: Paddy drying service providers	1.79	6.81	10.89	15.57
Intervention-6: Rice bran oil extraction	0.43	0.46	0.49	0.52
Total	***8.401***	***20.856***	***33.707***	***48.594***

9.8.2. *Pucca Chawal* Cluster-II

The yearly benefits stream from the six introduced interventions in focal Hafizabad district of Cluster-II is summarized in Table 25. It can be seen that the total benefits from the introduced interventions are worth of US$ 57.29 million by the 5th project year.

Table 25: Yearly Expected Gross Returns from *Pucca Chawal* Interventions in Cluster-II (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Intervention-1: Shifting to mech. Transplanting	0.22	0.88	2.01	3.61
Intervention-2: Diffusion of HYVs	0.70	2.82	6.42	11.55
Intervention-3: Improved management practice	2.32	4.70	7.13	9.62
Intervention-4: Adoption of rice combine harvester	0.38	1.64	3.98	7.74
Intervention-5: Paddy drying service providers	1.49	5.76	9.52	14.25
Intervention-6: *Saila* Rice Making	1.04	2.25	3.71	5.56
Total	***7.400***	***20.538***	***36.507***	***57.295***

9.9. Costs Associated with Proposed Interventions

9.9.1. Intervention-1: Gradual Shifting from Manual to Machine Transplanting to Combat Issue of Low Plant Population

9.9.1.1. Katcha Chawal Cluster-I

As mentioned earlier that in five years starting from 2nd year, total 15 percent area will be covered by using mechanical transplanter with annual incremental rate as 3.75 percent. As a result of adoption of mechanized transplanting intervention, an area of 23, 735 ha shall be mechanically transplanted by the 5th year of the project. As mechanical transplanting is 40% expensive than manual transplanting (however, by mechanical transplanting the plant population per ha will increases), it will result an additional cost to the farming community to the extent of USD 0.40 million by 5th year of the project (Table 26).

Table 26: Yearly Costs of Mechanical Transplanting in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Percent area covered by mechanical transplant	15%	3.75%	3.75%	7.50%	11.25%	15.00%
Area brought under mechanical transplant(ha)			5,934	11,867	17,801	23,735
Manual transplanting cost (US$/Ha)	74.07					
Rise in cost by shifting from manual to mechanical transplanting (US$/Ha)	40.0%					
Expected additional cost due to shifting from manual to mech. transplanting (Million US$)			***0.102***	***0.203***	***0.305***	***0.406***

9.9.1.2. Parboiled/Saila Chawal Cluster-II

The intervention of introducing mechanical transplanter is also suggested in this cluster due to same nature of issue as well as opportunity to overcome the problem of low plant population per ha, non-availability of labour during transplanting period, etc**.** In the cost analysis of Table 21b for Cluster-II, in five years starting from 2nd year, a total of 25 percent area shall be covered by using mechanical transplanters with annual increments as 6.25 percent. As a result of adoption of mechanized transplanting intervention, an area of 26,103 ha shall be mechanically transplanted by the 5th year of the project. Since mechanical transplanting is 40% expensive than manual transplanting, therefore, the additional cost to the farming community due to shifting to mechanical transplanting shall be 0.74 million US$ by 5th year of the project (Other details are presented in Table 27).

Table 27: Yearly Costs of Mechanical Transplanting in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Percent area covered by mechanical transplant	25%	6.25%	6.25%	12.50%	18.75%	25.00%
Area brought under mechanical transplant(ha)			6,526	13,051	19,577	26,103
Manual transplanting cost (US$/Ha)	74.07					
Rise in cost by shifting from manual to mechanical transplanting (US$/Ha)	40.0%					
Expected additional cost due to shifting from manual to mech. transplanting (Million US$)			***0.185***	***0.370***	***0.555***	***0.741***

9.9.2. Intervention-2: Yield Improvement by Diffusion of Modern High-yielding Varieties

9.9.2.1. Katcha Chawal Cluster-I

The diffusion of latest released high yielding varieties (HYVs) require purchasing of new seed, which is relatively expensive than the home retained seed of previous crop season. Moreover, it is also assumed that the farmers shall continue purchasing new seed for the additional plantation under new varieties. Therefore, additional expenses are involved on the part of farming community. Assuming that with the efforts of provincial Department of Agricultural Extension and other Agricultural Advisory Services of private sector, farmers are convinced to adopt new varieties, hence some additional expenses need to be incurred by the farming community in order to buy the seed of newly released varieties. It is estimated that the farming community has to spend nearly 0.66 million USD towards 5th year of the project. For further details, please see Table 28 below.

Table 28: Yearly Costs for Diffusion of HYV in *Katcha Chawal* Cluster-I of Sheikhupura District

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Area covered under basmati HYV (%)	50%	12.50%	12.50%	25.00%	37.50%	50.00%
Area planted under new HYV (ha)			19,779	39,558	59,336	79,115
Cost of raising nursery of new HYV(USD/ha)	16.67					
Increase in cost/ha due to new HYV(USD/ha)	25.00	8.33				

Additional cost due to shifting to HYV (Million USD)			0.16	0.33	0.49	0.66

9.9.2.2. Parboiled/Saila Chawal Cluster-II

Considering cluster-II, to achieve 20 percent productivity gain in 5 years of project life on account of diffusion of latest released HYV, 50 percent paddy area of the focal district will be covered in four years with 12.5 percent per annum increment staring from the 2nd year of the project. As a result, an additional cost of purchasing the seed of latest released high yield varieties will be nearly 0.44 million USD towards 5th year of the project. The details for other project years please see Table 29 below.

Table 29: Yearly Costs for Diffusion of HYV in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Area covered under basmati HYV (%)	50.0%	12.50%	12.50%	25.00%	37.50%	50.00%
Additional area planted under new HYV (ha)			13,051	26,103	39,154	52,205
Cost of raising nursery of new HYV(USD/ha)	16.67					
Increase in cost/ha due to new HYV(USD/ha)	25.00	8.33				
Additional cost due to shifting to HYV (Million USD)			0.11	0.22	0.33	0.44

9.9.3. Intervention-3: Yield Improvement by Better Crop Management Practices

As a result of improved management practices, the cost on seed (both because of the increase in quality and improvement in quality), nursery management practices, fertilizer consumption especially its balanced use, and labour harvesting practices will increase. We assume that all this will add 7% of the total cost in Cluster-I and 13% of the total cost in Cluster-II. The difference is because in cluster-I, improved management practices will involve not much of additional inputs, rather improved skills and knowledge through rendering additional advisory services of Agricultural Extension professionals, while in cluster-II, in addition of skills and knowledge additional inputs would be required. The detailed cost structure under traditional transplanting and improved practices is shown in Annexure-10.

9.9.3.1. Katcha Chawal Cluster-I

For achieving 5 percent yield increase through improved management practices, the farmers have to incur additional expenses worth US$ 13.29 million by the 5th year of the project (Table 30).

Table 30: Yearly Costs for Yield Improvement by Better Crop Management in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Paddy production cost at farm level (US$/ha)	1152.0					
Increase in cost due to adoption of better crop management practices (%)	7%	1.82%	1.82%	3.65%	5.47%	7.29%
Total increase in cost due to improved crop management practices (Million US$)			3.32	6.657	9.97	13.29

9.9.3.2. Parboiled/*Saila* Rice Cluster-II

The recurring cost incurred on providing improved management practice is assumed to the extent of 13 percent with an annual increment of 3.26 percent that was phased out in four years w.e.f. 2nd year through to 5th year respectively. Thus, total cost was computed to be 18.84 million USD on arresting of 5th year of the project life (Table 31).

Table 31: Yearly Costs for Yield Improvement by Better Crop Management in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Paddy production cost at farm level (US$/ha)	1383					
Increase in cost due to adoption of better crop management practices (%)	13%	3.26%	3.26%	6.52%	9.78%	13.05%
Total increase in cost due to improved crop management practices (Million US$)			*4.711*	*9.422*	*14.133*	*18.843*

9.9.4. Intervention-4: Reducing Farm Level Harvest Losses by Introducing Rice Combine Harvesters

Reducing the harvest and post-harvest losses is a big challenge virtually in all crops produced in Pakistan including rice. The gravity of this challenge is relatively more in perishable fruits and vegetable crops. In case of basmati rice, any mistake taken place at harvesting and/or post-harvest handling results not only a loss in the quality of the product produced, but also increases the proportion of by-products (particularly broken rice) produced during processing. Till recent past, the harvesting of paddy was done by using wheat combine harvesters, which not only results in loss of valuable rice straw (mainly burnt by the farmers in the field), leaving big stubbles in the field and grain shattering in the field. Therefore, to get rid of huge by-product, the farmers started burning the straw, which caused environmental pollution and chest diseases by inhaling smog in those days. Moreover, the ratio of broken rice produced during milling was also higher. Therefore, the need for introduction of some machine which harvest the paddy crop from the height close to the soil and preserves rice straw rather than resorting to its burning.

9.9.4.1. *Katcha Chawal Cluster-I*

In recent past, Kubota rice combine harvesters were introduced in the area by the private sector itself. This intervention has proved its worth in terms of controlling grain shattering in the field during harvesting and preserving rice straw which could be either fed to the animals or sold to the paper industry. The rental price of these combine harvesters are 33 percent higher than the conventional wheat combine harvesters, but the farming community warmly welcome this machine as well as evidence of fast adoption. In Table 35 below, the stream of costs associated with the use of Kubota rice combine harvesters is presented. It has been estimated that farming community has bear additional expenses amounting 2.32 million USD by shifting paddy harvesting of 126.58 thousand ha to Kubota rice combine harvesters by 5th year of the project. The other details are presented in Table 32.

Table 32: Yearly Costs About the Diffusion of Rice Combine Harvesters in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Paddy harvesting cost by using wheat combine harvesters (US$/Ha)	55.56					
Percent increase in cost by shifting to Kubota rice combine harvesters (%)	33.0%	8.25%	8.25%	16.50%	24.75%	33.00%
Percent increase in area towards Kubota rice combine harvesters (%)	100%	20.00%	20.00%	40.00%	60.00%	80.00%
Area harvested with Kubota rice combine harvesters (Ha)			31,646	63,292	94,938	126,584
Additional cost due to shifting to Kubota combine rice harvesters (Million US$)			***0.580***	***1.160***	***1.741***	***2.321***

9.9.4.2. *Parboiled/Saila Rice Cluster-II*

Turning to cluster-II, it has been estimated that farming community has bear additional expenses amounting 1.53 million USD by shifting paddy harvesting of 83.53 thousand ha to Kubota rice combine harvesters by 5th year of the project as depicted in Table 33.

Table 33: Yearly Costs of Diffusion of Rice Combine Harvester in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Paddy harvesting cost by using wheat combine harvesters (US$/Ha)	55.56					
Percent increase in cost by shifting to Kubota rice combine harvesters (%)	33.0%	8.25%	8.25%	16.50%	24.75%	33.00%

Percent increase in area towards Kubota rice combine harvesters (%)	100%	20.00%	20.00%	40.00%	60.00%	80.00%
Area harvested with Kubota rice combine harvesters (Ha)			20,882	41,764	62,646	83,528
Additional cost due to shifting to Kubota combine rice harvesters (Million US$)			***0.383***	***0.766***	***1.149***	***1.531***

9.9.5. Intervention-5: Introducing Dryers at Farm and Market Levels

Mycotoxins are naturally occurring toxins produced by certain molds and can be found in crops. Warm humid conditions accelerate their growth. One such mycotoxin is aflatoxin which damages DNA and increases incidence of liver cancer. High levels of aflatoxins have been reported in rice from India. Toxin reviews is a medical journal which published an article regarding aflatoxin in rice around the world. As per the article published in 2006, India has amongst the highest levels of incidence among rice producing countries. A survey covering 12 states showed that 16 percent samples exceeded the Indian permissible limits of 30 hg/kg, 61.5 percent of the samples reported aflatoxin level above 5 hg/kg. On the other hand, EU allows maximum level of 4 hg/kg of rice https://www.brecorder.com/2019/01/15/465958/fungi-toxins-and-basmati-exports/

Relative to Pakistan, India has a technologically advanced agriculture sector, more prone to using pesticides and fungicides manufactured domestically. Pakistan has not developed chemical pesticide market which has to be imported hence being too expensive to use. Thus, Pakistan has a comparative advantage in employing more organic farming which is why tricylazole limits are not a problem for basmati exports from Pakistan. However, improper storage and sun-drying of paddy increases the incidence of aflatoxins in rice. While the private sector has been fast in setting up driers in their units, therefore, this problem is addressed to a large extent. On the other hand, there is news that in the rice sector, the aflatoxin levels will be further revised by the European commission. Between the permissible limits of tricylazole and aflatoxins, Pakistan can increase basmati exports to EU further. However, government initiatives may be required to increase mechanical drying of paddies. Since warm humid conditions are required to decrease aflatoxin levels, antiquated methods of drying may hamper Pakistan's exports of basmati rice https://www.brecorder. com/2019/01/15/465958/fungi-toxins-and-basmati-exports/

9.9.5.1. Katcha Chawal Cluster-I

As discussed in previous section that the intention is practicing universal paddy drying in the area (i.e. 90%) or making it mandatory in the cluster area, which is currently operating at 20 percent level. Though the farming community has to face a nearly 25% quantitative loss by practicing paddy drying before taking it to the market, however, it is also assumed that market is responsive in terms of offering better prices to farmers brining dry paddy in the market. At present, what so ever the sun-drying of paddy is practiced, it is mainly done by domestic labour or permanently hired farm labour, whose opportunity cost falls around 40.38 USD per tonne.

It is estimated that by 5th year of the project, nearly 261 thousand tonnes of paddy shall be dried by using dryers, costing to the farming community as 5.221 million US$ (Table 34).

Table 34: Yearly Costs of Introducing Dryers in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Percentage of paddy currently dried	20%					
Target output to be dried by the dryers (%)	90%	18%	17.50%	35.00%	52.50%	70.00%
Current drying cost by sun-drying (US$/tonne)	20.83					
Paddy drying cost using dryers (US$/tonne)	40.83	20				
Total quantity of paddy dried by using paddy driers (tonnes)			53874	114065	182439	261036
Total cost of shifting to paddy dryers (Million US$)			*1.077*	*2.281*	*3.649*	*5.221*

9.9.5.2. Parboiled/Saila Rice Cluster-II

Considering the introduction of paddy driers in parboiled rice cluster-II of Hafizabad District, the same target of making it mandatory in the cluster area is also fixed, which is currently operating at 20 percent level. In this cluster, what so ever the sun-drying of paddy is practiced, it is also mainly done by domestic labour or permanently hired farm labour, whose opportunity cost falls around 10.71 USD per tonne. It is estimated that by 5th year of the project, more than 181 thousand tonnes of paddy shall be dried, costing to the farming community as 7.99 million US$ (See the details in Table 35).

Table 35: Yearly Costs of Introducing Dryers in *Pucca Chawal* Cluster-II

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Percentage of paddy currently dried (%)	20%					
Target output to be dried by the dryers (%)	80%	15%	15.00%	30.00%	45.00%	60.00%
Current drying cost by sun-drying (US$/tonne)	10.71					
Paddy drying cost using dryers (US$/tonne)	44.09	33.38				

Total quantity of paddy dried by using paddy driers (tonnes)			*34003*	*73274*	*121079*	*181233*
Total cost of shifting to paddy dryers (Million US$)			*1.499*	*3.231*	*5.339*	*7.991*

9.9.6. Intervention-6a: Oil Extraction from Rice Bran - *Katcha Chawal* Cluster-I

Rice bran is one of the abundant by products produced in the rice milling industry to yield familiar white rice. Research conducted during the last two decades has shown that rice bran is a unique complex of naturally occurring antioxidant compounds. In recent years, rice bran has been reckoned as a potential source of edible oil in its natural form (Moldnhauer *et al*., 2003; Iqbal *et al*., 2005; Chatha *et al*., 2006; Sagar and Ashraf, 1986). Young-Hee *et al*. (2002) reported that rice bran contains 15-20 percent of oil, depending upon degree of milling, variety and other agro-climatic factors. Rice bran oil, its natural state, contains several constituents of potential significance in diet and health. It also contains high valued protein, fat and dietary fiber. In addition to phytonutrients, vitamins and mineral and medicinally important anti-oxidants, γ-oryzanol (natural mixture of ferulic esters) rice bran has reckoned as potential source of edible oil (Iqbal et al., 2005).

9.9.6.1. Katcha Chawal Cluster-I

At present, virtually no rice bran oil extraction activity is going on in the targeted clusters. Our target is to utilize all the rice bran produced in the cluster for extracting rice bran oil, before utilizing it for other purposes. It has been estimated that from 2nd through 5th year, 3.65, 3.91, 4.17 and 4.47 thousand tonnes of rice bran shall be available in the cluster for making rice bran oil out of it. Based on the discussions made to various experts during the field visit, it came out that almost 250 US$ per tonne is the bran oil extraction cost, therefore, the stream of costs associated with bran oil extraction in the cluster shall be 0.143, 0.46, 0.49 and 0.52 million USD from 2nd through 5th year of the project (See other details in Table 36).

Table 36: Yearly Cost of Rice Bran Oil Extraction in *Katcha Chawal* Cluster-I

Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
Current % of bran used to extract bran oil	0.0%					
Rice bran to be used to extract bran oil (%)	80.0%	20.00%	20.0%	40.0%	60.0%	80.0%
Bran production to be used in bran oil (tonnes)	1.5%		*3,694*	*3,911*	*4,170*	*4,475*
Quantity of bran oil produced (tonnes)	@20%		369	391	417	447
Cost of bran oil extraction @ 249.57 $/t (MUS$)	249.57		0.43	0.46	0.49	0.52

9.9.7. Intervention-6: Parboiled/*Saila* Rice Making in Cluster-II

Parboiled or *Saila* rice is the rice that has been partially boiled in the husk. The three basic steps of parboiling are soaking, steaming and drying. These steps also make rice easier to process by hand, boost its nutritional profile and change its texture. About 50% of the world paddy production is parboiled. The parboiling treatment is practiced in many parts of the world such as India, Bangladesh, Pakistan, Myanmar, Malaysia, Nepal, Sri Lanka, Guinea, South Africa, Italy, Spain, Nigeria, Thailand, Switzerland, USA and France (Wikipedia).

9.9.7.1. Parboiled/Saila Rice Cluster-II

It is assumed that the present level of conversion of 50 percent of the Kainat basmati varieties into *Saila*-parboiled rice shall be enhanced to 80 percent of *Saila* making. The *Saila* rice is fetching relatively higher price in the domestic and international markets. However, in *Saila* rice, some degree of aroma present in basmati varieties is lost. The cost of preparation of *Saila* rice product from Kainat paddy is estimated nearly 51.3 USD per ton. Total cost incurred for making *Saila* rice of Kainat was estimated to the tune of 0.11, 0.252, 0.416 and 0.623 million USD starting from 2nd year through to 5th year respectively (Table 37).

Table 37: Yearly Cost of Making *Saila* Rice in *Pucca Chawal* Cluster-II

Sr. #	Items	Inputs	Incre-mental	Year-2	Year-3	Year-4	Year-5
1.	Cost of preparing paddy for *Saila* rice purpose (US$/ton)	51.28					
2.	Total cost of paddy production for *Saila* rice purpose (Million US$)			***0.117***	***0.252***	***0.416***	***0.623***

9.10. Total Summary of Costs

9.10.1. *Katcha Chawal* Cluster-I

Table 38, presents the summary of the yearly costs stream from the six introduced interventions in focal Sheikhupura district.0 It can observe that total costs associated with the introduced interventions shall worth from US$ 5.340 million in 2nd year to US$ 22.012 million by 5th project year – implying an increase of almost four times towards the end of the project period.

Table 38: Yearly Expected Costs incurred Against the Introduced Interventions in *Katcha Chawal* Cluster-I (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Intervention-1: Shifting to mech. Transplanting	*0.102*	*0.203*	*0.305*	*0.406*
Intervention-2: Diffusion of HYVs	*0.165*	*0.330*	*0.494*	*0.659*

Intervention-3: Improved management practice	*3.323*	*6.647*	*9.970*	*13.294*
Intervention-4: Adoption of rice combine harvester	*0.580*	*1.160*	*1.741*	*2.321*
Intervention-5: Paddy drying service providers	*1.077*	*2.281*	*3.649*	*5.221*
Intervention-6: Rice bran oil extraction	*0.092*	*0.098*	*0.104*	*0.112*
Total (Million US$) =	***5.340***	***10.719***	***16.263***	***22.012***

9.10.2. Parboiled/*Saila* Rice Cluster-II

Table 39 summarizes the yearly costs stream from the six introduced interventions in focal Hafizabad district. It can observe that the total costs related with the introduced interventions shall cost US$ 7.004 million in 2nd year to US$ 30.165 million by 5th project year – implying an increase of more than four times towards the end of the project period.

Table 39: Additional operational costs due to Interventions in Cluster-II (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Intervention-1: Shifting to mech. Transplanting	*0.185*	*0.370*	*0.555*	*0.741*
Intervention-2: Diffusion of HYVs	*0.109*	*0.218*	*0.326*	*0.435*
Intervention-3: Improved management practice	*4.711*	*9.422*	*14.133*	*18.843*
Intervention-4: Adoption of rice combine harvester	*0.383*	*0.766*	*1.149*	*1.531*
Intervention-5: Paddy drying service providers	*1.499*	*3.231*	*5.339*	*7.991*
Intervention-6: Making *Saila* of basmati rice	*0.117*	*0.252*	*0.416*	*0.623*
Total (Million US$) =	***7.004***	***14.258***	***21.918***	***30.165***

9.11. Net-Economic Benefits

9.11.1. *Katcha Chawal* Cluster-I

Table 40, summarizes the yearly stream of net-economic benefits (after offsetting all the operating costs) from the six introduced interventions in the focal point of the cluster, Sheikhupura district. The total net-benefits from the introduced interventions shall begin from US$ 3.062 million in 2nd year to US$ 26.582 million by 5th project year – implying an increase of more than ten times towards the end of the project period.

Table 40: Yearly Expected Costs against the Introduced Interventions in *Katcha Chawal* Cluster-I (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Total expected gross returns from cluster development interventions (Million US$)	***8.401***	***20.856***	***33.707***	***48.594***

Gross costs to be incurred on cluster development interventions (Million US$)	*5.340*	*10.719*	*16.263*	*22.012*
Net-economic benefit (Million US$)	***3.062***	***10.137***	***17.444***	***26.582***

9.11.2. *Pucca Chawal* Cluster-II

Table 41 summarizes the yearly stream of net-economic benefits from the six introduced interventions in focal, Hafizabad district. It can observe that the total net-benefits from the introduced interventions shall begin from US$ 0.396 million in 2nd year to US$ 27.131 million by 5th project year – implying an increase of more than nineteen times towards the end of the project period.

Table 41: Yearly Expected Costs against the Introduced Interventions in *Pucca Chawal* Cluster-II (Million US$)

Items	Year-2	Year-3	Year-4	Year-5
Total expected gross returns from cluster development interventions (Million US$)	*7.400*	*20.538*	*36.507*	*57.295*
Gross costs to be incurred on cluster development interventions (Million US$)	*7.004*	*14.258*	*21.918*	*30.165*
Net-economic benefit (Million US$)	***0.396***	***6.280***	***14.589***	***27.131***

9.12. Investments Need to be Made

9.12.1. *Katcha Chawal* Cluster-I

In order to improve the sample *Katcha Chawal* cluster, public investment under project approach is needed. As all the calculations are made on the basis of a 5-year project, therefore, the year stream on investments required for all the six proposed interventions is given in Table 29a below. Our results clearly show that nearly 33 million USD are need to be invested in 5 years project period. Moreover, the government shall provide loans amounting 12.44 million USD shall be utilized during the project period. Most of the expenses are in the form of 100% interest free loans to the service providers in the area and installation of rice bran oil extraction plant. The public sector investment pertains to the areas like strengthening of basmati rice research and extension services, and arranging farmers' training programs towards adoption of improved crop management practices.

9.12.2. Parboiled/*Saila* Rice Cluster-II

In order to improve the sample parboiled/*Pucca* rice cluster, public investment under project approach is needed in a number of areas. Our results clearly show that more than 25 million USD are needed to be invested in 5 years project period. Moreover, the government shall provide loans amounting 9.5 million USD shall be utilized during the project period. Most of the expenses are in the form of 100% interest free loans to the service providers in the areas of enhancement of *Saila* rice production in the cluster. The public sector investment pertains to the areas like strengthening of basmati rice research and extension services, and arranging farmers' training programs towards adoption of improved crop management practices. The details of these investments and government expenditures are illustrated in Table 45 for *Katcha Chawal* cluster and Table 42 for *Pucca Chawal* cluster.

Table 42: Yearly Stream of Public Investments Needed for the Development of *Katcha Chawal* Cluster-I (Million US$)

Items	Total	Year-1	Year-2	Year-3	Year-4
Strengthening basmati rice research (100% Public investment)	**1.852**	0.463	0.463	0.463	0.463
Popularization of mechanized transplanting (100% interest free loans to service providers)	**13.033**	1.303	2.607	3.910	5.213
Investment in Agri. Extension for diffusion of improved management practices (100% govt.)	**0.484**	0.121	0.121	0.121	0.121
Farmers trainings in best management practices (100% Government)	**6.265**	1.293	1.445	1.641	1.886
Investment in popularization of paddy dryers (100% interest free loans to service providers)	**15.477**	1.548	3.095	4.643	6.191
Popularization of Kubota type rice combine harvesters (100% interest free loans to service providers)	**0.202**	0.134	0.067	0.000	0.000
Investment for installing rice bran oil extraction units (100% interest free loan to private sector)	**1.500**	0.375	0.375	0.375	0.375
Investment to organize FEGs and provide basic infrastructure	**1.852**	0.463	0.463	0.463	0.463
Strengthening international links	**0.500**	0.125	0.125	0.125	0.125
Loans provided by the Govt.	**3.847**	0.471	0.794	1.121	1.462
Total investment on the cluster needed (Million US$)	**43.161**	5.833	9.092	12.399	15.836

Table 43: Yearly Stream of Public Investments Needed for the Development of *Pucca Chawal* Cluster-II (Million US$)

Items	Total	Year-1	Year-2	Year-3	Year-4
Strengthening basmati rice research (100% Public investment)	**1.8519**	0.463	0.463	0.463	0.463
Popularization of mechanized transplanting (100% interest free loans to service providers)	**8.6000**	0.860	1.720	2.580	3.440
Investment in Agri. Extension for diffusion of improved management practices (100% govt.)	**0.3609**	0.090	0.090	0.090	0.090
Farmers trainings in best management practices (100% Government)	**4.3501**	0.816	0.943	1.148	1.444
Investment in popularization of paddy dryers (100% interest free loans to service providers)	**10.2125**	1.021	2.043	3.064	4.085
Popularization of Kubota type rice combine harvesters (100% interest free loans to service providers)	**1.1074**	0.237	0.237	0.237	0.395

Investment for installing *Saila* rice plants (100% interest free loan to private sector)	**1.0000**	0.250	0.250	0.250	0.250
Investment to organize FEGs and provide basic infrastructure	**1.8519**	0.463	0.463	0.463	0.463
Loans provided by the Govt. (Million US$)	**0.500**	0.125	0.125	0.125	0.125
Strengthening international links	**2.6697**	0.323	0.544	0.773	1.030
Total investment on the cluster needed (Mil. US$)	**30.65**	4.19	6.41	8.73	11.32

9.13. Economic Viability of Basmati Rice Cluster Development Plan

9.13.1. *Katcha Chawal* Cluster-I

In Table 44, the discounted value of stream of investments incurred under project approach and the net-benefits achieved by the farming and non-farming business community are estimated on yearly basis. It revealed that the Internal Rate of Returns (IRR) for the basmati rice cluster development in Sheikhupura District is 23.7 percent --- clearly indicating an economically viable project. It is clearly showing worth investing into the cluster for the uplift of the basmati rice production in the area through various proposed farm and non-farm level investments.

Table 44: Net-Present Value and Internal Rate of Returns of Costs and Investments Incurred in *Katcha Chawal* Cluster-I

Items	Total sum	Year-1	Year-2	Year-3	Year-4	Year-5
Discount rate (%)	8.50%					
Discounted value of investments or costs (MUSD)	**43.161**	5.833	9.092	12.399	15.836	-
Discounted value of net economic returns (MUSD)		-5.833	-6.030	-2.262	1.608	26.582
Net Present Value (Million USD)	**6.569**					
Internal Rate of Returns (%)	**23.7%**					

9.13.2. Parboiled/*Saila* Rice Cluster-II

In Table 45, the discounted value of stream of investments incurred under project approach and the net-benefits achieved by the farming and non-farm business community are estimated on yearly basis. It revealed that the Internal Rate of Returns (IRR) for the basmati rice cluster development in Hafizabad District is 32.8 percent --- clearly indicating an economically more viable project than that of *Katcha Chawal* Cluster-I.

Table 45: Net-Present Value and Internal Rate of Returns of Costs and Investments Incurred in *Pucca Chawal* Cluster-II

Items	Total sum	Year-1	Year-2	Year-3	Year-4	Year-5
Discount rate (%)	8.50%					
Discounted value of investments or costs (MUSD)	30.65	4.19	6.41	8.73	11.32	-
Discounted value of net economic returns (MUSD)		-4.19	-6.02	-2.45	3.27	27.13
Net Present Value (Million USD)	9.513					
Internal Rate of Returns (%)	32.8%					

9.14. Key Product Intervention

The team believes that rice bran oil product development can be a key product intervention that can not only improve the competitiveness of Pakistani basmati rice value chain but also help the country to solve its ballooning edible oil import. Thus, a comprehensive feasibility study has been undertaken for exploring and exploiting the high value bran oil product by the future researchers (See Annexure-6 for the details). The feasibility of the bran oil depends upon the bran oil prices. Even with the lowest price of bran currently in the market, lower than the canola oil, the IRR of bran oil extraction turns out to be 47%. However, to achieve this, some technical issues like stabilization of the barn oil quality need to be resolved (the research in Kala Shah Kaku has already achieved this). Moreover, the bran oil extraction from the kainat paddy used for preparing parboiled (*Saila*) rice product may also be explored in the future.

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10. Annexures

Annexure-1: The Pedigree of Pusa-1121 Basmati Rice

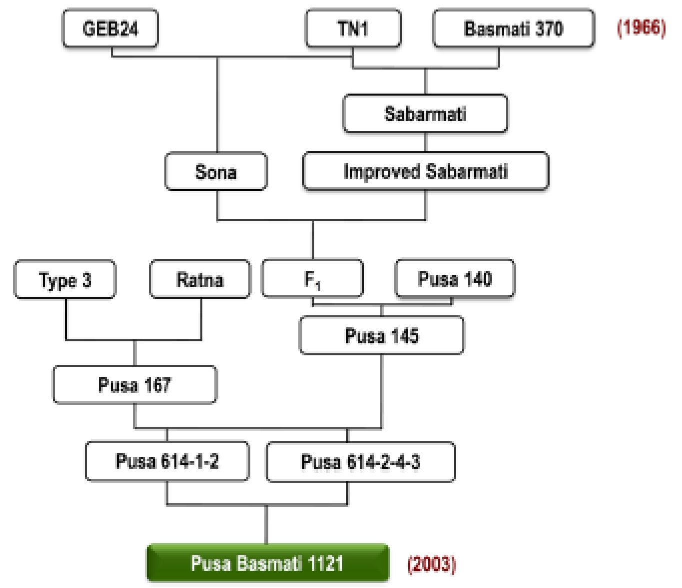
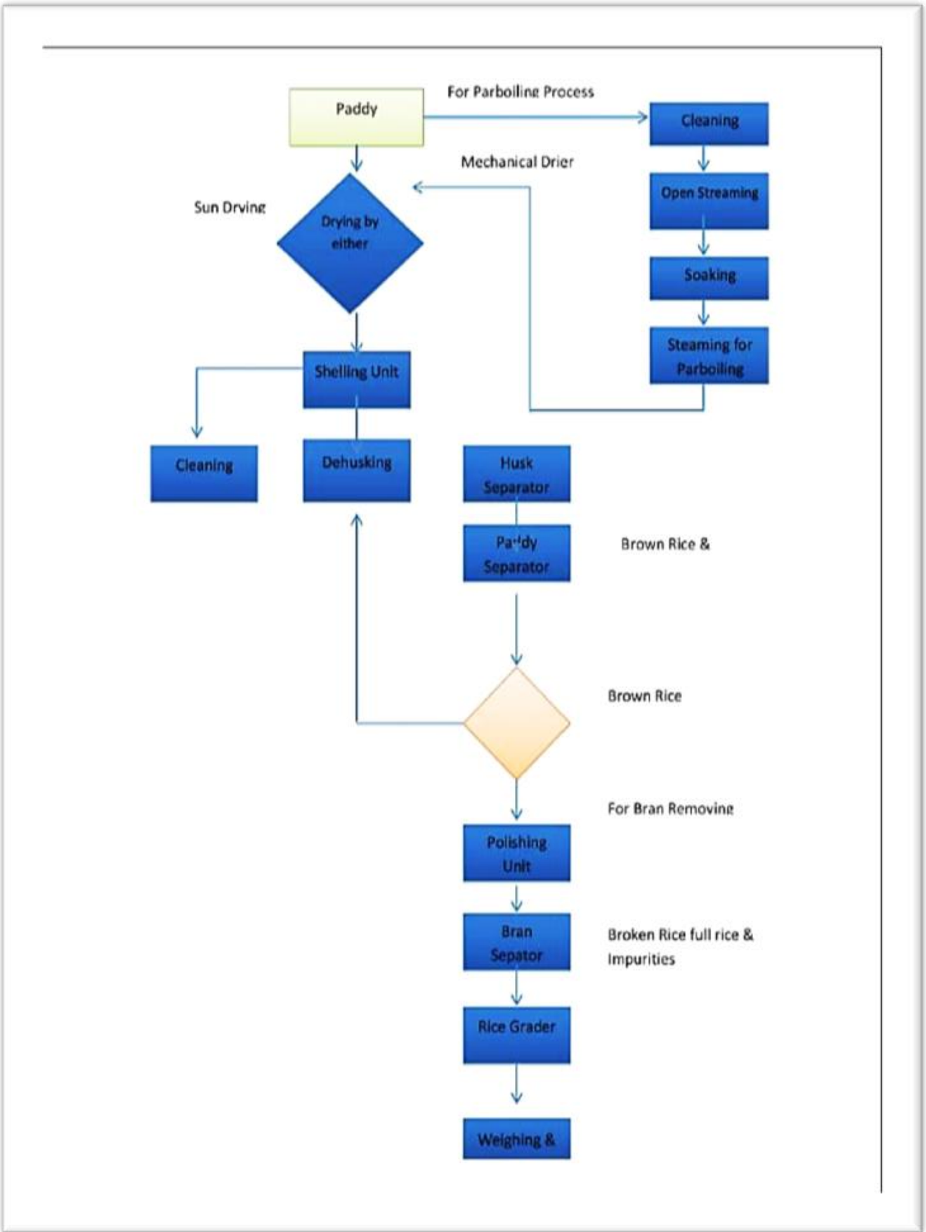


Fig. 2 Lineage of PB 1121 showing the contribution of several varieties including the traditional Basmati rice varieties Basmati 370 and Type 3. Values in parentheses are the year in which crossing was initiated (1966) and the year of release of the variety (2003)

Annexure-2. Raw Rice and Parboiled/*Saila* Rice Processing Stages (Adapted from SBP, 2016)



Annexure-3A: Pictures of Stakeholders consultation

Lodged Super Basmati Paddy Crop

Kubota Rice Combine Harvester

Wheat Combine Harvester

Sample of Basmati Paddy Supplied at Sale Centre

Mechanical Dryer.

Annexure-3B. Stakeholders consulted for gathering information about Basmati Rice/Saila Rice Clusters in *Kalar* Tract of Punjab, Pakistan

Sr.#	Name/ Designation	Organization/Business Name/Occupation	Address	Contact #
1	Omar Ashraf Sindhu	Farmer and Usman Rice mill owner	Sadoki Mianwali Road, Hameedpur Kalan, Tehsil Kamoki Distt Gujranwala	0300-8748787
2	Amer Seikh	Farmer	Narang Mandi, Sheikhupura Area	0300-7778812
3	Hajji Bilal Sadhu	Farmer	Kotli Mano Saidhu, Aamenabad, Area	0307-7278250
4	Muzammil	Farmer	Pagian, Narowal Road	0345-4316245
5	Azim	Farmer	Pagian, Narowal Road	0300-77967767
6	Azmat ullah laghai	Farmer	Ghalla Mandi, Hafizabad	0300-7525925
7	Shehbaz Cheema Brother's	Farmer/Rice Mill Owner	Aziz Chack, Daska Road, Wazirabad	0301-8644740
8	Azam Samore	Farmer	Jalalpur Bhattian, Hafizabad	
9	Inam Khaliq Chaudhry	Farmer	Depay Pur, Union Council Maju Chack, Tehsil Nowsheran Virkan	0323-6432880
10	Amjad Mahar	Commission Agent/ *Arthi*	Grain Market, Tatley Aali, Adda, Gujranwala - Sheikhupura Road	0305-6101940
11	Amjad Javed	Commission Agent/ *Arthi*	Master Allah Baksh and Sons Gunjh Mandi, Gujranwala	(055) 3844820/ 3844791
12	Mansoor Ahmed	Commission Agent/ Arthi	Faizan Medina Traders Shop # 68, Ghala Mandi, G.T Road Gujranwala	(055) 37349902
13	Chaudary Shehbaz Ahmed Cheema	Commission Agent/ *Arthi*	Aziz Chak Traders Sheikh Niaz Ahmed Ghala Mandi Daska Road Wazirabad	0301-8644740
14	Khurshid Sidhu	Agricultural Service Provider	Fertilizer dealer, Ghalla Mandi Mor Aimenabad, Wahndo road Ahmenabad	0300-8159223
15	Safdar Hussain Chatta	Agricultural Services Provider/Farmer	Chairman Sons Zarai Corporation Larri Aadda Warpaal Chatta(Rice Transplanter)	055-8706364
16	Dr. Iqrar khan (Dy. Dir)	Agri. Extension Deptt.	Near District Court, Gujranwala City	055-9200195
17	Dr. Javed Pathear (Dy. Dir. Agri.)	Agri. Extension Deptt.	Near District Court, Gujranwala City	0344-4042053
18	Engr. Naeem Faisal	Adaptive Research Deptt.	Agricultural Extension Complex, G.T Road Gujranwala	0334-4665465

Sr.#	Name/ Designation	Organization/Business Name/Occupation	Address	Contact #
19	Dr. Muhammad Akhtar, Director	Rice Research Institute	G.T Road, Kala Shah Kaku, Muridke	(042) 37951826
20	Dr. Nadeem Iqbal, Dy. Director	Rice Research Institute	G.T Road, Kala Shah Kaku, Muridke	(042) 37951826
21	Muhammad Asif Rana C/O Ch. Sameen	Manager Marketing, Atlas Foods Pvt. Ltd.	17 KM G.T Road Kamoke, Gujranwala	0321-3409724
22	Shahzad Ali Malik, MD	Guard Agriculture Research and Services Pvt. Ltd.	8th K.M., Raiwind Road, Lahore	042-35320563
23	Rana Zafar, Food Technologist	Guard Agriculture Research and Services Pvt. Ltd.	8th K.M., Raiwind Road, Lahore	042-35320563
24	Sajid Cheema, Station Manager	National Rural Support Program (NGO)	Rakhwala / Madray Wala Road, Hafizabad	0333-8109396
25	Kashif-ur-Rehman (Secretary General)	Rice Export Association of Pakistan	Suit # 405,421,4th Executive Floor, Sadiq Plaza, The Mall Road, Lahore	0300-8456715
26	Ali Hussain Asghar (Senior Vice Chairman)	Rice Export Association of Pakistan	Suit # 405,421,4th Executive Floor, Sadiq Plaza the Mall Lahore	0321-7861119
27	Abdul Ghafoor	Trading Corporation of Pakistan	Office building #1, 3rd Floor, Aiwan-e-Iqbal Complex, Egerton Road, Lahore	(042) 99206068
28	Raheel Rao	Trade Development Authority of Pakistan	62 Garden Block, Garden Town, Lahore	0333-4701230
29	Shafiq	Hassan Export, Corporation	Jalalpur Bhattian, Hafizabad	0300-4007440
30	Muhammad Sadeeq	Rice Trader	Tatley Aali Adda, Nowshera Virkan Road, Gujranwala	

Annexure-4: Classification of Paddy and Rice By-products

{Sagar, and Ashraf. (1986); NATIONAL COURIER, New Paper of (03/07/2018)}

Rice Bran

Rice Bran consists of 8 to 10 percent of rough rice exhibiting about 20 percent oil contents in it. In most of South-east Asian countries, the bran material is not fully exploited due to number of known and unknown reasons, especially in Pakistan. So, these needs to be explored on war footings. Since, the present study has proved its economic significance in Pakistan that is not less than the contribution made by maintaining the rice crop plant population density at par with the recommended levels. In Japan, a major proportion of edible oil comes from this source. Burma, Thailand, India, Nepal, and republic of Korea also manufacture edible oil from rice bran to some extent. Some agencies have attempted to explore the possibilities of its uses through extracting quality edible oil in Pakistan. But the bottleneck of moisture contents appearance in the rice bran triggers to rancid the oil quality due to up surging in the rates of free fatty acid (FFA) as per hour reaction of lipolysis enzymes. Some studies have determined that rice bran contains 2.5 percent FFA, so it is necessary to save the oil from decaying if treated the rice bran immediately after separation with some suitable chemicals to check hydrolysis. The rice bran contains high value edible material with 15 percent protein, 20 percent B vitamin, and very rich in other vitamin ingredients like thiamine, riboflavin, and pyridoxine to the tune of 2.26, 0.25 and 2.5 mg /100 gm., respectively. Bran oil has safe and valuable multiple uses viz., balanced animal feed preparation, vegetable cooking oils (contains 12-17 % lipids).

On other hand, the oil from parboiled rice is low in acid values (i.e., low contents of FFA). This special characteristic of oil extracted from parboiled rice bran seems to be subjected to treatment by steam which prevents lipase from decomposing the bran oil into free fatty acids. This area needs further probing for developing the understanding about the feasibility of oil extraction from parboiled paddy rice.

Rice Polish

Rice polish is usually considered the fraction of milled rice grain which is obtained by milling it for another pause after removing the bran. Its value on average basis is 4 percent but varies on milling depending on degree of hardness of rice kernel. Similar to rice bran, it is rich in nutrients viz., thiamine, riboflavin and pyridoxine to the extent of 1.84, 0.18 and 2.0 mg. per 100 gm., respectively. Oil and protein contents presence in rice polish bearing low protein and high protein rice grains are varied from 12.8 -13.7 percent and 13.1-18.8 percent, respectively (i.e., on dry weight basis). The lipid content ranges are from 9 to 15 percent. It is primary ingredient for stock feed but sometimes it is used in baby food and health food.

Rice germ

The germ constitutes 2 percent of the weight of the rice grain. About 80 to 90 percent of it is detached from the grain that gets mixed with the bran during the polishing of rice. Rice germ contains about 20 percent protein, 30 percent oil and 15 percent sugars. Similar to rice bran and rice polish, it contains vitamins B and E. The isolated germ also contains oil. The powdered rice germ is used in dietary formulations as well as pharmaceuticals. Keeping this in view, the Japanese have developed rice variety jumbo germ size and are grown for industrial uses. Technically advanced countries are already making best use of this byproduct. Since, Pakistan grows rice in abundance has many rice mills but this byproduct is being wasted due to unawareness and lack of technical knowhow.

Definitions and Classifications of Rice:

A) **RICE**: means milled rice includes cargo rice, white rice, glutinous rice and boiled rice (e.g., whole grain, head rice, big broken, broken or small broken):

1) **Cargo Rice**: (BROWN RICE, HUSKED RICE) means rice obtained from paddy of which only the husk has been removed. This includes whole grain, head rice, big broken, broken, and small broken;

2) **Plain or White Rice**: means rice obtained from paddy which has been husked and milled while by removing its bran layers. This includes its whole grain, head rice, big broken, broken, and small broken; and

3) **Parboiled Rice**: may be husked or milled rice processed from paddy or husked rice that has been soaked in water and subjected to a heat treatment so that the starch is fully gelatinized, followed by a drying process.

B) **GRAIN CLASSIFICATION**: means the proportional mixture of rice of different classes to form a grade Rice Kernel divided into four classes namely:

1) **Extra Long Grain**: Exhibits, head rice/whole grain measuring the average grain length of 6.90 mm or more depending upon type of variety;

2) **Long Grain**: Contains, head rice/whole grain measuring the average grain length of more than 6.0 mm but not more than 6.90 mm, and again depends upon variety;

3) **Medium Grain**: Reveals, head rice/whole grain measuring the average grain length of more than 5.0 mm but not more than 5.9 mm; and

4) **Short Grain**: Shows, the head rice/whole grain with the average grain length of 5.00 mm or less.

C) **YELLOW KERNEL**: means the kernel of which 25% or more of the surface area has turned yellow in color.

D) **CHALKY KERNEL**: means the kernel of which 50% or more of the surface area is white like the color of chalk.

E) **GREEN RICE**: means the kernel of green color in Cargo (Brown) rice which when broken is also green in color from inside or in the endosperm.

F) **BROKEN RICE**: Broken of size ¾ length of grain and above shall count as head rice.

The above definitions as well as classifications are standardized in the business circle of rice/ Paddy products' transaction in domestic and international trading. The same concepts have been discussed for interpretation in the present project report.

Annexure-5: District level area, production and yield of basmati rice

Table 46: District level area, production and yield of basmati rice in Punjab during 2016-17

District	Area (000 ha)	Production (000 tonnes)	Yield (kg/ha)
Attock......	0.000	0.000	-
Rawalpindi..........	0.000	0.000	-
Islamabad...........	0.000	0.000	-
Jhelum.............	1.220	2.090	1713
Chakwal............	0.000	0.000	-
Sargodha....District	27.110	43.850	1617
Khushab............	26.310	50.750	1929
Mianwali...........	6.070	10.250	1689
Bhakkar............	0.400	0.710	1775
Faisalabad.…	19.830	36.930	1862
Toba Tek Singh......	37.630	87.540	2326
Jhang...............	49.370	94.260	1909
Chiniot...............	31.970	56.380	1764
Gujrat......	33.690	47.580	1412
Mandi Baha-ud-Din...	57.460	104.840	1825
Sialkot............	114.930	205.660	1789
Narowal............	63.940	105.500	1650
Gujranwala..........	101.980	184.350	1808
Hafiz Abad..........	104.410	213.300	2043
Sheikhupura……	158.230	289.840	1832
Nankana Sahib …….	99.140	193.680	1954
Lahore.............	27.520	46.470	1689
Kasur...............	34.400	58.280	1694
Okara..............	72.430	142.510	1968
Sahiwal……….	27.520	56.980	2070
Pakpatan...........	46.540	95.630	2055
Multan.............	15.780	28.360	1797
Lodhran............	10.930	18.360	1680
Khanewal...........	28.730	57.130	1989
Vehari.............	33.180	62.190	1874
Muzaffargarh……	21.050	37.770	1794
Layyah.............	9.710	16.730	1723
D. G. Khan..........	0.000	0.000	-
Rajanpur...........	0.000	0.000	-
Bahawalpur……	13.760	25.330	1841
Bahawalnagar.........	58.270	116.950	2007
Rahimyar Khan.......	19.430	35.190	1811

Annexure-6: Rice Bran Oil Processing Plant

Pakistan can save billions of dollars spent on the import of edible oil, if the production of local oil seeds promoted and some other innovative options like extraction of rice bran oil is encouraged. The oil import bill is set to rise as the population is increasing with a fast pace which will hurt forex reserves. Therefore, government should promote edible oil sector to make the country self-sufficient. Primitive oil mills are wasting hundreds of thousands of oilseeds during oil extraction, while about 30 thousand tonnes of oil can be extracted from the rice bran which needs attention of the private sector. Per capita use of edible oil in Pakistan stands at 13 liters, while its usage is increasing by 3 percent per annum (Daily Nation, 18th October 2015).

The rice bran is a by-product of the rice milling process. The conversion of paddy into brown rice as well as well as white rice produces this by-product. Bran is the outer shell of our daily rice grain and is often removed during processing and used as animal feed and others. According to the American Heart Association, rice bran oil is the healthiest edible oil in the world. Rice bran oil may be the largest underutilized agricultural commodity in the world. The production and processing of rice bran oil are similar to many other vegetable oils. The cost per liter is close to sunflower oil, but relatively healthier. The production of rice bran oil is economically viable. Pakistan is also one of the largest exporters of rice in the world, but does not produce any bran oil like other countries. India is currently the largest producer of rice oil. Every year about 3-4 million tonnes are produced worldwide, mainly in Asian countries like Japan, Thailand and China. Increasing home cooking oil production is a good option. Pakistan currently produces 6.7 million tonnes of rice annually and can reduce its import edible oil bill by around $ 510 million, using the potential of producing rice bran oil. Pakistan can gradually improve the efficiency of rice bran oil technology. At present, domestic rice bran oil consumption is very low, so an aggressive marketing campaign is required to launch the product on the domestic market.

Objective:

The objective of this feasibility study is to estimate feasibility of the Rice bran oil on small scale processing plant for the future investors so that by following functions in the value chain can be incorporated:

- Crude rice bran → cleaning → softening → expanding → drying → to extraction and loading etc.

The process

Rice bran oil processing plant /oil leaching plant /oil solvent extraction machine process is given below:

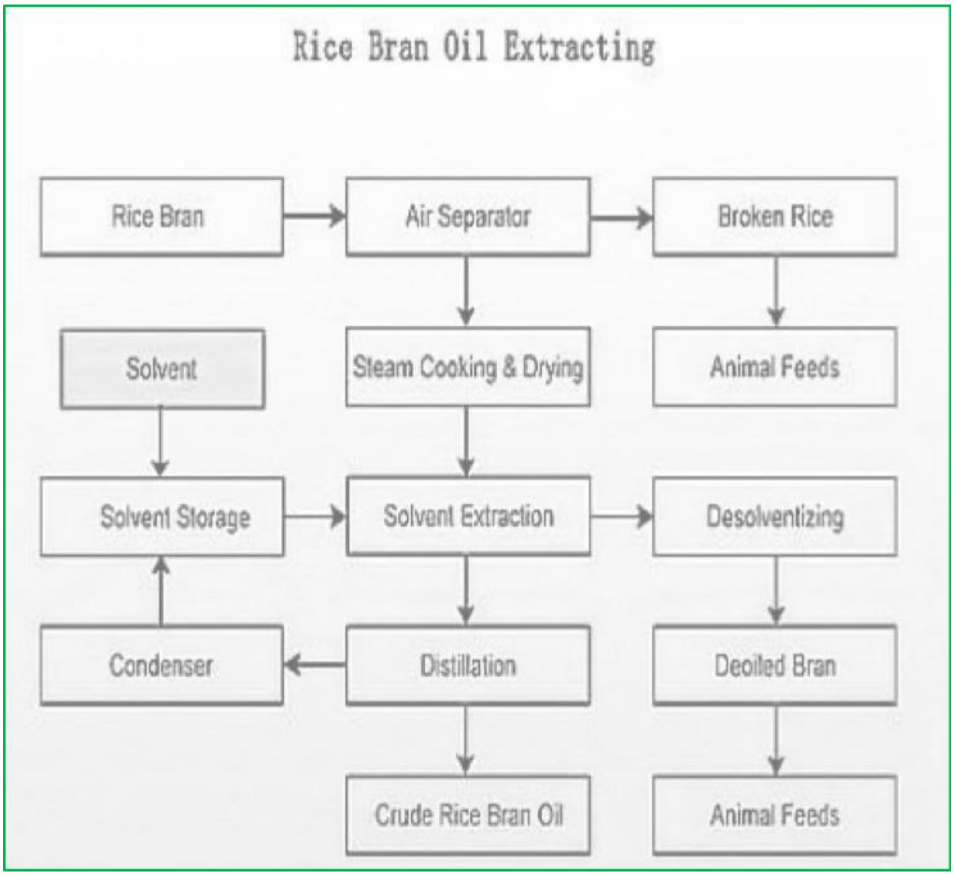
1. The material (for pre-treatment) is sent to rotary extraction by the scraper conveyor. The material will be extracted by the solvent or mix oil. After this step, we will get meal and mix oil.

2. Meal is sent to toaster. Through the toaster, the solvent in the meal will separate from the meal. The solvent goes to condenser and is recycled to rotary extraction.

3. After the mix oil from the rotary extraction enters into 1st evaporator and 2nd evaporator, most of the solvent in the mix oil is separated.

4. The mix oil from 2nd evaporator goes to stripping tower and almost all the solvent is separated. From the stripping tower, we can get crude oil and solvent. The solvent is sent to condenser and is recycled to rotary extraction.

Process Flow chart of Rice Bran Oil extraction



Specifications of Rice Bran Oil Processing Plant:

Craft features:

Create good production environment

1. Minimize the total fat loss, increase oil yield and output and improve the quality of oil and cake & meal.
2. Comprehensively utilize impurities and offal.
3. Perfectly match extraction production line, design different production processes according to different materials.

Rice bran oil processing plant /oil leaching plant/oil solvent extraction machine

Introduction:

It is composed mainly of extractor desolventizer, evaporators, stripping tower and condensers. The oil can be extracted from oil-bearing materials through solvent contacting, steeping or spraying of oil flake (soybean) or pre-pressed cake (rapeseed, cottonseed, sunflower seed, peanut, rice bran, sesame, tea seed, coconut etc.) based on solvent extractor, stainless steel tube condenser, aluminium alloy tube condenser or plate condenser, exhaust gas freezing recovery device are applied in the technology with advanced process and good performance.

1. Solvent extraction machine
2. Suitable for rice bran oil press
3. Pure oil, edible oil quality
4. Capacity: 10 tonnes/day
5. Used for hot and cold press

Rice Bran processing Machine

Rice Bran Processing Plant

Pictures of the processing machine

Machine's main equipment:

(1) The solvent extract equipment adopts stainless steel fixed grid tray, frequency conversion speed regulation, extract equipment storage tank feeding level is automatic control, high extracting efficiency, low energy consumption; Extracting condenser, steam degassing condenser, stripping condenser, evaporative condenser, the final condenser is aluminium alloy tube-type condenser, the condensation effect is fast.

(2) Wet meal dissolution using DTC toast-desolventizing, dissolution, drying in one machine. The production of finished meal powder is small, good colour, toast-desolventizing level is self-automatic control.

(3) Adopts film evaporation process, evaporation temperature is low, crude oil quality is good, energy saving, secondary steam from toaster and waste heat can be utilized, as the first evaporator heat source.

(4) Steam-lift crude oil and steam mixed oil heat exchange, save energy.

(5) The tail gas recovery uses the water bath type tail gas recovery device, the tail gas recovery two times utilization, reduces the solvent consumption.

Specification of Rice bran oil processing plant/oil solvent extraction machine

Condition:	New	Type:	Hot Air Dryer
Automatic Grade	Automatic	Voltage:	220V/380V/440V
Brand Name:	Hanson	Power(W):	5.5KW
Production capacity:	Rice Bran (15% to 20%)	Phosphoric acid:	2-3 Kg/t oil
Capacity:	10 tonnes/day, or According to request	Colour:	As required
Raw material:	Rice Bran	Advantage:	High oil yield, retain low power
Model Number:	CT-C-II	Weight:	1200 kg
Function:	Oil Solvent extractor	Certification:	ISO9001
Warranty:	1 Year	Year:	2019
After-sales Service Provided:	Engineers available to service machinery overseas	Dimension (L*W*H):	2000*1400*1850mm
Name:	Rice bran oil processing plant /oil leaching plant /oil solvent extraction machine	Area:	Depend on the capacity
Material:	Steel and Iron	Factory:	Henan Hanson, machinery Co., Ltd.

Plant and Machinery:

Productive Capacity: 10-40 Tonnes per day

Processing Material: Puffed Rice Bran

Major Equipment: Rotocel Extractor/Loop Extractor/Towline Extractor, D.T.D.C Desolventizer Toaster, Evaporation and Steam Stripping Equipment, Paraffin Recovery Equipment

Application: The extraction of rice bran oil, Get crude rice bran oil. The production line of rice bran oil extraction machine adopts the type of safe and advanced technology oil processing craft on basis of chemical extraction theory. Developed countries make processing of 90% oil by oil extraction process. The extraction process mainly includes extraction system, desolventizing and toasting system, evaporation system and condensation system.

Oil Extraction System: For extracting oil from Expanded rice bran to get Miscella, which is mixture of Oil and Hexane;

Wet Meal Desolventizing System: For removing Solvent from Wet Cake Meal, toast as well as dry Meal, to get proper finished Meal Product qualified for animal feed;

Miscella Evaporation System: For evaporating and separating Hexane out from Miscella under negative pressure;

Oil Stripping System: For thoroughly removing residual Solvent to produce standard Crude Oil for the following oil refining process

Solvent Condensing System: For recovering and circulating use of Hexane;

Paraffin Oil Recovering System: To recover residual Hexane

The cost of plant & machinery is estimated at US$ 18000 including installation and commissioning. The installed production capacity will be 1 tonne per day. The cost estimates for plant & machinery has been worked out based on the cost figures available from recent orders paced for similar items in the recent past, duly updated to cover the price escalation in the intervening period. These costs are given in the following tables:

Plant and Machinery

S. No.	Particulars	Quantity	Rate (US$)
1.	Bran Oil processing machine	1	8000
2.	Solar generator	1	3000
3.	Packaging machine, Pouch sealing machine	1	1000
4.	PU Building for Processing Unit Installation (1000 sq. ft.)	1	6000
	Total		**18000**

Misc. Fixed Asset Costs:

US$ **7320** has been estimated under the heading of miscellaneous fixed assets. The details of electrical installations for power distribution have been considered commensurate with the power load and process control requirements. Other miscellaneous fixed assets including furniture, office machinery & equipment, equipment for water supply, office stationery, telephone and refreshment, workshop, fire-fighting equipment, etc. will be provided on a lump sum basis as per information available with the consultants for similar assets. The details of miscellaneous fixed assets and their associated costs are been shown in table below:

Miscellaneous fixed asset cost

S. No.	Particulars	Quantity	Rate (US$)
1.	Office Equipment	1	1000
2.	Furniture and Fixture	1	1000
3.	Miscellaneous Accessories	1	1000
4.	Fire Fighting	1	70
5.	Computer with Accessories	2	1000
6.	Water Treatment Plant – 500 litres per hour	1	1000
7.	Loading Tempo	1	250
8.	Electrical and water lines Installation	1	2000
	Total		**7320**

Pre-Operative Expenses:

Expenses incurred prior to commencement of commercial production are covered under this head that total US$ **7632.** Pre-operative expenses include establishment cost, rent, taxes, traveling expenses and other miscellaneous expenses. It has been assumed that the funds from various sources shall be available, as required. Based on the project implementation schedule, the expected completion dates of various activities and the estimated phasing of cash requirements, interest during construction has been computed. Other expenses, under this head have been estimated on a block basis, based on information available for similar projects.

Pre-Operative Expenses

Sr. No.	Particular (for 1 year)	Amount (US$)
1.	Interest up to production @ 16% on term loan amount of US$ 29855 **(30% of total project cost)**	4777
2.	Electricity charges during construction period	1000
3.	Marketing Launch Expenses	1000
4.	Technology Know-how	3000
5.	Training expenses	1000
6.	Travelling Expenses	1000
	Total	**11777**

Cost of raw material:

Based on a processing capacity of 10 tonnes per day considering and 90 days of working per year, the annual raw material consumption of the pack house is 900 tonnes. The cost of bran based on its average selling price as determined through interview with randomly selected farmers and converting it into US$ (with conversion rate of one US$=135) is $170/tonne. Adding US$20 per tonne transportation cost from the field to processing unit, the raw material cost for pack house would be US$190.

Cost of raw material

Particulars	Rate per tonne (US$) for the raw Rice Bran at the wholesale	Qty. (Tonnes) per annum	Raw material cost (US$)
Raw Bran for Oil extraction	190	900	171000

Note: converting 1 tonne of Raw Rice bran will produce **10** % oil, so in the model we will be using conversion factor for oil extraction from per tonne raw rice bran.

Land Lease Charge:

Required land is 6,000 sq. ft. which has been considered on lease @ US$200 per annum for first three years and @ US$232 for the fifth year and subsequently @5% increase every year.

Table Land lease charges

S. No.	Year	Lease charges Per Annum (US$)
1.	1st year	200
2.	2nd year	200
3.	3rd year	210
4.	4th year	221
5.	5th year	232

	Total	**1063**

Electricity and Water Consumption Charges:

The unit cost of electricity has been considered @ PKR.20.70/ unit assuming that the entire power requirement is met from the grid. A power supply of 2.2 Kw is deemed appropriate. The expense on water supply, treatment and distribution has been suitably considered, based on the tariff by water and sanitation agency (WASA) for per month consumption of water tariff of @ 92.82 PKR/thousand gallons. Water requirements are approximately 100 gallons per day.

Electricity and water consumption charges

S. No.	Description	Amount Per Annum (US$)
1.	Power Consumption	4000
2.	Water Consumption	200
	Total	**4200**

Human Resource Cost

One pack house manager, one accountant for six months, one supervisor for complete year technical staff Salaries & wages (including benefits) for different categories of employees have been considered based on present day expenses being incurred by other industries in the vicinity. The breakdown of manpower and incidence of salaries & wages are detailed in the table Salary & Wages. Salary & wages are increased @ 5% every year.

Salaries and wages

Sr. No.	Description	Requirement	Salary/month (US$)	Salary/annum (US$)
1.	Plant Manager	1	600	7200
2.	Accountant	1	450	5400
3.	Supervisor	1	400	4800
4.	Skilled Workers	2	300	3600
5.	Driver	1	200	2400
6.	Security Guard	1	200	2400
	Total		**2150**	**25800**

Table 47: Cost of the Project

Sr. No.	Particular	Value (US$)
	Fixed costs:	
1.	Plant and Machinery	18000
2.	Misc. Fixed Assets	7320
3.	Pre-operative expenses	11777
	Operating costs:	
4.	Cost of raw material	171000
5.	Land lease charges	1063
6.	Electricity and water consumption	4200
7.	Salary and wages	25800
8.	Packaging Cost	44440
9.	Marketing Cost	1000
10.	Margin Money for Working Capital	1000
11.	Contingencies 5% of Fixed Assets	366
	Total variable costs	**285966**

Project Income Statement

Net profit (Net cash flow) = 36099

NPV =47,004

IRR =40%

Project Viability:

The Internal Rate of Return of the project is estimated at **…..**%, which is significantly higher than the bank return rate of 16%.Hence, the project is deemed financially viable. The NPV of the project is positive (US$ **….**) at a discount factor of 16% during the first 5 years of operation considered. This implies that the project generates sufficient funds to cover all its cost, including loan repayments and interest payments during the period. This also indicates that the project is financially viable over the long term.

Note: Extracting 1 tonne of raw rice bran will produce 20% of oil.

Annexure-7: Feasibility for Mechanical Rice Transplanting

Operating efficiency @0.45 acre per hr (ha per hr)	0.18					
Per day efficiency @10 hrs work every day (ha)	1.8					
Working days in a year	25					
Area transplanted in a season (ha)	46					
Revenue (US$)						
Increase in per ha yield (%)	**15%**		0.07	0.14	0.22	0.29
Total increase in production for the whole season (tonnes)			3.20	6.47	9.82	13.24
Price of paddy (US$/tonne)			377	377	377	377
Increase in revenue due to improved yield (US$)			**1207**	**2442**	**3705**	**4997**
Direct variable costs						
Cost of manual transplanting (US$/ha)			**226**	**226**	**226**	**226**
Cost of mechanical transplanting (US$/ha)			**171**	**171**	**171**	**171**
Saving in cost (US$/ha)			**56**	**56**	**56**	**56**
Total saving in cost during the season (US$)			**2528**	**2528**	**2528**	**2528**
Cost of training support by the government			14.8	14.8	14.8	14.8
Maintenance (2% of the machinery cost)			120	120	120	120
Depreciation			550	550	550	550
Increase management cost of paddy field due to improved plant population (0.05% of the initial cost)			2622	2622	2622	2622
Total variable cost			**779**	**779**	**779**	**779**
Gross profit			**428**	**1663**	**2926**	**4217**
Indirect fixed cost						
Machinery		-6000				
Total		**-6000**	**0**	**0**	**0**	**0**
Grand total cost		**-6000**	**779**	**779**	**779**	**779**

Net profit (Net cash flow)		**-6000**	**428**	**1663**	**2926**	**4217**
NPV	8.5 %		1,051			
IRR			15%			

Annexure-8: Feasibility for Combined Rice Harvester

Operating efficiency @6 acre per hr (ha per hr)	2.43					
Per day efficiency @8 hrs work every day (ha)	19.4					
Working days in a year	20					
Area harvested in a season (ha)	389					
Revenue (US$)						
Reduce post-harvest losses (%)	**8%**		8%	8%	8%	8%
Base year yield (t/ha)			1.87	1.90	1.92	1.94
Total increase in production due to reduce losses for the whole season (tonnes)			58	59	60	60
Price of paddy (US$/tonne)			377	377	377	377
Increase in revenue due to improved yield (US$)			**21977**	**22228**	**22482**	**22740**
Added value of rice straw (US$/ha)	**60**					
Increase in revenue due from straw saving (US$)			**23310**	**23310**	**23310**	**23310**
Total Revenue			**45287**	**45539**	**45793**	**46050**
Direct variable costs						
Cost of wheat harvester (US$/ha)			**56**	**56**	**56**	**56**
Cost of Kabuta rice harvester (US$/ha)-33% higher than the rice transplanter			**74**	**74**	**74**	**74**
Additional cost of rice harvester (US$/ha)			**18**	**18**	**18**	**18**
Labour cost			**31,040**	**31,040**	**31,040**	**31,040**
Total additional operating cost of harvester (US$)			**7,122.62**	**7,123**	**7,123**	**7,123**
Total variable cost			**38163**	**38163**	**38163**	**38163**
Gross profit			**-16186**	**-15934**	**-15680**	**-15423**
Indirect fixed cost						

Machinery		-19000				
Total		**-19000**	**0**	**0**	**0**	**0**
Grand total cost		**-19000**	**38163**	**38163**	**38163**	**38163**
Net profit (Net cash flow)		**-19000**	**7125**	**7376**	**7630**	**7887**
NPV	8.5%		5,066			
IRR			21%			

Annexure-9: Feasibility for Rice Dryer

Revenues		Year 1	Year 2	Year 3	Year 4	Year 5
Revenue (US$)						
Capacity of the dryer per day (tonnes)			15	15	15	15
Working days in a year			50	50	50	50
Quantity of rice that can be dried (tonnes)			750	750	750	750
Dried paddy (conversion factor=93%)			698	698	698	698
Premium for drying paddy (value addition) (US$/tonne)			64	64	64	64
Total revenues (US$)			**44748**	**44748**	**44748**	**44748**
Direct varaible vosts						
Labour cost			25200	25200	25200	25200
Electricity and water			2500	2500	2500	2500
Depreciation sost			1350	1350	1350	1350
Maintinance (5% of the machinery, equipment and furniture cost)			900	900	900	900
Land lease charges (5%) increment on annual		300	315	331	347	365
Marketing (US$5/tonne)			2250	2250	2250	2250
Office administration			556	556	556	556
Total variable cost			**33071**	**33086**	**33103**	**33120**
Gross profit			**44748**	**44748**	**44748**	**44748**
Indirect fixed cost			44.1			
Machinery		-18000				
Total		**-18000**	**0**	**0**	**0**	**0**
Grand total cost		**-18000**	**33071**	**33086**	**33103**	**33120**
Net profit (Net cash flow)		**-18000**	**11677**	**11662**	**11645**	**11628**
NPV	8.5 %		**18,595**			
IRR			**53%**			

Annexure-10-: Costs and revenues statistics of basmati cultivation by conventional transplanting and improved management practices (Rs/acre)

Item	Marginal (N=108)	Small (N=119)	Medium (N=53)	Large (N=61)	Overall (N=341)	Added cost due to improved practices
Seedbed preparation and nursery TP						
Disc plowing	450	346	519	381	415	0
Dry plowing	4,931	4,809	4,238	4,740	5,017	0
Dry planking	528	432	519	510	588	0
Wet plowing	5,899	6,204	6,157	6,134	6,086	0
Wet planking	1,832	1,821	1,643	1,772	1,791	0
Nursery raising	1,730	1,730	1,730	1,730	1,730	900
Nursery transplanting	9,885	9,885	9,885	9,885	9,885	1,000
Fertilizer, manure application						
Di-ammonium phosphate (50-kg bags,)	5,938	5,738	5,738	6,671	5,938	1000
Urea (50-kg bags,)	4,766	5,016	4,766	4,515	4,801	0
Nitrophos (50-kg bags,)	96	48	386	96	96	50
Other (e.g. sulfate of potash)	93	371	278	834	371	50
Boron	42	63	42	168	63	20
Zinc sulfate (10-kg bags)	1,390	1,520	1,353	1,594	1,464	500
Farmyard manure application	291	323	196	78	135	50
Green manuring	0	0	0	280	40	0
Irrigation						
Canal	210	210	210	210	210	0
Tubewells	13,662	15,756	13,202	14,850	15,736	0
Mixed (Canal+tubewell)	7,800	6,600	7,350	9,000	8,013	500
Plant protection						
Manual weeding	185	0	0	0	74	0
Weedicide	1,975	2,054	1,975	2,331	2,074	0
Granular pesticide	1,173	1,247	1,519	1,433	1,297	0
Pesticide spray	1,817	2,192	2,232	2,430	2,113	0
Harvesting and threshi						
Manual harvesting and threshing cost	717	337	85	36	132	20
Combine harvester for wheat cost	6,783	6,835	7,141	6,653	6,765	500
Combine harvester for ric cost	204	473	290	985	748	0
Cost estimates						
Total variable costs (Rs/ha)	72,192	73,539	71,163	76,329	74,837	4,590

Item	Marginal (N=108)	Small (N=119)	Medium (N=53)	Large (N=61)	Overall (N=341)	Added cost due to improved practices
Mark-up (12.5% per annum)	4,043	4,148	3,996	4,353	4,246	
Total fixed costs—land re for 6 months	43,245	43,245	43,245	43,245	43,245	
Total cost (Rs/ha)	119,480	120,932	118,404	123,927	122,328	
Yield (kg/ha)	3,675	3,878	3,778	3,762	3,781	
Value of straw	-	-	-	-	-	
Costs and returns estimates						
Total cost (Rs/ha)	119,480	120,932	118,404	123,927	122,328	
Production cost at farm gate (Rs/kg)	33	31	31	33	32	
Market costs/40-kg (transport+commission)	2	1.9	1.9	1.9	1.9	
Av. market price obtained (Rs/kg)	35	36	36	38	36	
Net income/ha (all costs included)	2,273	9,507	9,135	11,054	5,765	
Net income/ha excluding land rent	45,518	52,752	52,380	54,299	49,010	

ha = hectare, kg = kilogram, md = 40-kg; *Source: Baseline Survey data, 2017.*

Note: This table is taken from Bashire *et al.*, 2018 for traditional technology, while additional cost under improved technology is estimated after stakeholders' consultation.