CLUSTER DEVELOPMENT BASED AGRICULTURE TRANSFORMATION PLAN VISION-2025

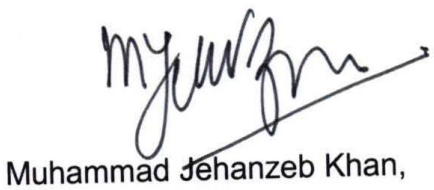
Garlic Cluster Feasibility and Transformation Study

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 analyzed 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 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 monumental 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 Ms. 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 garlic 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. Shahzad Kouser
Senior Author

Citation:

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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 Special Initiatives or the Centre for Agriculture and Bioscience International (CABI).

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LIST OF ACRONYMS

AC	Agro-Based Clusters
ACDF	Agriculture Cluster Development Fund
AVRDC	Asian Vegetable Research and Development Corporation
CIPM	Cluster Initiative Performance Model
FAO	Food and Agriculture Organization
FCSC	Farmers Common Service Centre
GAP	Good Agricultural Practices
GEGs	Garlic Enterprise Group
GoP	Government of Pakistan
ha	Hectare(s)
HYV	High Yielding Varieties
IFM	Improved Farm Management
IRR	Internal Rate of Return
KP	Khyber Pakhtunkhwa Province
NARC	National Agricultural Research Center
NGO	Non-Governmental Organization
PARC	Pakistan Agricultural Research Council
PCs	Producers' companies
PGA	Pakistan Garlic Association
PoP	Persistent Organic Pollutant
R&D	Research and Development
RSP	Rural Support Programmer
SGS	Société Générale de Surveillance
SHRI	Sindh Horticulture Research Institute
SWOT	Strengths, Weaknesses, Opportunities, and Threats
VOs	Village Organizations
WHO	World Health Organization
ZTBL	Zairi Taraqiati Bank Limited

EXECUTIVE SUMMARY

Garlic (Allium Sativum) is the second most popular cultivated allium after onion in the world. It is considered a significant spice for food and a prominent solution for different illnesses and physiological issues. Global production during 2017 of garlic has reached to 28.2 million tonnes cultivated on 1.58 million ha with an average yield of 17.8 tonnes per ha. China is the global leader with garlic production of 22.2 million tonnes. China also leads the world in its exports followed by Spain. The top importer of fresh garlic is Indonesia, followed by Brazil and Malaysia.

The garlic in Pakistan is cultivated on 8.1 thousand ha producing 70.9 thousand tonnes with an average yield of 8.8 tonnes per ha. The production in the country is expanding at 0.74% per annum, much lower than its population growth rate of 2.1% as well as global rate of 5.8%. This implies that unless the domestic production rate is improved, the country has to increasingly rely on imports which is already expanding at an alarming rate of 14% per annum and had reached to US$68 million in 2017. The per ha yield of garlic in Pakistan is less than one half of the world average and it is improving at only 0.60% compared to the average global improvement rate at 3.6% per annum, implying that Pakistan is losing its competitive position in the domestic and international markets. Pakistan has also lost its comparative position because of its lower rate of production increase than the world average. During 2001, Pakistan was at 19th position in the list of garlic producing countries which has slipped to 22nd position in 2017. Moreover, Pakistan did not benefit from the global garlic market which is fast expanding at 11% per annum rate and has reached to US$3.1 billion in 2017.

To improve these trends in garlic production and trade, the Planning Commission of Pakistan has initiated this study to analyze the whole value chain of garlic, identify gaps and potentials along the chain, and suggest economically viable interventions to improve Pakistan's competitiveness in garlic production and trade. To incorporate the regional context, the analysis is undertaken at the cluster level of major garlic producing areas in the country. To achieve these objectives, macro data related to garlic production, marketing, and trade were analyzed, a large number of stakeholders were consulted, and garlic related literature were reviewed. An EXL spreadsheet model was developed to analyze the economic feasibility of suggested interventions.

Garlic is produced all over Pakistan and is consumed by whole population in small amount. Although all provinces of Pakistan contribute to garlic production, this study based on regional data has identified four clusters named Northern Punjab Cluster, Central Khyber Pakhtunkhwa Cluster, Northern Balochistan Cluster and Southern Sindh Cluster comprising major garlic producing districts in the four provinces.

Through the consultation of stakeholders, several performance gaps are identified in the production, processing and marketing components of the existed garlic value chain, specifically with the seed technology, farm mechanization, availability of inputs, post-harvest

management, processing and market structures. These include various impact of climate change in different clusters like shortage of water in Sindh and Balochistan, use of waste water in Punjab, and high and low temperature in KP, little research on garlic varieties and optimal management practices, cultivation of old varieties, unrestricted Imports, suboptimal and imbalance use of input, planting-time shortage of labor and lack of mechanization in planting and harvesting, pest infestation, lack of community actions, and little primary processing at village level.

Despite these constraints, however, we also recognized that Pakistan has huge potential to overcome these constraints and boost its production due to fertile land, wide spread canal and tube well irrigation system, cheap labor, and possibility of learning from China through CPEC.

Based on the identified gaps and international average performance in garlic production and trade, performance targets were set and interventions were suggested at cluster level to meet these targets. These include promotion of high yielding varieties, capacity building of producers to introduce improved management practices, introducing garlic planter and harvester, and incentivizing value chain infrastructure to introduce sorting, grading, packaging, etc. and introduce store houses.

These interventions are to be initiated by government and executed in collaboration with participation of private sector including the farmers, processors, traders and their groups/associations. The total estimated investment of this cluster development/up-gradation plan is about US$5.84 million for all the clusters. Out of the total investment, about 82% will be borne by the public sector in the form of strengthening the garlic research and extension system, capacity building of stakeholders along the value chain, and incentives on encouraging farm mechanization and building village cold storages, while remaining 18% will come from the private sector. About 62% of the investment will be required at production level and remaining 38% at the value chain level.

This investment shall result in far reaching economic and social impacts, including increased productivity and production, higher quality, production value, income and employment, benefiting all the stakeholders of garlic clusters in all provinces. After discounting all the fixed and operational costs including those at the production, processing and value chain levels, the cluster upgradation plan is expected to increase the net returns to various stakeholders along the value chain, the present value of which will be US$13.2 million over a period of five years in all the clusters. In conclusion, the overall economic, social and environmental impact of the cluster development program shall be positive, sustainable and long lasting. Accounting for all the fixed costs and variable costs of proposed three interventions including the production improvement, mechanization improvement and post-harvest loss reduction, the estimated Internal Rate of Return (IRR) for all the clusters will be 105%. The cluster level information on investment, operational costs, net benefit, NPV, and IRR can be seen in the Summary Sheet attached below.

The positive and high estimated IRRs for all the clusters signify the fact that cluster development interventions are likely to improve the overall potential of the garlic value chain

across the country. Moreover, improved national production would help to save foreign exchange earnings of US$22 million on garlic import in the last year of the project.

This will be achieved only if the integrated approach of cluster development is adopted in meeting the gaps along the whole value chain, garlic related research and extension systems are strengthened, capacities of stakeholders to produce and handle the quality garlic are improved. Organization of Farmers Entrepreneur Groups will also be critical to overcome small farmers' economy of scale problem, gather appropriate investment, and enable them to participate in quality garlic market.

Summary Sheet of Garlic Cluster

Information	Central KP	Northern Punjab	Northern Balochistan	Southern Sindh	Overall
Area of the focal point (ha)	502	368	650	296	1816
Production of the focal point (tonnes)	5347	2822	5811	1558	15538
Area under cultivation (ha)	1,034	873	734	593	3,234
Total garlic production (tonnes)	12,489	7,151	6,635	3121	29,396
Default yield (tonnes/ha)	12.08	8.19	9.04	5.26	9.1
Additional production - improved variety (tonnes)	2572	2207	2157	959	7896
Additional value of production - improved variety (000US$)	1429.1	1226.2	1198.4	88.8	3942.4
Production increase – Improved practices (tonnes)	643.1	367.9	359.5	159.8	1,530.3
Additional value of production- improve practice (000 US$)	357.3	204.4	199.7	88.8	850.2
Saving in production – Lower postharvest losses (tonnes)	7,535	5,726	2,611	2895	18767
Additional value - lower Ph losses (Million US$)	3.362	2.417	0.704	1.033	7.516
Saving in sowing cost due to planter (US$)	43,158	32,386	1,792	13,374	90,710
Saving in harvesting cost due to harvester (US$)	6,562	8,856	1,792	550	17,761
No. of planters required	4	4	4	4	**16**
No. of harvesters required	12	12	8	8	**40**
No of cold storage required	4	4	4	4	**16**
Investments (000 US$)					
Investments on Research	888.3	750.0	630.5	509.4	2778.2
Investments on strengthening extension	200.0	200.0	200.0	200.0	800.0
Investments on training of stakeholders on value chain management	200.0	200.0	200.0	200.0	800.0
Investments on introduction of farm mechanization	109.9	109.9	80.9	80.9	381.6
Investments on reduce post-harvest losses through cold storage	240.4	240.4	240.4	240.4	961.5
Loan	38.5	38.5	35.3	8.8	121.2
Total investments	**1677.0**	**1538.7**	**1387.2**	**1239.6**	**5842.5**
Source of investment (Million US$)					
Total public sector investments, including loans and subsidies	**1.397**	**1.259**	**1.130**	**0.983**	**4.768**
Total private sector investment	**0.280**	**0.280**	**0.257**	**0.257**	**1.074**
Production level investments	1.088	0.950	0.831	0.709	3.578
Value chain level investments and processing	0.589	0.589	0.557	0.530	2.264
Economic Analysis (000 US$)					
Total production increase in 5th year (tonnes)	10,791	8,334	5,159	4,027	28,311
Gross revenue (undiscounted) in 5th year	5220.9	3907.1	2122.9	1676.0	12926.9
Additional operation costs in 5th year	464.5	286.4	239.2	187.2	1177.4
Net cash flow (undiscounted) in 5th year	4645.3	3527.0	1804.8	1425.1	11402.2
NPV	6603.1	4694.1	2478.7	1541.2	13185.9
Internal Rate of Return	154.0%	129.2%	98.4%	69.0%	104.9%

1. INTRODUCTION

1.1. Garlic Crop

Garlic (Allium sativum) is a perennial, herbaceous, and bulbous plant in the family of Amaryllidaceae. It is the second most important cultivated allium after onion. The plant is produced either in hardneck or in softneck. However, the softneck variety is the most popular and grown for its flavorful (pungent) and edible bulb. Garlic likes full sun and well-drained and fertile soil. It does best in friable sandy-clay-loam soil that has a high organic content. It grows well when the soil is sandy loam to loam and its pH is in the 6.2 to 6.8 range. The underground bulb can be up to 7cm in diameter and is comprised of 1-40 cloves. It is native to central Asia but grows wild in Italy and southern France. It has touched almost every major civilization of the ancient world. It is said that in old Egypt, the laborers who needed to construct the colossal pyramids were nourished with garlic, and the Bible specifies that the Hebrews made most of their sustenance with garlic. In World Wars I and II, garlic was used to counteract gangrene and today it is consumed to help against atherosclerosis and hypertension. Garlic is a prominent source of carbohydrate, protein, fat, phosphorous, vitamins and minerals. Ascorbic acid was found to be very high in green garlic. Detailed nutritive composition of fresh peeled garlic cloves and dehydrated garlic powder is presented in Annexure 1 (Pruthi, 1979). Fresh garlic offers more flavor and nutritional benefits. World Health Organization recommended consumption of 2-5 g of fresh garlic, 0.3-1.2 g of dried garlic powder or any other formulation that yields 2-5 mg of allicin compound per day (WHO, 1999).

Garlic is considered as a significant spice for food throughout the world. It is cultivated by numerous small scale growers for nearby markets. In the United States of America (USA) especially it is grown by large scale growers for selling as fresh. There are around 300 assortments of garlic developed around the world, especially in hot, dry spots.

1.2. Importance of Garlic:

Garlic offers many economic and health benefits to its producers and consumers.

A. **Economic Benefits:** Displayed beneath is the economic significance of garlic:
   a. **Cash Crop:** Indonesia is the world's largest import market of raw garlic, followed by Brazil, Vietnam, Malaysia and the USA.
   b. **Low Capital Investment:** Garlic production requires low capital investment as it is less attacked by harmful insects and diseases. It doesn't require modern storeroom and can be stored for a long period (up to a year) after reaping.
   c. **Flavoring in Food:** Garlic is a used to flavor food. It is also used as a food additive to prevent food poisoning.

d. **Pharmaceutical Industry:** Fresh garlic is commonly used in pharmaceutical industry due to its antioxidant property. It is utilized to produce supplements with enteric coatings.

e. **Pesticide Manufacturing Industry:** Due to natural fungicidal and pesticidal properties, garlic (in particular local desi garlic) is extensively used in pesticide manufacturing industry.

B. **Health Benefits:** Garlic is a standout amongst restorative herbs. After chopping or crushing, fresh garlic produces alicen, organosulfur compound, which is used to reduce inflammation and offer antioxidant benefits. Garlic offers many health benefits as:

a. **Respiratory Diseases:** Its antibiotic properties help to control throat infection and amygdalitis.
b. **Fungal Skin Diseases:** Raw garlic paste helps repressing athlete tingle or contagious fungal skin diseases when applied as a topical treatment.
c. **Reducing Blood Pressure:** Fresh garlic aroma in the body helps to dilate the blood vessels and regulate the circulation system
d. **Regulating Cholesterol:** Garlic helps to improve liver functioning, which is crucial in regulating cholesterol and triglyceride levels in the blood (Berthelod et al., 1998; Ashraf et al., 2014).
e. **Halting Arteriosclerosis:** Garlic plays a significant role in reducing arteriosclerosis, which restricts blood flow due to builds up of fats, cholesterol etc in and on the artery walls (plaque).

1.3. Garlic Production in Pakistan

In Pakistan, garlic is not only produced everywhere but it is also consumed by the whole population in almost all recipes as a condiment. It is the second widely cultivated vegetable after onion. Though farmers usually do not grow it as a cash crop; rather some area is put under its cultivation for family consumption. Old local white/pink garlic variety (called Desi lehsan) is mostly produced in all provinces except Balochistan. Recently, Chinese variety of garlic gains farmers' attention in Balochistan.

1.3.1. Regional Contribution

Punjab province contributes major share (38%) to the total garlic area in the country, although its share in production is relatively low (34%). The share of Khyber Pakhtunkhwa (KP) in garlic production is higher than its share in area because of its highest yield in the country. Hence, KP is the largest garlic producing province in the country. Punjab and KP contribute major share (over 79%) to the total garlic production. Share of Sindh in garlic production is far lower than its share in area because of its lowest per ha yield in the country.

Table 1: Provincial share in garlic production in Pakistan during 2016

Province	Area (000 ha)	Share in area (%)	Production (000 tonne)	Share in production (%)	Yield (tonne/ha)
Punjab	3.1	38.3	24.1	34.0	7.8
Sindh	1.3	16.0	6.8	9.6	5.2
KP	2.7	33.3	32.2	45.4	11.9
Balochistan	1.0	12.3	7.8	11.0	7.8
Pakistan	8.1	100.0	70.9	100.0	8.8

Source: MNFS&R (2017)

Overall, garlic area during 2001-17 more or less remained stable in the country. However, garlic production has slightly increased from 63.9 thousand tonnes in 2001 to 70.9 thousand tonnes in 2016 with an average annual growth rate of 0.95% (Table 2). This increase in production is contributed mainly due to the growth in yield at 0.57% per annum. Nevertheless, average garlic yield of Pakistan remained very low at 8.4 tonne per ha.

1.3.2. Regional trend in production

Over the 16 years, an upward trend is observed in area and production of garlic in Punjab, KP and Balochistan provinces (Table 2). However, Balochistan experienced the sharpest growth in area and production of garlic with 8.0% and 9.6% growth, respectively. In contrast, Sindh province has downward trends in area and production of garlic. Garlic yield has reduced in Punjab at an average annual growth rate of 0.37% but it experienced increasing trends in KP, Sindh and Balochistan provinces. Balochistan has the highest growth trend in yield (1.6%). This could be due to the suitability of soil and climatic conditions for garlic production or/and due to adoption of the latest Chinese variety of garlic. KP has the second highest growth in yield.

Table 2: Trends in area, production, and yield of garlic by province during 2001-16

Year	Punjab		Sindh		KP		Baluchistan		Pakistan	
	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes
2001	2.6	22.2	2.4	12	2.3	25.4	0.6	4.3	7.9	63.9
2002	2.6	21.1	1.7	7.3	2.3	24.9	0.4	3.2	7.0	56.5
2003	2.7	22.4	1.8	8.2	2.2	24.6	0.3	2.5	7.0	57.7
2004	2.7	22.9	2	9.7	2	22.3	0.2	1.6	6.9	56.5
2005	2.7	22.7	1.7	8.2	2	22.8	0.2	2.2	6.6	55.9
2006	2.8	22.9	2	10.4	1.9	21.6	0.3	2.4	7	57.3
2007	2.9	24.1	2.5	13	2.2	23.5	0.2	1.7	7.8	62.3
2008	2.8	23.4	2.7	14.3	2.4	24.7	0.2	1.4	8.1	63.8
2009	2.9	24.9	2.8	14.3	2	22	0.7	6	8.4	67.2

Year	Punjab		Sindh		KP		Baluchistan		Pakistan	
	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes	Area (000) ha	Prod (000) tonnes
2010	2.8	22.3	1.4	7.5	1.9	21.2	0.7	6.3	6.8	57.3
2011	3.1	24.3	0.9	4.6	1.8	19.5	0.8	6.9	6.6	55.3
2012	3.1	25.1	0.9	4.5	1.9	20.6	0.8	7.1	6.7	57.3
2013	3.2	25.6	1.1	6.1	1.9	21.9	0.8	7.0	7.0	60.6
2014	3.2	25.6	1.2	6.5	2.2	24.9	0.9	7.5	7.5	64.5
2015	3.1	25.1	1.2	6.3	2.8	34.2	0.9	7.5	8.0	73.1
2016	3.1	24.1	1.3	6.8	2.7	32.2	1.0	7.8	8.1	70.9
Annual growth (%)	1.53	1.16	-5.40	-4.30	-0.09	0.22	8.02	9.55	0.14	0.74

Source: MNFS&R (2017)

Note: The annual growth in per ha yield in a region can be estimated by taking the difference in the growth rates in production and area. Source: GoP (2017)

1.4. Garlic Trade of Pakistan

1.4.1. Garlic Imports

Pakistan heavily relies on garlic import mainly from China (Figure 1) due to low local domestic production, high domestic market demand and absence of physical infrastructure required for efficient post-harvest management and processing. In 2016-17, highest ever of 51 thousand tonnes of garlic was imported worth of US$93.2 million, implying that Pakistan imports about three forth of the garlic requirements of the country. With some variation, the average annual rate of increase in garlic imports during 2001-16 was 3.0%, while the value of imports has increased at a rate of 14% per annum because of an increasing trend in garlic imported prices over the period (Table 3).

Table 3: Trends in the garlic trade of Pakistan during 2001-16

Year	Import			Export			Trade deficit (million US$
	Quantity (000 tonnes)	Value (million US$)	Price (US$/tonnes)	Quantity (tonnes)	Value (000 US$)	Price (US$/tonnes)	
2001	15.8	5.5	351.9	1561	901	577.2	4.647
2002	25.5	9.8	384.6	2479	1583	638.6	8.21
2003	49.3	11.0	223.1	2161	846	391.5	13.65
2004	31.6	8.3	262.3	681	201	295.2	8.079
2005	51.0	18.0	353.6	51	17	333.3	18.029
2006	48.8	26.3	539.5	274	152	554.7	26.172

Year	Import			Export			Trade deficit (million US$
	Quantity (000 tonnes)	Value (million US$)	Price (US$/tonnes)	Quantity (tonnes)	Value (000 US$)	Price (US$/tonnes)	
2007	64.0	36.7	572.5	1079	783	725.7	35.883
2008	114.1	59.8	524.6	5813	1746	300.4	58.088
2009	83.8	21.4	255.6	766	279	364.2	21.138
2010	64.2	49.3	768.2	49	74	1510.2	49.265
2011	48.3	59.6	1232.7	203	255	1256.2	59.302
2012	28.5	18.5	650.3	919	898	977.1	17.614
2013	47.8	33.2	695.3	122	110	901.6	33.108
2014	57.8	45.1	779.0	84	126	1500.0	44.937
2015	31.5	58.6	1861.4	317	466	1470.0	58.163
2016	51.4	93.2	1814.2	643	1317	2048.2	91.881
2017	37.1	68.0	1834.2	1491	2955	1981.9	65.039
Growth rate (%)	3.1	14.0	10.9	-8.04	2.38	10.41	14.50

Source: FAOSTAT Trade Data http://www.fao.org/faostat/en/#data/TP

Garlic is imported from 13 different countries the largest amount (about 89% of total import) comes from China (Figure 1). Chinese garlic is highly demanded by urban consumers in Pakistan due to its easy peeling feature. Pakistan also marginally imports garlic from India.

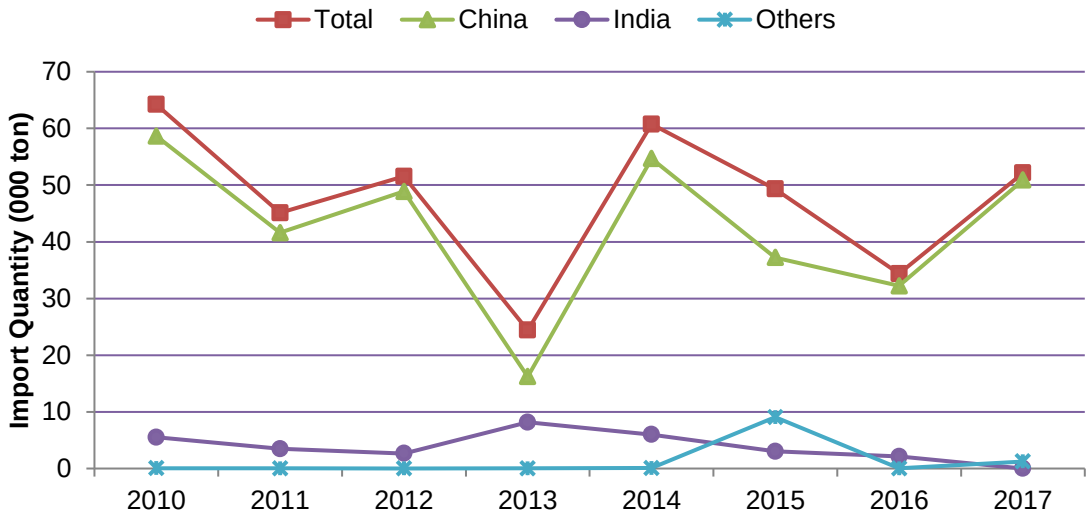


Figure 1: Trends in fresh garlic import for Pakistan by major importers during 2010-17

Source: GoP (Vari2018)

1.4.2. Garlic Export of Pakistan

Pakistan is also exporting negligible amount of garlic but to a long list of countries, and Pakistani export is highly variable with long-run declining trend during 2001-16. Although value

of export had a positive trend but it is far lower than the value of import causing a ballooning trade deficit at the rate of 14.5% per annum. Pakistan trade deficit has increased from just US$4.6 million in 2001 to US$65.0 million in 2017 (Table 3). It is worth noting that although Pakistan exports a small quantity compared to its imports, it generally earns higher export price compared to its import price partly perhaps because of its better pungency rate which can be used in spices.

During 2017 period, Pakistan has exported garlic to 42 countries including UK, UAE, Saudi Arabia, Sri Lanka, Malaysia, Maldives and others. There are considerable factors restricting Pakistan's garlic export such as low productivity and quality, unreliable supply, exchange rate volatility, certification for good agricultural practices (GAP) and Swiss certification (SGS-Société Générale de Surveillance or third-party examination). To export garlic to countries in the European Union, more than 124 regulations are required. Similarly, green trade barriers curtail its competitive power in the international market. Apart from this, the investment in garlic export sector has remained frustratingly low.

1.5. Global Context

1.5.1. Global Vs Pakistan Comparative Status

Table 4 presents compare the status of Pakistan's garlic sector with that at the global level. While Pakistan garlic area is equivalent to 0.51% of world's area, its production is only 0.25% of world production because of its lower than world average per ha yield. Pakistan garlic yield is less than one half of the world's average yield. Pakistan farm gate price is about 72% of the international average farm gate price, implying that Pakistani farmers are producing garlic at a lower cost than that of the world. Hence, the country has a competitive edge in garlic production. Low local price permits creating opportunity for export and value-added products of garlic in the forms of peeled, paste, powder, flakes etc. Moreover, value addition and processing can offer a huge potential to increase Pakistan's trade volume as pungency and low water content of local (desi) garlic is highly demanded by food industries. World has traded 15% of total garlic production in 2016, while Pakistan imports a large quantity of garlic which is almost 74% of its domestic production and exports only insignificant amount due to insufficient supply from domestic sources to meet the domestic needs.

Table 4: Competitiveness of garlic crop in Pakistan (2016)

Parameter	World	Pakistan	Share (%)
Area (000 ha)	1578	8.1	0.51
Production (000) tonne	28164	70.9	0.25
Value of production (Million US$)	39290	178.1	0.45
Yield (tonne/ha)	17.85	8.8	49.34
Farm gate price (US$/tonne)	1395	1309	93.82
Quantity of international trade (000 tonnes)-Imports	1962	51.4	2.62
Value of international trade (Million US$)-Imports	3607	93.198	2.58
Imports quantity as % of production	15.0	74.0	-

Parameter	World	Pakistan	Share (%)
Import value as % of production value	9.0	52.0	-
Average import prices (US$/tonne)	1838	1814	98.68
Volume of export (million tonnes)	1.96	0.001	0.05
Average export prices (US$/tonne)	1838	2048	111.4
Value of export (million US$)	3607	1.317	0.04

Source: FAOSTAT Production, Crop Data http://www.fao.org/faostat/en/#data/QC

FAOSTAT Trade Crop and Livestock Products http://www.fao.org/faostat/en/#data/TP

1.5.2. Global Production

In 2017, world garlic production is 27.2 million tonnes from an estimated area of 1.5 million ha. This corresponds an average yield of 18.09 tonne/ha (Table 4). During 1961-2015, world garlic production, per ha yield, and area all has experienced an upward trend (Figure 2)

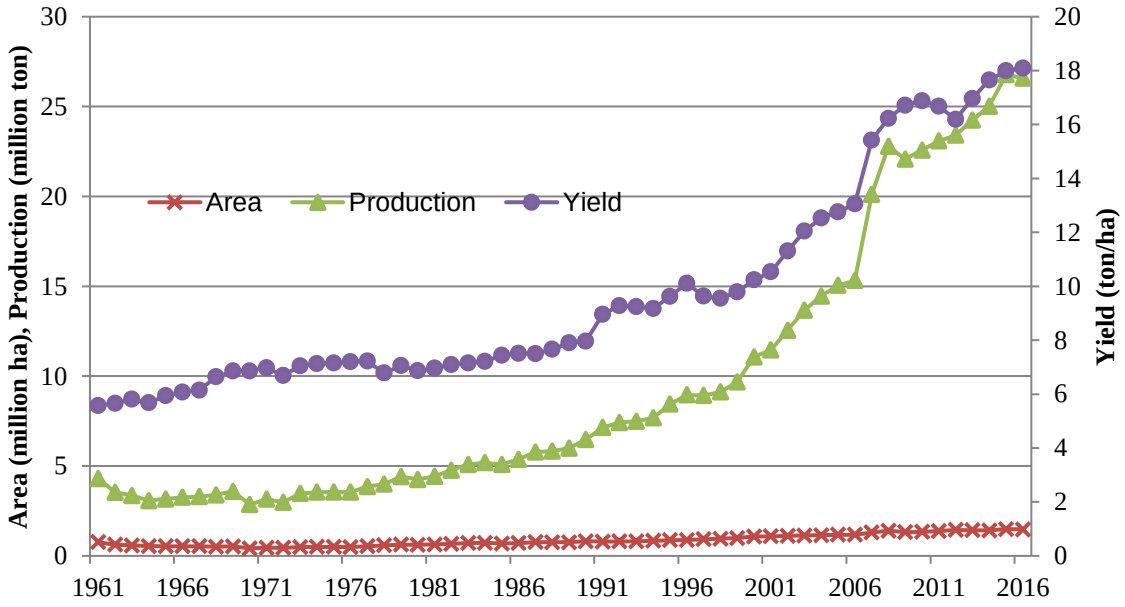


Figure 2: Trends in global garlic production, yield and harvested area during 1961-2016

Source: FAOSTAT Production, Crop Data http://www.fao.org/faostat/en/#data/QC

More recently during 2001-16, global production has increased at an average annual growth rate of 5.8%, which is higher than the international population growth rate at 1.19%. This implies that its per capita consumption is globally increasing. Garlic yield is improving at 3.6% per annum, while area under garlic expanded at 2.2% per annum (Table 5). These increases at the global level are much higher than those in Pakistan implying that Pakistan is losing its relative position in the world garlic market.

Table 5: Trend in global garlic production and trade during 2001-16

Year	World Garlic Production			World Garlic Export		
	Area	Production	Yield	Quantities	Values	Price
	(000 ha)	(000 tonnes)	(tonne/ha)	(000 tonne)	Million US$	US$/tonne
2001	1087.7	11457.9	10.5	867.4	503.1	580.1
2002	1108.2	12550.2	11.3	1348.5	647.1	479.9
2003	1134.7	13673.0	12.1	1452.2	629.4	433.4
2004	1153.8	14455.7	12.5	1453.5	707.0	486.4
2005	1179.3	15050.7	12.8	1512.2	918.5	607.4
2006	1173.7	15318.2	13.1	1525.7	1188.6	779.0
2007	1304.2	20111.3	15.4	1759.0	1325.4	753.5
2008	1403.7	22780.8	16.2	1829.0	1072.6	586.4
2009	1320.6	22072.4	16.7	1910.0	1554.0	813.6
2010	1337.1	22574.8	16.9	1675.9	3040.4	1814.2
2011	1384.8	23087.1	16.7	1975.1	2834.9	1435.3
2012	1445.8	23407.0	16.2	1755.6	1989.9	1133.4
2013	1429.5	24248.8	17.0	1970.5	2040.5	1035.5
2014	1417.0	25027.7	17.7	2116.3	2071.4	978.8
2015	1500.2	27005.3	18.0	2139.5	2489.9	1163.8
2016	1517.9	27251.3	18.0	1964.1	3607.0	1836.5
2017	1577.8	28164.1	17.9	2172.1	3142.2	1446.6
Annual growth (%)	2.3	5.8	3.6	4.2	11.0	6.8

Source: FAOSTAT Production, Crop Data http://www.fao.org/faostat/en/#data/QC

FAOSTAT Trade Crop and Livestock Products http://www.fao.org/faostat/en/#data/TP

China is the major garlic producing country of the world with 0.8 million ha and 22.2 million tonnes of production. China also has the highest per ha yield. This is remotely followed by India with less than half the per ha yield obtained in China (Table 6). Pakistan has to learn a lot from Chinese successful experience in garlic production, especially developing its successful value chain.

Table 6: Major garlic producing countries of the world, 2016.

Rank	Country	Area (000 ha)	Country	Production (000 tonnes)	Country	Yield (tonne/ha)
1	China	815	China	22160	China	27.2
2	India	321	India	1693	Korea, R.	13.6
3	Bangladesh	66	Bangladesh	425	Spain	10.0
4	Myanmar	28	Korea, R.	294	Russian F.	9.4
5	Russian F.	27	Spain	275	Myanmar	7.4
6	Spain	27	Egypt	275	Bangladesh	6.4

Source: FAOSTAT Production, Crop Data http://www.fao.org/faostat/en/#data/QC

1.5.3. Global Trade

The export of garlic has more than doubled from 0.87 million tonnes in 2001 to 2.2 million tonnes in 2017 with an average growth rate of 4.2% per annum during the period (Table 5). This growth is much higher than the growth in production suggesting that garlic is increasingly becoming a commercial crop as its higher proportion is being consumed somewhere else than where it is produced. The rate of increase in the value of exported garlic is even higher at 11% per annum. It has reached US$3.14 billion in 2017 from US$0.56 million in 2001. There is demand pressure on garlic supplies as export prices has been increasing at a rate of 6.8% per annum during the period. Pakistan hardly benefited from this fast expanding international garlic export market as its value of garlic export increased at only 2.4% per annum, while trend in the quantity of garlic exported has been negative during the period.

Being top producer, China also has secured the first position in terms of value of international exports by exporting fresh garlic of US$2.645 billion in 2017 (Table 7). China is followed by Spain, Argentina and others. Pakistan is ranked at 28th position by exporting garlic of US$3.0 million.

Table 7: Top garlic exporters of the world (2017)

Rank	Country	Value (million US$)	Quantity (000 tonnes)	Value Share (%)
1	China	2,645	1,530.7	73.3
2	Spain	416	162.3	11.5
3	Argentina	162	77.7	4.5
4	Netherlands	90	30.7	2.5
5	France	43	14.7	1.2
6	Italy	37	10.0	1.0
7	Chile	31	10.1	0.8
8	India	20	21.5	0.5
9	USA	19	10.1	0.5
10	Peru	19	12.6	0.5
28	Pakistan	3.0	1,5	0.04

FAOSTAT Trade Crop and Livestock Products http://www.fao.org/faostat/en/#data/TP

In 2017, Indonesia ranked as first in terms of value of international imports of garlic by importing fresh garlic worth of US$590 million. Indonesia is followed by Brazil, Malaysia, United States of America, and others. Due to low yield potential of existing garlic varieties and high domestic demand, Pakistan has spent precious foreign exchange of US$ 68 million in 2017 to import fresh garlic, particularly Chinese garlic from China; which is equivalent to about 94% of the country's total import due to its uniform size and easily peeling features. The high volume of total import of 37.1 thousand tonnes makes Pakistan the 11th largest garlic importer in the world. The value of total world import in 2017 is about US$68 million (Table 8).

Table 8: Top garlic importers of the world (2016)

Rank	Country	Import Quantity (000 tonnes)	Country	Import Value (Million tonnes)	Value Share (%)
1	Indonesia	589.6	Indonesia	549.8	19.17
2	Brazil	159.3	Brazil	287.5	10.03
3	Malaysia	154.1	USA	222.4	7.76
4	USA	89.8	Malaysia	186.6	6.51
5	Philippines	68.0	UAE	88.4	3.08
6	UAE	60.9	Germany	83.2	2.90
7	Russian F.	53.9	Netherlands	81.7	2.85
8	Saudi Arabia	46.5	Russian F.	78.2	2.73
9	Bangladesh	42.7	France	69.6	2.43
10	Thailand	41.8	Saudi Arabia	68.9	2.40
11	Pakistan	37.1	Pakistan	68.0	2.37
12	Netherlands	34.4	Italy	60.4	2.11
13	World	1968.3	World	2867.106	100.0

FAOSTAT Trade Crop and Livestock Products http://www.fao.org/faostat/en/#data/TP

1.6. Need of the Study

Summarizing the above macro-level analysis, garlic in Pakistan is cultivated on 8.1 thousand ha producing 70.9 thousand tonnes with an average yield of 8.8 tonnes per ha. The production in the country is expanding at 0.74% per annum, much is lower than its population growth rate of 2.1% as well as global rate of 5.8%. This implies that unless the domestic production rate is improved, the country has to increasingly rely on imports which is already expanding at an alarming rate of 14% per annum and had reached to US$63 in 2017. The per ha yield of garlic in Pakistan is less than one half of the world average and it is improving at only 0.60% compared to the average global improvement rate at 3.6% per annum, implying that Pakistan is losing its competitive position in the domestic and international market. Pakistan has also lost its comparative position because of its lower rate of production increase than the world average. During 2001, Pakistan was at 19th position in the list of garlic producing countries which has slipped to 22nd position in 2017. Moreover, Pakistan did not benefit from the global garlic market which is fast expanding at 11% per annum rate and has reached to US$3.1 billion in 2017.

To improve these trends in garlic production and trade, the Planning Commission of Pakistan has initiated this study to analyze the whole value chain of garlic, identify gaps and potentials along the chain, and suggest economically viable interventions to improve Pakistan's competitiveness of garlic in national and international markets. To incorporate the regional context, the analysis will be undertaken at the cluster level of major garlic producing areas in Pakistan.

2. GOALS AND PURPOSE

The overall goal of this study is to improve the competitiveness of the garlic sector and thus contribute to *the Cluster Development Based Agriculture Transformation Plan -V2025* for garlic in Pakistan. The specific objectives of the study are:

1. To identify the major clusters of garlic production in Pakistan
2. To conduct a detailed diagnosis and SWOT of the garlic value chain in each cluster
3. To identify technological, institutional, infrastructure and policy gaps in each cluster
4. Assess the potential of garlic production in each garlic producing cluster
5. Suggest technological, institutional, infrastructure and policy interventions to achieve the cluster potentials
6. Conduct economic and social feasibility of the suggested interventions

After characterizing the value chain of garlic in various clusters, identify gaps and potentials, various strategies are suggested to achieve these targets and the feasibility of the package of interventions is worked out.

3. METHODOLOGY

The data and information related to the characteristics, constraints, potentials and needed interventions to meet the constraints in garlic clusters were collected from three sources:

a) ***Macro-Data***. Relevant macro data were collected from various published and unpublished reports of government and non-governmental organizations and internet search on garlic value chain (See annexure 2 for the macro data sources)

b) ***Stakeholders Consultations***. Primary information was collected through consultation meetings with farmers, input dealers, traders, processors, extension agents and researchers using pretested and structured questionnaires designed separately for each cluster (See annexure 3 for the list of stakeholders consulted).

c) ***Literature Review*****.** The literature related to the functioning, gaps, and interventions in garlic value chain is reviewed and synthesized (See Annexure 2 for the literature reviewed).

Following generic parameters and indicators are used in collecting the data:

- Garlic crop and its importance
- Review of garlic sector in Pakistan
- Global context of garlic sector;
- Cost of production, harvesting, and post-harvest management of garlic from the growers;
- Marketing, trading, and processing from traders, wholesalers, retailers, and processors;
- Issues and constraints related to production, harvesting, drying, marketing, storing, trading, and processing from all stakeholders;
- Recommendations and benchmarks based on global parameters;

The author then used these data to first identify the garlic clusters in the country and then used his subjective judgment in prescribing the characteristics of each cluster. The author also identified the strengths, weaknesses, opportunities, and threats (SWOT) of each cluster, investigated the functioning of existing value chain, and quantified the cluster potentials. Based on the above analysis, we then proposed the interventions for improvement in each cluster. The costs and benefits of each intervention are also estimated to finally work out the Internal Rate of Return of the whole package. A Garlic Transformation Plan is also formulated, which identifies sustainable cluster upgrading strategies for the development of the garlic sector that can help creating significant economic opportunities for producers, processors and all the stakeholders participating at different points of the value chain.

4. LITERATURE REVIEW

Bosworth and Broun (1996) has defined cluster as the geographical concentration of industries benefitting through co-location. Numerous efforts have been made to organize data related to clusters. A standout amongst the significant efforts is the Cluster Meta-Study, which is an inventory of 833 existed clusters belonging to 49 countries, including 24 developing nations (Van der Linde, 2002). Besides industrial clusters, this study looks into important properties of clusters, the explanations for the presence or absence of competitiveness and examples of cluster development in agriculture. This meta-study also included a successful cluster of surgical instruments in Sialkot, Pakistan. Similarly, Sölvell et al. (2003) have prepared The Cluster Initiative Greenbook, which assembles data related to 250 cluster activities throughout the world. This book also provides the cluster initiative performance model (CIPM) to assess four components of cluster activities including its settings, goals, execution and procedure of advancement. The Global Competitiveness Report presents similar information on general cluster characteristic existed in 75 nations. Some nations, for instance, the United States, the United Kingdom and Sweden, have mapped activities of clusters over the whole domain. Porter and Ketels (2003) have investigated competitiveness of existed clusters in the United Kingdom. The European Commission has conducted a comparative survey of 34 regional clusters in 17 European countries (European Commission, 2002). The report proposes upgradation of underdeveloped clusters by efficiency-enhancing cooperation between firms and strengthening links to the knowledge infrastructure.

The importance of clusters is increasing in developing countries. Cluster studies demonstrate that small-scale firms including agricultural businesses are concentrating on lower-value specialties despite targeting higher-value markets (Dijk and Sverrisson, 2011; Ketels et al., 2006). They also conclude that advancing clusters in developing nations is difficult in developing nations unless different organizations can work together in cluster development programs. Cluster initiatives may help to solve multifaceted problems of subsistence farming in developing countries. The Food and Agriculture Organization (FAO) of the United Nations has launched agro-based clusters (AC) to raise on-farm productivity, and market-oriented and higher value-added production of selected agricultural commodities by engaging farmers, agribusinesses and institutions involved in agriculture (FAO, 2010). FAO has established ACs of coffee, cut flower, fish, fruits, grapes, good agricultural practices (GAP), livestock, root crop and wine in Asia, Africa and Latin America. The extant literature shows that small farmers, who are poorly organized, and have weaker linkages among stakeholders, dominate ACs in developing countries. Therefore, external support from national and international organizations is usually required.

Nonetheless, few vegetable clusters have been established to stay competitive. India has recently developed a very successful garlic cluster in Rajasthan state (Thornton, 2017). Similarly, South Africa has also invested in garlic cluster (AFF, 2017). Pakistan has garlic clusters in almost every province; however, each cluster is suffering from reduced garlic productivity. Various studies have been conducted to improve garlic production. Majeed et al. (1994) conducted date of planting cum varietal trial on garlic and found significant difference

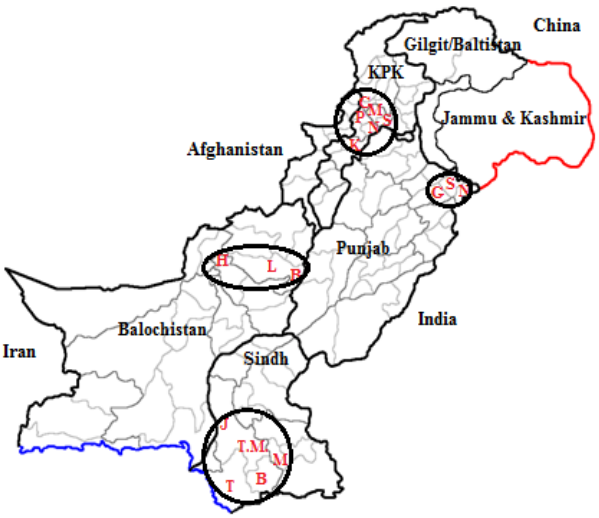
in fresh yield among cultivars. Three varieties Swat local, Tarnab Peshawar and Italian were evaluated in Swat valley at three different dates of sowing and highest yield was found in Italian variety (Khan et al., 1997). Ahmad et al. (2017) have evaluated impact of different plant spacing on garlic rust (*Puccinia allii*), bulb yield and yield component of garlic. They have found that 20cm plant spacing results in good quality and rust-free garlic production. Rahman et al. (2011) have conducted field experiment in Dera Ismail Khan and have found positive relationship between increased manual weed removal timings and garlic bulb yield. Garlic production has important gender dimensions as women also play important role in its sowing and weeding practices (Taj et al., 2009). Difference in performance of various garlic cultivars under different conditions have also been reported by many researchers (Majeed et al., 1994; Khan et al., 1997; Mahmood et al., 2001). They have found that exotic Chinese cultivar has higher yield than Italian, GS-I, and Lehson Ghulabi. Newly released high yielding local garlic variety NARC G-1 has huge potential to improve garlic yield in Pakistan (PARC, 2018). Hence, proper use of latest technology and agricultural inputs can definitely enhance the garlic production.

Government of Pakistan is spending massive amount of foreign reserves (US$ 93 million) on garlic import due to high garlic demand and low yield potential of existing garlic varieties in the country, therefore, there is immediate need to improve existed or develop new garlic clusters.

5. CLUSTER IDENTIFICATION AND CHARACTERISTICS

5.1. Identification of Clusters

Garlic is produced in all provinces of Pakistan. In Punjab province, it is produced in 36 out of 37 districts; Sindh, in 19 out of 23 districts; Khyber Pakhtunkhwa, in 16 out of 22 districts and in Balochistan, it is produced in 11 out of 30 districts (Annexure 4). We proposed improving existed garlic clusters in only major and neighboring districts of each province (Figure 3). So we identify the following four major garlic clusters in Pakistan (Table 9):



: Figure 3: Map of existing and new garlic clusters in Pakistan

1. **Northern Punjab Cluster**: This cluster consists of three northern Punjab districts of Sialkot, Narowal and Gujranwala. These districts contribute about 28% to the garlic production in the province. Sialkot is considered as the focal point of the cluster as it occupies the highest garlic area (12%) in the cluster and is well connected with the provincial capital agriculture market in Lahore (Table 9).
2. **The Central KP Cluster**: It includes Kohat, Swabi, Charsadda, Peshawar, Nowshera and Mardan. The cluster comprises 53% of the garlic area in the province. Kohat is taken as the focal point of the cluster as it alone occupies 26% of the total provincial garlic area (Table 9).
3. **Northern Balochistan Cluster:** It includes Harnai, Loralai and Jafarabad districts. This cluster occupies 86% of the garlic area in this province. Hernai district is taken as the focal point of the cluster as it alone contributes 76% of the total garlic area in the province (Table 9).

4. **Southern Sindh Cluster**: It encompasses Mirpurkhas, Badin and Jamshoro, representing 64% of the crop area in this province. Mirpur Khas is the focal point of the cluster as it contributes 24% of the total provincial garlic area (Table 9).

Table 9: Cluster specifications of garlic in each province (2013-14)

Northern Punjab Cluster		Central KP Cluster		Northern Balochistan Cluster		Southern Sindh Cluster	
Districts	Area (ha)	Districts	Area (ha)	Districts	Area (ha)	Districts	Area (ha)
Sialkot	368 (12)	Kohat	502 (26)	Harnai	650 (76)	Mirpurkhas	296 (24)
Narowal	268 (8)	Swabi	316 (16)	Loralai	49 (6)	Badin	175 (14)
Gujranwala	237 (7)	Charsadda	216 (11)	Jafarabad	35 (4)	Jamshoro	122 (10)
-	-	Peshawar	214 (11)	-	-	-	-
-	-	Nowshera	201 (10)	-	-	-	
-	-	Mardan	191 (10)	-	-	-	-
Total area in cluster	873 (28)	Total area in cluster	1034 (53)	Total area in cluster	734 (86)	Total area in cluster	593 (48)
Total area in province	3163	Total area in province	1962	Total area in province	851	Total area in province	1225

Note: The values in parenthesis are the contribution (%) of each district/cluster in total garlic area of the respective province.

Source: GoP (2015a)

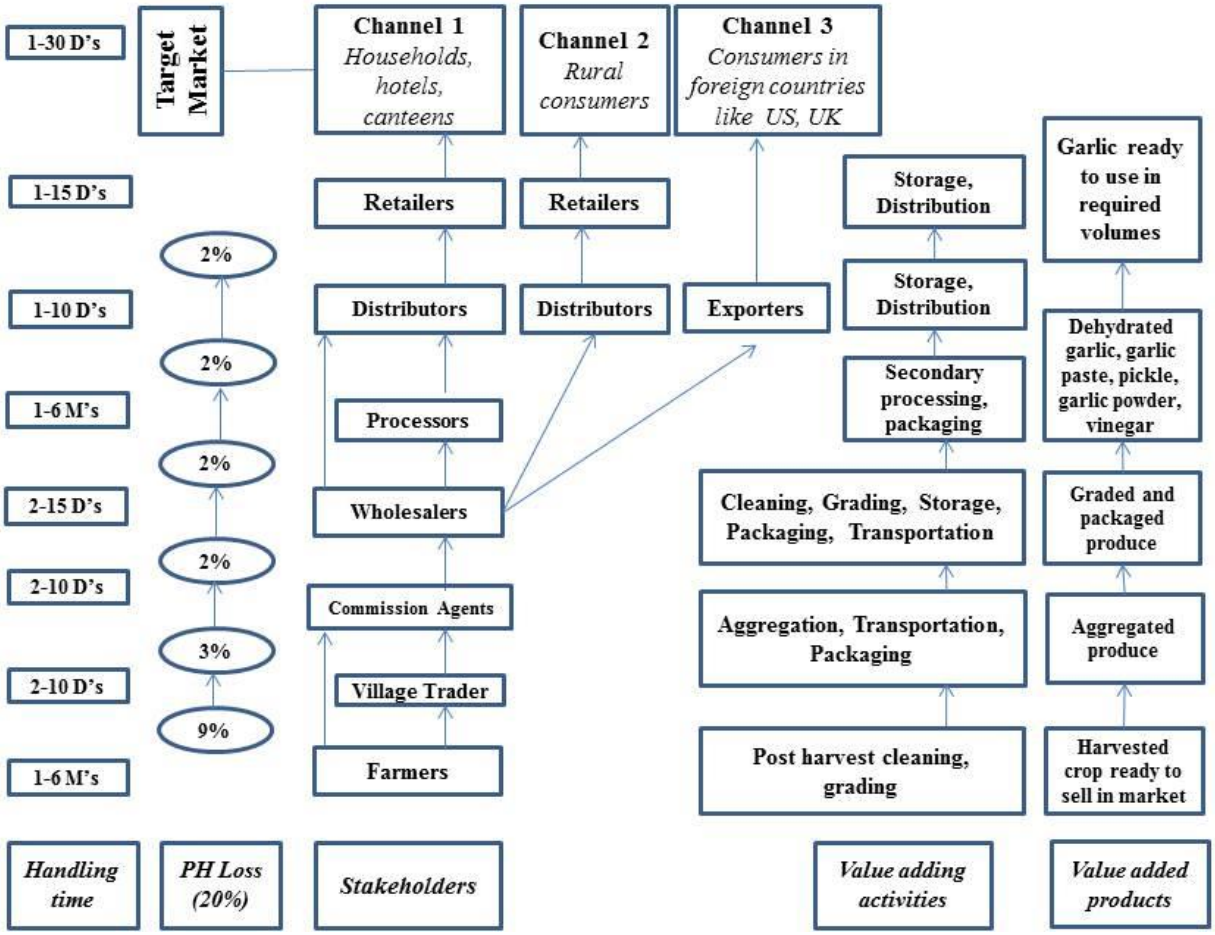
5.2. Comparison of Cluster Characteristics

The main focus of the Punjab cluster is to meet garlic demand of the nearby domestic markets stretched through Lahore to Faisalabad. The KP cluster covers the nearby consumers' market including Islamabad and Rawalpindi. The KP cluster also provides desi garlic to all food industries in Karachi and Lahore. The Balochistan cluster meets national demand of Chinese garlic in particular when it is unavailable in the international market. Sindh cluster meets consumers' demand of nearby markets. For the export window, the KP and Balochistan clusters can target the Middle East and South Asian markets because of their better quality (See Annexure 5 for overall comparison of salient characteristics in all the four clusters).

5.3. Description of Garlic Value Chain

Many small farmers, traders, service providers and end users are involved in the value chain of garlic in Pakistan as illustrated in Figure 4. This value chain map shows vertical integration from production to consumption, whilst there is little horizontal coordination between competing stakeholders like wholesalers. In the KP cluster, majority farmers are growing local lines of Lehsan Gulabi (pink garlic or desi variety), which was released by Ayub Agricultural Research Institute (AARI), Faisalabad in 1990. After initial post-harvest cleaning and grading, farmers market their fresh garlic mostly through village traders or commission agents. At the

farm level, there are limited facilities of post-harvest management, for example, cold storage, cleaning, and grading. Village traders aggregate the produce at the village level and sell to either commission agents or wholesalers after further grading and packaging. Food processors like Shan, Ahmed, Laziza etc in Karachi prefer purchasing fresh desi garlic of KP due to its high pungency feature and procure through commission agents or wholesalers. Food processors process fresh garlic to make garlic secondary processed products like paste, powder, pickle, etc. as shown in Annexure 6. They also use it in their recipes like garlic ketchup, chili sauce etc. Distributors (Pharhia) distribute fresh garlic to retailers. Retailers sell garlic (either fresh or processed) to urban and rural consumers through channel 1 and 2, respectively. Channel 3 is viewed to cater fresh garlic from wholesalers to exporters. Currently, farmers' share in the customer's rupee is only 20% while other stakeholders, for example, village traders, commission agents, wholesalers and retailers enjoy big share of 80% in the shopper's rupee. There are about 20% post-harvest losses in this cluster.



:**Figure 4: Value chain map of garlic in Pakistan**

The value chain map of garlic in Punjab cluster is very similar to similar to KP cluster. However, few differences are observed like main wholesale markets of desi garlic from this cluster are in Lahore or Faisalabad besides nearby markets. Small proportion of this garlic is processed

by food processors in Lahore like Mitchel etc. Some wholesalers in Lahore also export fresh desi garlic to foreign countries. There are also about 20% post-harvest losses in this cluster.

In Balochistan cluster, farmers prefer to produce Chinese variety of garlic, which is known as Chinese-2 garlic in local markets. Commission agents in wholesale markets of Lahore and Faisalabad do advance contracts with these farmers to produce Chinese-2 garlic as at that time Chinese garlic stops coming due to sowing season in China. Through Dera Ghazi Khan, Chinese-2 garlic reaches wholesale markets of Punjab. The post-harvest losses are also about 20% in this cluster. There is no processing of Chinese garlic produced in this clusters.

However, due to low productivity and quality, small proportion of this garlic is exported to nearby international markets.

Sindh cluster only meets demand of rural households in the cluster. Due to poor productivity and quality, the processors in the province nor being exported by the traders neither process desi garlic produced here. The post-harvest losses are also about 20% in this cluster.

In these clusters, a large number of small farmers are engaged in generating small volumes of surpluses. Naturally, their transaction costs are high and that affect their net income. In order to increase economies of scale, there is need to create organizations like Garlic Farmers Enterprise Groups (FEGs) by bringing farmers together in the form of voluntary groups and federating 20 to 25 such groups into a larger group. These larger groups will be operating on behalf of their members and will thrive to pool their produce to generate marketable volumes, for collective bargaining with buyers, for bulk procurement of services and packaging material, branding and marketing. This will be a good base to build on in future to create a more professional and effective garlic growers' association that could provide loans, training, marketing, and other services, thus maximizing small farmers' welfare. These groups will be the vehicles for collective society actions like managing pest, group certification thus reducing the certification cost, assuring quality to the traders thus reducing the monitoring costs, and start contract farming.

Various institutions like NGOs, agriculture input organizations, Vegetable Export Association, Food Processing Industries, Ministry of National Food Security and Research (MNFS&R), provincial departments, National Bank and Zarai Taraqiati Bank Limited (ZTBL) are already working in all clusters but their intensity varies across clusters. For example, in Balochistan, farmers have little access of to ZTBL loans, R&D system through MNFS&R and provincial department is relatively weak, and few NGOs are working because of the security issues. While in Punjab, these systems are relatively stronger but coordination between provincial and federal research system is weak.

5.4. SWOT Analysis

5.4.1. Overview

The SWOT analysis was conducted to analyze strengths, weaknesses, opportunities and threats of garlic commodity in the selected clusters. The data obtained through focus group discussions with different stakeholders involved in garlic value chain are used in the analysis.

5.4.2. Central KP Cluster

The KP cluster has comparative advantage of garlic production in terms of agroecological conditions such as water, climate, soil, farming experience etc. Major strengths, weaknesses, opportunities and threats of KP cluster are reported in Table 10.

Table 10: SWOT analysis of central Khyber Pakhtunkhwa cluster

Parameters	Strengths	Weaknesses	Opportunities	Threats
Environment/ Climate Change	Loam soil texture and warm sub-humid climate makes the cluster ideal for cultivating garlic.	Prolonged winter and sudden rise in temperature affect garlic settings.	Scope for digitizing garlic production to inform local weather conditions	Severe cold/weather conditions hamper garlic bulb size
	Availability of canal irrigation throughout the year.	Require electric motor to pull canal water	Use of solar energy source may reduce environmental pollution	Drought during winter and shortage of canal water
Garlic Varieties	High pungency of local varieties such as Lehsan Gulabi (local), White Desi (local) etc.	Sticky, thin, intact and unpeelable skin of local garlic	Scope for developing new varieties of garlic meeting household and food industry demand by the public or private research stations.	Limited research funds
		Only two local varieties (Lehsan Gulabhi and NARC-G1) have been approved so far.		
		Limited availability of certified, quality, and pure variety seed	Scope for establishment of producers' companies (PCs) as a part of Farmers Enterprise Group (FEGs) to purchase high yielding varieties (HYV) of garlic.	Fluctuate in the time of sowing due to climate change.
Input Supplies	Growing demand for fertilizers and pesticides	Non-availability of appropriate quality of fertilizer	Proper monitoring and evaluation of input supply system helps to reduce input adulteration problem.	Use of adulterated fertilizer

Parameters	Strengths	Weaknesses	Opportunities	Threats
		Declining organic matter in soils	Increasing poultry production and poultry manure is an opportunity to halt the declining organic matter.	Use of adulterated or expired pesticides.
		Lack of knowledge of Persistent Organic Pollutant (PoP) & Good Agricultural Practices (GAP) for garlic production.	Information dissemination on PoP and GAP	Injudicious use of chemicals
Production Management Practices	Experienced farmers who know garlic cultivation for a long time	Majority of farmers are illiterate and have small farm size.	Scope for establishment of planting, harvesting, and quality sorting and grading facilities by PCs as a part of FCSC.	Cloudy weather, rainfall at the time of harvesting etc
		Low plant population		
		Insufficient hoeing can reduce bulb size.	Contract farming with defined quantity and quality parameters	
	Intercropping with tobacco etc	Flooded irrigation deteriorates garlic quality	Arrangements of training modules for farmers on the latest methods of sowing, plant protection, intercropping, efficient irrigation method, harvesting, etc. by several national (NARC, provincial departments, private sector, etc.) and international organizations (AVRDC).	Difficulty of training illiterate farmers about the latest production methods and techniques
		Improper harvesting procedure		
		Labour constraint at sowing and harvesting stages due to its competition with wheat crop		
Infrastructure	Good road infrastructure connecting KP garlic cluster with all main markets in the country and the biggest port in the country.	Inadequate infrastructural facilities like storage with producers, traders, processors and at market level, which result in marketing inefficiencies.	Establish storage facilities by PCs as a part of FCSC.	Failure in trust among PCs members
Cluster Interaction	Large number of farmers in garlic clusters	Little interaction among farmers and researchers	Possibility of learning from progressive farmers in the cluster	Lack of optimal coordination

Parameters	Strengths	Weaknesses	Opportunities	Threats
		Producers have little information about the quality requirements in national and international markets	Strong relation between Commission Agents/Wholesaler and Contractors (each have knowledge about quality demand at least in national market) can be transformed into quality-based supply contract	and integration among stakeholders
		No contract farming with defined quantity and quality parameters		
		Little credit availability from formal institutes for any actor of cluster		
Marketing	Farmers receive prices based on the variety or product quality	Lack of market information due to disconnect of farmers with the market	Emerging supermarkets can introduce contract with farmers, which may improve retailing quality, and reduce post-harvest losses and trading margin	Supermarkets may exclude small farmers due to their limited supply
		Little capacity of farmers and traders and little quality infrastructure to produce, handle, and market the quality product	Financial support by the commission agents and wholesalers to harvesting contractors can be converted into quality-based delivery contracts	Weather risk may limit supply
		Auctioning in the wholesale market with visual and spot grading	Bulk selling can result in better result for growers	High price risk
Trade/Export	The KP produces garlic from April to May, whereas there is a significant gap in supply from Europe during this period.	Limited availability of HYV and pest and disease resistant varieties of garlic bulbs.	Purchase of HYV and pest and disease resistant varieties of garlic by PCs as a part of FCSC.	Adverse weather conditions affect garlic shelf life.
	Few traders start exporting garlic to neighboring high value markets by making direct contract with importers	Lack of farm mechanization for planting and harvesting increases cost of production and reduces garlic competitiveness in	Purchase of garlic planter and harvester by PCs as a part of FCSC.	Exporting of poor quality garlic has threatened its whole export

Parameters	Strengths	Weaknesses	Opportunities	Threats
		the international market.		
		Food safety standards and traceability (EuropGAP, Global Gap, SGS, etc.) are major obstacles to enter into high end international markets	Training farmers on food safety standards	High cost of certifications and quality standards
Processing	Demand of garlic is rising quickly owing to higher sales of branded food pickles, curry products, herbal products, pastes and medicines.	Lack of market information regarding prevailing prices, arrivals etc., which force farmers to sell in village locally.	Scope for tie up of PCs through contract farming with firms like Mitchell's, Ahmed, Shan, National; garlic processing units; housing societies in urban areas and retail outlets.	Failure in contract farming
	Pungency and stickiness of desi garlic grown in KP is liked by food processing industry for their recipes.	Stickiness of desi garlic disrupt the peeling and paste making efficiencies	Scope for establishment of primary processing facilities under contract farming by PCs as a part of FCSC with food industries.	
	Raw garlic is used to produce garlic powder, garlic salt, garlic vinegar, and garlic bread etc., contributing significantly to food industry.	Lack of grading and sorting facilities. Limited primary and secondary processing units (mainly in Karachi) for garlic and its by-products such as garlic pealing/ paste units.	Processing of the bulbs as peeled, dehydrated flakes, powder and paste will have potential to contribute to garlic value addition that will significantly increase availability of garlic and related by-products.	

5.4.3. Northern Punjab Cluster

The Punjab cluster has comparative advantage of garlic production in terms of agro ecological conditions such as water, climate, soil, farming experience etc. Major strengths, weaknesses, opportunities and threats of Punjab cluster are reported in Table 11.

Table 11: SWOT analysis of northern Punjab cluster

Parameters	Strengths	Weaknesses	Opportunities	Threats
Environment/ Climate Change	Sandy loam soil texture and temperate climate makes the cluster suitable for garlic cultivation.	Sudden rise in temperature affect garlic settings.	Scope for digitizing garlic production to inform local weather conditions	Abrupt weather conditions hamper garlic bulb size
	Availability of canal and tube well irrigation throughout the year.	Tube well water is very expensive.	Use of solar energy may reduce pumping cost and environmental pollution	Drought during winter and shortage of canal water
Garlic Varieties	High pungency of local varieties such as Lehsan Gulabi (local), White Desi (local) etc.	Sticky, thin, intact and unpeelable skin of local garlic	Scope for developing new varieties of garlic meeting household and food industry demand by national public or private research stations.	Limited research funds
		Only two local varieties (Lehsan Gulabhi and NARC-G1) have been approved yet.		
		Limited availability of certified, quality, and pure variety seed	Scope for establishment of Producers' companies (PCs) as a part of Farmers Common Service Centre (FCSC) to purchase high yielding varieties (HYV) of garlic.	Fluctuate in the time of sowing due to climate change.
Input Supplies	Growing demand for fertilizers and pesticides	Non-availability of appropriate quality of fertilizer	Proper monitoring and evaluation of input supply system helps to reduce input adulteration problem.	Use of adulterated fertilizer
		Declining organic matter in soils	Increasing poultry production and poultry manure is an opportunity to halt the declining organic matter.	Use of adulterated or expired pesticides.
		Lack of knowledge of Persistent Organic Pollutant (PoP) & Good Agricultural Practices (GAP) for garlic production.	Information dissemination on PoP and GAP	Injudicious use of chemicals
Production Management Practices	Experienced farmers who know garlic cultivation for a long time	Majority of farmers are illiterate and have small farm size.	Scope for establishment of planting, harvesting, and quality sorting and grading facilities by	Cloudy weather, rainfall at the time of harvesting etc
		Low plant population		

Parameters	Strengths	Weaknesses	Opportunities	Threats
			PCs as a part of FCSC.	
		Insufficient hoeing can reduce bulb size.	Contract farming with defined quantity and quality parameters	
		Flooded irrigation deteriorates garlic quality	Arrangements of training modules for farmers on the latest methods of sowing, plant protection, intercropping, efficient irrigation method, harvesting, etc. by several national (NARC, provincial departments, private sector, etc.) and international organizations (AVRDC).	Difficulty of training illiterate farmers about the latest production methods and techniques
		Improper harvesting procedure		
		Labour constraint at sowing and harvesting stages due to its competition with wheat crop		
Infrastructure	Good road infrastructure connecting Punjab garlic cluster with nearby main markets	Inadequate infrastructural facilities like storage with producers, traders, processors and at market level, which result in marketing inefficiencies.	Establish storage facilities by PCs as a part of FCSC.	Failure in trust among PCs members
Cluster Interaction	Large number of farmers in garlic clusters	Little interaction among farmers and researchers	Possibility of learning from progressive farmers in the cluster	Lack of optimal coordination and integration among stakeholders
		Producers have little information about the quality requirements in national and international markets	Strong relation between Commission Agents/Wholesaler and Contractors (each have knowledge about quality demand at least in national market) can be transformed into quality-based supply contract	
		No contract farming with defined quantity and quality parameters		
		Little credit availability from formal institutes for any actor of cluster		
Marketing	Farmers receive prices based on the variety or product quality	Lack of market information due to disconnect of farmers with the market	Emerging supermarkets can introduce contract with farmers, which may improve retailing quality, and reduce	Supermarkets may exclude small farmers due to their limited supply

Parameters	Strengths	Weaknesses	Opportunities	Threats
			post-harvest losses and trading margin	
		Little capacity of farmers and traders and little quality infrastructure to produce, handle, and market the quality product	Financial support by the commission agents and wholesalers to harvesting contractors can be converted into quality-based delivery contracts	Weather risk may limit supply
		Auctioning in the wholesale market with visual and spot grading	Bulk selling can result in better result for growers	High price risk
Trade/Export	Punjab produces garlic from March to April whereas there is a significant gap in supply from Europe during this period.	Limited availability of HYV and pest and disease resistant varieties of garlic bulbs.	Purchase of HYV and pest and disease resistant varieties of garlic by PCs as a part of FCSC.	Adverse weather conditions affect garlic shelf life.
	Few traders start exporting garlic to neighboring high value markets by making direct contract with importers	Lack of farm mechanization for planting and harvesting increases cost of production and reduces garlic competitiveness in the international market.	Purchase of garlic planter and harvester by PCs as a part of FCSC.	Exporting of poor quality garlic has threatened its whole export
		Food safety standards and traceability (EuropGAP, Global Gap, SGS, etc.) are major obstacles to enter into high end international markets	Training farmers on food safety standards	High cost of certifications and quality standards
Processing	Demand of garlic is rising quickly owing to higher sales of branded food pickles, curry products, herbal products, pastes and medicines.	Lack of market information regarding prevailing prices, arrivals etc., which force farmers to sell in village locally.	Scope for tie up of PCs through contract farming with firms like Mitchell's; garlic processing units; housing societies in urban areas and retail outlets.	Failure in contract farming

Parameters	Strengths	Weaknesses	Opportunities	Threats
	Pungency and stickiness of desi garlic grown in Punjab is liked but not as much as KP by food processing industry of the province for their recipes.	Stickiness of desi garlic disrupt the peeling and paste making efficiencies	Scope for establishment of primary processing facilities under contract farming by PCs as a part of FCSC with food industries.	
	Raw garlic is used to produce garlic powder, garlic salt, garlic vinegar, and garlic bread etc., contributing significantly to food industry.	Lack of grading and sorting facilities. Limited primary and secondary processing units (mainly in Karachi) for garlic and its by-products such as garlic pealing/ paste units.	Processing of the bulbs as peeled, dehydrated flakes, powder and paste will have potential to contribute to garlic value addition that will significantly increase availability of garlic and related by-products.	

5.4.4. Northern Balochistan Cluster

The Balochistan cluster has comparative advantage of producing Chinese garlic in terms of agro ecological conditions such as water, climate, soil, farming experience etc. There is no secondary processing of Chinese garlic produced in this cluster due to low pungency. Major strengths, weaknesses, opportunities and threats of Balochistan cluster are reported in Table 12.

Table 12: SWOT analysis of northern Balochistan cluster

Parameters	Strengths	Weaknesses	Opportunities	Threats
Environment/ Climate Change	Shallow loamy gravelly soil texture and cold desert climate makes the cluster ideal for cultivating garlic.	Prolonged winter and sudden rise in temperature affect garlic settings.	Scope for digitizing garlic production to inform local weather conditions	Severe cold/weather conditions and militancy can hamper garlic production
	Availability of only ground water for irrigation.	Require electric motor to pull ground water	Use of solar energy may reduce tube well cost and environmental pollution	Lowering water table can pose a serious threat to availability of irrigation water
Garlic Varieties	Easy peeling feature of Chinese garlic variety performing best in this cluster	Low pungency and stickiness of Chinese garlic	Scope for increasing garlic area in this cluster to meet domestic demand of Chinese garlic in the cluster	Limited research funds
		Only two local varieties (Lehsan Gulabhi and NARC-G1) have been approved yet.		
		Limited availability of certified, quality, and pure variety seed	Scope for establishment of Producers' companies (PCs) as a part of Farmers Common Service Centre (FCSC) to purchase high yielding varieties (HYV) of garlic.	Fluctuate in the time of sowing due to climate change.
Input Supplies	Growing demand for fertilizers and pesticides	Non-availability of appropriate quality of fertilizer	Proper monitoring and evaluation of input supply system helps to reduce input adulteration problem.	Use of adulterated fertilizer
		Declining organic matter in soils	Increasing poultry production and poultry manure is an opportunity to halt the declining organic matter.	Use of adulterated or expired pesticides.
		Lack of knowledge of Persistent Organic Pollutant (PoP) & Good Agricultural Practices (GAP) for garlic production.	Information dissemination on PoP and GAP	Injudicious use of chemicals

Parameters	Strengths	Weaknesses	Opportunities	Threats
Production Management Practices	Experienced farmers who know garlic cultivation for a long time	Majority of farmers are illiterate and have small farm size.	Scope for establishment of planting, harvesting, and quality sorting and grading facilities by PCs as a part of FCSC.	Cloudy weather, rainfall at the time of harvesting etc
		Low plant population		
		Insufficient hoeing can reduce bulb size.	Contract farming with defined quantity and quality parameters	
		Flooded irrigation deteriorates garlic quality	Arrangements of training modules for farmers on the latest methods of sowing, plant protection, intercropping, efficient irrigation method, harvesting, etc. by several national (NARC, provincial departments, private sector, etc.) and international organizations (AVRDC).	Difficulty of training illiterate farmers about the latest production methods and techniques
		Improper harvesting procedure		
		Labour constraint at sowing and harvesting stages due to its competition with wheat crop		
Infrastructure	New roads under China Pakistan Economic Corridor (CPEC) has connected Balochistan to main markets of Punjab through Dera Ghazi Khan and the biggest port in the country.	Inadequate infrastructural facilities like storage with producers, traders, processors and at market level, which result in marketing inefficiencies.	Establish storage facilities by PCs as a part of FCSC.	Failure in trust among PCs members
Cluster Interaction	Large number of farmers in garlic clusters	Little interaction among farmers and researchers	Possibility of learning from progressive farmers in the cluster	Lack of optimal coordination and integration among stakeholders
		Producers have little information about the quality requirements in national and international markets	Strong relation between Commission Agents/Wholesaler and Contractors (each have knowledge about quality demand at least in national	
		No contract farming with defined quantity and quality parameters		

Parameters	Strengths	Weaknesses	Opportunities	Threats
		Little credit availability from formal institutes for any actor of cluster	market) can be transformed into quality-based supply contract	
Marketing	Farmers receive prices based on the variety or product quality	Lack of market information due to disconnect of farmers with the market	Emerging supermarkets can introduce contract with farmers, which may improve retailing quality, and reduce post-harvest losses and trading margin	Supermarkets may exclude small farmers due to their limited supply
		Little capacity of farmers and traders and little quality infrastructure to produce, handle, and market the quality product	Financial support by the commission agents and wholesalers to harvesting contractors can be converted into quality-based delivery contracts	Weather risk may limit supply
		Auctioning in the wholesale market with visual and spot grading	Bulk selling can result in better result for growers	High price risk
Trade/Export	Balochistan produces from May to June whereas there is a significant gap in supply from Europe during this period.	Limited availability of HYV and pest and disease resistant varieties of garlic bulbs.	Purchase of HYV and pest and disease resistant varieties of garlic by PCs as a part of FCSC.	Adverse weather conditions affect garlic shelf life.
	Few traders start exporting garlic to neighboring high value markets by making direct contract with importers	Lack of farm mechanization for planting and harvesting increases cost of production and reduces garlic competitiveness in the international market.	Purchase of garlic planter and harvester by PCs as a part of FCSC.	Exporting of poor quality garlic has threatened its whole export
		Food safety standards and traceability (EuropGAP, Global Gap, SGS, etc.) are major obstacles to enter into high end international markets	Training farmers on food safety standards	High cost of certifications and quality standards

5.4.5. Southern Sindh Cluster

The Sindh cluster meets local households' demand of garlic crop. Due to poor quality, garlic being produced in this cluster is neither being processed nor being exported. Major strengths, weaknesses, opportunities and threats of Sindh cluster are reported in Table 13.

Table 13: SWOT analysis of southern Sindh cluster

Parameters	Strengths	Weaknesses	Opportunities	Threats
Environment/ Climate Change	Silty loam soil texture and warm desert climate makes the cluster suitable for cultivating garlic.	Sudden rise in temperature affect garlic settings.	Scope for digitizing garlic production to inform local weather conditions	Drought during winter and shortage of canal water hamper garlic bulb size
	Availability of canal irrigation throughout the year.			
Garlic Varieties	High pungency of local varieties such as Lehsan Gulabi (local), White Desi (local) etc.	Sticky, thin, intact and unpeelable skin of local garlic	Scope for developing new varieties of garlic meeting household and food industry demand by national public or private research stations.	Limited research funds
		Only two local varieties (Lehsan Gulabhi and NARC-G1) have been approved yet.		
		Limited availability of certified, quality, and pure variety seed	Scope for establishment of Producers' companies (PCs) as a part of Farmers Common Service Centre (FCSC) to purchase high yielding varieties (HYV) of garlic.	Fluctuate in the time of sowing due to climate change.
Input Supplies	Growing demand for fertilizers and pesticides	Non-availability of appropriate quality of fertilizer	Proper monitoring and evaluation of input supply system helps to reduce input adulteration problem.	Use of adulterated fertilizer
		Declining organic matter in soils	Increasing poultry production and poultry manure is an opportunity to halt the declining organic matter.	Use of adulterated or expired pesticides.
		Lack of knowledge of Persistent Organic Pollutant (PoP) & Good Agricultural Practices (GAP) for garlic production.	Information dissemination on PoP and GAP	Injudicious use of chemicals

Parameters	Strengths	Weaknesses	Opportunities	Threats
Production Management Practices	Experienced farmers who know garlic cultivation for a long time	Majority of farmers are illiterate and have small farm size.	Scope for establishment of planting, harvesting, and quality sorting and grading facilities by PCs as a part of FCSC.	Cloudy weather, rainfall at the time of harvesting etc
		Low plant population		
		Insufficient hoeing can reduce bulb size.	Contract farming with defined quantity and quality parameters	
	Intercropping with tobacco etc.	Flooded irrigation deteriorates garlic quality	Arrangements of training modules for farmers on the latest methods of sowing, plant protection, intercropping, efficient irrigation method, harvesting, etc. by several national (NARC, provincial departments, private sector, etc.) and international organizations (AVRDC).	Difficulty of training illiterate farmers about the latest production methods and techniques
		Improper harvesting procedure		
		Labor constraint at sowing and harvesting stages due to its competition with wheat crop		
Infrastructure	Good road infrastructure connecting Sindh garlic cluster with the main markets in this province	Inadequate infrastructural facilities like storage with producers, traders, processors and at market level, which result in marketing inefficiencies.	Establish storage facilities by PCs as a part of FCSC.	Failure in trust among PCs members
Cluster Interaction	Large number of farmers in garlic clusters	Little interaction among farmers and researchers	Possibility of learning from progressive farmers in the cluster	Lack of optimal coordination and integration among stakeholders
		Producers have little information about the quality requirements in national and international markets	Strong relation between Commission Agents/Wholesaler and Contractors (each have knowledge about quality demand at least in national market) can be transformed into quality-based supply contract	
		No contract farming with defined quantity and quality parameters.		
		Little credit availability from formal institutes for any actor of cluster		

Parameters	Strengths	Weaknesses	Opportunities	Threats
Marketing	Farmers receive prices based on the variety or product quality	Lack of market information due to disconnect of farmers with the market	Emerging supermarkets can introduce contract with farmers, which may improve retailing quality, and reduce post-harvest losses and trading margin	Supermarkets may exclude small farmers due to their limited supply
		Little capacity of farmers and traders and little quality infrastructure to produce, handle, and market the quality product	Financial support by the commission agents and wholesalers to harvesting contractors can be converted into quality-based delivery contracts	Weather risk may limit supply
		Auctioning in the wholesale market with visual and spot grading	Bulk selling can result in better result for growers	High price risk
Trade/Export	Sindh produces from February to March whereas there is a significant gap in supply from Europe during this period.	Limited availability of HYV and pest and disease resistant varieties of garlic bulbs.	Purchase of HYV and pest and disease resistant varieties of garlic by PCs as a part of FCSC.	Adverse weather conditions affect garlic shelf life.
		Lack of farm mechanization for planting and harvesting increases cost of production and reduces garlic competitiveness in the international market.	Purchase of garlic planter and harvester by PCs as a part of FCSC.	Exporting of poor quality garlic has threatened its whole export
		Food safety standards and traceability (EuropGAP, Global Gap, SGS, etc.) are major obstacles to enter into high end international markets	Training farmers on food safety standards	High cost of certifications and quality standards

6. CHALLENGES FACED BY THE CLUSTERS

6.1. Constraints of Climate Change

All the garlic clusters have many similarities and dissimilarities. Climate change is one of the major constraints faced by farmers in all clusters. Prolonged winter and sudden rise in temperature that affect garlic settings in KP cluster. Use of wastewater irrigation in Punjab cluster deteriorates garlic quality. Sindh cluster is facing shortage of canal water. However, Balochistan cluster is suffering from extreme shortage of water. Over extraction due to solar pumping and prolonged drought has further aggravated this problem. Because of climate constraints, adjustments in garlic clusters have self-started, which fluctuate in diverse financial, institutional and socioeconomic settings. Rresearch investment by public and privet sectors is required to mitigate climate change in garlic clusters.

6.2. Unrestricted Imports

Garlic is an input intensive crop with heavy fertilizer and high number of irrigation requirements. In China these inputs are relatively cheap because they are heavily subsidized compared to in Pakistan where these are heavily taxed. Thus input use on garlic in China is much higher than in Pakistan and the former get high per ha yield. In addition, foreign exchange rate of Pakistani Rupee is highly overvalued. Unrestricted garlic imports from China without incorporating these factors make Pakistani garlic farmers out rightly uncompetitive compared to their counterpart in China.

6.3. Production Level Constraints

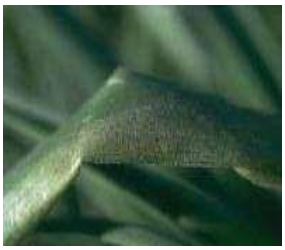
Garlic is an important cash crop of rabbi season. Low productivity and profitability are the common features of all the clusters. Moreover, farmers in all clusters have little information about the quality requirements in the national and international markets. Farmers are using below suboptimal and imbalance inputs, which, therefore, impact the output. Farmers face difficulty to get enough labor to plant garlic on time, maintain optimum spacing and uniform plant density. Low plant density with labor contract is the common cause of low yield. Moreover, manual planting is tedious, time-consuming and costly. Cultivation of old varieties is another cause of low yield (AMIS, 2005). Very little research investment is made in garlic sector. Except NARC variety, NARC-G_1 recently released in 2018 and Ayub Agriculture Research Institute's (AARI) variety of Lehsan Gulabi release in 1990s nothing came out from the research system. The AARI's variety has relatively poor quality and smaller size as shown in Figure 5.

Figure 5: NARC-G1 and Lehsan Gulabi (approved garlic varieties)

Lack of farm mechanization for planting and harvesting and competition of labor at planting and harvesting stage in particular with wheat is very common in all clusters. According to an estimate, garlic planter and harvester can reduce cost of production by 80%. Poor water management is also a major problem. Further, research institutes have little funds on varietal development of garlic and to train farmers about high tech methods and techniques. FAO (2007) has suggested mechanized farm operations, improved storage conditions and packing to minimize post-harvest losses in garlic. These interventions of pre- and post-harvest management will be part of our cluster up-gradation program.

Along with this, garlic diseases and pests are major impediment to farmers' net income in all clusters. According to an estimate, garlic losses due to pathogens and pests are around 2-5%. However, farmers may recognize a problematic crop situation in the field but may not identify its casual pathogens or pests and related solution. This logistic problem in crop protection requires educating and training of rural extension staff and sending them to the rural suburbs to assist farmers. The major garlic fungal and viral diseases along with their symptoms and control measures have been presented in the Table 14 below:

Table 14: Major garlic diseases and their control measures

Name	Symptoms	Management
Downy mildew 	Pale spots appears on leaves with powdery mass development; leaf tips fall	Abstain from planting tainted sets; plant in well-draining regions; crush all contaminated yield debris; apply foliar spray of sulphur fungicides at 2g/liter at 15 days interval to control disease

Name	Symptoms	Management
Purple Blotch 	Small whitish lesions appear on leaves with purple centres that increase in size rapidly; severely infected foliage may kick the bucket	Reduce leaf wetness by planting in well-depleting soil and timing water system to enable plants to dry; spraying of fungicides like Mancozeb @ 2.5 g/litre, at 15 day intervals is very useful to control disease
Mosaic 	Mosaic virus transmitted by aphids infects emerging leaves showing chlorotic mottling or streaks on leaves; hinders plant development and diminishes bulb size	Plant infection free cloves, spraying of monocrotophos @ 0.5 ml/litre helps to control disease
Rust 	Little white flecks form on leaves and stems, which form into circular or extended orange and black pustules; severe infestations can make leaves yellow and die.	No resistance known; remove infected leaves, use fungal free cloves in well-depleting soil; control weeds around crop; apply suitable fungicide.

The major garlic insect pests along with their symptoms and control measures have been presented in the Table 15 below:

Table 15: Major garlic insect pests and their control measures

Name	Symptoms	Management
Thrips 	Thrips are major pests of garlic crop. After eating leaf surface, they turn it into whitish or silvery surface	Spraying of Malathion at1 ml/ litre or Methyldemeton at 0.75 ml/ litre gives good control

Name	Symptoms	Management
Stem and Bulb Nematodes 	Nematodes are tiny worms infesting the tissues of garlic stem and bulb and causing the basal portion of mature plants to swell. They drastically reduce the yield.	Pre-planting soil fumigation with dichloro-propenedichloropropane mixture @ 500 kg/ha is recommended.
Eriophyid mites 	These mites are so small that their invasions are usually ignored. Infected plants have twisted leaves with conspicuous yellow streaking. Long storage leads to severe attack by mites.	Abstain from planting infected cloves. Water spray also washes off the parasites from the plant.
Bulb mites 	Mites are shiny, creamy white and bulbous appearance. They cause stunted plant development, lessened stand and globules decaying in ground.	Try not to plant progressive crops of onion or garlic in same area. Treat garlic seed cloves with hot water prior to planting may help diminish mite population.
Leaf miners 	Leaf miners are larvae of a yellow fly that lives in and eats leaf tissue of plants. They appear as white trails on leaves; early infestation can lessen yield.	After indication of leaf mining, use bug sprays or expel plants from soil promptly.
Red spider mite 	Adults and nymphs feed on the undersides of the leaves. The upper surface of the leaves ends up stippled with little dots and silk webbing is visible.	Abstain from planting progressive garlic crops and through water spray also washes off the parasites from the plant.

Name	Symptoms	Management
Onion maggot 	These bugs are grayish flies, which lay white eggs around the base of the plant. Hinders or shrinks seedlings; plant will ordinarily break at soil line if an attempt is made to pull it up.	Spraying of granular bug spray gives good results

6.4. Post-Harvest Constraints

In Pakistan, post-harvest losses start from harvesting and continue throughout the post-harvest chain. These losses occur due to various reasons, such as improper handling and transportation, harsh temperature and lack of cool chain system, improper storage, bio-deterioration, insects, etc. After harvesting, drying of fresh garlic is compulsory to remove excessive moisture from the outer skin of bulb. Farmers do drying of garlic after harvesting in the field for 3-5 days in the sun. Drying also helps to reduce storage losses. At present, farmers have limited facilities for primary post-harvest management like cleaning, drying, grading, packaging and storage (Figure 6-9). Because of inappropriate storerooms, spoilage and losses may occur due to mishandling and rodents. Appropriate way to temporarily store garlic is to hang after bundling as shown in Figure 8. Post-harvest losses during storage at the farm level are about 3-10% of fresh garlic. Garlic cloves start sprouting at 4.4 ºC. For long storage, cold storehouse with 0.5ºC and 60-70% relative humidity is recommended.

Figure 6: Insufficient Transportation

After harvesting, drying of fresh garlic is compulsory to remove excessive moisture from the outer skin of bulb. Farmers do drying of garlic after harvesting in the field for 3-5 days in the sun. Drying also helps to reduce storage losses. At present, farmers have limited facilities for primary post-harvest management like cleaning, drying, grading, packaging and storage (Figure 6-9).

Figure 7: Poor storage facilities

Because of inappropriate storerooms, spoilage and losses may occur due to mishandling and rodents. Appropriate way to temporarily store garlic is to hang after bundling as shown in Figure 8. Post-harvest losses during storage at the farm level are about 3-10% of fresh garlic. Garlic cloves start sprouting at 4.4 ºC. For long storage, cold storehouse with 0.5ºC and 60-70% relative humidity is recommended.

Figure 8: Garlic drying

Moreover, there is no appropriate transport facility available to protect from abrupt changes in weather. Appropriate transport facilities and packing in presentable form reduces post-harvest losses.

Figure 9: Modern packaging of garlic

6.5 Marketing Level Constraints

In all clusters at the village level, there is lack of market information regarding prevailing prices, crop arrivals etc. and few alternate marketing channels, which force farmers to sell to local traders. Local traders exploit small farmers by paying them lower prices. While determining the price, produce quality counts little. After aggregating and packaging in 20 Kg bags, local traders further sell to commission agents. Distress sale is obligatory on some farmers as they must repay the loan availed from traders during the time of sowing for seed, fertilizers etc. Few farmers have advanced marketing contracts with commission agents. The presence of a long chain of middlemen diminishes the producer's share in consumer's rupee. Further, numerous inefficiencies prevail in the markets i.e. delay in installment, high commission charges, delay in weighing and sale, various types of discretionary charges reasoning for religious and charitable purposes etc. Farmers are not engaged in the export of fresh garlic, although few commission agents in Lahore and Karachi wholesale markets are.

6.6 Processing Level Constraints

At present, there are limited primary and secondary processing units for garlic and its by-products such as peeled garlic, garlic paste, powder, oil etc., in all clusters. Food industries such as Shan, National, Ahmed, Laziza, Zaiqa etc, in Karachi and Mitchels in Lahore are preferred using desi garlic for garlic paste making, garlic pickles, garlic, ketchup making, vinegar, and other recipes like Biryani. However, these industries face problem in peeling desi garlic through peeler due to its heterogeneous size and high stickiness. After some peeling, they have to remove stickiness from garlic belt. Therefore, they have to manually peel unpeeled thin and small sized cloves. However, manual peeling is expensive and unhygienic, although mechanical peelers are available in the market (Figure 10).

Figure 10: Garlic peeler and paste maker

7 CLUSTER DEVELOPMENT POTENTIAL

In this section, an attempt has been made to evaluate the potential in all clusters in terms of increased production, area expansion, reduction in post-harvest losses and enhanced processing, based on the targets set in section 2 (targets) for incremental improvements in the cluster performance. In addition, both quantitative and qualitative analyses are presented to explain the nature of potential in various segments of the garlic value chains and possibilities of absorption of additional supply in the four main clusters.

7.1. Production Potential

As mentioned in section 1, the global average yield of garlic is 18.1 tonnes/ha in 2016, whereas in Pakistan it is 8.8 tonnes/ha – thus a yield gap of 9.3 tonnes/ha exists (FAO, 2017). The estimated average yield for KP, Punjab, Balochistan and Sindh clusters in 2016 are 11.9 tonnes/ha, 7.8 tonnes/ha, 7.8 tonnes/ha and 5.2 tonnes/ha, respectively. The newly released garlic cultivar NARC-G1 gave the best survival (100%), minimum and wider leaves/plant (10), average plant height (38.2 cm), minimum cloves (8.3) per bulb and comparatively larger bulbs, maximum bulb weight (126.6 gm) and maximum fresh yield (25.6 tonne/ha) at the vegetable program (HRI), National Agricultural Research Council (NARC) Islamabad (Khan et al., 2018). However, we have suggested increasing yield by 25% in central KP cluster, 25% in northern Punjab cluster, 35% in northern Balochistan cluster and 35% in southern Sindh cluster from the current base due to adoption of high yielding varieties and improved farm management practices, over five years. Luckily, recently released cultivar NARC-G1 has the highest yield of 26 tonnes/ha in the farmers' filed and the yield is quite stable across various garlic clusters in the country. This variety can almost double the production potential at farm-level than the existing varieties grown by farmers. However, we assume 20-30% increase in yield with the adoption of NARC-G1 variety across various clusters through the cluster development program, depending upon their existing yield levels.

Research has also shown that improved farm management (IFM) practices like timely sowing, managing plant density, managing irrigation frequency and intentisty, optimal and balanced use of inputs particularly fertilizer, effective control of diseases, insects and weeds etc. can significantly improve the garlic yield (Diriba-Shiferaw, 2016; Rehman et al., 2012). However, we assume only 5% increase in yield due to IFM practices because adoption of such practices is slow and require knowledge intensive and concerted efforts to pursue farmers.

Nevertheless, this intervention, if pursued vigorously, can easily increase garlic yield by 30-35% and result in an additional production of 3.2 thousand tonnes, 2.6 thousand tonnes, 2.5 thousand tonnes, and 1.1 thousand tonnes valued at US$ 1.8 million, US$ 1.4 million, US$ 1.4 million, and US$ 0.6 million in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively. Implementing this strategy alone can save about 14% of the garlic import

of the country.This increase in production can almost entirely be absorbed by local high demand. Increased production potential shall result in creation of 400, 500, 300 and 200 new jobs at production level in the KP, Punjab, Balochistan and Sindh clusters, respectively. The new jobs are expected to be created at various levels in value chain support services.

: **Figure 11: Garlic Digger and harvester**

7.2. Farm Mechanization Potential

Garlic production is a very labor intensive enterprise. Its production is facing severe labour constraints at the planting and harvesting stages. Garlic planter not only helps increasing crop yield by maintaining optimal plant density but also reduces cost of production significantly (Figure 12). Similarly, garlic harvester not only improves harvest quantity and quality but also reduces cost of production drastically (Figure 11). The discussion with stakeholders suggests that if appropriate modern planting and harvesting techniques are adopted, then cost of production would reduce by 80%.

Figure 12: Garlic planter and harvester

We assume only 25% of the total garlic area under mechanized planting in each cluster under cluster development program. Based on crop area and planting capacity of the planter, this

intervention demands introduction of 8 planters to each cluster in five years. The intervention can increase garlic yield by 5% and results in an additional production of 40.19 tonnes, 32.19 tonnes, 31.46 tonnes, and 13.99 tonnes in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively. Total value of increased yield and cost saving from sowing mechanization yields US$ 65 thousand, US$ 50 thousand, US$ 19 thousand, and US$ 21 thousand in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively.

Similarly, we assume 25% of the total garlic area under mechanized harvesting. Based on production estimates and harvesting capacity of the harvester, this intervention demands introduction of 16 harvesters to the KP, Punjab and Balochistan clusters and 12 harvesters to Sindh cluster in five years. The intervention can save harvesting cost of US$ 6.5 thousand, US$ 8.8 thousand, US$ 1.8 thousand, and US$0.6 thousand in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively.

Implementing planting and harvesting mechanization alone can give benefits of US$ 72 thousand, US$ 59 thousand, US$ 21 thousand, and US$ 22 thousand in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively.

7.3. Reduction in Post-Harvest Losses

One of the major concerns of agriculture in the country is high post-harvest losses. For example, garlic losses account for nearly 20% of the total production in the KP cluster. Similarly, in all other clusters, these losses are 10% of production. These losses can be reduced through suggested interventions like modern harvesting techniques, safe transportation, proper drying, storage and packing, which we are suggesting in the next section. The discussion with different stakeholders suggests that if appropriate harvest and post-harvest strategies are adopted, these losses can be halved. This will generate additional income to producers as well as value chain actors, worth of US$ 3.4 million, US$ 2.4 million, US$ 0.7 million and US$ 1.0 million in the KP, Punjab, Balochistan and Sindh clusters in the fifth year, respectively, at the existing garlic prices in each cluster. Country-wide, this is likely to add more than US$ 7.5 million of additional value in the garlic value chain. Moreover, enhanced marketable garlic production due to improved storage and reduced post-harvest losses (18.8 thousand tonnes) will save about 39% of the garlic import of the country.

In summary, if the country invests on R&D, farm mechanization and storage and quality infrastructure, it can generate a total of US$ 13 million in terms of enhanced income to farmers, middlemen, and traders, and generate 1800 employment to the poor people in the garlic growing in crop and value chain management processes thus bringing down poverty in rural areas. Blooming garlic sector will also bloom the rural environment with garlic colors.

8 PLAN, POLICIES AND STRATEGIES

8.1. Plan

Based on the gaps and potentials as discussed above, following research-based cluster development plan along with targets to be achieved is proposed for a five-year development project to make garlic an internationally competitive product.

No.	Targets
1.	Increase yields by 50% in central KP, 60% in northern Punjab, 70% in northern Balochistan and 90% in southern Sindh clusters from the current base with the adoption of high yielding varieties and improved farm management practices
2.	Improve farm mechanization in garlic production to reduce production cost on 50% of the total garlic area in the cluster
3.	Reduce post-harvest losses by half (from 20% to 10% in Khyber Pakhtunkhwa cluster, and from 10% to 5% in Punjab, Sindh and Balochistan clusters
4.	Increase processing by 3% of total garlic production by adding value through product development such as peeled garlic, garlic paste, garlic powder, garlic flakes, garlic oil etc. and promote the use of garlic in food recipes.

8.2. Policy Reforms

The structure of subsidies and incentives in the agriculture sector should be reorganized to make these clusters specific and results oriented. Following policy measures shall be adopted:

- Import duties on garlic should be rationalized keeping in view the subsidized inputs and other incentives available to Chinese and Indian garlic farmers.
- Import duties on clearly defined pre- and post-harvest tools and equipment, like planter, harvester, farm-level cold storage should be eliminated for certain period
- Import of garlic germplasm, hybrids and varieties should be funded through PARC
- Establishment of Garlic Entrepreneur Groups (GEGs) at the Union Council Level in all the clusters. The government will guide the GEGs and monitor its functioning through a paid business manager. The GEGs will have initial endowment fund and generate its own funds through membership fee to sponsor various garlic related R&D activities
- Encouraging the Garlic Traders and Processors Association
- Revenues lost through these measures should be recovered by doubling import duties on raw garlic and value-added garlic products within the limit of WTO

8.3. Strategies for All Clusters

8.3.1. Production Level Strategies

To increase yields by 30-35% from the current base, over five years, following strategies are suggested:

a) Establishment of National Garlic Research and Development Center at NARC to lobby for favorable policies for the garlic sector and sponsor research on all value chain issues of garlic including mechanization, processing etc. The provincial research systems will establish garlic research stations in each cluster for adaptive research, such as testing new hybrids, varieties, machines, management models, etc.
b) The GEG will identify the garlic R&D issues and seek grants from government or fund research from its own resources
c) Promote specialized extension to solve special garlic problems on need and paid basis from GEGs funds
d) Introducing latest garlic varieties and hybrids developed by the research system
e) Test and adapt imported varieties and hybrid in local condition and allow farmers to choose the best material
f) Develop special garlic varieties that will be easy to peel and keep original aroma in collaboration with China
g) Promote Good Agricultural Practices (GAP) at the farm level
h) Promote Improved Farm Management (IFM) practices like timely sowing, managing plant density, managing irrigation frequency and intensity, optimal and balanced use of inputs particularly fertilizer, effective control of diseases, insects and weeds etc.
i) Establish Farmer Fields School (FFS) to train on adoption of high yielding varieties (HYV), GAP and IFM

8.3.2. Farm Mechanization Level Strategies

To increase yields and reduce cost of production, we assume mechanizing sowing and harvesting activities on 25% of total garlic area in all clusters, over five years, the following strategies are suggested:

a) Import 32 garlic planters for all clusters over four years
b) Provide two planters to GEG of major garlic producing district of central KP, northern Punjab and northern Balochistan clusters in the second year, and then providing remaining planters to other major districts in the coming years
c) Import 60 garlic harvesters for all clusters over four years
d) Provide four harvesters to GEG of major garlic producing district of central KP, northern Punjab and northern Balochistan clusters in the second year, and then providing remaining 36 harvesters to other major districts in the coming years

e) Provide three harvesters to GEG of major garlic producing district of southern Sindh cluster in the first year, and then providing remaining 9 harvesters to other major districts in the coming years
f) Organize farmers' training to use garlic planters and harvesters efficiently and effectively

8.3.3. Post-Harvest Level Strategies

To reduce post-harvest losses by 10-26% in all clusters, the following strategies are suggested at the farm-level:

a) Introduce garlic maturity index and train the harvesters to harvest garlic at appropriate maturity stage
b) Import 16 cold machines for all clusters over first four years
c) Establish four cold store houses of half acre through GEG to store 10% of the total garlic production in all clusters over four years to encourage cold storage, grading, packing etc.
d) Train farmers and storage people to maintain the quality of garlic through contractors and GEGs

9 FEASIBILITY ANALYSIS

9.1. Overview

Interventions are being proposed here to increase garlic yield, reduce cost of production and reduce post-harvest losses; so as to reduce import and increase the overall value of the produce for the farmers and for other sector stakeholders. Cost and benefit analysis has been done separately for each of the four clusters.

The economic and financial analysis of garlic clusters has been carried out by identifying the benefits of the proposed interventions and their associated costs. Cost and benefit analysis has been done in a five-year timeframe; separately for each of the four clusters. Discounted cash flow analysis has been carried out to work out the economic viability of the proposed interventions in terms of net present value (NPV) and internal rate of return (IRR).

9.2. Key Interventions, Benefits and Costs

Following three key interventions have been proposed for transformation of garlic sector of Pakistan.

i) improvement in garlic yield by introducing new varieties and improved farm management practices
ii) introduction of garlic planter and harvester
iii) reduction in garlic post-harvest losses

The expected benefits by implementing the proposed interventions have been based on certain assumptions, which have been decided in discussion with garlic sector experts. Expected benefits have been calculated with reference to the baseline situation of each of the four clusters. Based on the assumptions, the value addition by implementing these interventions has been calculated in a five-year timeframe.

The resources required for the implementation of the proposed interventions package include i) additional operational costs of improved garlic production, farm mechanization, and reduced post-harvest losses, and ii) sector development investments like R&D by government, iii) fixed capital investment in machinery, store house etc. by government and private sector, iv) investment on extension, v) investment on training of stakeholders on value chain management. The whole analysis has been based on incremental costs and benefits of the proposed interventions.

The detailed feasibilities of garlic planter, harvester and storehouse are separately estimated and explained in annexures 6, 7 and 8, respectively. For each cluster, the number of planters, harvesters and storehouses required were estimated based on the estimated garlic area, quantities, and capacity of the machines. Total investment and operational costs of these

modern technologies in each cluster were incorporated in the main feasibility model. However, in the following section, we just explained the feasibility of the whole package of interventions.

9.3. Central KP Garlic Cluster

9.3.1. Current Situation

The study has considered 1,034 ha of area under garlic production in six major districts (Kohat, Swabi, Charsadda, Peshawar, Nowshera and Mardan) of central KP garlic cluster, which is currently producing 12,489 tonnes of garlic per year. Current yield in the cluster is 12.08 tonnes/ha. Annual yield growth of garlic without intervention is observed at 0.59% from 2001 to 2016 in KP. Garlic current production situation is presented in Table 16

Table 16: Central KP cluster – current production situation

Current Situation	Base Year
Area under cultivation (ha)	1,034
Total garlic production (tonnes)	12,489
Default yield (tonnes/ha)	12.08
Annual yield growth without intervention (%)	0.59
Farm gate price of garlic (US$/tonne)	556

Annual expected garlic production and its value at the current farm gate price in the next five years in a no-intervention scenario are also shown in Table 17:

Table 17: Central KP – garlic production in no-intervention scenario

	Year 1	Year 2	Year 3	Year 4	Year 5
Default yield (tonnes/ha)	12.15	12.22	12.29	12.37	12.44
Annual expected garlic production (tonnes) without intervention at farm gate level	12,563	12,637	12,711	12,786	12,862
Total value of production at farm gate before intervention (000 US$)	6979.3	7020.4	7061.9	7103.5	7145.4

9.3.2. Benefits of the Proposed Interventions

9.3.2.1. Intervention 1 – Introduction of improved varieties and Management practices

Improved farm management practices (IFM) and R&D in garlic cultivation will lead to increase garlic yield. The research will introduce new high yielding varieties (HYV) such as NARC-G1 recently released from other provincial research system in the country or import from other

countries. These new varieties and hybrids (already released in other provinces of Pakistan or in other countries having similar situation) will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Farmers will be allowed to select the best material for cultivation. The provincial extension department in collaboration with NGOs will also demonstrate large-scale field demonstration of improved farm management practices and new best performing varieties and development partners starting from the first year and continue until the fourth year. The improved management practices demonstrated on farmers' field will include high yielding garlic varieties, proper sowing timings, optimal population density, and proper input, judicious & proper use of insecticides, proper irrigation and uprooting through farmers' trainings. It is estimated that introduction of HYV in central KP cluster will increase the garlic yield by 20% over a period of four years.

However, it is assumed that farmers will gradually adopt IFM practices; thus, yield increase due to IFM in the cluster will also be gradual at a rate of 5% per year starting from the second year. Based on these assumptions, the value of increased garlic production at the existing rate of US$ 556 per tonne is shown in 18.

Table 18: Central KP cluster - increased garlic value by increased production

Increased Production	Year 2	Year 3	Year 4	Year 5
Increase yield by 20% due to adoption of high yielding varieties (HYV) over four years, with 5%/year increase	5.0%	10%	15%	20%
Increase yield due to adoption of HYV (tonne/ha)	0.61	1.23	1.85	2.49
Additional production from enhanced yield tonne	632	1,271	1,918	2,572
Expected additional value from increased yield (US$) due to HYV adoption	351,022	706,187	1,065,530	1,429,089
Increase yield by 5% due to improved farm management (IFM) over four years, with 1%/year increase	1%	3%	4%	5%
Increase yield due to IFM (tonne/ha)	0.15	0.31	0.46	0.62
Additional production from improved IFM tonne	158	318	479	643
Expected additional value from increased yield (US$) due to IFM	87,756	176,547	266,382	357,272
Total Impact of First Intervention				
Total expected additional yield from first intervention (tonne/ha)	0.76	1.54	2.32	3.11
Total expected additional production from first intervention tonne	790	1,589	2,397	3,215
Total expected additional value of output from first intervention (US$)	**438,778**	**882,733**	**1,331,912**	**1,786,361**

9.3.2.2. Intervention 2 – Mechanization of garlic planting and Harvesting

Introduction of farm mechanization in garlic cultivation will lead to increase garlic yield and reduce cost of production. The government will import garlic planters and harvesters from other countries and will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Large scale field demonstration of these machines will be demonstrated by the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. It is assumed to introduce these machines on 25% of the total garlic area in central KP over a period of four years. These machines will be gradually adopted at a rate of 6% per year starting from the second year. It is assumed that a planter will take 2 hours to plant one acre and one planter will be busy 8 hours a day as explained in annexure 7. Then we computed planting capacity for a month and converted onto one ha. So planting capacity of one planter will be 49 ha. It is estimated introduction of planter in central KP cluster will save cost of production as manual planting is very expensive and will increase the garlic yield by 5% over a period of four years as it will improve plant density. Harvester will be assumed to take 5 hours to uproot garlic from one acre and one harvester will be busy 8 hours a day as explained in annexure 7. Hence, harvesting capacity of one harvester will be 19 ha per month. It is estimated introduction of harvester in central KP cluster will also save cost of production as manual harvesting is very expensive. Based on these assumptions, the value of increased garlic production and cost saving at the existing rate of US$ 556 per tonne is shown in Table 19.

Table 19: Central KP cluster - garlic cost saving by increased mechanization

Farm Mechanization	Year 2	Year 3	Year 4	Year 5
Sowing Mechanization				
Mechanized Sowing				
Area under mechanized planting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under sowing mechanization (ha)	65	129	194	259
Saving in sowing cost (US$)	10,789	21,579	32,368	43,158
Increase in yield due to sowing mechanization (%)	1.25%	2.50%	3.75%	5.00%
Increase in yield (tonne/ha)	0.01	0.04	0.09	0.16
Additional production from sowing mechanization (tonnes)	0.62	4.97	16.86	40.19
Expected increase in value of output from sowing mechanization (US$)	343	2,759	9,365	22,330
Total expected return from mechanization (US$)	11,132	24,337	41,733	65,487
Harvesting Mechanization				
Area under mechanized harvesting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under harvesting mechanization (ha)	65	129	194	259
Saving in harvesting cost (US$)	1,641	3,281	4,922	6,562
Total Impact of Second Intervention				
Total expected additional value of output and cost saving from second intervention (US$)	**12,773**	**27,618**	**46,655**	**72,049**

9.3.2.3. Intervention 3 – Introduction of village-level cold storages

Garlic crop faces the issue of high post-harvest losses of up to 20%, implying that 20% of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost forever. To reduce these losses, small scale cold store houses will be incentivized under FEG in the cluster as explained in Annexure 9. It is assumed that 10% of garlic production will be stored over a period of four years and stored garlic will enjoy better price of US$ 600 per tonne. Moreover, farmers will be trained on the harvesting index for garlic to help them identify appropriate matured garlic and proper drying of garlic after harvesting. It is estimated that with these proposed post-harvest practices, these losses can be reduced to 10%. This will lead to increasing the value of the garlic crop for the farmer and the downstream players in the value chain. It has been assumed that reduction in post-harvest losses will occur from the second year of interventions when the results of improved value chain management practices will be realized. Again the adoption of these practices will be gradual by the farmers, thus a linear gradual storage and reduction in losses at a rate of 2.5% per year has been assumed. Based on these assumptions, the value of increased garlic production in central KP cluster is shown in Table 20.

Table 20: Central KP cluster – increased garlic production by reducing post-harvest losses

Post-Harvest Management	Year 2	Year 3	Year 4	Year 5
Percentage of production that will be stored (%)	2.5%	5%	7.5%	10%
Production that will be stored tonne	336	715	1140	1612
Expected additional value due to new storage (US$)	14919	31789	50669	71633
Reduction in post-harvest losses after storage intervention (%)	2.5%	5%	7.5%	10%
Enhanced marketable garlic production due to reduced post-harvest losses tonne	336	1794	3566	5923
Expected additional value from reduction of losses (US$)	186,489	996,640	1,981,331	3,290,821
Total expected additional value of output from third intervention (US$)	**201,408**	**1,028,430**	**2,032,000**	**3,362,454**

9.3.3. Total Benefits Summary

Summary of the value of the benefits of the proposed interventions is shown in Table 21.

Table 21: Central KP cluster - summary of the value of benefits of interventions

Benefits Value (US$)	Year 2	Year 3	Year 4	Year 5
Value of Increased Production	438,778	882,733	1,331,912	1,786,361
Value of Increased Farm Mechanization	12,773	27,618	46,655	72,049
Value of Increased Storage and Reduced Post-Harvest Losses	201,408	1,028,430	2,032,000	3,362,454
Total Value	**652,959**	**1,938,782**	**3,410,567**	**5,220,865**

9.3.4. Enhanced Costs of the Proposed Interventions

The above proposed interventions will add cost of producing, mechanizing, and value addition of garlic. The costs of the proposed interventions involve two types of costs i) value chain improvement costs and ii) sector support interventions costs.

9.3.4.1. Value Chain Improvement Costs

The proposed sector transformation plan includes interventions both for on-farm and off-farm activities. Improvement entails spending more money for carrying out those activities on modern lines. Existing costs and the proposed incremental increases for different cost heads are shown in Table 22.

Table 22: Central KP cluster – value chain cost head

Value Chain Improvement	Cost	Incremental Increase
Production Inputs and Harvest (land preparation, inputs, labor, etc.) (US$/ha)	1799	19%
Operating cost of storage at focal point (US$/t)	6	-
Operating cost of mechanization (US$/ha)	228	-

It is assumed that operating costs of storage and mechanization will not increase in the project implementation period. Based on the above unit costs, total value chain costs for the entire cluster were calculated in Table 22. It was assumed that costs will be incurred from the second year of implementation. Total planned increase in cost of production was distributed over four years. It means that one fourth of the intended increase will happen in the second year which will increase to 5%, and so on until the fifth year of implementation. Total increase in cost of storage and mechanization are calculated for assumed quantities stored and assumed area mechanized in that year. Value chain costs projections are shown in Table 23.

Table 23: Central KP cluster – value chain improvement costs

Value Chain Improvement Costs	Year 2	Year 3	Year 4	Year 5
Percentage increase in the costs of production (Inputs and Harvest)	5%	9%	14%	19%
Total increase in cost of production (Inputs and Harvest) in the focal point (US$)	86,604	173,208	259,812	346,416
Total increase in the operating cost of storage at focal point (US$)	1,905	4,059	6,469	9,146
Total increase in operating cost of mechanization (US$)	29,530	59,061	88,591	118,122
Total Costs (US$)	**116,134**	**232,269**	**348,403**	**464,537**

9.3.4.2. Cluster Development Interventions Costs

Central KP garlic cluster has huge growth potential by virtue of the diverse agro ecological conditions of the province. A program of variety development suited to local environment, establishment of Garlic Research Station (instead of full Institute) may be launched, which will work under the main National Garlic Research Institute in Sindh for development of Garlic open pollinated varieties and hybrid. Other interventions include promotion of good agronomic practices, improved farm management practices, and farm mechanization to improve the quality of fresh garlic and its product demand in local markets, and establishment of cold storages houses by the GEG.

Table 24: Central KP cluster - inputs and infrastructure needs for cluster development

S #	Cluster Strategy	Interventions	Implementing Agency
1.	Production Level Strategies: (Increase yields by 25% in 5 years)	Develop a Cluster Development Project • Establishment of Garlic Research Institutes for variety & Hybrid development and Seed production • Seed will be provided to farmers on discounted rate. • Establishment of model farms with good agronomic practices. • Certify these model farms, using IPPC protocols and other certifications, including organic, Fair trade, and others	PARC/DoA KP/Private sector
2.	Extension Level Strategies	• Distribute information on varietal adoption to farmers • Distribute information on improved farm management practices to farmers • Train farmers to use garlic planter and harvester	PARC/DoA KP/Extension department/Private sector
3.	Training of Stakeholders on Value Chain Management Level Strategies	• Train stockholders on proper drying of garlic produce • Train stockholders on grading and packing of garlic produce • Train stockholders on proper storage of garlic produce • Establishing link between different stockholders	PARC/DoA KP/Extension department/Private sector
4.	Farm Mechanization Level Strategies: (Introduce planters and harvesters on 25 % garlic area)	• Import garlic planters • Import garlic harvesters • Introduce planters and harvesters on 25% garlic area from major garlic growing districts	PARC/DoA KP/Trade/Private sector
3.	Post-Harvest Level Strategies: (Establish cold store houses to store 10% of total garlic produce)	• Application of latest post-harvest technologies used by other garlic exporting countries. • Establishment of cold store houses at major garlic growing districts.	PARC/DoA KP/Private sector

The proposed budget for cluster development interventions for central KP cluster will be US$1.68 million (Table 25). The federal government should provide about 20% of this investment, by establishing an Agriculture Cluster Development Fund (ACDF) under PSDP. The remaining 80% should come from the provincial budgets.

This proposed cluster development cost will be spent in a period of four years starting from year 1. It is assumed that all the fixed cost of establishing garlic research station to develop new varieties for central KP cluster will be spent in year 1. However, its operating cost, which will be 25% to the fixed cost, will be spread equivalently over next 4 years. Investments on extension and research will be spent as 40% in year 1, 30% in year 2, and 15% each in year 3 and year 4. 2 planters and 4 harvesters will be imported for central KP cluster based on crop area and machine capacity every year each year. Similarly, one cold store house will be established in central KP cluster in each year as per assumptions used for calculating benefits. With these assumptions, the cost distribution is shown in Table 25.

Table 25: Central KP cluster – cluster development investments cost projections

Investment Head	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Strengthening of research (000 US$)	444.13	111.03	111.03	111.03	111.03	888.26
Investments on extension (000 US$)	80.00	60.00	30.00	30.00	-	200.00
Training of stakeholders on value chain management (000 US$)	80.00	60.00	30.00	30.00	-	200.00
Introduction of farm mechanization) (000 US$)	26.00	26.00	26.00	26.00	-	104.00
Reduce post-harvest losses through storage and training) (000 US$)	60.10	60.10	60.10	60.10	-	240.39
Government Loan (000US$)	9.63	9.63	9.63	9.63	-	38.53
Total investments (000US$)	701.33	328.23	268.23	268.23	-	1,677.04

9.3.5. Economic Viability of Development Plan

Based on the benefits and the costs of the proposed interventions package in the above paragraphs, the economic viability of the proposition has been calculated in terms of project's NPV and IRR. Discounted cash flow analysis has been carried out using an annual discount rate of 8.5%. Calculations and results are shown in Table 26.

Table 26: Central KP cluster - economic viability of proposed interventions package

Economic Viability	Year 1	Year 2	Year 3	Year 4	Year 5
Net Benefits of the Interventions (US$)	-690,228	335,830	1,681,652	3,153,438	5,109,832
Discounted Value of Net Benefits (US$)	-646,383	275,846	1,307,891	2,267,4352	3,398,270
NPV (US$)	6,603,057				
IRR	154%				

A positive NPV of US$ 6.64 million indicates that the interventions package proposed for uplift and transformation of central KP garlic cluster is an economically viable proposition.

9.4. Northern Punjab Garlic Cluster

9.4.1. Current Situation

The study has considered 873 ha of area under garlic production in the three major districts of the garlic cluster (Sialkot, Narowal and Gujranwala) of northern Punjab which is currently producing 7,151 tonnes of garlic per year. Current yield in the cluster is 8.19 tonnes/ha. Annual yield growth of garlic without intervention is observed at 0.57% from 2001 to 2016 in Punjab. Garlic current production situation is presented in Table 27.

Table 27: Northern Punjab cluster – current production situation

Current Situation	Base Year
Area under cultivation (ha)	873
Total garlic production tonne	7,151
Default yield (tonne/ha)	8.19
Annual yield growth without intervention (%)	0.57%
Farm gate price of garlic (US$/tonne)	556

Annual expected garlic production and its value at the current farm gate price in the next five years in a no-intervention scenario are also shown in Table 28:

Table 28: Northern Punjab – garlic production in no-intervention scenario

	Year 1	Year 2	Year 3	Year 4	Year 5
Default yield (tonne/ha)	8.24	8.28	8.33	8.38	8.43
Annual expected garlic production tonne without intervention at farm gate level	7,192	7,233	7,274	7,315	7,357
Total value of production at farm gate before intervention (Million US$)	3.995	4.018	4.041	4.064	4.087

9.4.2. Benefits of the Proposed Interventions

9.4.2.1. Intervention 1 – Introduction of improved varieties and Management practices

Improved farm management practices (IFM) and R&D in garlic cultivation will lead to increase garlic yield. The research will introduce new high yielding varieties (HYV) such as NARC-G1 recently released from other provincial research system in the country or import from other countries. These new varieties and hybrids (already released in other provinces of Pakistan or in other countries having similar situation) will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Farmers will be

allowed to select the best material for cultivation. Large scale field demonstration of improved farm management practices and new best performing varieties will also be demonstrated by the provincial extension department in collaboration with NGOs and development partners

starting from the first year and continue until the fourth year. The improved management practices demonstrated on farmers' field will include: high yielding garlic varieties, proper sowing timings, optimal population density, proper input, judicious & proper use of insecticides, proper irrigation and uprooting through farmers' trainings. It is estimated that introduction of HYV in northern Punjab cluster will increase the garlic yield by 30% over a period of four years. However, it is assumed that farmers will gradually adopt IFM practices; thus yield increase due to IFM in the cluster will also be gradual at a rate of 5% per year starting from the second year. Based on these assumptions, the value of increased garlic production at the existing rate of US$ 556 per tonne is shown in Table 29.

Table 29: Northern Punjab cluster - increased garlic value by increased production

Increased Production	Year 2	Year 3	Year 4	Year 5
Increase yield by 30% due to adoption of high yielding varieties (HYV) over four years, with 5%/year increase	7.5%	15%	23%	30%
Increase yield due to adoption of HYV (tonne/ha)	0.62	1.25	1.89	2.53
Additional production from enhanced yield tonne	542	1,091	1,646	2,207
Expected additional value from increased yield (000 US$) due to HYV adoption	301.4	606.2	914.4	1,226.2
Increase yield by 5% due to improved farm management (IFM) over four years, with 1%/year increase	1%	3%	4%	5%
Increase yield due to IFM (tonne/ha)	0.10	0.21	0.31	0.42
Additional production from improved IFM tonne	90	182	274	368
Expected additional value from increased yield (US$) due to IFM	50,227	101,028	152,405	204,365
Total expected additional yield from first intervention (tonne/ha)	0.72	1.46	2.20	2.95
Total expected additional production from first intervention tonne	633	1,273	1,920	2,575
Total expected additional value of output from first intervention (US$)	351.6	707.2	1066.8	1430.6

9.4.2.2. Intervention 2 – Mechanization of planting and harvesting

Introduction of farm mechanization in garlic cultivation will lead to increase garlic yield and reduce cost of production. The government will import garlic planters and harvesters from other countries and will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Large scale field demonstration of these machines will be demonstrated by the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. It is assumed to introduce these machines on 25% of the total garlic area in northern Punjab

over a period of four years. These machines will be gradually adopted at a rate of 6% per year starting from the second year. It is assumed that planter will take 2 hours to plant one acre and one planter will be busy 8 hours a day as explained in annexure 7. Then we computed planting capacity for a month and converted onto one ha. So planting capacity of one planter will be 49 ha. It is estimated introduction of planter in northern Punjab cluster will save cost of production as manual planting is very expensive and will increase the garlic yield by 5% over a period of four years as it will improve plant density. Harvester will be assumed to take 5 hours to uproot garlic from one acre and one harvester will be busy 8 hours a day as explained in annexure 7. Hence, harvesting capacity of one harvester will be 19 ha per month. It is estimated introduction of harvester in northern Punjab cluster will also save cost of production as manual harvesting is very expensive. Based on these assumptions, the value of increased garlic production and cost saving at the existing rate of US$ 556 per tonne is shown in Table 30.

Table 30: Northern Punjab cluster - garlic cost saving by increased mechanization

Farm Mechanization	Year 2	Year 3	Year 4	Year 5
Sowing Mechanization				
Area under mechanized planting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under sowing mechanization (ha)	55	109	164	218
Saving in sowing cost (US$)	8,097	16,193	24,290	32,386
Increase in yield due to sowing mechanization (%)	1.25%	2.50%	3.75%	5.00%
Increase in yield (tonne/ha)	0.01	0.04	0.08	0.15
Additional production from sowing mechanization (tonnes)	0.49	3.98	13.50	32.19
Increase in value of output from sowing mechanization (US$)	275	2,210	7,501	17,882
Total expected return from sowing mechanization (US$)	8,371	18,403	31,791	50,268
Harvesting Mechanization				
Area under mechanized harvesting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under harvesting mechanization (ha)	55	109	164	218
Saving in harvesting cost (US$)	2,214	4,428	6,642	8,856
Total Impact of Second Intervention				
Total expected additional value of output and cost saving from second intervention (US$)	**10,585**	**22,831**	**38,433**	**59,125**

9.4.2.3. Intervention 3 – Introduction of village level cold storage

Garlic crop faces the issue of high post-harvest losses of up to 20%, implying that one-fifth of what is produced never reaches to the consumer for whom it was grown, and the effort and money required to produce it are lost forever. To reduce these losses, small scale cold store houses will be incentivized under FEG in the cluster as explained in annexure 9. It is assumed that 15% of garlic production will be stored over a period of four years and stored garlic will enjoy better price of US$ 600 per tonne. Moreover, farmers will be trained on the harvesting index for garlic to help them identify appropriate matured garlic and proper drying of garlic after harvesting. It is estimated that with these proposed post-harvest practices, these losses

can be reduced to 10%. This will lead to increasing the value of the garlic crop for the farmer and the downstream players in the value chain. It has been assumed that reduction in post-harvest losses will occur from the second year of interventions when the results of improved value chain management practices will be realized. Again the adoption of these practices will be gradual by the farmers, thus a linear gradual storage and reduction in losses at a rate of 2.5% per year has been assumed. Based on these assumptions, the value of increased garlic production in northern Punjab cluster is shown in Table 31.

Table 31: Northern Punjab cluster – increased garlic production by reducing post-harvest losses

Post-Harvest Management	Year 2	Year 3	Year 4	Year 5
Percentage of production that will be stored (%)	3.8%	7.5%	11.3%	15.0%
Production that will be stored tonne	295	641	1041	1495
Expected additional value due to new storage (US$)	13110	28503	46246	66429
Reduction in post-harvest losses after storage intervention (%)	2.5%	5.0%	7.5%	10.0%
Enhanced marketable garlic production due to reduced post-harvest losses tonne	197	1237	2514	4232
Expected additional value from reduction of losses (US$)	109,252	687,224	1,396,894	2,351,023
Total expected additional value of output from third intervention (US$)	122,362	715,727	1,443,140	2,417,452

9.4.3. Total Benefits Summary

Summary of the value of the benefits of the proposed interventions is shown in Table 32.

Table 32: Northern Punjab cluster - summary of the value of benefits of interventions

Benefits Value (US$)	Year 2	Year 3	Year 4	Year 5
Value of Increased Production	351,592	707,193	1,066,835	1,430,555
Value of Increased Farm Mechanization	10,585	22,831	38,433	59,125
Value of Increased Storage and Reduced Post-Harvest Losses	122,362	715,727	1,443,140	2,417,452
Total Value	**484,539**	**1,445,751**	**2,548,409**	**3,907,132**

9.4.4. Enhanced Costs of the Proposed Interventions

The above proposed interventions will add cost of producing, mechanizing, and value addition of garlic. The costs of the proposed interventions involve two types of costs i) value chain improvement costs and ii) sector support interventions costs.

9.4.4.1. Value Chain Improvement Costs

The proposed sector transformation plan includes interventions both for on-farm and off-farm activities. Improvement entails spending more money for carrying out those activities on modern lines. Existing costs and the proposed incremental increases for different cost heads are shown in Table 33.

Table 33: Northern Punjab cluster – value chain cost head

	Cost	Incremental Increase
Production Inputs and Harvest (land preparation, inputs, labor, etc.) (US$/ha)	1450	15%
Operating cost of storage at focal point (US$/tonne)	6	-
Operating cost of mechanization (US$/ha)	228	-

It is assumed that operating costs of storage and mechanization will not increase in the project implementation period. Based on the above unit costs, total value chain costs for the entire cluster were calculated in Table 33. It was assumed that costs will be incurred from the second year of implementation. Total planned increase in cost of production was distributed over four years. It means that one fourth of the intended increase will happen in the second year which will increase to 5%, and so on until the fifth year of implementation. Total increase in cost of storage and mechanization are calculated for assumed quantities stored and assumed area mechanized in that year. Value chain costs projections are shown in Table 34.

Table 34: Northern Punjab cluster – value chain improvement costs

Value Chain Improvement	Year 2	Year 3	Year 4	Year 5
Percentage increase in the costs of production (Inputs and Harvest)	4%	7%	11%	15%
Total increase in cost of production (Inputs and Harvest) in the focal point (US$)	46,673	93,347	140,020	186,693
Total increase in the operating cost of storage at focal point (US$)	1,674	3,639	5,905	8,481
Total increase in operating cost of mechanization (US$)	24,932	49,865	74,797	99,729
Total Costs (US$)	**71,606**	**143,211**	**214,817**	**286,422**

9.4.4.2. Cluster Development Interventions Costs

Northern Punjab garlic cluster has huge growth potential by virtue of the diverse agro ecological conditions of the province. A program of variety development suited to local environment, establishment of Garlic Research Station (instead of full Institute) may be launched, which will work under the main National Garlic Research Institute in Sindh for development of Garlic open pollinated varieties and hybrid. Other interventions include promotion of good agronomic practices, improved farm management practices, and farm

mechanization to improve the quality of fresh garlic and its product demand in local markets, and establishment of cold storages houses by the GEG.

Table 35: Northern Punjab cluster - inputs and infrastructure needs for cluster development

S #	Cluster Strategy	Interventions	Implementing Agency
1.	Production Level Strategies: (Increase yields by 35% in 5 years)	• Develop a Cluster Development Project • Establishment of Garlic Research Institutes for variety & Hybrid development and Seed production • Seed will be provided to farmers on discounted rate. • Establishment of model farms with good agronomic practices. • Certify these model farms, using IPPC protocols and other certifications, including organic, Fair trade, and others	PARC/DoA Punjab/Private sector
2.	Extension Level Strategies	• Distribute information on varietal adoption to farmers • Distribute information on improved farm management practices to farmers • Train farmers to use garlic planter and harvester	PARC/DoA Punjab/Extension department/Private sector
3.	Training of Stakeholders on Value Chain Management Level Strategies	• Train stockholders on proper drying of garlic produce • Train stockholders on grading and packing of garlic produce • Train stockholders on proper storage of garlic produce • Establishing link between different stakeholders	PARC/DoA Punjab/Extension department/Private sector
4.	Farm Mechanization Level Strategies: (Introduce planters and harvesters on 25 % garlic area)	• Import garlic planters • Import garlic harvesters • Introduce planters and harvesters on 25% garlic area from major garlic growing districts	PARC/DoA KP/Trade/Private sector
3.	Post-Harvest Level Strategies: (Establish cold store houses to store 15% of total garlic produce)	• Application of the latest post-harvest technologies used by other Garlic exporting countries. • Establishment of cold store houses at major garlic growing districts	PARC/DoA KP/Private sector

The proposed budget for cluster development interventions in northern Punjab cluster will be US$ 1.49 million (Table 36). About 20% of this investment should be provided by the federal government, by establishing an Agriculture Cluster Development Fund (ACDF) under PSDP. The remaining 30% should come from the provincial budgets.

This proposed cluster development cost will be spent in a period of four years starting from year 1. It is assumed that all the fixed cost of establishing garlic research station to develop new varieties for northern Punjab cluster will be spent in year 1. However, its operating cost, which will be 25% to the fixed cost, will be spread equivalently over next 4 years. Investments on extension and research will be spent as 40% in year 1, 30% in year 2, and 15% each in year 3 and year 4. 2 planters and 4 harvesters will be imported for northern Punjab cluster based on crop area and machine capacity every year each year. Similarly, one cold store house will be established in northern Punjab cluster in each year as per assumptions used for calculating benefits. With these assumptions, the cost distribution is shown in Table 36.

Table 36: Northern Punjab cluster – cluster development investments cost projections

Investment Head	Year 1	Year 2	Year 3	Year 4	Total
Strengthening of research (000 US$)	374.98	93.74	93.74	93.74	749.96
Strengthening of extension (000 US$)	80.00	60.00	30.00	30.00	200.00
Training of stakeholders on value chain management (000 US$)	80.00	60.00	30.00	30.00	200.00
Introduction of farm mechanization) (000 US$)	27.47	27.47	27.47	27.47	1049.86
Reduce post-harvest losses through storage and training) (000 US$)	60.1	60.1	60.1	60.1	240.39
Loan (000 US$)	9.63	9.63	9.63	9.63	38.53
Total investments (000 US$)	621.07	299.84	239.84	239.84	1494.34

9.4.5. Economic Viability of Development Plan

Based on the benefits and the costs of the proposed interventions package in the above paragraphs, the economic viability of the proposition has been calculated in terms of project's NPV and IRR. Discounted cash flow analysis has been carried out using an annual discount rate of 8.5%. Calculations and results are shown in Table 37.

Table 37: Northern Punjab cluster - economic viability of proposed interventions package

	Year 1	Year 2	Year 3	Year 4	Year 5
Net Benefits of the Interventions (000 US$)	-621.07	184.70	1,205.91	2,308.57	3,813.39
Discounted Value of Net Benefits (000US$)	-582.65	147.47	935.43	1,657.80	2,536.08
Of net Benefits					
NPV (000US$)	4,694.120				
IRR	129%				

A positive NPV of US$4.73 million indicates that the interventions package proposed for uplift and transformation of northern Punjab garlic cluster is an economically viable proposition.

9.5. Northern Balochistan Garlic Cluster

9.5.1. Current Situation

The study has considered 734 ha of area under garlic production in three major districts (Harnai, Loralia and Jafarabad) of northern Balochistan garlic cluster, which is currently producing 6,635 tonnes of garlic per year. Current yield in the cluster is 9.04 tonnes/ha. Annual yield growth of garlic without intervention is observed at 1.62% from 2001 to 2016 in Balochistan. Garlic current production situation is presented in Table 38.

Table 38: Northern Balochistan cluster – current production situation

Current Situation	Base Year
Area under cultivation (ha)	734
Total garlic production tonne	6,635
Default yield (tonne/ha)	9.04
Annual yield growth without intervention (%)	1.62
Farm gate price of garlic (US$/tonne)	556

Annual expected garlic production and its value at the current farm gate price in the next five years in a no-intervention scenario are also shown in Table 39:

Table 39: Northern Balochistan – garlic production in no-intervention scenario

	Year 1	Year 2	Year 3	Year 4	Year 5
Default yield (tonne/ha)	9.19	9.33	9.49	9.64	9.80
Annual expected garlic production tonne without intervention at farm gate level	6,742	6,852	6,963	7,076	7,190
Total value of production at farm gate before intervention (000 US$)	3745.83	3806.51	3868.17	3930.84	3994.52

9.5.2. Benefits of the Proposed Interventions

9.5.2.1. Intervention 1 – Introduction of improved varieties and management practices

Improved farm management practices (IFM) and R&D in garlic cultivation will lead to increase garlic yield. The research will introduce new high yielding varieties (HYV) such as NARC-G1 recently released from other provincial research system in the country or import from other countries. These new varieties and hybrids (already released in other provinces of Pakistan or in other countries having similar situation) will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Farmers will be allowed to select the best material for cultivation. Large scale field demonstration of improved farm management practices and new best performing varieties will also be demonstrated by

the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. The improved management practices demonstrated on farmers' field will include: high yielding garlic varieties, proper sowing timings, optimal population density, proper input, judicious & proper use of insecticides, proper irrigation and uprooting through farmers' trainings. It is estimated that introduction of HYV in northern Balochistan cluster will increase the garlic yield by 30% over a period of four years. However, it is assumed that farmers will gradually adopt IFM practices; thus yield increase due to IFM in the cluster will also be gradual at a rate of 5% per year starting from the second year. Based on these assumptions, the value of increased garlic production at the existing rate of US$ 556 per tonne is shown in Table 40.

Table 40: Northern Balochistan cluster - increased garlic value by increased production

Increased Production	Year 2	Year 3	Year 4	Year 5
Increase yield by 30% due to adoption of high yielding varieties (HYV) over four years, with 5%/year increase	7.5%	15%	23%	30%
Increase yield due to adoption of HYV (tonne/ha)	0.70	1.42	2.17	2.94
Additional production from enhanced yield tonne	514	1,044	1,592	2,157
Expected additional value from increased yield (000 US$) due to HYV adoption	285.49	580.23	884.44	1,198.36
Increase yield by 5% due to improved farm management (IFM) over four years, with 1%/year increase	1%	3%	4%	5%
Increase yield due to IFM (tonne/ha)	0.12	0.24	0.36	0.49
Additional production from improved IFM tonne	86	174	265	360
Expected additional value from increased yield due to IFM (000 US$)	47.58	96.70	147.41	199.73
Total Impact of First Intervention				
Total expected additional yield from first intervention (tonne/ha)	0.82	1.66	2.53	3.43
Total expected additional production from first intervention tonne	600	1,218	1,857	2,517
Total expected additional value of output from first intervention (000 US$)	333.07	676.93	1031.85	1398.08

9.5.2.2. Intervention 2 – Mechanization of Planting and Harvesting

Introduction of farm mechanization in garlic cultivation will lead to increase garlic yield and reduce cost of production. The government will import 2 garlic planters and 4 garlic harvesters from other countries and will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Large scale field demonstration of these machines will be demonstrated by the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. It is assumed to introduce these machines on 25% of the total garlic area in northern Balochistan over a period of four years. These machines will be gradually adopted at a rate of

6% per year starting from the second year. It is assumed that planter will take 2 hours to plant one acre and one planter will be busy 8 hours a day as explained in annexure 7. Then we computed planting capacity for a month and converted onto one ha. So planting capacity of one planter will be 49 ha. It is estimated introduction of planter in northern Balochistan cluster will save cost of production as manual planting is very expensive and will increase the garlic yield by 5% over a period of four years as it will improve plant density. Harvester will be assumed to take 5 hours to uproot garlic from one acre and one harvester will be busy 8 hours a day as explained in annexure 7. Hence, harvesting capacity of one harvester will be 19 ha per month. It is estimated introduction of harvester in northern Balochistan cluster will also save cost of production as manual harvesting is very expensive. Based on these assumptions, the value of increased garlic production and cost saving at the existing rate of US$ 556 per tonne is shown in Table 41.

Table 41: Northern Balochistan cluster - garlic cost saving by increased mechanization

Farm Mechanization	Year 1	Year 2	Year 3	Year 4	Year 5
Sowing Mechanization					
Area under mechanized planting (25% of the total garlic area)		6%	13%	19%	25%
Increase area under sowing mechanization (ha)		46	92	138	184
Saving in sowing cost (US$)		448	896	1,344	1,792
Increase in yield due to sowing mechanization (%)		1.25%	2.50%	3.75%	5.00%
Increase in yield (tonne/ha)		0.01	0.04	0.09	0.17
Additional production from sowing mechanization tonne		0.47	3.81	13.06	31.46
Expected increase in value of output from sowing mechanization (US$)		260	2,115	7,255	17,476
Total expected return from sowing mechanization (US$)		708	3,011	8,599	19,268
Harvesting Mechanization					
Area under mechanized harvesting (25% of the total garlic area)		6%	13%	19%	25%
Increase area under harvesting mechanization (ha)		46	92	138	184
Saving in harvesting cost (US$)		448	896	1,344	1,792
Total Impact of Second Intervention					
Total expected additional value of output and cost saving from second intervention (US$)		**1,156**	**3,907**	**9,943**	**21,059**

9.5.2.3. Intervention 3 – Introduction of village level cold storages

Garlic crop faces the issue of high post-harvest losses of up to 20%, implying that 20% of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost forever. To reduce these losses, small scale cold store houses will be incentivized under FEGs in the cluster as explained in Annexure 9. It is assumed that

15% of garlic production will be stored over a period of four years and stored garlic will enjoy better price of US$ 600 per tonne. Moreover, farmers will be trained on the harvesting index for garlic to help them identify appropriate matured garlic and proper drying of garlic after harvesting. It is estimated that with these proposed post-harvest practices, these losses can be reduced to 10%. This will lead to increasing the value of the garlic crop for the farmer and the downstream players in the value chain. It has been assumed that reduction in post-harvest losses will occur from the second year of interventions when the results of improved value chain management practices will be realized. Again the adoption of these practices will be gradual by the farmers, thus a linear gradual storage and reduction in losses at a rate of 2.5% per year has been assumed. Based on these assumptions, the value of increased garlic production in northern Balochistan cluster is shown in Table 42.

Table 42: Northern Balochistan cluster – increased garlic production by reducing post-harvest losses

Post-Harvest Management	Year 1	Year 2	Year 3	Year 4	Year 5
Percentage of production that will be stored (%)		3.8%	7.5%	11.3%	15.0%
Production that will be stored tonne		279	614	1006	1461
Expected additional value due to new storage (US$)		12420	27283	44729	64921
Reduction in post-harvest losses after storage intervention (%)		2.5%	5.0%	7.5%	10.0%
Enhanced marketable garlic production due to reduced post-harvest losses tonne		186	454	771	1150
Expected additional value from reduction of losses (US$)		103,496	252,140	428,191	638,797
Total expected additional value of output from third intervention (US$)		**115,915**	**279,423**	**472,921**	**703,718**

9.5.3. Total Benefits Summary

Summary of the value of the benefits of the proposed interventions is shown in Table 43.

Table 43: Northern Balochistan cluster - summary of the value of benefits of interventions

Benefits Value (US$)	Year 1	Year 2	Year 3	Year 4	Year 5
Value of Increased Production		333,069	676,930	1,031,845	1,398,081
Value of Increased Farm Mechanization		1,156	3,907	9,943	21,059
Value of Increased Storage and Reduced Post-Harvest Losses		115,915	279,423	472,921	703,718
Total Value		**450,141**	**960,260**	**1,514,708**	**2,122,859**

9.5.4. Enhanced Costs of the Proposed Interventions

The above proposed interventions will add cost of producing, mechanizing, and value addition of garlic. The costs of the proposed interventions involve two types of costs i) value chain improvement costs and ii) sector support interventions costs.

9.5.4.1. Value Chain Improvement Costs

The proposed sector transformation plan includes interventions both for on-farm and off-farm activities. Improvement entails spending more money for carrying out those activities on modern lines. Existing costs and the proposed incremental increases for different cost heads are shown in Table 44.

Table 44: Northern Balochistan cluster – value chain cost head

Value Chain Improvement	Cost	Incremental Increase
Production Inputs and Harvest (land preparation, inputs, labor, etc.) (US$/ha)	1548	14%
Operating cost of storage at focal point (US$/t)	6	-
Operating cost of mechanization (US$/ha)	228	-

It is assumed that operating costs of storage and mechanization will not increase in the project implementation period. Based on the above unit costs, total value chain costs for the entire cluster were calculated in Table 44. It was assumed that costs will be incurred from the second year of implementation. Total planned increase in cost of production was distributed over four years. It means that one fourth of the intended increase will happen in the second year which will increase to 5%, and so on until the fifth year of implementation. Total increase in cost of storage and mechanization are calculated for assumed quantities stored and assumed area mechanized in that year. Value chain costs projections are shown in Table 45.

Table 45: Northern Balochistan cluster – value chain improvement costs

Value Chain Improvement Costs	Year 1	Year 2	Year 3	Year 4	Year 5
Percentage increase in the costs of production (Inputs and Harvest)		3%	7%	10%	14%
Total increase in cost of production (Inputs and Harvest) in the focal point (US$)		38,841	77,683	116,524	155,366
Total increase in the operating cost of storage at focal point (US$)		1,586	3,483	5,711	8,289
Total increase in operating cost of mechanization (US$)		20,963	41,925	62,888	83,850
Total Costs (US$)		**59,804**	**119,608**	**179,412**	**239,216**

9.5.4.2. Cluster Development Intervention Costs

Northern Balochistan garlic cluster has huge growth potential by virtue of the diverse agro ecological conditions of the province. A program of variety development suited to local environment, establishment of Garlic Research Station (instead of full Institute) may be launched, which will work under the main National Garlic Research Institute in Sindh for development of Garlic open pollinated varieties and hybrid. Other interventions include promotion of good agronomic practices, improved farm management practices, and farm mechanization to improve the quality of fresh garlic and its product demand in local markets, and establishment of cold storages houses by the GEG (Table 46).

Table 46: Northern Balochistan cluster - inputs and infrastructure needs for cluster development

S #	Cluster Strategy	Interventions	Implementing Agency
1.	Production Level Strategies: (Increase yields by 35% in 5 years)	Develop a Cluster Development Project • Establishment of Garlic Research Institutes for variety & Hybrid development and Seed production • Seed will be provided to farmers on discounted rate. • Establishment of model farms with good agronomic practices. • Certify these model farms , using IPPC protocols and other certifications, including organic, Fair trade, and others	PARC/DoA Balochistan/ Private sector
2.	Extension Level Strategies	• Distribute information on varietal adoption to farmers • Distribute information on improved farm management practices to farmers • Train farmers to use garlic planter and harvester	PARC/DoA Balochistan /Extension department/Private sector
3.	Training of Stakeholders on Value Chain Management Level Strategies	• Train stockholders on proper drying of garlic produce • Train stockholders on grading and packing of garlic produce • Train stockholders on proper storage of garlic produce • Establishing link between different stockholders	PARC/DoA Balochistan /Extension department/Private sector
4.	Farm Mechanization Level Strategies: (Introduce planters and harvesters on 25 % garlic area)	• Import garlic planters • Import garlic harvesters • Introduce planters and harvesters on 25% garlic area from major garlic growing districts	PARC/DoA Balochistan /Trade/Private sector
3.	Post-Harvest Level Strategies: (Establish cold store houses to store 15% of total garlic produce)	• Application of latest post-harvest technologies used by other Garlic exporting countries. • Establishment of Cold stores at major garlic growing districts	PARC/DoA Balochistan /Private sector

The proposed budget for cluster development interventions in northern Balochistan cluster will be US$ 1.37 million (Table 47). About 20% of this investment should be provided by the federal government, by establishing an Agriculture Cluster Development Fund (ACDF) under PSDP. The remaining 80% should come from the provincial budgets.

This proposed cluster development cost will be spent in a period of four years starting from year 1. It is assumed that all the fixed cost of establishing garlic research station to develop new varieties for northern Balochistan cluster will be spent in year 1. However, its operating cost, which will be 25% to the fixed cost, will be spread equivalently over next 4 years. Investments on extension and research will be spent as 40% in year 1, 30% in year 2, and 15% each in year 3 and 4. Two planters and 4 harvesters will be imported for northern Balochistan cluster based on crop area and machine capacity every year. Similarly, one cold store house will be established in the cluster every year. With these assumptions, the cost distribution is shown in Table 47.

Table 47: Northern Balochistan cluster – cluster development investments cost projections

Investment (000 US$)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Strengthening of research	315.27	78.82	78.82	78.82	78.82	630.55
Investments on extension	80.00	60.00	30.00	30.00		200.00
Training of stakeholders on value chain management	80.00	60.00	30.00	30.00		200.00
Introduction of farm mechanization	20.23	20.23	20.23	20.23		80.93
Reduce post-harvest losses through storage and training)	60.10	60.10	60.10	60.10		240.39
Loan	8.84	8.84	8.84	8.84	0.00	35.35
Total investments	561.37	284.92	224.92	224.92	78.82	1374.93

9.5.5. Economic Viability of the Development Plan

Based on the benefits and the costs of the proposed interventions package in the above paragraphs, the economic viability of the proposition has been calculated in terms of project's NPV and IRR. Discounted cash flow analysis has been carried out using an annual discount rate of 8.5%. Calculations and results are shown in Table 48.

Table 48: Northern Balochistan cluster - economic viability of proposed interventions package

	Year 1	Year 2	Year 3	Year 4	Year 5
Net Benefits of the Interventions (000 US$)	-561.37	165.23	735.35	1,289.79	2,044.04
Discounted Value of Net Benefits (000US$)	-520.22	137.75	573.31	928.47	1,359.38
Of net Benefits					
NPV (US$)	2,478,680				
IRR	98%				

A positive NPV of US$ 2.49 million indicates that the interventions package proposed for uplift and transformation of northern Balochistan garlic cluster is an economically viable proposition.

9.6. Southern Sindh Garlic Cluster

9.6.1. Current Situation

The study has considered 593 ha of area under garlic production in five major districts (Mirpurkhas, Badin and Jamshoro) of southern Sindh garlic cluster, which is currently producing 3,121 tonnes of garlic per year. Current yield in the cluster is 5.26 tonnes/ha. Annual yield growth of garlic without intervention is observed at 0.48% from 2001 to 2016 in Sindh. Garlic current production situation is presented in Table 49.

Table 49: Southern Sindh cluster – current production situation

Current Situation	Base Year
Area under cultivation (ha)	593
Total garlic production tonne	3,121
Default yield (tonne/ha)	5.26
Annual yield growth without intervention (%)	0.48
Farm gate price of garlic (US$/tonne)	556

Annual expected garlic production and its value at the current farm gate price in the next five years in a no-intervention scenario are also shown in Table 50:

Table 50: Southern Sindh cluster – garlic production in no-intervention scenario

	Year 1	Year 2	Year 3	Year 4	Year 5
Default yield (tonne/ha)	5.29	5.31	5.34	5.36	5.39
Annual expected garlic production tonne without intervention at farm gate level	3,136	3,151	3,166	3,181	3,197
Total value of production at farm gate before intervention (US$)	1,742, 212	1,750, 574	1,758, 977	1,767, 420	1,775, 904

9.6.2. Benefits of the Proposed Interventions

9.6.2.1. Intervention 1 – Introduction of improved varieties and management practices

Improved farm management practices (IFM) and R&D in garlic cultivation will lead to increase garlic yield. The research will introduce new high yielding varieties (HYV) such as NARC-G1 recently released from other provincial research system in the country or import from other countries. These new varieties and hybrids (already released in other provinces of Pakistan or in other countries having similar situation) will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Farmers will be allowed to select the best material for cultivation. Large scale field demonstration of improved farm management practices and new best performing varieties will also be demonstrated by

the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. The improved management practices demonstrated on farmers' field will include: high yielding garlic varieties, proper sowing timings, optimal population density, proper input, judicious & proper use of insecticides, proper irrigation and uprooting through farmers' trainings. It is estimated that introduction of HYV in southern Sindh cluster will increase the garlic yield by 30% over a period of four years.

However, it is assumed that farmers will gradually adopt IFM practices; thus yield increase due to IFM in the cluster will also be gradual at a rate of 5% per year starting from the second year. Based on these assumptions, the value of increased garlic production at the existing rate of US$ 556 per tonne is shown in Table 51.

Table 51: Southern Sindh Cluster - Increased Garlic Value by Increased Production

Increased Production	Year 2	Year 3	Year 4	Year 5
Increase yield by 30% due to adoption of high yielding varieties (HYV) over four years, with 5%/year increase	7.5%	15%	23%	30%
Increase yield due to adoption of HYV (tonne/ha)	0.40	0.80	1.21	1.62
Additional production from enhanced yield tonne	236	475	716	959
Expected additional value from increased yield (US$) due to HYV adoption	131,293	263,847	397,670	532,771
Increase yield by 5% due to improved farm management (IFM) over four years, with 1%/year increase	1%	3%	4%	5%
Increase yield due to IFM (tonne/ha)	0.07	0.13	0.20	0.27
Additional production from improved IFM tonne	39	79	119	160
Additional value from increased yield due to IFM (US$)	21,882	43,974	66,278	88,795
Total Impact of First Intervention				
Total expected additional yield from first intervention (tonne/ha)	0.46	0.93	1.41	1.89
Total expected additional production from first intervention tonne	276	554	835	1,119
Total additional value of output from first intervention (US$)	**153,175**	**307,821**	**463,948**	**621,566**

9.6.2.2. Intervention 2 – Mechanization of Planting and Harvesting

Introduction of farm mechanization in garlic cultivation will lead to increase garlic yield and reduce cost of production. The government will import garlic planters and harvesters from other countries and will be directly tested under farmers' condition starting from the first year and continue until the fourth year of the project. Large scale field demonstration of these machines will be demonstrated by the provincial extension department in collaboration with NGOs and development partners starting from the first year and continue until the fourth year. It is assumed to introduce these machines on 25% of the total garlic area in southern Sindh over a period of four years. These machines will be gradually adopted at a rate of 6% per year starting from the second year. It is assumed that planter will take 2 hours to plant one acre

and one planter will be busy 8 hours a day as explained in annexure 7. Then we computed planting capacity for a month and converted onto one ha. So planting capacity of one planter will be 49 ha. It is estimated introduction of planter in southern Sindh cluster will save cost of production as manual planting is very expensive and will increase the garlic yield by 5% over a period of four years as it will improve plant density. Harvester will be assumed to take 5 hours to uproot garlic from one acre and one harvester will be busy 8 hours a day as explained in annexure 7. Hence, harvesting capacity of one harvester will be 19 ha per month. It is estimated introduction of harvester in southern Sindh cluster will also save cost of production as manual harvesting is very expensive. Based on these assumptions, the value of increased garlic production and cost saving at the existing rate of US$ 556 per tonne is shown in Table 52.

Table 52: Southern Sindh Cluster - Garlic Cost Saving by Increased Mechanization

Farm Mechanization	Year 2	Year 3	Year 4	Year 5
Mechanized Sowing				
Area under mechanized planting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under sowing mechanization (ha)	37	74	111	148
Saving in sowing cost (US$)	3,344	6,687	10,031	13,374
Increase in yield due to sowing mechanization (%)	1.25%	2.50%	3.75%	5.00%
Increase in yield (tonne/ha)	0.01	0.02	0.05	0.09
Additional production from sowing mechanization tonne	0.22	1.73	5.87	13.99
Farm Mechanization	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Increase in value of output from sowing mechanization (US$)	120	962	3,262	7,770
Total expected return from sowing mechanization (US$)	3,463	7,649	13,293	21,144
Harvesting Mechanization				
Area under mechanized harvesting (25% of the total garlic area)	6%	13%	19%	25%
Increase area under harvesting mechanization (ha)	37	74	111	148
Saving in harvesting cost (US$)	138	275	413	550
Total Impact of Second Intervention				
Total expected additional value of output and cost saving from second intervention (US$)	**3,601**	**7,924**	**13,705**	**21,694**

9.6.2.3. Intervention 3 – Introduction of village level cold storage

Garlic crop faces the issue of high post-harvest losses of up to 20%, implying that 20% of what is produced never reaches the consumer for whom it was grown, and the effort and money required to produce it are lost forever. To reduce these losses, small scale cold store houses will be incentivized in the cluster under FEG as explained in annexure 9. It is assumed that 26% of garlic production will be stored over a period of four years and stored garlic will enjoy better price of US$ 600 per tonne. Moreover, farmers will be trained on the harvesting index for garlic to help them identify appropriate matured garlic and proper drying of garlic after harvesting. It is estimated that with these proposed post-harvest practices, these losses can be reduced to 10%. This will lead to increasing the value of the garlic crop for the farmer and

the downstream players in the value chain. It has been assumed that reduction in post-harvest losses will occur from the second year of interventions when the results of improved value chain management practices will be realized. Again the adoption of these practices will be gradual by the farmers, thus a linear gradual storage and reduction in losses at the rates of 6.5% and 2.5% per year, respectively has been assumed. Based on these assumptions, the value of increased garlic production in southern Sindh cluster is shown in Table 53.

Table 53: Southern Sindh cluster – increased garlic production by reducing post-harvest losses

Post-Harvest Management	Year 1	Year 2	Year 3	Year 4	Year 5
Percentage of production that will be stored (%)		6.5%	13.0%	19.5%	26.0%
Production that will be stored tonne		223	484	784	1126
Expected additional value due to new storage (US$)		9900	21505	34860	50029
Reduction in post-harvest losses after storage intervention (%)		2.5%	5.0%	7.5%	10.0%
Enhanced marketable garlic production due to reduced post-harvest losses tonne		86	520	1054	1769
Expected additional value from reduction of losses (US$)		47,597	289,091	585,292	982,751
Total expected additional value of output from third intervention (US$)		**57,497**	**310,596**	**620,153**	**1,032,780**

9.6.3. Total Benefits Summary

Summary of the value of the benefits of the proposed interventions is shown in Table 54.

Table 54: Southern Sindh cluster - summary of the value of benefits of interventions

Benefits Value (US$)	Year 2	Year 3	Year 4	Year 5
Value of Increased Production	153,175	307,821	463,948	621,566
Value of Increased Farm Mechanization	3,601	7,924	13,705	21,694
Value of Increased Storage and Reduced Post-Harvest Losses	57,497	310,596	620,153	1,032,780
Total Value	**214,273**	**626,341**	**1,097,806**	**1,676,040**

9.6.4. Enhanced Costs of the Proposed Interventions

The above proposed interventions will add cost of producing, mechanizing, and value addition of garlic. The costs of the proposed interventions involve two types of costs i) value chain improvement costs and ii) sector support interventions costs.

9.6.4.1. Value Chain Improvement Costs

The proposed sector transformation plan includes interventions both for on-farm and off-farm activities. Improvement entails spending more money for carrying out those activities on

modern lines. Existing costs and the proposed incremental increases for different cost heads are shown in Table 55.

Table 55: Southern Sindh cluster – value chain cost head

Value Chain Improvement	Cost	Incremental Increase
Production Inputs and Harvest (land preparation, inputs, labor, etc.) (US$/ha)	1387	15%
Operating cost of storage at focal point (US$/t)	6	-
Operating cost of mechanization (US$/ha)	228	-

It is assumed that operating costs of storage and mechanization will not increase in the project implementation period. Based on the above unit costs, total value chain costs for the entire cluster were calculated in Table 55. It was assumed that costs will be incurred from the second year of implementation. Total planned increase in cost of production was distributed over four years. It means that one fourth of the intended increase will happen in the second year which will increase to 5%, and so on until the fifth year of implementation. Total increase in cost of storage and mechanization are calculated for assumed quantities stored and assumed area mechanized in that year. Value chain costs projections are shown in Table 56.

Table 56: Southern Sindh cluster – value chain improvement costs

Value Chain Improvement Costs	Year 2	Year 3	Year 4	Year 5
Percentage increase in the costs of production (Inputs and Harvest)	4%	7%	11%	15%
Total increase in cost of production (Inputs and Harvest) in the focal point (US$)	29,873	59,746	89,619	119,492
Total increase in the operating cost of storage at focal point (US$)	1,264	2,746	4,451	6,388
Total increase in operating cost of mechanization (US$)	16,936	33,871	50,807	67,743
Total Costs (US$)	**46,809**	**93,617**	**140,426**	**187,235**

9.6.4.2. Cluster Development Interventions Costs

Southern Sindh garlic cluster has huge growth potential by virtue of the diverse agro ecological conditions of the province. A program of variety development suited to local environment, establishment of Garlic Research Station (instead of full Institute) may be launched, which will work under the main National Garlic Research Institute in Sindh for development of Garlic open pollinated varieties and hybrid. Other interventions include promotion of good agronomic practices, improved farm management practices, and farm mechanization to improve the quality of fresh garlic and its product demand in local markets, and establishment of cold storages houses by the GEG (Table 57).

Table 57: Southern Sindh cluster - inputs and infrastructure needs for cluster development

S #	Cluster Strategy	Interventions	Implementing Agency
1.	Production Level Strategies: (Increase yields by 35% in 5 years)	Develop a Cluster Development Project • Establishment of Garlic Research Institutes for variety & Hybrid development and Seed production • Seed will be provided to farmers on discounted rate. • Establishment of model farms with good agronomic practices. • Certify these model farms, using IPPC protocols and other certifications, including organic, Fair trade, and others	PARC/DoA Sindh/Private sector
2.	Extension Level Strategies	• Distribute information on varietal adoption to farmers • Distribute information on improved farm management practices to farmers • Train farmers to use garlic planter and harvester	PARC/DoA Sindh /Extension department/Private sector
3.	Training of Stakeholders on Value Chain Management Level Strategies	• Proper drying of garlic produce • Grading and packing of garlic produce • Proper storage of garlic produce • Establishing link between different stakeholders	PARC/DoA Sindh /Extension department/Private sector
4.	Farm Mechanization Level Strategies: (Introduce planters and harvesters on 25 % garlic area)	• Import garlic planters • Import garlic harvesters • Adaptation of garlic planters and harvesters to cluster-level situation. • Introduce planters and harvesters on 25% garlic area from major garlic growing districts	PARC/DoA Sindh /Trade/Private sector
3.	Post-Harvest Level Strategies: (Establish cold store houses to store 26% of total garlic produce)	• Application of latest post-harvest technologies used by other garlic exporting countries. • Establishment of cold store houses at major garlic growing districts	PARC/DoA Sindh/Private sector

The proposed budget for cluster development interventions in southern Sindh cluster will be US$ 1.23 million (Table 58). About 20% of this investment should be provided by the federal government, by establishing an Agriculture Cluster Development Fund (ACDF) under PSDP. The remaining 80% should come from the provincial budgets.

This proposed cluster development cost will be spent in a period of four years starting from year 1. It is assumed that all the fixed cost of establishing garlic research station to develop new varieties for southern Sindh will be spent in year 1. However, its operating cost, which will be 25% to the fixed cost, will be spread equivalently over next 4 years. Investments on extension and research will be spent as 40% in year 1, 30% in year 2, and 15% each in year

3 and year 4. In each year, 2 planters and 3 harvesters will be imported for southern Sindh cluster based on crop area and machine capacity starting from the 2nd year. Similarly one cold store house will be established in southern Sindh cluster in each year as per assumptions used for calculating benefits. With these assumptions, the cost distribution is shown in Table 58.

Table 58: Southern Sindh cluster – cluster development investments cost projections

Investment Head	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Strengthening of research (US$)	254,710	63,677	63,677	63,677	63,677	509,420
Investments on extension (US$)	80,000	60,000	30,000	30,000	-	200,000
Training of stakeholders on value chain management (US$)	80,000	60,000	30,000	30,000	-	200,000
Introduction of farm mechanization) (US$)	21,000	21,000	21,000	21,000	-	84,000
Reduce post-harvest losses through storage and training) (US$)	60,096	60,096	60,096	60,096	-	240,385
Total investments (US$)	**495,806**	**264,774**	**204,774**	**204,774**	**63,677**	**1,233,805**

9.6.5. Economic Viability of Cluster Development Plan

Based on the benefits and the costs of the proposed interventions package in the above paragraphs, the economic viability of the proposition has been calculated in terms of project's NPV and IRR. Discounted cash flow analysis has been carried out using an annual discount rate of 8.5%. Calculations and results are shown in Table 59.

Table 59: Southern Sindh cluster - economic viability of proposed interventions package

	Year 1	Year 2	Year 3	Year 4	Year 5
Net Benefits of the Interventions (US$)	-495,806	-50,501	421,567	893,032	1,612,363
Discounted Value of Net Benefits (US$)	-464,400	-42,246	330,649	644,943	1,072,294
Of net Benefits					
NPV (US$)	1,541,240				
IRR	69%				

A positive NPV of US$ 1.55 million indicates that the interventions package proposed for uplift and transformation of southern Sindh garlic cluster is an economically viable proposition.

10. PROGRAMS AND PLANS

This report presented an overview of the potential of garlic sector in Pakistan. Garlic crop is identified among 33 crops having potential for cluster development as a part of the V2025 of Government of Pakistan. In addition to discussions on the gaps and constraints of identified garlic clusters in KP, Punjab, Baluchistan and Sindh, this report gives recommendations for cluster development in all provinces; and estimated the economic and social impact of the cluster development interventions that shall set new frame conditions at production, mechanization, and marketing level of garlic value chain in all provinces. In support of the findings and recommendations presented in previous sections, the following plans and programs are proposed for further value addition.

To support the strategies and interventions proposed in section 9 of this report, the following programs/plans are recommended to further strengthening the interventions and to create greater opportunities for participation and learning.

10.1. Program for Organization and Networking of Stakeholders

The following program is proposed for organization of stakeholders at different levels of value chain.

Table 60: Program for organization and networking of stakeholders

S#.	Area of Action	Purpose	Institutions to be involved	Priority
1. Central Khyber Pakhtunkhwa (KP) Cluster				
1.1	• Form Garlic Farmer Enterprise Groups (GEGs) at grassroots level. 6 GEGs in total with each having a membership of at least 25 farmers. KP cluster has 6 garlic producing districts, and thus 1 FEG per district	Organization of garlic farming community for collective action	Village Organizations (VOs), DoA KP, NGOs, KP rural support program (RSP) and extension department	Short to medium term (1 to 2 years)
2. Northern Punjab Cluster				
2.1	• Form Garlic Farmer Enterprise Groups (FEGs) at grassroots level. 3 FEGs in total with each having a membership of at least 25 farmers. Punjab cluster has 3 garlic producing districts, and thus 1 FEG per district	Organization of garlic farming community for collective action	Village Organizations (VOs), DoA Punjab, NGOs, Punjab rural support program and extension department	Short to medium term (1 to 2 years)

S#.	Area of Action	Purpose	Institutions to be involved	Priority
3. Northern Balochistan Cluster				
3.1	• Form Garlic Farmer Enterprise Groups (FEGs) at grassroots level. 3 FEGs in total with each having a membership of at least 25 farmers. Balochistan cluster has 3 garlic producing districts, and thus 1 FEG per district	Organization of garlic farming community for collective action	Village Organizations (VOs), DoA Balochistan, NGOs, Balochistan rural support program and extension department	Short to medium term (1 to 2 years)
4. Southern Sindh Cluster				
4.1	• Form Garlic Farmer Enterprise Groups (FEGs) at grassroots level. 5 FEGs in total with each having a membership of at least 25 farmers. Sindh cluster has 5 garlic producing districts, and thus 1 FEG per district	Organization of garlic farming community for collective action	Village Organizations (VOs), DoA Sindh, NGOs, Sindh rural support program and extension department	Short to medium term (1 to 2 years)

10.2. Program for Research Reform

The following program indicative areas for further research to strengthen the garlic cluster in the four provinces are proposed along with the estimated costs as:

Table 61: Program for Research Reform

S#.	Identification of Areas for Further Research	Research Purpose/ Priority	Indicative Research Institutions
1. Central Khyber Pakhtunkhwa (KP) Cluster			
1.1	• To start Garlic Variety Development Program (Selection, adoption & development of high yielding varieties (HYV)) • Distribution of HYV seed to farmers at discounted rate. • Establishment of Model farms with good agronomic practices • Research into climate change related negative impacts such as new diseases and shifts in crop cycle • To take preventive & curative measures to eradicate the garlic diseases.	Improve and secure garlic production (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute Swat, RSP, NGOs

S#.	Identification of Areas for Further Research	Research Purpose/ Priority	Indicative Research Institutions
	• Establishment of Garlic diagnostic centers at least one at division level.		
1.2	• Import garlic planters and harvesters • Distribution of machines through GEG in major garlic producing districts	Improve farm mechanization (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute, Private businesses
1.3	• Develop garlic maturity index • Develop training modules on adoption of HYV farm mechanization and proper storage • Develop formats for Farmer Field Schools (FFS) for on-farm training of Garlic producers	Improve farm management through training and extension (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute Swat, RSP, extension department
1.4	• Identify suitable garlic traders to support the cluster • Identify suitable garlic buyers to link with in premium markets through a market survey • Consultation to decide on implementation strategy – wholesale market or individual traders • Develop mental understanding between producers, traders and processors • Create market linkages for quality produced garlic	Improve value chain management product (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute Swat, RSP, extension department
1.5	• Identify most suitable cold storage • Develop cold storage infrastructure	Develop Cold-Chain Infrastructure for Fresh Garlic Trading Medium to long Term (2 to 5 years)	GEG clusters; Farmer Associations; Business associations and cooperatives.
2. Northern Punjab Cluster			
2.1	• To start Garlic Variety Development Program (Selection, adoption & development of high yielding varieties (HYV)) • Distribution of HYV seed to farmers at discounted rate. • Establishment of Model farms with good agronomic practices • Research into climate change related negative impacts such as new diseases and shifts in crop cycle	Improve and secure garlic production (Short to medium term (1 to 5 years)	PARC, Ayub Agricultural Research Institute (AARI) Faisalabad, RSP, NGOs

S#.	Identification of Areas for Further Research	Research Purpose/ Priority	Indicative Research Institutions
	• To take preventive & curative measures to eradicate the garlic diseases. • Establishment of Garlic diagnostic centers at least one at division level.		
2.2	• Import garlic planters and harvesters • Distribution of machines through GEG in major garlic producing districts	Improve farm mechanization (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute, Private businesses
2.3	• Develop garlic maturity index • Develop training modules on adoption of HYV farm mechanization and proper storage • Develop formats for Farmer Field Schools (FFS) for on-farm training of Garlic producers	Improve farm management through training and extension (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute, RSP, extension department
2.4	• Identify suitable garlic traders to support the cluster • Identify suitable garlic buyers to link with in premium markets through a market survey • Consultation to decide on implementation strategy – wholesale market or individual traders • Develop mental understanding between producers, traders and processors • Create market linkages for quality produced garlic	Improve value chain management product (Short to medium term (1 to 5 years)	PARC, Agriculture Research Institute, RSP, extension department
2.5	• Identify most suitable cold storage • Develop cold storage infrastructure	Develop Cold-Chain Infrastructure for Fresh Garlic Trading Medium to long Term (2 to 5 years)	GEG clusters; Farmer Associations; Business associations and cooperatives.
3. Northern Balochistan Cluster			
3.1	• To start Garlic Variety Development Program (Selection, adoption & development of high yielding varieties (HYV)) • Distribution of HYV seed to farmers at discounted rate. • Establishment of Model farms with good agronomic practices • Research into climate change related negative impacts such	Improve and secure garlic production (Short to medium term (1 to 5 years)	PARC Agricultural Research and Development Center Quetta RSP, NGOs

S#.	Identification of Areas for Further Research	Research Purpose/ Priority	Indicative Research Institutions
	as new diseases and shifts in crop cycle • To take preventive & curative measures to eradicate the garlic diseases. • Establishment of Garlic diagnostic centers at least one at division level.		
3.2	• Import garlic planters and harvesters • Distribution of machines through GEG in major garlic producing districts	Improve farm mechanization (Short to medium term (1 to 5 years)	PARC Agricultural Research and Development Center Quetta, Private businesses
3.3	• Develop garlic maturity index • Develop training modules on adoption of HYV farm mechanization and proper storage • Develop formats for Farmer Field Schools (FFS) for on-farm training of Garlic producers	Improve farm management through training and extension (Short to medium term (1 to 5 years)	PARC Agricultural Research and Development Center Quetta, RSP, extension department
3.4	• Identify suitable garlic traders to support the cluster • Identify suitable garlic buyers to link with in premium markets through a market survey • Consultation to decide on implementation strategy – wholesale market or individual traders • Develop mental understanding between producers, traders and processors • Create market linkages for quality produced garlic	Improve value chain management product (Short to medium term (1 to 5 years)	PARC Agricultural Research and Development Center Quetta, RSP, extension department
3.5	• Identify most suitable cold storage • Develop cold storage infrastructure	Develop Cold-Chain Infrastructure for Fresh Garlic Trading Medium to long Term (2 to 5 years)	GEG clusters; Farmer Associations; Business associations and cooperatives.
4. Southern Sindh Cluster			
2.1	• To start Garlic Variety Development Program (Selection, adoption & development of high yielding varieties (HYV)) • Distribution of HYV seed to farmers at discounted rate. • Establishment of Model farms with good agronomic practices	Improve and secure garlic production (Short to medium term (1 to 5 years)	PARC, Sindh Agriculture University Tando Jam, RSP, NGOs

S#.	Identification of Areas for Further Research	Research Purpose/ Priority	Indicative Research Institutions
	• Research into climate change related negative impacts such as new diseases and shifts in crop cycle • To take preventive & curative measures to eradicate the garlic diseases. • Establishment of Garlic diagnostic centers at least one at division level.		
2.2	• Import garlic planters and harvesters • Distribution of machines through GEG in major garlic producing districts	Improve farm mechanization (Short to medium term (1 to 5 years)	PARC, Sindh Agriculture University Tando Jam, Private businesses
2.3	• Develop garlic maturity index • Develop training modules on adoption of HYV farm mechanization and proper storage • Develop formats for Farmer Field Schools (FFS) for on-farm training of Garlic producers	Improve farm management through training and extension (Short to medium term (1 to 5 years)	PARC, Sindh Agriculture University Tando Jam, RSP, extension department
2.4	• Identify suitable garlic traders to support the cluster • Identify suitable garlic buyers to link with in premium markets through a market survey • Consultation to decide on implementation strategy – wholesale market or individual traders • Develop mental understanding between producers, traders and processors • Create market linkages for quality produced garlic	Improve value chain management product (Short to medium term (1 to 5 years)	PARC, Sindh Agriculture University Tando Jam, RSP, extension department
2.5	• Identify most suitable cold storage • Develop cold storage infrastructure	Develop Cold-Chain Infrastructure for Fresh Garlic Trading Medium to long Term (2 to 5 years)	GEG clusters; Farmer Associations; Business associations and cooperatives.

Note: The estimated costs for research plan mentioned in the above table have already been counted as part of the cluster investments given in section 10.

11. CONCLUSION

Garlic is an important condiment in Pakistan as it is produced all over the country and is consumed by whole population. However, due to low yield and poor quality, its current production is not sufficient to meet consumer demand. Therefore, on an average, the country is spending foreign exchange earnings of US$ 63 million on import of 48 thousand tonnes of garlic from neighboring countries particularly China in the last fifteen years. This makes Pakistan the 7th largest importer in the world. This study assumes that this import quantity will rise at the rate of population growth rate (2.1%) in the country. However, Pakistan has huge potential to boost his production due to fertile land, wide spread canal and tube well irrigation system, cheap labor, and proximity and good relation with China which is the major garlic producing country of the world and having more than double the yield of Pakistan.

The purpose of this study is to identify gaps and potentials and suggest policies, strategies and interventions to enhance the competitiveness of garlic value chain in the country. The analysis was designed at cluster level to incorporate the regional variation in garlic value chain.

This study identifies four garlic clusters comprising major garlic producing districts in each province. In these clusters, three key interventions including production improvement, farm mechanization improvement and storage interventions have been proposed to increase garlic production, reduce post-harvest losses, and improve the quality of garlic supply. Total expected additional production from all clusters is reported in Table 61 for four years of interventions. Due to enhanced production, 54% of garlic import will be saved in the 5th year of the project, which will be equivalent to US$ 22 million. In brief, garlic cluster development offers huge economic benefits in terms of production creation and import saving.

Table 62:Impact of cluster development on import saving in Pakistan

	Year 1	Year 2	Year 3	Year 4	Year 5
Garlic import quantity (000 t)	48	49	50	51	52
Value of garlic import (million US$)	38	39	40	41	41
Total expected additional production from all clusters (000 t)	-	4	11	19	28
Import saving (%)	-	9	22	37	54
Import saving (million US$)	-	3	9	15	22

12. ANNEXURES

Annexure 1: Composition of fresh and dehydrated garlic

Particulars	Fresh Peeled Garlic Cloves	Dehydrated Garlic Powder
Moisture (%)	62.8	5.2
Carbohydrate (%)	29	71.04
Protein (%)	6.3	18
Fat (%)	0.1	0.6
Mineral matter (%)	1	3.2
Fiber (%)	1	2
Calcium (%)	0.03	0.1
Phosphorus (%)	0.31	0.42
Potassium (%)	-	1.1
Iron (%)	0.01	0.004
Niacin (%)	-	0.74
Sodium (%)	-	0.01
Vitamin A. I. U.	-	175
Nicotinic acid (mg/100g)	0.4	-
Vitamin C (mg/100g)	13	12
Vitamin B (mg/100g)	-	0.68
Vitamin B_2 (mg/100g)	-	0.08

Source: Puthi (1979)

Annexure 2: Macro data sources and literature reviewed

AFF 2017. A profile of the south African garlic market value chain. Agriculture, Forestry and Fisheries (AFF) Department, Republic of South Africa.

Ahmed, I., Khan, M.A., Khan, N., Ahmed, N., Waheed, A., Saleem, F.Y., Khan, S. and Aslam, S. 2017. Impact of plant spacing on garlic rust (Puccinia allii), bulb yield and yield component of garlic (Allium sativum). Pakistan Journal of Agricultural Research, 30(4), 380-385.

AMIS 2005. Marketing of Garlic: Problems & Prospects. Agricultural Marketing Information Service (AMIS), Directorate of Agriculture (Economics & Marketing), Punjab.

Ashraf, M., Butt, M.S., Ahmad, I, Saeed, M.K. and Syed, Q. 2014. Hypocholesterolemic perspectives of garlic soup containing bioactive ingredients. World Journal of Pharmaceutical Research, 3(7), 949-970.

Berthelod, H.K., Sudhop, T. and Bergmann, K.V. 1998. Effect of a garlic oil preparation on serum lipoprotein on serum lipoproteins and cholesterol metabolism: a randomized controlled trial. Journal of the American Medical Association, 279, 1900-1902.

Bosworth, B. and Broun, D. 1996. Connect the Dots: Using Cluster-Based Strategies to Create Urban Employment. Firm Connections 4(2): 1–6.

Dijk, M.P.V. and Sverrisson, A. 2003. Enterprise clusters in developing countries: mechanisms of transition and stagnation. Entrepreneurship & Regional Development, 15, 183-206.

Diriba-Shiferaw, G. 2016. Review of Management Strategies of Constraints in Garlic (Allium sativum L.) Production. The Journal of Agricultural Sciences 11(3), 186-207.

European Commission, 2002. Regional clusters in Europe. Observatory of European SMEs Report No. 3, the Netherlands.

FAO 2007. Garlic Post-Harvest Operations. Food and Agriculture Organization of the United Nations.

FAO 2010. Agro-based clusters in developing countries: staying competitive in a globalized economy. Agricultural management, marketing and finance occasional paper No. 25. Food and agriculture organization of the United Nations Rome, Italy.

FAO 2017. FAOStat. Accessed from: http://www.fao.org/faostat/en

FAOSTAT (Food and Agriculture Organization Statistics) Production, Crops http://www.fao.org/faostat/en/#data/QC

FAOSTAT, (Food and Agriculture Organization Statistics). 2020. Trade, Crops and Livestock Products http://www.fao.org/faostat/en/#data/TP

GoP 2015a. Crops Area and Production - 2013-14 (By Districts). Ministry of National Food Security and Research, Pakistan. http://www.mnfsr.gov.pk/frmDetails.aspx

GoP 2015b. Pre-Feasibility Study Cold Storage (FRUIT & VEGETABLE). Small and Medium Enterprises Development Authority Ministry of Industries & Production Government of Pakistan, Islamabad.

GoP 2017. Agriculture Statistics of Pakistan 2015-2016. Ministry of National Food Security & Research, Government of Pakistan, Islamabad. Accessed from http://www.mnfsr.gov.pk/frmDetails.aspx

GoP 2018. Trade Statistics 2007-17. Pakistan Bureau of Statistics, Government of Pakistan, Islamabad.

Ketels, C., Lindqvist, G. and Sölvell, Ö. 2006. Cluster initiatives in developing countries and transition economies. Center for Strategy and Competitiveness, Stockholm.

Khan, H., Hussain, M.M., Jellani, G., Tariq, S., Naseeb, T. and Mahmood, S. 2018. Evaluation of Garlic Genotypes for Yield and Yield Components in Islamabad, Pakistan Environment. The Nucleus A Quarterly International Scientific Journal, 55(1). Available at http://www.thenucleuspak.org.pk/index.php/Nucleus/article/view/328

Khan, H.A., Derawadan, M.K. and Majeed, A. 1997. Environment effect on garlic genotypes for yield and yield component in Swat Valley. Sarhad Journal of Agriculture, 13, 357-361.

Mahmood, T., Khokhar, K.M., Hussain, S.I. and Bhatti, M.H. 2001. Studies on garlic cultivars for yield and yield component. Sarhad Journal of Agriculture, 17, 209-212.

Majeed, A., Derawadan, M.K. and Khan, H. 1994. Annual report of co-operative research programme on vegetable at NWFP. Agriculture Research Station, (North) Mingora Swat, Pakistan, pp: 8-10.

MNFS&R (Ministry of Food Security and Research). 2017. Agriculture Statistics of Pakistan 2017-18., Economic Wing, MNFS&R, Government of Pakistan, Islamabad.

MNFS&R (Ministry of National Food Security and Research (2017). Fruit, Vegetable & Condiments Statistics of Pakistan: Economic Wing, MNFS&R. Government of Pakistan, Islamabad www.amis.pk/files/F&V%20Statistics%202015-16.pdf

PARC 2018. New Garlic Variety is suitable for all provinces of Pakistan. NARC, Islamabad. Archived from http://parc.gov.pk/index.php/en/168-parc-flash-news-2018/1514-history-created-by-parc-scientists-by-locally-developing-the-highest-yielding-garlic-variety

Porter, M.E. and Ketels, C.H.M. 2003. UK Competitiveness: Moving to the Next Stage. Department of Trade and Industry (DTI) Economics Paper.

Pruthi, J.S., 1979. Spices and Condiments. National Book Trust/Sangam Book Depot, New Delhi, India.

Rahman, H., Ullah, K., Sadiq, M., Khan, H.U., Khan, M.A., Khattak, A.M. 2011. RELATIONSHIP BETWEEN MANUAL WEEDS REMOVAL TIMINGS AND GARLIC (Allium sativum L.) PRODUCTION. Pakistan Journal of Weed Science Research, 17(3), 285-292.

Rahman, H.U., Khattak, AM., Sadiq, M., ULLAH, K., Javaria, S., and Ullah, I. 2012. Influence of different weed management practices on yield of garlic crop. Sarhad Journal of Agriculture, 28(2), 213-218.

Sölvell, Ö., Lindqvist, G. and Ketels, C. 2003. The Cluster Initiative Greenbook. First Edition. Center for Strategy and Competitiveness, Stockholm.

Taj, S., Aujla, K.M., Sharif, M. and Yasmin, Z. 2009. GENDER DIMENSIONS OF LABOUR PARTICIPATION IN VEGETABLE FARMING SYSTEM IN DISTRICT ATTOCK OF PUNJAB, PAKISTAN. Journal of Agriculture Research, 47(1), 91-100.

Thornton, G. 2017. Value Chain Analysis: Garlic. Rajasthan Agricultural Competitiveness Project, India.

UNIDO, 2001. Development of Clusters and Networks of SMEs. The programme of the United Nations Industrial Development Organization (UNIDO), Private Sector Development Branch.

Van der Linde, C. 2002. The Cluster Mata-Study. Institute for Strategy and Competitiveness, Harvard Business School. http://www.isc.hbs.edu/MetaStudy2002Bib.pdf

WHO 1999. Monographs on selected medicinal plants, Vol. 1. World Health Organization. Geneva.

Annexure 3: List of stakeholders consulted

#	Name	Title	Location	Contact
1.	Hamyun Khan	PSO, Horticulture Research Institute, National Agriculture Research Center, Islamabad	Islamabad	03149702022
2.	Ziarat Khan	Farmer	Swabi, KP	03449214259
3.	Sher Aslam	Farmer	Swabi, KP	03339423695
4.	Gul Muhammad	Farmer	Swabi, KP	03429212065
5.	M. Ismail	Research Officer, Agricultural Research Station, Swabi	Swabi, KP	03459167494
6.	Khan Bahadur	Farmer	Nowshera, KP	03409111987
7.	Zameer Khan	Farmer	Nowshera, KP	03005899801
8.	Zahid Ali	Farmer	Nowshera, KP	03119130216
9.	Siraj M.	Farmer	Nowshera, KP	03109042085
10.	Ibrar	Farmer	Nowshera, KP	03345543401
11.	Abdul Bari	Fruit and Vegetable Research Center, Agricultural Research Institute, Mangora	Swat, KP	0946812284
12.	M. Hanif Lahori	Commission Agent/Importer, Sabzi Mandi	Faisalabad, Punjab	03006564047
13.	Malik Ismatullah	Commission Agent/Importer, Sabzi Mandi	Faisalabad, Punjab	03469600044
14.	Bao Imran	Commission Agent, Sabzi Mandi	Lahore, Punjab	03006141701
15.	Khalil Bhatti	Trader (exporter/importer), Sabzi Mandi	Lahore, Punjab	03008453969
16.	Naeem Warhaich	Commission Agent, Sabzi Mandi	Daska, Punjab	03006406257
17.	Ahmad Ali	Farmer	Daska, Punjab	03008711169
18.	Arif Raza	Farmer	Mirpur Khas, Sindh	03008170856
19.	Mian Saleem	Farmer/exporter	Mirpur Khas, Sindh	03003300370
20.	Prof. Dr. Aijaz Ahmed Soomro	Scientist, Sindh Agriculture University, Tandojam	Sindh	03023473482
21.	Zarar Shah	Trader	Karachi	03161333881
22.	Khalid Khatiawar	Commission Agent, Sabzi Mandi	Karachi, Sindh	03332424101
23.	Musarat Hussain	Procurement Officer, National Foods	Karachi, Sindh	03003679609
24.	Agha Shabab	Director, Laziza	Karachi, Sindh	03468227744
25.	M. Ayaz	Farmer	Harnai, Balochistan	03168017350
26.	Fateh Ali	Farmer	Harnai, Balochistan	03169852132
27.	M. Zahid	Scientist, PARC Agricultural Research and Development Center, Quetta	Balochistan	03342462087

Annexure 4: Garlic production in Pakistan

unjab			Sindh				Khyber Pakhtunkhwa				Baloc
a)	Production (tonnes	Yield (tonnnes/ha)	Districts	Area (ha)	Production (tonnene	Yield (tonnes/ ha)	Districts	Area (ha)	Production (tonnes	Yield (tonnes/ ha)	Districts	Area (ha)
368	2822	7.7	Mirpurkhas	296	1558	5.3	Kohat	502	5347	10.7	Harnai	6
268	2397	8.9	Badin	175	900	5.1	Swabi	316	4441	14.1	Loralai	
237	1932	8.2	Jamshoro	122	663	5.4	Charsadda	216	2701	12.5	Jafarabad	
202	1540	7.6	Thatta	113	603	5.3	Peshawar	214	2696	12.6	Khuzdar	
180	2159	12.0	T.M.Khan	80	427	5.3	Nowshera	201	3452	17.2	Barkhan	
150	1077	7.2	Tando Allahyar	74	395	5.3	Mardan	191	2674	14.0	Panjgoor	
129	1321	10.2	Larkana	70	379	5.4	Swat	110	930	8.5	Zhob	
124	1252	10.1	Umerkot	63	339	5.4	Haripur	102	572	5.6	Turbat	
97	794	8.2	Sanghar	46	247	5.4	Bunir	51	380	7.5	Nushki	
97	624	6.4	Hyderabad	42	220	5.2	Malakand	27	171	6.3	Mastung	
92	698	7.6	Dadu	33	172	5.2	Dir Lower	10	55	5.5	Sibi	
85	756	8.9	Shaheed Benazir Abad	25	135	5.4	Shangla	8	41	5.1	**Total**	**8**
85	567	6.7	Matiari	22	118	5.4	Chitral	4	24	6.0		
85	470	5.5	Khairpur	16	86	5.4	Hangu	4	3	0.8		
82	593	7.2	N. Feroze	13	70	5.4	Dir Upper	3	29	9.7		
81	403	5.0	Ghotki	12	65	5.4	Karak	3	8	2.7		
72	502	7.0	Tharparkar	11	59	5.4	**Total**	**1962**	**23524**	**8.7**		
70	554	7.9	Shikarpur	7	38	5.4						
65	520	8.0	Sukkur	5	27	5.4						
65	468	7.2	**Total**	**1225**	**6501**	**5.3**						
64	578	9.0										
59	336	5.7										
51	313	6.1										
49	538	11.0										
48	566	11.8										
40	348	8.7										
40	261	6.5										
34	113	3.3										
32	227	7.1										
30	148	4.9										
27	254	9.4										
15	153	10.2										
14	110	7.9										
12	90	7.5										

12	81	6.8										
2	14	7.0										
3163	**25579**	**7.8**										

Source: GoP (2015)

Annexure 5: Characteristics and comparison of garlic clusters

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
Province	Punjab	Khyber Pakhtunkhaw	Balochistan	Sindh
Districts	Sialkot, Narowal, and Gujranwala	Kohat, Swabi, Charsadda, Peshawar, Nowshera, and Mardan	Harnai, Loraliai, and Jafarabad	Mirpurkhas, Badin and Jamshoro
Harvested Area of the cluster (has)	873	1138	719	786
Production of the cluster (tonnes)	7151	15964	6412	4151
Yield of the cluster (tonnes/ha)	8.19	14.03	8.92	5.28
Percentage of the crop area that lies in the cluster	11.75%	15.32%	9.68%	10.58%
Focal point	Sialkot	Kohat	Harnai	Mirpur Khas
Area of the focal point (ha)	368	502	650	296
Production of the focal point (tonnes)	2822	5347	5811	1558
Yield of the focal point (tonnes/ha)	7.7	10.7	8.9	5.3
Geographical and Environmental Factor	Sandy loam and Clay loam soils	Loamy soil	Shallow loamy gravelly soil	Silty loam soil. Best for garlic cultivation.
	Flat plains	Flat plains	Flat plains and hilly	Flat plains
	32° North latitude and 74° East longitude	34° North latitude and 72° East longitude	29.9° North latitude, 69.5° East longitude	24.7° North latitude and 67.9° East longitude

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
	Climate is warm and temperate.	Climate is warm and sub-humid.	Climate is cold desert.	Climate is warm desert.
	Availability of water for irrigation from Marala ravi link canal throughout the year. Tube-well water is also used in case of shortage.	Availability of water for irrigation from Steefa canal and Kabul river canal through pumping from the out the year.	Availability of stream water and tube well water in Harnai and tube-well water in Lorali and Barkhan for irrigation	Availability of water for irrigation from Jamrau canal and Mirwah canal.
	Prolonged winter during sowing and sudden rise in temperature during harvesting badly affect garlic crop.	Prolonged winter during sowing and sudden rise in temperature during harvesting badly affect garlic crop.	Prolonged winter during sowing and sudden rise in temperature during harvesting badly affect garlic crop.	Prolonged winter during sowing and sudden rise in temperature during harvesting badly affect garlic crop.
Garlic Growers	Mostly small holding size (<5 acres)	Mostly small holding size (<5 acres)	Mostly small holding size (<5 acres)	Mostly medium (5-12.5 acres) and large holding size (> 12.5 acres)
	Majority of farmers in this region have primary schooling.	Majority of farmers in this region are illiterate and preferred growing old cultivars like local white desi garlic	Majority of farmers in this region are illiterate and unable to follow new production technology.	Majority of farmers in this region are illiterate and unable to follow new production technology.
	Female hired labor is used for sowing of cloves, while male hired labor is used for harvesting.	Mostly male members of family are involved in garlic production. However, hired labor is used for sowing and harvesting. Growers faced severe constraints of labor for harvesting due to its competition with wheat crop	Small farmers manage crop themselves. However, 2 (owner):1 (tenant) is common form of tenancy.	Small farmers manage crop themselves. However, 1/2:1/2 is common form of tenancy.
Seed Varieties	OPV: Local White Desi, Lehsan Gulabi, JS-1, Chinese (Exotic), MJ-84, Iranian (Exotic), Italian (Exotic), NARC-G1	OPV: Local White Desi, Lehsan Gulabi, Chinese (Exotic), JS-1, Banu Local, Peshawar Local, Swat G1, Iranian (Exotic), Italian (Exotic), NARC-G1	OPV: Harnai, White Chinese (Exotic), Local White Desi, NARC-G1	OPV: Local White Desi, Lehsan Gulabi

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
Product Features	Good quality of Desi and Chinese garlic	The best quality of Desi garlic (Kohat) preferred by food industries like Shan, National etc for their recipes	The best quality of Chinese garlic called garlic II, preferred by urban consumers	Good quality of Desi and Chinese garlic
	Pungent, sticky, thin, intact and unpeelable skin	Very pungent, sticky, thin, very intact and unpeelable skin	Less pungent, less sticky but hard and easily peelable skin of Chinese variety	Pungent, sticky, thin, unpeelable skin and very hard bulb
	Average weight of garlic bulb is 29-45 grams.	Average weight of garlic bulb is 32-55 grams.	Average weight of Chinese garlic bulb is 37-60 grams.	Average weight of garlic bulb is 17-35 grams.
	Average weight of garlic clove is 1.33 grams.	Average weight of garlic clove is 1.73 grams.	Average weight of Chinese garlic clove is 3 grams.	Average weight of garlic clove is 1.13 grams.
	Average number of cloves per bulb is 20-30.	Heterogeneous in the size of garlic bulb. Average number of cloves per bulb is 26-40 cloves/bulb	Relatively homogeneous in the size of Chinese garlic bulb. Average number of cloves per bulb is 10-20 cloves/bulb	Average number of cloves per bulb is 20-25.
	-	Desi garlic of KP is highly preferred by Food processors like Shan, Ahmed, Laziza etc for their recipes.	Chinese garlic variety grown in Balochistan is highly demanded by Punjab wholesalers and urban consumers when imported Chinese garlic is unavailable due to its sowing stage in China.	-
Planting	Start sowing on 5-10 September	Start sowing on 14-15 September	Start sowing from October to November	Start sowing on 5-15 September
	Row to row distance=8 inches	Row to row distance= 7-8 inches	Row to row distance=8 inches	Row to row distance= 6-8 inches
	Plant to plant distance= 3-4 inches	Plant to plant distance= 2-3 inches	Plant to plant distance= 3-4 inches	Plant to plant distance= 4 inches
	Cloves are planted half inch deep on flat bed.	Cloves are planted half inch deep on flat bed.	Cloves are planted half inch deep on flat bed.	Cloves are planted half inch deep on ridges due to saline soils
	Average seed rate = 350 kg/acre	Average seed rate = 300 kg/acre	Average seed rate = 250 kg/acre	Average seed rate = 280 kg/acre

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
	Average seed cost is Rs 26000/acre	Average seed cost is Rs 24000/acre	Average seed cost is Rs 30000/acre	Average seed cost is Rs 28000/acre
	Sowing cost is Rs 18000/acre	Sowing cost is Rs 16000/acre	Sowing cost is Rs 15000/acre	Sowing cost is Rs 17000/acre
	Usually home saved seed of local cultivar is used	Usually home saved seed of local cultivar is used	Usually home saved seed of local cultivar is used	Usually home saved seed of local cultivar is used
	Hired women are involved in sowing cloves.	Family/hired men are involved in sowing cloves.	Family /hired men are involved in sowing cloves.	Women of tenant family are involved in sowing cloves.
Inputs/Management Practices	• 1 rotavator @ Rs 1200/hour for 2 hours/acre=Rs 2400 • 2 cultivator ploughing @ Rs 1200/hour for 2 hours/acre= Rs 4800 • 1 leveler @ Rs 1200/hour for one hor = Rs 1200	• 1 rotavator @ Rs 1200/hour for 2 hours/acre=Rs 2400 • 2 cultivator ploughing @ Rs 1000/hour for 2 hours/acre= Rs 4000 • 1 leveler@ Rs 1200/hour for one hor = Rs 1200	• 1 rotavator @ Rs 1200/hour for 2 hours/acre=Rs 2400 • 2 cultivator ploughing @ Rs 1200/hour for 2 hours/acre= Rs 4800 • 1 leveler @ Rs 1200/hour for one hor = Rs 1200	• 1 rotavator @ Rs 1200/hour for 2 hours/acre=Rs 2400 • 2 cultivator ploughing @ Rs 1000/hour for 2 hours/acre= Rs 4000 • 1 leveler@ Rs 1200/hour for one hor = Rs 1200 • Ridge making @Rs 1200/hour for 2hours/acre= Rs 2400
	Farm Yard Manure @ Rs 4000/trolley/acre	Farm Yard Manure @ Rs 5000/2 trolleys(10 tonnes/trolley)/acre	Farm Yard Manure @ Rs 2500/half trolley/acre	Farm Yard Manure @ Rs 3500/trolley/acre
	• 1.5 bags of Urea @ Rs 1800/bag=Rs 2700/acre • 1 bag of Nitrophos @ Rs 2200= Rs 2200/acre • 2 bags of DAP @ Rs 3000/bag= Rs 6000/acre	• 3 bags of Urea @ Rs 1700/bag=Rs 5100/acre • 3 bags of DAP @ Rs 3000/bag= Rs 9000/acre • 1 bag of Single Super Phosphate (SSP) @ Rs 1200/bag = Rs 1200	• 3 bags of Urea @ Rs 1700/bag=Rs 5100/acre • 3 bags of DAP @ Rs 3000/bag= Rs 9000/acre	• 1 .5 bags of Single Super Phosphate @ Rs 1200/bag=Rs 1800/acre • 1 bag of DAP @ Rs 2900/bag= Rs 2900/acre • 3 bags of Nitrophos @ Rs 2500/bag = Rs 7500
	Crop is also attacked by Thrips and it is also controlled	• At sowing stage, termite and cutworm (bulb insects) attack the crop. It is	Crop is also attacked by Thrips and it is also controlled by 2	Crop is also attacked by Thrips and it is also controlled

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
	by 2 sprays of Furadon granules @ Rs 800/8kg/acre.	controlled by 2 sprays of Furadon granules @ Rs 600/8kg/acre. • Crop is also attacked by Thrips and it is also controlled by 2 sprays of Furadon granules @ Rs 600/8kg/acre.	sprays of Furadon granules @ Rs 600/8kg/acre.	by 2 sprays of Lambda @ Rs 600/acre.
	Crop is attacked by Downy Mildew disease and is treated by 2 sprays of Ridomil Gold @ Rs 680/250g/acre	Crop is attacked by Downy Mildew disease and is treated by 2 sprays of Tilth @ Rs 800/acre	Crop is attacked by Downy Mildew disease and is treated by 2 sprays of Ridomil Gold @ Rs 680/250g/acre	Crop is attacked by Downy Mildew disease and is treated by 2 sprays of Ridomil Gold @ Rs 680/250g/acre
	• Pre-emergence weedicide: Stamp @ Rs1500/500ml/acre.	• Pre-emergence weedicide: Pendimethaline @ Rs1500/500ml/acre. • Pre+Post-emergence weedicide: Aksifen@ Rs 500/200ml/acre	• Pre-emergence weedicide: Pendimethaline @ Rs1500/500ml/acre.	• Pre-emergence weedicide: Premixtra @ Rs1000/500ml/ acre.
	3 manual hoeing with 5 laborers @ Rs 6000/acre	3-4 manual hoeing with 4 laborers @ Rs 8000-10000/acre	3 manual hoeing with 4 laborers @ Rs 5200/acre	3-4 manual hoeing with 3 laborers @ Rs 6500/acre
	Land rent is Rs 90,000/acre/year	Land rent is Rs 80,000/acre/year	Land rent is Rs 70,000/acre/year	Land rent is Rs 85,000/acre/year
	Mostly farmers are self-financing their crop. However, some are getting inputs on credits from input dealers.	Mostly farmers are self-financing their crop. However, some are getting inputs on credits from input dealers.	Usually farmers are financed by commission agents or wholesalers.	Usually farmers are financed by local trader called Bunnya (Hindu sect).
	4-5 tube-well irrigations @ Rs 5000/acre	2 canal irrigations at sowing, 3 canal irrigation near bulb formulation+ 2 canal irrigations before harvesting = Rs 1000/acre+Rs 4000 for fuel charges to operate motor to pull water from canal to field situated relatively high	7 tube-well water irrigations @ Rs 10000/acre	5-6 canal water irrigations @ Rs 800/acre

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
Harvesting	• Some farmers sell standing crop while others manual harvest, dry in the field for 2-3 days and then make bundles of garlic stems in the field. • Harvesting and bundling cost is Rs 45000/acre. • Some farmers also involve in grading and packaging of garlic in 20 kg plastic bags. Bag price is Rs 15-20/bag and packaging cost is Rs 1550.	• Some farmers sell standing crop while others manual harvest, dry in the field for 5-6 days and then make bundles of garlic stems in the field. • Harvesting and bundling cost is Rs 42000/acre. • Some farmers also involve in grading and packaging of garlic in 20 kg plastic bags and packaging cost is Rs 1450.	• Manual harvesting, drying in the field for 2-3 days and then bundling garlic stems in the field. • Harvesting and bundling cost is Rs 35000/acre. • Some farmers also involve in grading and packaging of garlic in 20 kg plastic bags and packaging cost is Rs 1250	• Manual harvesting, drying in the field for 2-3 days and then bundling garlic stems in the field. • Harvesting and bundling cost is Rs 44000/acre. • Some farmers also involve in grading and packaging of garlic in 20 kg plastic bags and packaging cost is Rs 1350
Supply Cycle	March to April	April to May	May to June	Feb to March
Transportation/Infrastructure	• Mainly transported by truck and Suzuki pick-ups • Suzuki charges = Rs 1500-2000/1000kg/trip • Truck charges = Rs 5000-6000/3000/trip	• Mainly transported by truck and Suzuki pick-ups • Suzuki charges = Rs 1500-2000/1000kg/trip • Truck charges = Rs 5000-6000/3000/trip	• Mainly transported by truck and Suzuki pick-ups • Suzuki charges = Rs 1500-2000/1000kg/trip • Truck charges = Rs 130/50kg bag of garlic from Loralai to Multan	• Mainly transported by truck and Suzuki pick-ups • Suzuki charges = Rs 1500-2000/1000kg/trip • Truck charges = Rs 5000-6000/3000/trip
	In case of low prices, farmers hang garlic bundles in dry and well ventilated store rooms for 3-4 months.	In case of low prices, farmers hang garlic bundles in dry and well ventilated store rooms for 3-4 months.	-	-
	Poor storage facilities in rural areas. However, in few Sabzi Mandis, cold store houses for garlic are available	Poor storage facilities	Road and storage facilities are very poor, especially in Harnai	No cold store houses

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
Vegetable Markets	7 vegetable markets: Sabzi Mandi Bhadal, Sialkot; Sabzi Mandi Sambrial, Sialkot; Sabzi Mandi Daska, Sialkot; Sabzi Mandi Gujranwala; Sabzi Mandi Alipur Chatta, Gujranwala; Sabzi Mandi Narowal, Sabzi Mandi Shakkargarh, Narowal	7 vegetable markets: Sabzi Mandi Topi, Swabi; Sabzi Mandi Shahi Bagh, Peshawar; Sabzi Mandi Jahangirpura, Peshawar; Sabzi Mandi Naway Adda, Mardan; Sabzi Mandi, Mardan; Sabzi Mandi, Nowshera; Pabbi Sabzi Mandi, Nowshera	2 vegetable markets: New Sabzi Mandi, Loarali and Sabzi Mandi Dera Ghazi Khan	5 vegetable markets: Sabzi Mandi Mirpur Khas; Sabzi Mandi Matli, Badin; Sabzi Mandi TM Khan; New Sabzi Mandi, Karachi
Supply Chain	Farmers sell their crop either in standing form or in harvested from to local trader called Bupari. Local traders do grading of garlic crop and pack them in 20 kg plastic bags. Then, Bupari sell to commission agents/wholesalers in nearby Sabzi Mandi	Farmers sell their crop either in standing form or in harvested from to local trader called Bupari. Local traders do grading of garlic crop and pack them in 20 kg plastic bags. Then, Bupari sell to commission agents/wholesalers in nearby Sabzi Mandi	Farmers sell their crop either in standing form or in harvested from to local trader called Bupari. Local traders do grading of garlic crop and pack them in 20 kg plastic bags. Then, Bupari sell to commission agents/wholesalers in nearby Sabzi Mandi or Sabzi Madi of Dera Ghazi Khan.	Small farmers are selling crop to local trader called Bannya (Hindu sect) because they have taken credit or inputs on credits from him. However, large farmers are selling garlic after packaging to commission agents or wholesalers in Sabzi Mandi.
	In some cases, farmers are financed by local trader or commission agents or wholesalers. Thus the contractor is obliged to sell the produce through that trader.		Usually farmers are financed by local trader or commission agents or wholesalers. Thus the contractor is obliged to sell the produce through that trader.	Usually small farmers are financed by Bannya. Thus the contractor is obliged to sell the produce through that Bannya.
	Final grading is done by Pharria in Sabzi Mandi and then by retailers.	Final grading is done by Pharria in Sabzi Mandi and then by retailers.	Final grading is done by Pharria in Sabzi Mandi and then by retailers.	Final grading is done by Pharria in Sabzi Mandi and then by retailers.

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
	Garlic price is Rs 20/kg at farm level, while at it is Rs 50 at whole sale level. At retail level, it is Rs 150-200/kg.	Garlic price is Rs 20/kg at farm level, while at it is Rs 50 at whole sale level. At retail level, it is Rs 150-200/kg.	Garlic price is Rs 20/kg at farm level, while at it is Rs 40 at whole sale level. At retail level, it is Rs 120-150/kg.	Garlic price is Rs 20/kg at farm level, while at it is Rs 50 at whole sale level. At retail level, it is Rs 150-200/kg.
	-	Some progressive farmers or whole salers of KP were directly supplying Desi Garlic to New Sabzi Mandi of Karachi due to high demand by food processors	-	Commission agents or whole sellers are supplying Desi white garlic of KP to Food Processors in Karachi like Shan, Ahmed, Laziza etc after or before peeling.
Export	Pakistan exported 1288 tonnes garlic in 2017 to 26 countries of Rs 275 million. However, Pakistan imported 52 tonnes garlic of Rs 10 billion, mainly from China (51 tonnes) in 2017. of Few traders have started exported garlic to neighboring high value market like middle east countries.	-	-	Few traders have started exporting Chinese garlic to neighboring high value market like Dubai
	Lack of farm mechanization for planting and harvesting raises cost of production and reduces garlic competitiveness in international market.	Lack of farm mechanization for planting and harvesting raises cost of production and competition of labor at planting and harvesting stage with wheat crop.	Lack of farm mechanization for planting and harvesting raises cost of production and competition of labor at planting and harvesting stage with wheat crop.	Lack of farm mechanization for planting and harvesting raises cost of production and competition of labor at planting and harvesting stage with wheat crop.

Salient Features	1st Cluster (Northern Punjab Cluster)	2nd Cluster (Central KP Cluster)	3rd Cluster (Northern Balochistan Cluster)	4th Cluster (Southern Sindh Cluster)
Knowledge Dissemination	Knowledge/experience sharing networks are by experienced farmers, input dealers and by trainings, farmer field days organized by extension agents	Knowledge/experience sharing networks are by experienced farmers, input dealers and by trainings, farmer field days organized by extension agents	Knowledge/experience sharing networks are by experienced farmers and input dealers.	Knowledge/experience sharing networks are by experienced farmers and input dealers.
Research and Development	Horticulture Research Institute of Ayub Agriculture Research Institute (AARI), Faisalabad and Horticulture Research Institute of National Agriculture Research Centre (NARC), Islamabad are working to develop new varieties of Garlic. Till now Pakistan has only 2 approved varieties of garlic: Lehsan Gulabi by AARI in 1990 and NARC G-1 by NARC in 2018	Agriculture Research Station Swabi, Horticulture Section of Agriculture Research Institute Tarnab, Peshawar, and Horticulture Section of Agricultural Research Institute Mingora Swat	Directorate of Agricultural Research Fruit, ARI, Sariab, Quetta and Pakistan Agriculture Research Council, Quetta	Sindh Horticulture Research Institute (SHRI), Mirpur Khas, Sindh
Socioeconomic Networks	-	Model Farm Services Centers (MFSC) at district level, Farm Services Centers (FSC) at tehsil level, Farmers Union develop by extension department	-	-
Gender Involvement	Family female or hired female labor is involved in sowing, hoeing, and drying the crop on house floor	Family female or hired female labor is involved in sowing, hoeing, and drying the crop on house floor	Family female or hired female labor is involved in sowing, hoeing, and drying the crop on house floor	Family female or hired female labor is involved in sowing, hoeing, and drying the crop on house floor

Source: Feedback from different stakeholders and survey of secondary sources (Annexures 3 and 4)

Annexure 6: Garlic secondary processed products

Annexure 7: Cost of garlic planters

Manual planting of garlic is very technical, laborious and expensive. This is due to labour constraint in the months of September-November and the way to plant individual cloves. Individual cloves are separated from the bulbs and are planted by hand one inch deep and four inches apart on ridges and flat seed beds. However, garlic planting by tractor mounted planter is a preferred method as in machine-planting, cloves are evenly distributed at very least cost.

Under cluster development program, this project proposes importing of garlic planter and distributing through GEG. Machinery cost of one planter includes imported machinery price and GST @17% on the imported machinery. All costs are given in below table. We assume that planting one acre requires 2 hours and one planter will be busy 8 hours a day. On the base of these assumptions, we have computed planting capacity for one ha and one month. Hence, a planter can plant 49 ha in a month. We have assumed that initially 25% of the total garlic area will be planted with a planter and planter will be used at 75% planting capacity. Hence, 2 planters will be imported in each year starting from the second year for each cluster. In the first year of mechanization, 2 planters will be introduced to major garlic producing district through GEG to make it a model mechanized district. In the coming years, next garlic producing districts will be selected.

Costs of Mechanized Planting	
Planting capacity @0.5 per acre for 30 days (ha)	49
Machinery cost of planter (US$)	3000
Operational cost of planter (US$/ha)	55
Maintenance cost (US$)	300
Depreciation cost (US$)	300
Maintenance and depreciation cost (US$/ha)	12.4
Total operating cost (US$/ha)	67

Manual planting costs US$ 234/ha (e.g., in KP cluster), while mechanical planting will cost US$ 67/ha as shown in the above table. Hence, net benefits of mechanized planting is US$ 167/ha.

Annexure 8: Cost of garlic harvesters

Manual harvesting of garlic is very technical, laborious and expensive. This is due to severe labour constraint in the months of March-April as wheat harvesting also initiated in these months. Moreover, uprooting of each garlic bulb demands time and energy. However, garlic harvesting by tractor mounted harvester is a preferred method as in machine-harvesting, bulbs are uprooted with least damage at very least cost.

Under cluster development program, this project proposes importing of garlic harvester and distributing through GEG. Machinery cost of one harvester is US$ 5000 and it includes imported machinery price and GST @17% on the imported machinery. All costs are given in the below table. We assume that harvesting one acre requires 5 hours and one harvester will be busy 8 hours a day. On the base of these assumptions, we have computed harvesting capacity for one ha and one month. Hence, a harvester can harvest 19 ha in a month. We have assumed that initially 25% of the total garlic area will be harvested with a harvester and a harvester will be used at 75% harvesting capacity. Hence, 4 harvesters will be imported in each year starting from the second year for each cluster. In the first year of mechanization, 4 harvesters will be introduced to major garlic producing district through GEG to make it a model mechanized district. In the coming years, the next garlic producing districts will be selected.

Costs of Mechanized Harvesting	
Harvesting capacity @0.5 per acre for 30 days (ha)	19
Machinery cost (US$)	5000
Operational cost of planter (US$/ha)	110
Maintenance cost (US$)	500
Depreciation cost (US$)	500
Maintenance and depreciation cost (US$/ha)	51.5
Total operating cost (US$/ha)	161

Manual harvesting costs US$ 187/ha (e.g., in KP cluster), while mechanical harvesting will cost US$161/ha as shown in the above table. Hence, the net benefits of mechanized harvesting is US$ 25/ha.

Annexure 9: Cost of cold store house

Garlic is available throughout the year at varying prices. The prices of garlic during the months of March and May are at its lowest during the year. During this time period, it is viable to store garlic to ensure its edible characteristics, freshness for longer period of time and secure reasonable prices. Therefore, a small scale cold store house will be established under FEG in the first year of the project on half Kanal of land in the major garlic producing district of each province, similar to cold store houses proposed by Small and Medium Enterprises Development Authority (GoP, 2015b). It is suggested to purchase land instead of getting on rent or lease as the project life is very long and plant & machinery used in the project is expensive. Moreover, the required land should be closely located to garlic farm and vegetable markets. A building including cold store hall, machinery room, manager's office, accounts and procurement office, generator's room, wash room and ware house for good arrival and packaging will be constructed on this land. Ammonia compressor will be imported for cold store hall. Moreover, this cold hall will be insulated and having vegetable steel racks. Office furniture and fixture will include tables, chairs, sofa set, energy savers, security cameras, ceiling fans and electric fittings. Office equipment will comprise computer, printer and scanner, telephone and UPS. The total fixed cost of capital is US$ 60096. The details of all the fixed and working capitals are given in the below table:

Cost of Cold Store House		
Capital cost	**PKR**	**US$**
Land	500,000	3,704
Building	3,860,719	28,598
Plant & Machinery	3,406,063	25,230
Office Equipment	10,344	77
Furniture & Fixture	81,500	604
Pre operational expenses, Utilities Installations & contingencies	254,379	1,884
Total Capital Cost	**8113,004**	**60,096**
Working Capital		
Equipment Spare Part Inventory	34,061	252
Upfront Insurance Payment	170,303	1,262
Cash	169,091	1,253
Total Working Capital	**3734,55**	**2,766**
Total Project Cost	**8,486,459**	**62,863**

Note: Cost estimates are based on GoP (2015b).

One manager, one accountant, one plant operator, one sweeper and two security guards will be hired. This cold house can store 487.5 tonnes of fresh garlic based on GoP (2015b). Total operating cost is assumed US$ 6 per tonne (calculated after dividing working capital cost with storage capacity). The cost of the proposed cold store house project is PKR 8.49 million (US$ 63 thousand).

Twenty percent of the fixed capita cost will be provided by the government provided FEG agrees to gather the 80% of the remaining capital and operating cost. Initially, government will also share the salary of the manager, but after four years the manger costs will be shifted to

FEG. Any farmer can get the services of the cold storage depending on the availability of the space in the store at market price. The benefits will be distributed among the FEG members based on the proportion of their contribution in the fixed investment cost.