CLIMATE-SMART AGRICULTURE INVESTMENT PLAN

PUNJAB AND KHYBER PAKHTUNKHWA

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Bioversity International
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Foreword

At the time of writing this foreword (August 2022), one third of Pakistan is under water, with the country experiencing flooding on a scale comparable to the devastating "once in a century" 2010 floods. It is estimated that 800,000 farm animals have perished, 2 million acres of crops and orchards have been damaged, and 33 million people have been displaced—including members of the team who have supported in preparing this report. This flooding followed a period of extreme high temperatures and water stress from March to May, with temperatures across Pakistan reaching the highest levels in 60 years and drought conditions impacting the countries rabi wheat crop. Rather than 2022 being an anomaly, it is instead a stark warning of what the future holds for Pakistan under climate change. As a country already considered the 8th most impacted country globally, climate change is projected to further undermine the resilience and adaptive capacity of the agriculture sector and the 39% of the population who directly rely on it for their livelihoods.

Faced with these challenges it is critical that measures are taken to support Pakistan's agriculture sector, both modernising it to meet the needs of a growing population and ensuring this process is undertaken in an equitable way that leaves no one behind, with many of Pakistan's most vulnerable reliant on agriculture for their livelihoods. Climate-Smart Agriculture (CSA) through its focus on increasing productivity in an environmentally and socially sustainable way, strengthening farmers' adaptation and resilience to climate change, and its support for greenhouse gas emissions (GHG) mitigation efforts, has considerable potential to bring about some of the positive changes needed in Pakistan's agriculture sector. CSA is however not a new concept, with many of the interventions that may be considered "climate-smart" already firmly embedded within the national policy landscape.

The Climate-Smart Agriculture Investment Planning (CSAIP) framework was developed to support the transition from CSA recommendations to tangible action on CSA implementation. Based on the needs of national and international agricultural practitioners and program implementers, the CSAIP approach supports the development of targeted investments into the agriculture sector that can deliver crosscutting impacts across the three CSA pillars (productivity, adaptation, and mitigation). Considering Pakistan's small per capita contribution to global GHG emissions, the analysis focusses on measures that can boost agricultural productivity in the face of climate change, highlighting where mitigation co-benefits exist.

Pakistan's Climate-Smart Agriculture (CSA) Investment Plan is structured in two broad components: context analysis (Chapter 1) and CSA investment prioritization (Chapter 2). Each step serves as input to the others, moving from a careful analysis of the agricultural and socio-economical context; climate change projections, hazards, and impacts on agriculture; and the policy, institutions, and financial landscape in Punjab, KP and Pakistan as a whole (Chapter 1), to the identification and evaluation of CSA investments opportunities in Punjab and KP, followed by a prioritization of investment and research packages and corresponding financial analyses (Chapter 2). These two components were developed based on strong engagement with the key decision-makers, experts, and participating institutions, supported by a detailed review of the available literature, online resources, and the mining of data from past work conducted by the Alliance on CSA in Pakistan.

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The SAR project is a multi-year development project with programming on climate change adaptation and climate risk management, with a focus on women and vulnerable communities. The project is focused on the provinces of Punjab and Khyber Pakhtunkhwa, with activates including climate risk assessments, adaptation planning and financing, and unlocking international climate finance.

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Table of Contents

Abbreviations

AARI	Ayub Agricultural Research Institute
ADB	Asian Development Bank
ADP	Annual Development Plan
AEZ	Agro-ecological zone
BCA	Biological control agent
BOI	Board of investment
CABI	Centre for Agriculture and Bio-Sciences International
CSA	Climate-smart agriculture
CSAIP	Climate-smart agriculture investment planning
CIAT	International Center for Tropical Agriculture
COVID-19	Coronavirus disease 2019
CO_2eq	Carbon dioxide equivalent
CPEC	China Pakistan Economic Corridor
DAC	Development Assistance Committee
DFI	Direct foreign investment
EbA	Ecosystem-based Adaptation
ESG	environmental, social and governance
FATA	Federally Administered Tribal Areas
FDI	Foreign direct investment
FFS	Farmer field school
FY	Fiscal Year
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
HDI	Human Development Index
HR	human resources
ICT	Information and communications technology
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated pest management
IWMI	International Water Management Institute
IO	Investment opportunity
IRR	Internal Rate of Return
KP	Khyber Pakhtunkhwa
KPBOIT	KP Board of investment and Trade

MDB	Multilateral development bank
MFSC	Model Farm Service Centers
MoCC	Ministry of Climate Change
MoPDSI	Ministry of Planning, Development and Special Initiatives
MRV	Monitoring, reporting and verification
MT	Million tonnes (Megatonnes)
NDC	Nationally Determined Contributions
NPB	Nature performance bond
NPV	Net present value
ODA	Official development assistance
OECD	Organization for Economic Cooperation and Development
OOF	Other official flows
PARB	Punjab Agricultural Research Board
PARC	Pakistan Agriculture Research Council
PBIT	Punjab Board of Investment and Trade
PDMA	Punjab Provincial Disaster Management Authority
PIK	Potsdam Institute for Climate Impact Research
PKR	Pakistani rupee
PPP	Public private partnership
PSDP	Public Sector Development Program
RCP	Representative Concentration Pathway
SECP	Securities and Exchange Commission of Pakistan
SEED	Sustainable Energy & Economic Development Programme
SEZ	Special Economic Zones
SDG	Sustainable Development Goal
SMART	Strengthening Markets and Rural Transformation in Punjab
SME	small and medium-sized enterprise
TUF	University of Faisalabad
UAP	University of Agriculture Peshawar
UET	University of Engineering and Technology Peshawar
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollars
WAPDA	Water and Power Development Authority
WWF	World Wildlife Fund
YDI	Youth development index

Executive summary

Agriculture is Pakistan's 2nd most important economic sector after the services sector, contributing over 19% to Pakistan's gross domestic product (GDP), and employing almost 40% of the population, of which a majority are women. The majority of the population (63%) live in rural areas, for which agriculture is directly or indirectly the main source of income. Agriculture is predominantly subsistence-based though slowly becoming more commercial, with the average farm size standing at 2.26ha. Smallholder farmers predominantly cultivate cereal crops (wheat, maize, rice), cotton, sugarcane, vegetables and fruits in two main seasons (*kharif* and *rabi*). More than 8 million farming households rear some small, medium, or large livestock units for milk and meat production, deriving 35-40% of income from this source. Punjab produces more than half of the national production of the five main crops (maize, wheat, cotton, sugarcane, and rice) and 25% of the national production of livestock, highlighting the economic importance of agriculture for the province and its role in maintaining national food security. Although KP is a smaller contributor of staple crops than Punjab, the province is a major producer of other economically important crops such as barley and tobacco. Furthermore, smallholders in KP derive 20% of their income from livestock rearing. In both provinces the agriculture, forestry and fishing sectors employ a considerable amount of the population (41% in Punjab, 32% in KP), of which more than 60% of workers are women. Primary agriculture therefore represents a significant source of livelihood for rural workers and in particular women.

While the agriculture sector grew 2.8% in FY2021, both crop and livestock productivity remain low and will need to increase to keep up with the rapid population growth and higher demand for food, which are threatening food security. While the yields of the main cereal and fruit crops have increased in Punjab in the last eight years, yield gaps remain when compared to regional and global averages, especially for wheat. In KP, yields have decreased for wheat, maize, fruits, and fodder in the last decade. Livestock production of cattle, buffalo, sheep, goats, and poultry, has grown considerably over the years in the whole country, emerging as the largest sub-sector in agriculture (60.1% of agricultural GDP). However, the sector needs further development to increase per unit animal productivity and export potential of products. In general, smallholder farmers need improved provision of inputs, extension, credit, and institutional support to stay competitive in current and emerging markets. Dwindling surface water resources and the over exploitation of ground water coupled with higher water requirements due to unpredictable rainfall and higher rates of evapotranspiration, threaten the sustainability of Pakistan's food production. In a country where the prevalence of moderate-or-severe food insecurity is still widespread (17.6% of households in KP, and 17.5% in Punjab), the livelihoods of smallholder farmers are being increasingly threatened, and will likely be further threatened in the face of climate change.

Climate change impacts on Pakistan's agricultural production are already widespread and expected to worsen in coming years. Temperatures have risen by 0.6°C in the past century and will continue to do so at a faster rate depending on the emissions scenario, with the north of the country experiencing the highest temperature increases (including KP), and the south and interior showing the highest absolute temperatures (including Punjab). When coupled with the predicted more frequent and intense heatwaves in all provinces, and the increasingly unpredictable monsoon rainfall patterns, these will negatively affect the yields of cereal crops (especially wheat) and livestock health. Pakistan is no stranger to the negative impacts of climate change, being the 8th country most affected by extreme weather events between 2000-2019. Droughts and floods have already had a devastating impact on agriculture-dependent livelihoods and the overall economy, with the cycle of disasters eroding the adaptive capacity of effected communities. Most regions (including Punjab and KP) have been classified as severe-to-high drought prone areas. The floods of 2010-2014 alone caused economic losses of USD$18 billion and damaged 4.3million ha of agricultural land.

The Ministry of Climate Change (MoCC), the Ministry of National Food Security and Research, and the Ministry of Planning, Development and Special Initiatives (MoPDSI) are the primary actors in charge of the development and implementation of climate change, agriculture, and development-related policies. The National Climate

Change Policy 2021 was developed according to Paris Agreement targets and Sustainable Development Goals (SDGs), including measures for climate change adaptation in agriculture-related sectors. The National Food Security Policy 2018 promotes measures to tackle factors constraining agricultural growth, such as investing in modern practices and technologies, increasing access to inputs, extension, and credit, and enhancing capacity building, which are needed to increase production and food security. Pakistan Vision 2025 is Pakistan's national development plan and highlights seven priority areas strongly linked to agriculture. At the provincial level, the Agriculture Departments of KP and Punjab are responsible for the implementation of the provincial agriculture and livestock policies.

Agricultural research activities are coordinated at a provincial level by the Directorate of Agriculture Research KP and the Punjab Agriculture Research Board (PARB) along with academic institutions such as The University of Agriculture Peshawar (UAP) and the University of Agrciulture Faisalabad (UAF), with coordination and support from the Pakistan Agricultural Research Council (PARC). The Model Farm Service Centers (MFSCs) of KP is another important institution providing inputs and advisory to farmers. Public funds for agriculture and development are channelled through provincial Annual Development Plans (ADPs), which in Punjab and KP have focused on financing the construction and upgrading of irrigation infrastructure and on-farm water management technologies. After water-related activities, farm mechanisation, extension and advisory, and livestock sector development are the agricultural policy areas that have been receiving the most public funding.

An analysis of policy areas to support and advance agriculture was carried out in consultation with provincial stakeholders, with policy objectives supporting agriculture research and innovation, food security, value chain development, institutional capacity building, policy reform, and disaster preparedness considered of very high importance. An assessment of the current coverage of such policy priority areas revealed that all agriculture policy areas under review are at least partially covered by the current federal and provincial policy frameworks in agriculture, climate change and food security. It was however noted that many of the policies suffer from funding and implementation gaps, which limit the effective realization of the objectives outlined in the policy documents.

Opportunities to attract private sector investment in agriculture have been highlighted by the Boards of Investment at national and provincial level, which set out a number of opportunities for increased engagement in public private partnerships (PPP). Continued efforts are needed to create an enabling environment that facilitates domestic and international funding towards climate change adaptation and mitigation in agriculture. The private sector in Pakistan includes domestic and international companies which provide a wide range of crop and livestock inputs, advisory services, and processing facilities. The Pakistan Board of Investment (BOI) was recently established to facilitate private sector investment, and highlights food processing of horticultural and livestock products as a priority area for investment in Pakistan. The Punjab Board of Investment and Trade (PBIT) and KP Board of Investment and Trade (KPBOIT) identify investments in increased value addition, reduced post-harvest losses, and food processing as potential opportunities in the provinces. To strengthen the regulatory frameworks for private sector investment, the Public Private Partnership (PPP) Authority was established, promoting greater PPP engagement in the agriculture sector. Though Pakistan is a major recipient of bilateral and multilateral funding, currently financing a range of CSA-linked projects, the share of international funds allocated to agriculture remains low. Unlocking additional finance from domestic and international sources, for instance through green and climate finance instruments, would accelerate efforts to achieve the country's recently updated Nationally Determined Contributions (NDCs).

Following an extensive process reviewing available data sources and engaging with key stakeholders from across the two provinces, nine climate-smart agriculture (CSA) investment opportunities (IO) were prioritised for Punjab and twelve for KP. The CSA investment opportunities were identified by mining existing data on climate hazards and priority interventions at the national, provincial and district level, followed by an extensive review of the current policy and programming priorities to align the investment packages with existing initiatives and avoid duplication. The CSA investment packages were further reviewed and refined by conducting key stakeholder consultations. This iterative process resulted in nine CSA investment opportunities for Punjab and twelve for KP, ranging from scaling CSA interventions at farm level to institutional capacity development.

A prioritization exercise with provincial experts from government, academia and the private sector identified the climate smartness (composite of adaptation, mitigation, and productivity scores), investment risk, and scalability potential of each investment opportunity. Combined with the investment priorities of relevant organizations, these results informed the selection of two investment packages and two research packages for detailed review. The two investment packages identified seek to develop financing models through public private partnerships for the scaling on improved technologies, for which full cost benefit analyses were conducted. The two research packages are focused on the generation of knowledge products to support future provincial programming, for which only the costs were assessed. Deep dive assessments were developed for the four packages, which included a detailed needs assessment, proposed activities, tentative costs and the key institutions to be involved.

INVESTMENT PACKAGES

5.1 Financing model for developing smallholder farm mechanisation

5.2 Enhancing biocontrol production and implementation capacity for integrated pest management

RESEARCH PACKAGES

6.1 Integrated farming with native fruit trees

6.2 Strategy development & awareness raising to counter wild boar attacks in Kurram, Orakzai, & North Waziristan

The rates of farm mechanisation in KP remain low, with consequences for agricultural productivity. The proposed investment package looks to improve the access of farmers in KP to affordable farm mechanisation through investments in local manufacturing capacity and the establishment of innovative financing models to support mechanisation service delivery. Mechanisation was identified as a key area for agricultural productivity improvement, currently remaining much more underdeveloped in KP than in Punjab (e.g., only 4.5% of tractors in Pakistan are operating in KP). Existing policies such as KP Agriculture Policy 2015-2025 and other ongoing schemes on farm mechanisation create a supportive environment to scale this investment in KP. The proposed intervention includes provisions to support research and development on locally adapted farm machinery through improved institutional coordination, and the development of business models to scale mechanisation as a service (i.e., by strengthening public-private partnerships to bundle mechanisation providers with financial support programs). The implementation of this package should be led by the Directorate of Agriculture Engineering, Agriculture Department KP, which already supports the development of farm technologies and would facilitate outreach to farmers and service providers. The program could be further supported by research institutions such as the Department of Agriculture Engineering, from the University of Engineering and Technology Peshawar (UET), in addition to partnering with financial institutions with provincial presence which could provide credit support for mechanisation uptake.

The cost-benefit analysis for the mechanisation package shows positive net present value (NPV), indicating a generally good return on investment. The financial analysis comparing the costs of implementing mechanisation with the potential gains in agricultural productivity shows positive NPV at both the farmer and program level. Cost-benefit analyses for the 4 most promising farm machinery items (zero tillage drilling machine, multi-crop thresher, raised bed planter, and mechanical weeder) under three different scenarios for farmers (purchasing, renting, or buying and sub-renting to other farmers) showed that farmers with less than 1ha could not recover the costs of purchasing any of the farm equipment, while farmers with 4ha showed positive NPV under all but one scenario (multi-crop thresher), with the rental model showing higher returns. The farm machinery service provider model shows to be particularly promising, as it would allow farmers who can afford to purchase farm machinery to profitably rent their equipment to farmers who are not able to undergo such investment, with the latter still benefiting from the increased machinery availability. The implementation of a large mechanisation program to provide 800 farm implements over a 10-year period versus the associated program costs also shows positive NPV, indicating its profitability.

Table ES.1 Gains from CSA implementation: Rationale for investments

TYPE OF PACKAGE	CSA OPPORTUNITY	ON-FARM VALUE	PAKISTANI IMPORTANCE	PROJECTED CLIMATE CHANGE RESPONSE	SCENARIO WITHOUT INVESTMENT	MAIN INVESTMENT OBJECTIVE
INVESTMENT	Farm mechanisation development	Economic, food security	Utilization of farm machinery in Pakistan remains low, especially in KP, resulting in lower yields and higher labour requirements	The expected increase in temperature, rainfall unpredictability and extreme weather events threaten crop productivity	Decreased productivity	Growth
INVESTMENT	Integrated pest management	Economic, environmental, farmers' health, food security	Insect pests such as fruit flies, aphids or borers are causing serious crop losses for major crops in Pakistan (maize rice, sugarcane, fruits, etc.). The overuse of chemical pesticides is often the only control measure	The changes in climatic conditions are creating favourable environments for the spread of insect pests, which will increase crop losses and further decrease productivity	Continued chemical fertilizer overuse, with consequences for farmers (impact on health, high input costs, reduced export potential) and environmental degradation.	Adaptation and growth
RESEARCH	Integrated farming with native fruit trees	Ecosystem services, nutrition, food security, economic	The forested areas of KP have a critical watershed function, in addition to sustaining the livelihoods of farming communities	The higher frequency of heavy rainfall and droughts will continue to cause flash floods, soil erosion, and landslides, exacerbating watershed and soil degradation	Reduced food security, exacerbated environmental degradation	Adaptation, mitigation and growth
RESEARCH	Wild boar strategy	Economic, food security	Wild boar attacks are causing considerable losses of staple crops in KP (maize, rice, and wheat) and effective control measures from farmers and institutions are lacking	The increasingly warmer temperatures will continue to drive wild boars into farming areas of KP, exacerbating crop losses and human-wildlife conflicts	Increased economic losses for farmers and food insecurity	Adaptation

With the climate in KP projected to continue getting warmer and wetter, the conditions will become more favourable for the spread of insect pests. The investment package on integrated pest management proposes mainstreaming biocontrol strategies to increase crop productivity and reduce chemical input use, with benefits for farmers' health and incomes, and the environment. The importance of integrated pest management (IPM) is recognized in key federal and provincial policies. Although an IPM framework has been developed for KP, experts and farmers remain widely unaware of such recommendations and the potential of biological control agents (BCA) to reduce the overuse of chemical inputs. The investment package proposed aims to mainstream the use of BCA as part of IPM measures in the province by focusing on three key components: 1) research support to identify pest specific BCA/IPM strategies, 2) capital investment to increase lab production capacity of priority BCA (by upgrading existing labs and building new labs), and 3) capacity development of IPM researchers, extension staff, input suppliers and farmers. The identified implementing institution for this package includes the Directorate of Agriculture Research, Agriculture Department KP, who has the mandate for developing integrated pest and disease management strategies and has 14 research stations operational across the province. Other institutions such as the Model Farm Service Centers (MFSC) could support with outreach to farmers, and the Centre for Agriculture and Bio-Sciences International (CABI) could provide technical support on IPM implementation.

The financial analysis for the IPM program also shows positive NPV under two discount rate scenarios, indicating profitability for farmers from increased crop productivity and reduced pesticide costs. The cost-benefit analysis of the proposed IPM program to promote BCA adoption also showed potential productivity gains from BCA treatment within the range of 5-25% for the six crops evaluated (wheat, tomato, potato, peach, apple, and orange), in addition to a 10-30% reduction in pesticide use and therefore the associated costs. Taking into account the capital investment to upgrade 4 existing labs and construct 4 new labs as well as the human resources and operational costs, the overall programme is found to be profitable, with an Internal Rate of Return (IRR) of 104%. The programme showed positive NPV under two discount rate scenarios and under a 25% decrease in BCA efficiency, indicating benefits to farmers would outweigh the cost of the program. This profitability was measured by comparing the private benefits of farmer beneficiaries (reduced losses and pesticide costs) with the programme costs, therefore, it does not return a profit to the programme implementers but rather generates more value for the sector than it costs.

In addition to the economic benefits associated with increased yields and decreased crop losses, the investment packages proposed would create additional environmental benefits in the short and long term, such as reduced water pumping due to higher water use efficiency, soil carbon sequestration from improved soil quality, and reduced chemical input use. In instances where there were found to be tradeoffs across the different CSA pillars, these were weighed up and presented to support decision making. The implementation of the proposed mechanisation program with the aim of providing agricultural mechanisation services to 867ha per year over a 10-year period in KP would lead to several environmental benefits. Such benefits include reductions in herbicide use, water savings from the raised bed planting and soil carbon sequestration. Tradeoffs between total CO_2 abated versus emitted from the increased use of farm machinery were considered and should be taken into account when implementing the proposed program. The introduction of an IPM program with a focus on scaling BCA in KP would also show associated environmental benefits, mainly from the reductions of chemical input in the range of 5-30% depending on the crop, insect pest, and biological control agent combination.

Integrating native fruit trees and fish farming within local agricultural systems in the mountains of KP offer a wide range of environmental and financial benefits, such as countering watershed and soil degradation and generating new sources of income for farmers. The forested area of KP plays a key role in regulating water flows, though deforestation and unsustainable agriculture are degrading the watersheds. The increased frequency of heavy precipitation events is also exacerbating flash floods, soil erosion and landslides in steep areas. To prevent further land degradation, several restoration programs have been put into place such as The One Billion Tree Tsunami Afforestation Project, however, the potential of agroforestry remains unexplored. Integrating native fruit and nut species with fodder and small-scale fish farming was identified as a promising strategy to strengthen the existing tree planting initiatives in KP., enhancing environmental benefits and offering new income-generating opportunities for farmers. However, the lack of training on plantation management and the difficulty accessing tree seeds and seedlings remain barriers for implementation. The proposed intervention focuses on three components: 1) research to map priority watersheds using geographic information systems (GIS), and to identify appropriate tree species and agroforestry systems, 2) development of input and output markets through enhancing the capacity of seed nurseries, training farmers in orchard management, and improving storage, processing and marketing of produce, and 3) promoting integrated fish farming of trout and carp through capacity building and financial support. The implementation of market-related activities could be led by the Forestry Department and the Department of Fisheries.

With the increasing agricultural losses experienced by farming communities of KP due to wild boar attacks and the lack of appropriate control measures, developing research and institutional capacities is key to effectively respond to this pressing threat to farmers' livelihoods. The proposed research package on wild boar strategy development addresses these key issues. Highlighted by the National Climate Change Policy 2021, human-wildlife conflict prevention is essential for effective conservation of mountain biodiversity and the livelihoods of farming communities in the face of climate change. The expansion of wild boar populations into farming areas of KP due to the changes in climate is becoming a more pressing issue, and control measures require coordinated efforts between farmers and institutions. The proposed research package would focus on addressing three key aspects: 1) research on the distribution of wild boar populations, the factors driving them into conflict with farming communities

and effective management practices, 2) enhancing human capital by training local extension providers and farmers on the most effective methods for wild boar attack prevention and 3) enhancing institutional support through the development of a holistic program and implementation framework for boar control agreed upon by key stakeholders. Potential implementing institutions of the research component of this package would be the Agriculture Department and the Forestry, Wildlife and Environmental Department, which have the mandate of crop protection from wildlife. Other identified potential partner institutions include WWF Pakistan.

Chapter 1
Context Analysis

Section

1

The Agricultural Context

HIGHLIGHTS

- Pakistan is the 5th most populous country, with a predominantly rural population (63%). Agriculture is the 2nd sector in terms of economic importance, contributing 19.2% to GDP, and the largest employer (39.2% of the population). Smallholders dominate the sector, with 90.8% of farms in Punjab and 79.8% in KP being smaller than 5ha. Women make up 69.8% of all agricultural workers, but continue to be excluded from education, land ownership, credit, and technology.
- Wheat, rice, cotton, maize, and sugarcane are the five main food and cash crops, covering 50% of the total harvested area in Pakistan. Punjab contributes more than half of their production, while KP is a major producer of other important commodities including tobacco and barley. Livestock is the largest agriculture subsector, contributing 60.1% to GDP, and an important economic activity for smallholders in both provinces. Sheep, goats, cattle, buffalo, and poultry, are the main species reared.
- Pakistan's climate is mostly semi-arid to arid, with great regional variation. Punjab hosts fertile agriculture plains fed by the Indus Basin Irrigation System, and experiences wide temperature variations between summer and winter. KP is largely mountainous with large geographic disparities in temperature and high rainfall rates. KP is also home to a large share of Pakistan's forest area (27.7%).
- Water resources are deteriorating due to poor irrigation methods, improper water drainage, and overextraction of groundwater, which is accelerating soil salinization. Pakistan's rate of deforestation is the highest in South Asia. Conflicts over resource scarcity (mostly water) between economic sectors and provinces are becoming increasingly common.
- With 46% of national emissions coming from agriculture, forestry, and other land uses, it is understandable that the sector has been identified as a target for future emissions reductions under Pakistan's updated NDC. Enteric fermentation accounts for most of the emissions (61%), followed by manure left on pasture (11%) and synthetic fertilizers (10%), to which both Punjab and KP contribute greatly.
- Other challenges faced by the agriculture sector include the rising food and energy prices, increased food demand due to population growth, inefficient regulation of food commodities and trade, and the lack of support for value chain development of essential commodities and high value agricultural products.

1.1 Pakistan and its people

Pakistan is the world's 5th most populous country and has a distinctive young population, mostly rural. Between 1998 and 2017, the population of Pakistan increased by 57% reaching 207 million people in the last national census (excluding Azad Kashmir and Gilgit-Baltistan) (GoP PBS, 2017). Almost two thirds of the total population (59%) are aged 15-59 years, with 27% falling in the 15-29 age group (GoP Finance Division, 2021). The youth bulge that is distinctive of Pakistan's demographic profile has great economic potential if tapped effectively by promoting access to skills and opportunities (UNDP, 2020). The growth poles of Pakistan's economy are situated along the Indus River. The diversified economies of Karachi and major urban centres in Punjab coexist with lesser developed areas in other parts of the country. Despite recent progress, wealth and income inequalities can still be observed between and within the four provinces. Punjab population is found mostly in the two richest quintiles, Khyber Pakhtunkhwa is better represented among the lower-middle classes, and Balochistan and Sindh are more widely represented among the poorest 20% (UNDP, 2020). In 2018, 63.3% of the total population resided in rural areas (FAOSTAT, 2022). Income inequalities within provinces are determined largely by the urban-rural divide but are also prominent within urban areas.

Pakistan still shows low levels of human development and high gender inequality, and it is facing rising unemployment. The country's average unemployment rate stands at 6.9%, the highest in 10 years, with urban areas facing higher unemployment (7.9%) than rural areas (6.4%) and women being almost twice as likely to be unemployed (10%) as men (5.9%) (GoP PBS, 2019). Youth's employment-to-population ratio and the percentage of fully-employed youth also seem to be worsening (UNDP, 2020). Pakistan ranked 154th among 189 countries on UN's Human Development Index (HDI) in 2020, and it has the 2nd lowest HDI value among South Asian countries (UNDP, 2020). At the regional level, Azad Jammu and Kashmir is Pakistan's most developed region with an HDI of 0.621; followed by Sindh, Punjab, KP, Gilgit-Baltistan, the Newly Merged Areas of KP and lastly Balochistan with the lowest HDI (0.473) (UNDP, 2020). The youth development index (YDI) has improved gradually over time, however, young men's YDI value (0.605) is twice that of young women, reflecting poor progress in employment-related indicators especially for young women (UNDP, 2020). In 2019, Pakistan ranked 135th out of 189 countries on the Gender Inequality Index among medium human development countries (UNDP, 2019). In 2022, Pakistan also ranked 145th out of 146 countries on the Global Gender Gap Index, highlighting the high level of gender imparity compared to most countries (World Economic Forum, 2022).

Inflation and COVID-19 are pushing people deeper into poverty and food insecurity, increasing their vulnerability to economic and climate-related shocks. Multidimensional poverty is experienced by 38.3% of the population, with an additional 12.9% at risk of being pushed into it (UNDP, 2020). It is estimated that the COVID-19 pandemic has impacted the livelihoods of more than 7 million workers, and consequently a rise of 33.7% in poverty is projected (Rasheed et al., 2021). The current wave of inflation in the country, especially amidst the aftermath of COVID-19, has also affected people's purchasing power including their ability to access food, with food price inflation remaining elevated at 12.5% in urban areas and 13.2% in rural areas (Asian Development Bank, 2021). Despite Pakistan's achievements towards the 2030 Zero Hunger Targets, 16% of households in Pakistan still suffer from moderate or severe food insecurity (GoP PBS & MoPD&SI, 2021). In addition, 18% of households are undernourished (Afridi et al., 2021). Pakistan currently ranks 92nd out of 116 countries in the Global Hunger Index with a score of 24.7, indicating serious level of hunger (Concern Worldwide & Welthungerhilfe, 2021). While 94% have access to basic drinking water services, only 68% have access to safely managed sanitation services (GoP PBS & MoPD&SI, 2021). Moreover, only 22% of the population have access to internet facilities (Rasheed et al., 2021).

Punjab is the largest province of Pakistan in terms of economy and population. With 110 million people, Punjab represents 54% of the country's total population, of which 60% reside in rural areas (PWD, 2022). The province contributes the largest share to Pakistan's GDP, approximately 60%, and has a large concentration of small and medium-sized enterprises (SMEs) (ADB, 2017a). Income inequality in Punjab has always been high, with the richest 20% having a GDP per capita 5.2 times greater than the poorest 20% (UNDP, 2020). Punjab's

unemployment rate currently stands at 6.8%, the second highest in Pakistan (GoP PBS, 2021). Approximately 14.4% of households in Punjab experience moderate-to-severe food insecurity (they are forced to reduce the amount and quality of food during the year to meet household needs), with an additional 3.1% experiencing severe food insecurity (household members go without eating for entire days) (Afridi et al., 2021; FAO, 2022b).

Khyber Pakhtunkhwa is the third largest contributor to the economy and has recently expanded with the merger of tribal districts in the northwest. With 35.49 million people (4.99 million from the recently added Newly Merged Districts), KP constitutes 17% of the country's population with the majority living in the rural areas (GoP PBS, 2017). KP's unemployment rate is the highest in the country, standing at 8.8% (GoP PBS, 2021). Although KP has been improving due to growing remittances and recent trade developments, there is a significant discrepancy in human development between the newly merged districts and the rest of the province. KP has a medium level of human development with a HDI of 0.546, however, the Newly Merged Districts have the 2nd lowest HDI of all Pakistani regions (0.216) (UNDP, 2020). The Newly Merged Areas also have 73.7% of their population living in multidimensional poverty compared to 49.2% for rest of the province (OPHI & UNDP, 2016). The prevalence of moderate-to-severe food insecurity in KP stands at 16.7%, the highest of all provinces, and severe food insecurity is experienced by 0.9% of households (Afridi et al., 2021).

1.2 Climate, geography, and agro-ecological zones (AEZs)

Pakistan lies in the temperate zone and its climate and topography is varied with semi-arid to arid lowland Indus plains, dry coastal climate, arid climate in the west and east desserts, and cooler climate in the northern highlands (WBG & ADB, 2021). The country is situated on a steep incline from the Arabian Sea to the Himalayas, with altitude ranging from sea level to 8500m (GoP, 2016a). The Indus River is Pakistan's primary freshwater source, largely fed by the glaciers of the Himalayas, and it flows through the west of the country on its way to the sea, creating the fertile Indus Basin. The climate in Pakistan is temperate. The majority of the country receives very little rainfall, except for the Northern regions which can receive more than 200mm during the monsoons (WBG & ADB, 2021). Most annual rainfall occurs in the summer (July-September) during the southwest monsoon, while the winter receives some rainfall due to western systems (prevailing winds from the Mediterranean (CIAT & World Bank, 2017b; WBG & ADB, 2021). These forces influence the two main cropping seasons: kharif and rabi. Kharif season spans from April-June (sowing to October-December (harvesting) and it is suitable for the cultivation of summer crops (rice, sugarcane, cotton, maize, pulses). Rabi season begins in October-December until April-May and it is when the winter crops are grown (wheat, lentil, tobacco, rapeseed, barley and mustard) (ADB, 2017b; CIAT & World Bank, 2017).

Khyber Pakhtunkhwa's climate varies with elevation, with heavy rainfall and colder temperatures in the northern mountains, and low rainfall and higher temperatures in the south. The province hosts the majority of Pakistan's forests. The mountainous areas of KP experience cold winters, cool summers, and heavy rainfall, whereas the capital Peshawar and the south experience higher temperatures and low rainfall. KP is one of the coldest regions of Pakistan, with an average annual temperature of 22.3°C (GoKP ITB, 2022). The highest temperatures are reached in June, with maximum temperatures of 38.7°C during the day, and the lowest temperatures are reached in January with minimum temperatures of 3.3°C at night (World Data, 2022). Precipitation in KP fluctuates throughout the year, averaging about 928 mm annually in the whole province, with the northern regions receiving up to 1719 mm of rainfall per year (GoKP BOS & P&DD, 2021). The land under forest cover in KP amounts to 14.8% of the province, and it constitutes 27.74% of the total forested area of Pakistan (GoKP BOS & P&DD, 2021).

Punjab is predominantly at plain level in the arid to semi-arid region, and experiences wide temperature variations between summer and winter. The submountain areas in the north receive most of the provinces' rainfall. Punjab is characterized by its plains, with some hilly terrain in the north-west and south-west and a desert belt in the south eastern region (GoP, 2016b). Punjab's three main climatic seasons include

hot summers (April to June), monsoon (July to Sep) and cold/foggy and milder winters (Oct to March) with an average annual temperature of 24°C (A. Ahmad et al., 2019; Climate Data, 2022). Wide variations between temperature extremes can also be observed in Punjab, with maximum daytime temperatures of 40°C in June, and minimum night time temperatures of 5.4°C in January (World Data, 2022). During monsoon, average annual rainfall ranges between 1140-1270 mm in the sub-mountain region and 508-630 mm on the plains (A. Ahmad et al., 2019). Hosting the Indus River System, Punjab is known as the 'grain basket' of the country for its rich fertile alluvial soils and irrigated plains (A. Ahmad et al., 2019).

Agroecological zoning undertaken in 1980 has evolved due to changes in climate characteristics. The past country-level agroecological zoning included 10 different agroecological zones (AEZs) and 15 crop production regions based on physiography, climate, land use and water availability. Recently, the zoning has been revised for different provinces based on soil, landform, and the evolved climatic characteristics in the last four decades to enable improved land use and adequate crop diversification. For Punjab, AEZs have been expanded from 4 broad categories with 11 subzones to 14 zones in 2019 to match the soil, water and environmental characteristics with the provincial production patterns (A. Ahmad et al., 2019; Table 1). For KP, the most recent zoning divided the province into 5 zones and 9 sub-zones based on temperature, rainfall, topography and altitude (Gov KP & P&D, n.d.; Table 1). However, more detailed zoning is needed in KP (especially in the Newly Merged Areas) to update KP's AEZs in order to develop adaptation and mitigation strategies in agriculture in the province (Miller et al., 2021).

Table 1: Updated Agroecological Zones (AEZs) of Punjab and Khyber Pakhtunkhwa (A. Ahmad et al., 2019; GoKP, n.d.-a)

PROVINCE	ZONE ID	ZONE NAME
Punjab	I	Cholistan desert
	II	Arid irrigated
	III	Cotton-sugarcane
	IV	Rod-i-Kohi
	V	Semi-desert irrigated
	VI	Mix cropping
	VII	Cotton mix cropping
	VIII	Maize wheat mix cropping
	IX	Thal-Gram crop
	X	Rice-wheat
	XI	Thal zone 2
	XII	Rice zone
	XIII	Groundnut-medium rainfall
	XIV	High rainfall
Khyber Pakhtunkhwa	AI	High Dry Mountains
	AII	Sub Mountain Valleys
	BI	Sub Humid Mountains
	BII	Wet Mountains
	CI	Valley Plains
	DI	Piedmont Plain
	DII	Semi-arid Piedmont
	E	Western Mountains
	F	Desert Plains

1.3 The importance of agriculture

Pakistan is a lower-middle income economy and the services sector has outgrown the agriculture sector in its economic importance. In 2020, the national GDP was USD 263.69 billion with a GDP per capita of USD 1,260.1, making Pakistan a lower-middle income economy (World Bank Data, 2022b). Although promoted to an emerging market in 2017, Pakistan was recently downgraded to a frontier market economy due to no longer meeting the standards for size and liquidity (MSCI, 2021). Pakistan's GDP grew by an average of 4.09% from 2000 to 2021, with a negative growth of –0.94% in 2020 (State Bank of Pakistan, 2020a). Agriculture's contribution to GDP gradually trended downward from around 53% in the 1950s to around 26% in the 1990s, and since then it has remained relatively stable currently contributing 23.1% (State Bank of Pakistan, 2020b). The service sector is the largest contributor to GDP at 61.7%, followed by the agriculture sector and industry contributing 19.2% and 19.1% respectively (GoP Finance Division, 2021). It is estimated that the provisional GDP growth in FY2021 will be 3.9% on account of 4.4% growth in the services sector, 3.6% in industry, and 2.8% growth in agriculture (GoP Finance Division, 2021).

Wheat, rice and maize are the three main staple food crops, rice is an important exportable commodity and cotton and sugarcane are the main cash crops. Livestock is the largest agriculture sub-sector. The 5 major crops (cotton, wheat, rice, sugar cane and maize) cover over 50% of the harvested area, and in 2021 added 22.49% to value addition in agriculture and 4.32% to GDP (GoP Finance Division, 2021). Wheat and rice occupy the greatest area, followed by cotton and maize. Cotton and sugarcane contribute to the textile and sugar agro-industries. Growth in the agriculture sector slowed from 3.3% in 2020 to 2.77% in 2021, missing the 2.8% target (Asian Development Bank, 2021). Production of all major crops except cotton increased due to a combination of reasons such as increase in cultivated area, favorable weather conditions, government policies and/or improved seed varieties. Cotton production has witnessed a declining trend since 2018, mainly due to a decline in the sown area, rising pest attacks and monsoon rains. As a result, the textile industry has been increasingly relying on raw cotton imports, since it is the industry's basic raw material (TDAP, 2021). Livestock is the largest agriculture sub-sector, representing more than half of Pakistan's agricultural GDP (60.07%), contributing 11.53% to Pakistan's total GDP and having achieved 3.06% growth in 2020-21 (GoP Finance Division, 2021). Small ruminants (sheep and goats) account for about 36.8% of the total livestock population, with cattle and buffalo accounting for 30.5% and poultry 30.3% (GoP Finance Division, 2021). The poultry industry has been gaining more importance and growing at a rate of 8% per year, currently making Pakistan the 11th largest poultry producer worldwide (GoP Finance Division, 2021).

Table 2: Major crops of Pakistan in 2021 (GoP Finance Division, 2021)

CROP	AREA (hectares)	PRODUCTION (tonnes)	YIELD (kg/ha)	CONTRIBUTION TO GDP (%)	VALUE ADDITION TO AGRICULTURE (%)
Cotton *(kharif)*	2,079,000	1,513,714.28	578	0.6	3.1
Sugarcane *(kharif)*	1,165,000	81,009,000	69,536	0.7	3.4
Rice *(kharif)*	3,335,000	8,419,000	2,524	0.7	3.5
Wheat *(rabi)*	9,178,000	27,293,000	2,974	1.8	9.8
Maize *(kharif)*	1,418,000	8,465,000	5,970	0.6	3.4

Punjab produces a significant share of the country's main crops. The main crops in Punjab are sugarcane, wheat, cotton, maize, rice, citrus and mango. Punjab produces 86.7% of the country's maize, 75.5% of the wheat, 69.2% of the cotton, 66.9% of the sugarcane and 55.2% of the rice (GoP BOS & P&D, 2020). Punjab also produces 77.2% of the national production of mangoes, and 97.2% of the production of citrus fruits (GoP BOS & P&D, 2020). Of the total reported area in Punjab, 72.1% is cultivated and only 8.4% is culturable waste, and 34.5% of the total cropped area is sown more than once (GoP BOS & P&D, 2020) (GoP BOS & P&D, 2020). Punjab counts with 5 distinctive crop production regions, including maize-wheat-oilseed rainfed cropping systems in the northwest, rice-wheat in the northeast, mixed crop systems (wheat-sugarcane-maize-rice) in

the east, rainfed pulses-wheat systems in the west, and cotton-wheat grown mostly in the south of the province (GoPb PDD, 2018). Almost half of the total cropped area in Punjab is dedicated to wheat (41%), 13% to fodder, 12% to cotton, 12% to rice, 5% to gram, 5% to sugarcane and the remaining 12% to other crops (maize, bajra, rape and mustard, jowar, potato, etc, excluding orchards; (GoP BOS & P&D, 2020). In the last 8 years, yields have increased considerably for maize and tomato with only moderate increases in rice, sugarcane, cotton, mango and potato. However, yield increases in the wheat crop have lagged behind those of other crops (Table 3).

Table 3: Major crops of Punjab; Punjab Crop Reporting Service (GoPJB CRS, 2021)

	% SHARE OF NATIONAL PRODUCTION	YEAR 2020-21			% CHANGE 2013-16 TO 2018-21[1]		
		AREA (ha)	PRODUCTION (tonnes)	YIELD (kg/ha)	AREA (ha)	PRODUCTION (tonnes)	YIELD (kg/ha)
Wheat	75.5	6,746,120	20,900,000	3,098	-1.82	0.05	4.15
Rice	55.2	2,394,529	5,301,000	2,214	15.70	26.27	8.81
Sugarcane	66.9	776,998	57,000,000	73,359	-1.96	14.60	16.54
Cotton	69.2	1,546,306	857,480	710	-21.48	-29.45	14.89
Maize (autumn + spring)	86.7	463,770	4,491,100	9,684	11.01	39.97	31.96
Mango	77.2	99,058	1,321,461	13,340	-7.91	4.28	13.24
Tomato	-	7,862	147,317	18,737	10.14	49.40	36.06
Potato	-	220,648	5,682,000	25,751	21.59	41.86	17.09

Khyber Pakhtunkhwa constitutes only 7% of the total area cultivated in Pakistan but contributes greatly to tobacco, barley and fruit production. The main kharif crops in KP are maize, sugarcane, rice, fruits and vegetables, and the main rabi crops are wheat, gram, tobacco and barley (GoKP BOS & P&DD, 2021). The three main crop production zones of KP are rainfed maize-wheat systems in the north, pulses-wheat in the east, and mixed crop systems in the interior of the province (Rana et al., 2021). During Kharif season, 64.5% of the area is dedicated to maize cultivation, followed by sugarcane (15.6%), rice (9.2%), fruits (5.1%) and vegetables (3.3%). During Rabi season, 84.5% of the area is cultivated with wheat, 3.9% with gram, 3.3% with tobacco and 2.4% with barley (GoKP BOS & P&DD, 2021). Although the contribution of KP to the country's production of staple food crops is much lower than in Punjab, KP produces 64.89% of the national tobacco production and 35.58% of the national barley production (GoKP BOS & P&DD, 2021). KP is also a major fruit-producing province, most of which are grown during Kharif season (watermelon, muskmelon, peach, plum, apricot, pear, apple, dates and pomegranate) but also during Rabi season (citrus, guava, loquat, banana and mulberry) (GoKP, 2019a). Owing to its rugged and mountainous terrain, KP's cultivated area stands at 1.88 million hectares (22.5% of the reported area), 15.8% is culturable waste and 14.8% is forested land (GoKP BOS & P&DD, 2021). About half of the cultivated land in the province is irrigated through a network of government and privately-owned canals (GoKP BOS & P&DD, 2020). Yields have declined for wheat, maize, rabi fruits and vegetables, kharif fruit and rabi fodder in the 8-year period from 2012 to 2020. Rabi fruits and Kharif fodder have seen the highest percentage decline of 7.74 and 14.2%, respectively (Table 4). Yields have increased for rice, sugarcane and kharif vegetables.

[1] % change between the averages of the first 3 and last 3 years in an 8-year period from 2013 to 2021

Table 4: Major crops of Khyber Pakhtunkhwa; KP crop reporting service (GoKP CRS, 2021)

	% SHARE OF NATIONAL PRODUCTION	YEAR 2019-20			% CHANGE 2012-15 TO 2017-20[2]		
		AREA (ha)	PRODUCTION (tonnes)	YIELD (kg/ha)	AREA (ha)	PRODUCTION (tonnes)	YIELD (kg/ha)
Wheat	4.53	727,280	1,130,360	1,554	-0.73	-2.30	-1.62
Rice	2.14	64,900	158,490	2,442	17.30	36.56	16.89
Sugarcane	8.60	109,360	5,753,960	52,615	9.59	24.00	13.20
Maize	12.18	452,620	881,620	1,948	-0.19	-1.11	-0.87
Kharif fruits	ND	36,050	326,620	9,060	0.36	-7.39	-7.74
Rabi fruits	ND	8,450	66,780	7,903	0.99	-2.59	-3.60
Rabi vegetable	ND	14,340	160,680	11,205	-6.77	-6.84	-0.15
Kharif vegetable	ND	23,190	212,370	9,158	-12.20	4.75	18.29
Kharif fodder	ND	43,896	669,150	15,244	13.94	-2.15	-14.20
Rabi fodder	ND	57,863	1,333,572	23,047	-5.09	-6.07	-1.11
Tobacco	64.89	ND	ND	ND	ND	ND	ND
Barley	35.58	ND	ND	ND	ND	ND	ND

ND = No data

Livestock rearing is a key strategy for smallholders in Punjab and KP, both for commercial purposes and food security. Livestock activities are common across the whole country and particularly in rain-fed regions, as it is a key livelihood strategy for subsistence farmers, especially women and people lacking land ownership rights (CIAT & World Bank, 2017). According to the last Agricultural Census (2010), 3.9 million households in Pakistan were livestock holders, of which 50.38% were in Punjab, and 8.87% were in KP (GoP PBS, 2010). Punjab is a major livestock producer in the country, with 42.8% of households owning livestock which is used for meat and milk consumption and for income generation to meet household expenses (GoP BOS & P&D, 2020). Smallholder farmers with 6 animals or less account for 88% of all livestock owners (GoPb, 2016). For Punjab, the latest numbers on livestock date back to the Punjab Livestock Census of 2018, when Punjab reared 32.4% of all cattle in the country (15 million), 36.4% of the buffaloes (14 million), 19.9% of the sheep (6 million) and 19.6% of the goats (15 million) (Table 5) (GoPJB L&DDD, 2018; GoP Finance Division, 2019). Most of the livestock population in KP is reared by smallholder subsistence farmers, who typically own 1-4 animals, and 3% of the livestock is reared by peri-urban commercial farms, which typically own over 30 animals (GoKP ALFCD, 2018). Approximately 20% of the net income of farming households in KP is generated by animal husbandry (GoKP ALFCD, 2018). According to the KP Livestock Policy 2018, 30-40% of the livestock in KP is kept by transhumant/nomadic livestock farmers who mainly graze goats and sheep on the plain areas and foothills in the winter and move their animals to alpine pastures in the summer (GoKP ALFCD, 2018). Rangeland pastures account for 26.5% of the total land area of the province and support an estimated 60% of the livestock (GoKP ALFCD, 2018). The latest data on livestock numbers in KP is from 2019, when the province was home to 10 million heads of cattle (21% of national headcount), 3 million buffalo (7.8%), 16 million goats (21.3%), 4 million sheep (13.9%), and 27 million poultry (Table 6) (GoKP LDD, 2019; GoP Finance Division, 2019). From the total national livestock head count of the eight major species (cattle, buffalo, sheep, goats, camels, horses, donkeys, mules, excluding poultry), approximately 25.2% of livestock is reared in Punjab, and 17.1% is reared in KP (calculated from GoKP L&DD, 2019; GoP Finance Division, 2019; GoPJB L&DDD, 2018).

[2] % change between the averages of first 3 and last 3 years in an 8-year period from 2012 to 2020.

Table 5: Estimated livestock population of the major livestock species in Punjab in 2018 (in millions) (GoPJB L&DDD, 2018; GoP Finance Division, 2019)

SPECIES	NUMBER OF LIVESTOCK HEADS IN PAKISTAN (FY2018)	NUMBER OF LIVESTOCK HEADS IN PUNJAB (2018)	% SHARE OF PUNJAB
Cattle	46.1	14.95	32.4%
Buffalo	38.8	14.12	36.4%
Sheep	30.5	6.06	19.9%
Goat	74.1	14.56	19.6%
Asses/Donkeys	5.3	0.69	13.0%
Camels	1.1	0.06	5.4%
Horses	0.4	0.09	22.5%
Mules	0.2	0.01	5.0%
Poultry	ND	13.75	ND
Total (minus poultry)	**196.5**	**50.54**	**25.7%**

ND = No data

Table 6: Estimated livestock population of the major livestock species in Khyber Pakhtunkhwa in 2019 (in millions) (GoKP L&DD, 2019; GoP Finance Division, 2019)

SPECIES	NUMBER OF LIVESTOCK HEADS IN PAKISTAN (FY2019)	NUMBER OF LIVESTOCK HEADS IN KP (2019)	% SHARE OF KP
Cattle	47.8	10.04	21.0%
Buffalo	40.0	3.13	7.8%
Sheep	30.9	4.30	13.9%
Goat	76.1	16.18	21.3%
Camels	1.1	0.06	5.5%
Horses	0.4	0.08	20.0%
Asses/donkeys	5.4	0.56	10.4%
Mules	0.2	0.07	35.0%
Poultry	ND	27.7	ND
Total (minus poultry)	**201.9**	**34.42**	**17.1%**

ND = No data

Agriculture accounts for 17% of total exports (US$ 4.3 billion) and 54% of total imports (US$ 8.4 billion), making Pakistan a net importer (TDAP, 2021). The top agricultural exports by value in FY2021 included rice, fruit and vegetables, meat, fish, tobacco, spices, oil seeds, nuts, horticulture and livestock (GoP Finance Division, 2021). The top agricultural imports edible oil (palm oil and soyabean), cotton, wheat, pulses, tea, spices, milk, sugar and dry fruits and nuts (GoP Finance Division, 2021). Pakistan's food import bill grew by 54% in 2021, to bridge the shortfall in agriculture production and increase the country's food security. Imports of most food products have been showing an increasing trend, including milk, wheat, dry fruits and nuts, tea, spices, soybean, pulses and sugar (TDAP, 2021). On the contrary, food exports only registered an increase of 1% in 2021, showing that the growth in the sector is almost stagnant (TDAP, 2021). Exports of sugar and wheat have been inconsistent in recent years. In 2019, the government banned wheat exports and in 2020 allowed duty-free wheat imports to meet the domestic demand (TDAP, 2021). Sugar exports declined 100% in FY2021 due to shortages in production, for which Pakistan allowed the import of 300,00 metric tonnes of sugar (TDAP, 2021). Rice exports decreased by 6% in 2021, due to the COVID-19 pandemic and a large price difference with Indian rice which was preferred by the international market. Exports of raw cotton (the main non-food agriculture commodity) declined by 95% in 2021 due to a shortage in production, causing the textile industry to import USD 1.4 billion of raw cotton in that year, an increase of 68% with respect to the previous year (TDAP, 2021). The textile industry, which contributes to 61% of the country's exports and is one the most important sectors of Pakistan's trade, is now heavily reliant on raw cotton imports. As a result, the government has allowed duty-free imports of raw cotton.

Table 7: Major agricultural exports in 2020-2021; Pakistan Economic Survey 2021 (provisional data) (GoP Finance Division, 2021)

COMMODITY	USD MILLION	MT
Rice	1,560.4	2,885,388
Fruits	378.3	829,224
Fish and fish preparations	303.6	136,370
Meat and meat preparations	248.2	72,863
Vegetables	246.1	699,159
Spices	70.3	17,446
Oil seeds, nuts and kernels	28.0	68,808
Raw cotton	0.6	499
Other food items	448.9	ND

ND = No data

Table 8: Major agricultural imports in 2020-2021; Pakistan Economic Survey 2021 (provisional data) (GoP Finance Division, 2021)

COMMODITY	USD MILLION	MT
Edible oil (soyabean & palm)	1,909.3	2,516,069
Raw cotton	1,032.1	624,945
Wheat unmilled	983.3	3,612,638
Pulses	448.4	842,777
Tea	435.1	194,962
Spices	157.6	135,410
Milk & milk food	146.2	43,929
Sugar	127.5	279,529
Dry fruits	69.7	60,995
Other food items	1,844.3	ND

ND = No data

1.4 Farmer livelihoods

The agriculture sector is Pakistan's largest employer and a key income source for 30% and 65% of economically active men and women, respectively (World Bank Data & ILO, 2019). Agriculture, forestry, hunting and fishing employ the majority of the labor force (39.2%) followed closely by the service sector 37.8%; (GoP PBS, 2019). In Punjab, agriculture, forestry and fishing employ 40.7% of the labor force (29.7% men, 69.8% women), whereas in KP the sector employs 32.3% (24.9% men, 64.8% women; (GoP PBS, 2019). Primary agriculture therefore represents a big share of employment and a significant source of livelihood, especially for rural women. With strong forward and backward linkages with the secondary and tertiary sectors, agriculture has the potential to further spur economic growth. This can have an economy-wide multiplier effect as it stimulates activity in other sectors such as input supplies, transport, processing, logistics, and financial services.

Smallholder farms dominate the rural landscape in Pakistan, with an average farm size of 2.6ha (Phambra et al., 2020). Casual employees and full-time family workers make up most of the agricultural work force. Of the approximately 8,264,000 farms in Pakistan, 63.5% are located in Punjab and 18.7% in KP (GoKP BOS & P&DD, 2021; GoP BOS & P&D, 2020). In Punjab, the average farm size is 2.26h whereas KP shows some of the smallest average landholdings in the country with an average farm size of 1.46ha (Phambra et al., 2020). Moreover, in Punjab 90.8% of farms are smaller than 5ha, with 41.9% being smaller than 1 ha. In KP, 79.8% of farms are smaller than 5ha and 30.9% are smaller than 1ha (Table 9). The country's farm area has barely increased over the last 40 years and its ownership has become more concentrated, with fewer people owning

larger landholdings (UNDP, 2020). In the last agricultural census in 2010, agricultural employees in farming households amounted to 49.8 million, composed primarily of casual employees (54.2%), followed by full time family workers (32.9%), part time family workers (9.5%) and finally permanent employees (9.4%) (PBS & GoP, 2010).

More than two thirds of agricultural workers are women (69.8%), highlighting their importance in the sector (GoP PBS, 2019) yet there are significant gender disparities in agricultural work. Pakistan's 9.1 million women agricultural workers are particularly vulnerable, since they often engage in unpaid agricultural work, and suffer from greater poverty and discrimination (UNDP, 2020). Despite their high economic participation in the sector, women in Pakistan are less likely to own income generating assets like land and machinery, have limited decision making power, and lack access to land ownership and credit (FAO, 2015; UNDP, 2020). In both Punjab and KP, women carry out crop production activities but have a higher contribution to livestock production (FAO, 2015). In addition to their agricultural duties, women in Punjab and KP also spend about 25-35h per week on household chores, for which they are often considered part-time agricultural workers while suffering from the double burden of farm work and household work (FAO, 2015). Access to education for agricultural women is also significantly lower than for their male counterparts, with rural men showing much higher literacy rates than rural women in both Punjab (men: 67%, women: 48%) and KP (men: 71%, women: 35 %) (GoP Finance Division, 2021). Furthermore, the recently launched Climate Change Gender Action Plan for Pakistan recognises that climate change impacts will disproportionately affect women, and especially rural women in agriculture (IUCN Pakistan, 2022). Given these constraints, it is key to promote gender equality and empowerment of women in agriculture and identify means of enhancing the economic impact of women's work in the sector.

Table 9: Size distribution of farm holdings ; Punjab Development Statistics 2020 & Development Statistics of KP 2021 (GoP BOS & P&D, 2020; KPBOS P&DD, 2021)

PUNJAB			KP		
SIZE (ha)	NUMBER	PERCENTAGE	SIZE (ha)	NUMBER	PERCENTAGE
0-1	2,203,000	41.9%	0-1	476,330	30.9%
1-5	2,555,000	48.7%	1-5	768,237	49.8%
5-60	488,000	9.3%	5-50	290,244	18.8%
>60	4,000	0.07%	>50	7,034	0.46%
TOTAL	5,250,000	99.9%	TOTAL	1,541,845	99.9%

Table 10: Percentage of employed skilled agricultural, forestry and fishery workers in Pakistan by gender in 2020-21 ; Labour Force Survey 2020-21 (PBS, 2021)

METRIC	PAKISTAN	PUNJAB	KP
% of labour force considered skilled agricultural workers	33.23%	35.18%	30.57%
Of which Women	41.53%	46.87%	36.99%
Of which Men	58.47%	53.13%	63.00%
TOTAL	100%	100%	99.99%

1.5 Water use and allocation

Pakistan's has moved from a water-abundant to a water-stressed country in the last 60 years. Pakistan withdraws a significantly larger fraction of the water supply than other South Asian countries consume per capita, but this has been gradually declining (Figure 1; (FAO, 2022a). Water availability per capita has fallen from 6000m^3 in 1960 to 1071m^3 in 2021 due to population growth, urbanization, climate change and competition for water resources (Salman, 2021). Water availability per capita is projected to fall further to 1000m^3 by 2025 which

would make Pakistan transition from a water-stressed to a water-scarce country (GoP & PDD, 2014). Agriculture is a highly consumptive and water inefficient sector, consuming 97% of the fresh water resources of the country (Salman, 2021). An increase in the demand for water in agriculture is also projected, since climate change impacts could exacerbate the country's arid climate and reliance on water from the glacial melt in the north.

The Indus Basin Irrigation System River provides water for 90% of food production in Pakistan (Janjua et al., 2021), though poor irrigation methods are leading to high water losses and inefficiencies. Over extraction of groundwater resources is accelerating soil salinization. The Indus Basin Irrigation System, a comprehensive network of irrigation infrastructure including barrages and canals, is one of the largest contiguous irrigation systems in the world (Janjua et al., 2021). Although 94% of the agricultural land in Pakistan is equipped for irrigation, only 53.2% is actually irrigated (CIAT & World Bank, 2017; World Bank Data, 2022a). One third (27%) of the irrigation water comes from surface water supplies, with the remaining two thirds (73%) directly or indirectly coming from groundwater supplies (Qureshi, 2020). The high demand for water has increased the reliance on groundwater extraction, which currently amounts to 64 Km3/year (FAO, 2022a) making Pakistan the 3rd largest user of ground water worldwide (Qureshi, 2020). Of the 1.2 million tubewells in the country, 85% are in Punjab and 3.8% are in KP. Unchecked extraction is causing ground water levels to drop and increased soil salinization, with 21% of the irrigated area currently affected by salinity (Qureshi, 2020). Furthermore, more than 60% of the water is lost due to leakage and seepage and at the field level due to poor irrigation (Warraich, 2020) methods that need upgrading, highlighting the high-water inefficiency of the system (Warraich, 2020).

Water allocation guided by the 1991 Water Apportionment Accord has led to disputes over water sharing between provinces, which are exacerbating with the decreasing water availability nationwide. Under the Indus Waters Treaty in 1960, Pakistan gave up its control over three eastern tributaries of the Indus River. Before the treaty, Pakistan's Indus River system received 144.3 Km^3, now receiving only 98.7 Km^3 (Salman, 2021). Water allocation among the provinces is guided by the 1991 Water Apportionment Accord, including for agricultural use (Table 11; GoP IRSA, 1991). When flow exceeds 144.75 km^3, Punjab and Sindh both receive 37%, KP receives 14% and Balochistan 12% of 141.05 km^3 (Table 11; GoP IRSA, 1991). Provinces often dispute over water sharing, claiming that water distribution is not enforced properly especially during extreme conditions (floods and drought) (D. Hassan et al., 2019). In the past 5 years, water availability during Kharif season decreased from 88.1 Km^3 to 75.9 Km^3, and during the Rabi season it increased slightly from 36.6 Km^3 to 38.5 Km^3 (GoP Finance Division, 2021). The National Water Policy of 2018 set out an objective to increase water storage capacity by 12.3 Km^3, for which two major dams and 500 small dams are being constructed (GoP Finance Division, 2021).

Table 11: Water allocation among provinces (km^3); Indus Water Accord 1991 (GoP IRSA, 1991)

PROVINCE	RABI SEASON (km^3)	KHARIF SEASON (km^3)	YEARLY SHARE (km^3)
Punjab	23.30	45.76	69.03
Sindh[b]	18.29	42.00	60.17
Balochistan	1.25	3.51	4.78
KPK	2.83	4.29	7.13
Ungauged Canals	1.48	2.22	3.7
TOTAL	**45.70**	**95.4**	**144.87**

[b] including already sanctioned urban and industrial uses for metropolitan Karachi

Figure 1: Water withdrawal per capita for municipal, industrial and agricultural use (m³); AQUASTAT database (FAO, 2022a)

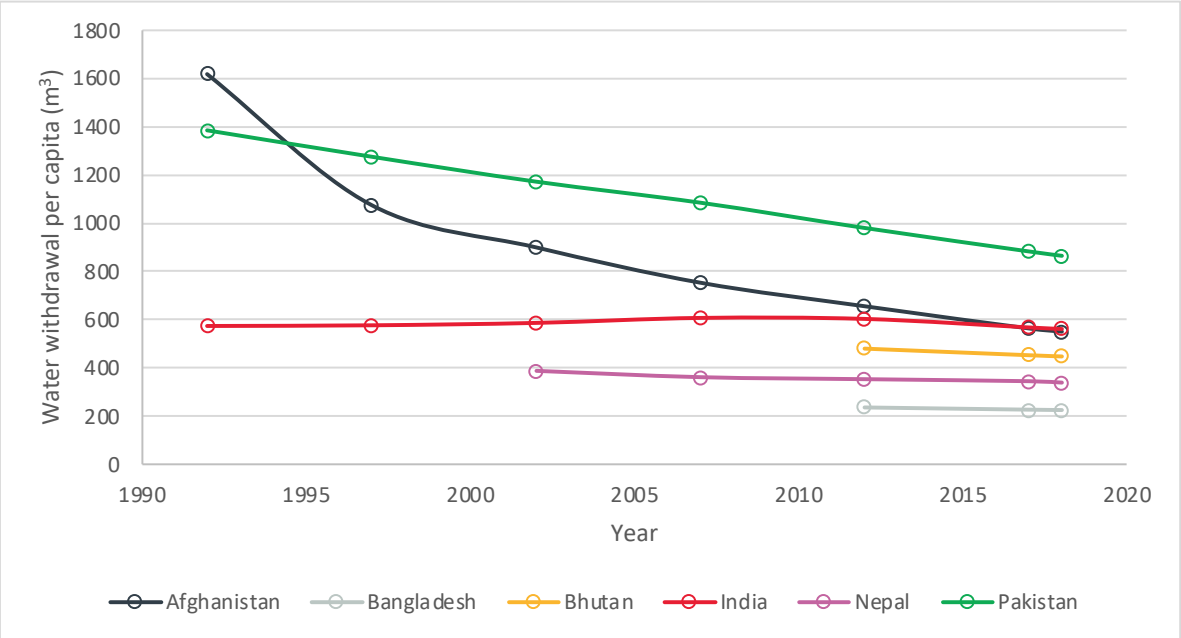
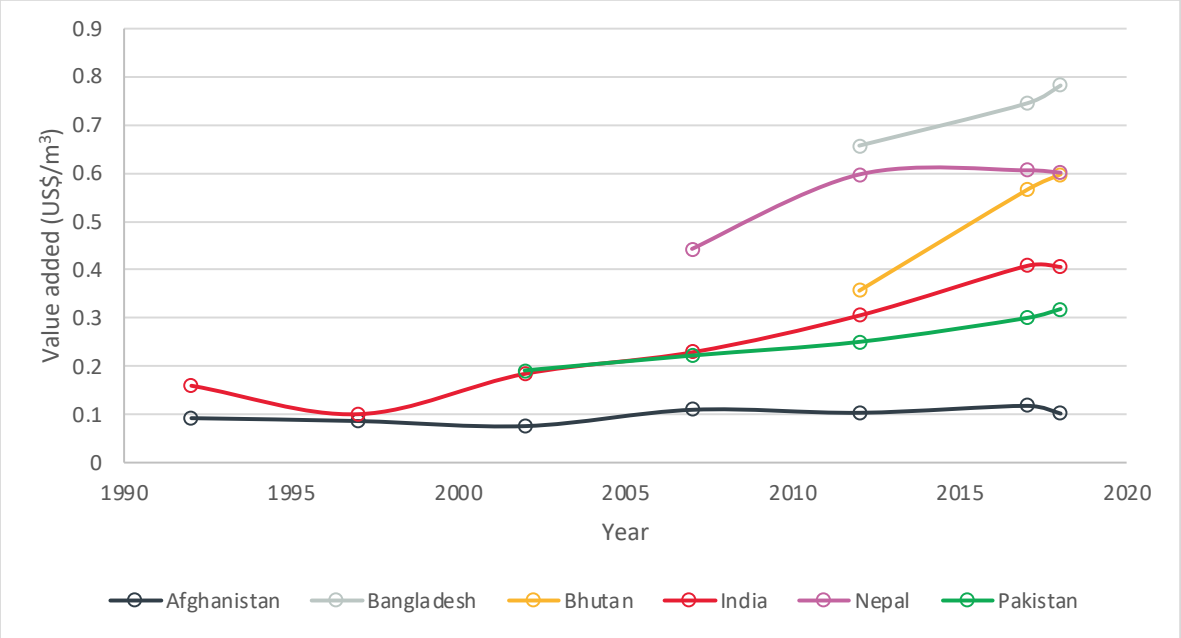


Figure 2: Agriculture water use efficiency: value added per unit water used in agriculture, including livestock, aquaculture and irrigated crops (US$/m³); AQUASTAT database (FAO, 2022a)



1.6 Greenhouse gas (GHG) emissions

Almost half of Pakistan's GHG emissions come from agriculture, forestry, and other land uses (46%), the other half coming from the energy sector (45%), and to a lesser extent industrial processes (5%) and the waste sector (4%) (UNFCCC, 2021). Pakistan's agricultural sector produced about 204 MT of CO_2eq in 2019, representing a 30% increase in emissions in this sector in the past 10 years and they are expected

to continue rising (FAOSTAT, 2022). Although Pakistan's contribution to global emissions represented only 0.8% in 2019, Pakistan was the 5th country with the highest emissions from agriculture in that year (FAOSTAT, 2022). More than half (61%) of all agricultural emissions in the country between 1990-2017 were generated by enteric fermentation, with the remainder due to manure left on pastures (11%), synthetic fertilizers (10%), rice cultivation (7%), manure management (6%) and crop residues (2%) (FAOSTAT, 2022).

Data on GHG emissions does not exist at the provincial level, however, both Punjab and KP significantly contribute to emissions from agriculture, while also presenting opportunities for mitigation. Punjab rears over 25% of the national livestock population and produces 55.2% of the country's rice, therefore it is responsible for at least one quarter of emissions from enteric fermentation and half of emissions from rice cultivation, respectively (calculated from GoPJB L&DDD, 2018; GoP Finance Division, 2019; GoPJB CRS, 2021). The agriculture and forestry sector in KP are also likely responsible for the majority of emissions of the province. KP rears 17.1% of the major livestock species and produces 2% of the national rice production, therefore contributing 17% to the total enteric fermentation emissions in the country and 2% to emissions from rice (calculated from GoKP L&DD, 2019; GoP Finance Division, 2019; GoKP CRS, 2021). In addition, Khyber Pakhtunkhwa is responsible for 90% of all tree cover loss between 2001 and 2021, which in total amounted to a 1.0% decrease in tree cover (9.75kha) in the last decade, and 3.56MT of CO_2 emissions (Global Forest Watch, 2022). Opportunities exist to reduce emissions in KP and Punjab through the adoption of better practices, particularly reducing methane from enteric fermentation, promoting better manure storage and management, reducing methane for rice cultivation, and improving irrigation and water management (CDNK, 2016). Likewise, the forestry sector in KP presents excellent opportunities for mitigation.

1.7 Challenges in the agricultural sector

Pakistan's agricultural sector is facing growing challenges, including (i) social challenges, (ii) challenges related to prices, trade, and regulations, (iii) natural resources, and (iv) agriculture support services.

1.7.1 Social challenges

Rising population, urbanization and inflation are deteriorating social indicators and putting greater pressure on farmers. Rapid population growth has been a trend all over Pakistan, with Punjab's population growing at 2% annually and KP at 2.4% (FAO, 2019a; GoPb, 2017b). Pakistan also shows the highest urbanization rate in South Asia, and it is projected that by 2025 half of the population will live in cities (UNDP Pakistan, 2018). Rising urbanization has not happened with the necessary increase in growth, jobs and productivity, leading to inequality, poverty and environmental degradation (UNDP Pakistan, 2018). Furthermore, the growing housing shortage and the difficulty in accessing land has resulted in an urban sprawl that has expanded to fertile agricultural land, shrinking the agriculture production area (UNDP Pakistan, 2018). Coupled with population growth and therefore a higher demand for food, farmers in rural Pakistan face increasing pressure. The COVID-19 pandemic has also resulted in rising poverty, unemployment, and food and housing insecurity for the vulnerable, many of which are rural agricultural workers, undoing the recent progress in development and exacerbating inequalities (UNDP, 2020).

High inflation, institutional gaps, and poor economic opportunities are leading to outmigration of rural workers. Although average consumer inflation slowed from 10.7% to 8.9% in FY2020, the rising food an energy prices kept it above the 6.5% set by the State Bank of Pakistan (Asian Development Bank, 2021). In addition to high inflation, the projected rise in taxes in order to pay off public debt poses another threat to the Pakistani population. Pakistan's public debt has been consistently increasing since 2020 and as of March 2022, it stood at 42.9 PKR (USD 214.5 billion), 76.6% of the country's GDP (SBP, 2022b; WB, 2022b). Both domestic and external debt have increased in the past 3 years, which has not been matched by the growth of gross national income and exports (WB, 2022a). Institutional gaps and political instability are also reducing foreign investment, which is needed for agricultural development (Mangi & Vishnoi, 2021). Furthermore, prolonged conflict in certain

areas coupled with poor economic opportunities and lack of resources, are also driving outmigration of the rural agricultural workers to other provinces and internationally, especially in KP (FAO, 2019a). Outmigration will also be exacerbated by extreme weather events and natural disasters, which are already a main cause for migration in Pakistan (FAO, 2016; Savelli et al., 2021).

Stronger farmer organization and government support is needed for farmers to cope with the growing challenges in agriculture and to empower women. The education levels among the rural population are low (especially for women, who have higher difficulties accessing education) and will need to increase to keep up with the growing challenges in agriculture (FAO, 2015). Land ownership restrictions also limit farmers' capacity to adopt risk coping strategies, with access to credit from financial institutions for risk management being significantly higher for owner farmers than for tenant farmers (R. Ullah et al., 2019). This is especially a problem for rural women in agriculture, who lack access to land ownership rights. In fact, gender inequality and discrimination are main issues in the agriculture sector, with women lacking access to not only land, but also to the latest technologies, extension support, credit, and decision making (FAO, 2015). Farmer organization networks and water use communities also need strengthening to address the current and future market and climate challenges. Despite considerable developments in farmer organization in the last 70 years, more needs to be done to support smallholders in staying competitive, including strengthening provincial government support, channelling government services to farmer organizations, and increasing capacity building of members (ACIAR, 2019). Strong farmer organization and government support is absolutely needed to facilitate access to credit, extension services, quality inputs, new farming technologies and practices, and improving management skills, so farmers can adapt their systems to the threats of climate change (ACIAR, 2019).

1.7.2 Prices, trade, and regulations

The rising global food and energy prices along with supply disruptions pose major risks for the agricultural sector in Pakistan. The recovery of global activity from the COVID-19 pandemic and the increased demand for commodities has led to a rise in inflation globally, especially in emerging markets and developing economies such as Pakistan, which have suffered a depreciation of their currency (TDAP, 2021). As a result, food and energy prices in Pakistan have been rising, especially for essential commodities from and for agriculture (oil, gas, wheat, sugar, palm oil, soybean, fertilizers, and other inputs). In Pakistan, food price inflation has remained elevated due to supply chain disruptions, increased support for wheat and sugarcane and an extended wet monsoon season (Asian Development Bank, 2021). Other underlying causes of price increases are stagnant agricultural productivity, inefficient use of natural resources (mainly water) and weather-related shocks (D. Khan et al., 2021). In addition, global disruptions of energy supplies from Russia are driving energy prices up, which poses a threat for an oil-importing country like Pakistan (Qaiser, 2022). The rise in energy prices could lead to many negative cascade effects such as higher electricity rates, living costs and unemployment, which will be suffered the most by low-income workers including from agriculture (Qaiser, 2022). Indeed, consultations with stakeholders in KP and Punjab identified price fluctuations as a major risk factor for agriculture in both provinces.

Pakistan has increased its import dependency, especially of food products, and imports are becoming more expensive. Maintaining competitive export prices is another challenge for Pakistan's trade. The depreciating value of the Pakistani rupee against the US dollar has contributed to the rise in imports, since imports are becoming more expensive over time and triggering panic buying in the market (Geo News Business Desk, 2022). The growing reliance on food imports poses a threat to food security, since it drives food prices further up leaving nutritious foods out of reach of low-income households (Savelli et al., 2021). Regarding exports, maintaining prices of export crops such as cotton at competitive levels with the international market while ensuring profit for growers has also been a great challenge for policy makers. The ongoing Russo-Ukraine war will also likely have negative effects on Pakistan's trade, since Pakistan imports a significant amount of wheat from Ukraine (39% of total imported wheat in 2021) which will be directly impacted by the current conflict.

Inefficient regulation of food commodities (mainly wheat and sugarcane) has left farmers out of government support, and difficult their entrance to new export markets of high-value agricultural

products. The government has focused on supporting a few food commodities (mainly wheat and sugarcane), since sugar production is costly, and wheat is the main staple food in Pakistan. However, consumers and smallholders have not reaped the benefits of the government support to the wheat sector, which mainly benefits large farmers, middlemen who buy from smallholders, and the flour mills which receive the subsidies that do not translate to lower consumer prices (D. Khan et al., 2021). Regulations in the sugar sector also need reform, with liberalization of sugar imports being needed to reduce prices and contain domestic market fluctuations (D. Khan et al., 2021). The government focus on supporting wheat and sugarcane has discouraged the production of high-value crops, resulting in Pakistan being an importer of horticultural products. Pakistan could take better advantage of new export opportunities of fresh produce and livestock products (D. Khan et al., 2021), however, the transition from over dependence on cash crops to other high value food commodities would require considerable financial, infrastructure, input and policy support from the government, private sector and institutions (CIAT & FAO, 2018).

1.7.3 Natural resources

Deficiency in water availability, land degradation and forest loss are the main threats to natural resources in Pakistan. The changing climatic conditions are affecting the availability and quality of natural resources, mainly water. The majority of the country's territory (80%) is classified as arid to semi-arid, especially in Punjab, which relies extensively on the Indus Basin irrigation system (WBG & ADB, 2021). There is a heavy reliance on irrigation which is highly inefficient due to seepage and leakage and poor irrigation practices at farm level. The increased demand for irrigation water in agriculture and for other sectors and the reduced water availability poses a severe threat to water resources management in Pakistan (CIAT & World Bank, 2017b). Unchecked groundwater abstraction for agriculture and industry is also reducing water quality, and the water table and aquifers have become contaminated by unregulated discharge(N. Iqbal et al., 2020; Qureshi, 2015). Overextraction of groundwater (especially in saline areas), waterlogging and a lack of drainage in irrigated systems of the Indus Basin are increasing soil salinity problems (Qureshi, 2020). Soil and forest degradation are additional threats to natural resources in Pakistan. The World Wildlife Fund (WWF) says Pakistan lost 43,000 hectares of forest land every year from 2000 to 2010, which is the highest rate of deforestation in South Asia (Baloch, 2022). The coastal areas are also suffering from degradation with largescale restoration programs required. Stakeholder consultations identified that with the worsening of natural resources, conflicts due to resource scarcity pose a high risk for agriculture in Punjab and KP.

1.7.4 Agriculture support services

Low mechanisation and technology adoption, poor infrastructure, and a lack of access to credit, limit farmers' capacity to access and compete in national and international markets. The backbone of the agriculture sector is composed of smallholder farmers, who lack access to machinery, modern farming methods and technologies, storage facilities and transportation, electricity, inputs, and improved seeds (Spielman et al., 2017). The high prices and the lack of support from the government restrict farmers from adopting better techniques and technologies. While irrigation is widely available in both Punjab and KP, access to machinery for land preparation and harvesting is still difficult, due to the lack of availability for appropriate machinery and high costs (FAO & GoKP, 2015; CIAT & FAO, 2018). Rural areas lack properly constructed farm to market roads, processing, and storage facilities, resulting in high levels of post-harvest losses, especially for high value perishable foods such as vegetables and livestock (GoP, 2014). The lack of post-harvest facilities and inadequate market infrastructure severely restrict outcomes, leading to low prices for farmers (ACIAR, 2019). In Pakistan, smallholders are very isolated from markets and depend upon local contractors and middlemen to sell their produce, which makes them easily exploited with high levels of middleman profit capture. This market isolation also reduces the flow of information to smallholders and thus their ability to adjust to changing market conditions (ACIAR, 2019). Furthermore, lack of access to formal financing options limits the adoption of technological innovations. Farmers in Pakistan, smallholders rely heavily on informal sources of credit, since minimal asset ownership and lack of collateral limits farmers' access to credit markets (GoPb, 2017a). Other major issues limiting smallholder access to credit in Pakistan are low financial inclusion and financial literacy,

low credit disbursement for livestock and dairy farmers, high transaction costs of lending to smallholders and unsuitable lending products, lengthy bank procedures and lack of credit in time of need, and lack of credit for women (ACIAR, 2019).

Adoption of insurance solutions to de-risk smallholder farmers in Pakistan is limited despite the urgency to build climate resilience. Parametric or index-based insurance is a promising solution that remains largely untapped in Pakistan. Farmers receive payouts based on a predetermined metric (such as weather, yields and vegetation levels) without the need for government to declare a calamity or the need for physical assessments. Index-based insurance products are often bundled with credit support. However, progress is slow with a few ad-hoc pilot interventions implemented in some parts of the country. Pakistan does not have a national crop insurance framework but deliberations are underway with key stakeholders (MEFIN, 2018). In recent years, FinTech and other companies are also receiving regulatory support to enable innovation in crop insurance (Securities and Exchange Commission of Pakistan, 2019). Yet, considerable challenges need to be overcome to effectively service remote areas. Index insurance should be integrated into broader programs for development and climate risk management, informed by appropriate risk assessments and context analysis (Greatrex et al., 2015). Insurance often makes up the last component of a climate risk management plan, only used to transfer risk that cannot be reduced in any other way.

Effective climate information services and early warning systems for farmers in Pakistan are not developed. Climate information services and early warning systems in Pakistan are underdeveloped and underutilized (WMO, 2021). National public institutions, mandated to collect, analyse, and communicate meteorological and hydrological data, lack the necessary capacities to provide such services. Moreover, Pakistan's datasets on temperature, precipitation, soil moisture, and other climate parameters are absent or inaccessible, making it difficult to forecast risks (Tauqeer Sheikh, 2021). Pakistan has also not developed a national framework for climate services, which would facilitate collaboration among national institutions to deliver science-based climate projections and services (Tauqeer Sheikh, 2021).

Extension services are not reaching many smallholders and need modernisation to enhance smallholders' capacity to enter new markets. The lack of extension services is another major constraint faced by smallholders, of which provincial governments are responsible of providing (ACIAR, 2019). In Punjab, although the Agriculture Department has a large force of extension service personnel, extension services are still weak, with only 27% of farming households surveyed reporting visits from extension agents (IFPRI, 2016; ACIAR, 2019). In KP, farmers also have limited access to agricultural extension services, with farmers in rainfed areas reporting receiving extension support less than once per year (A. Ullah & Khan, 2019). The state-funded Model Farm Service Centers (MFSC), introduced in KP by the provincial government in 2008, have improved farmers' access to advisory services and quality agricultural inputs such as seeds, fertilizers and machinery. However, additional efforts and funding are needed to ensure that the extension services provided through the MFSCs reach farmers in remote areas and their capacity is also enhanced (GoP, 2014; Shah et al., 2019). Modernizing extension services is also needed in order for farmers to move away from the production of grains towards other high value products, such as livestock, to meet the requirements of modern food supply chains (ACIAR, 2019). Moreover, extension services need to cater not only to large commercial farmers, but also smallholders and women in agriculture (ACIAR, 2019).

Section

2

Climate change and Pakistan's agriculture

The modelling results presented in this chapter are taken from a climate change analysis conducted by the Potsdam Institute for Climate Impact Research (PIK) under the GIZ SAR project, which can be found in its entirety in their 2022 "Climate Risk Profile for Pakistan" (PIK, 2022). The profile provides an overview of projected climate change and related impacts on different sectors—including agriculture. The analysis models two future climate change scenarios or Representative Concentration Pathways (RCP), a low emission scenario (RCP2.6) and a medium to high emissions scenario (RCP6.0), to 2080 looking at key climate parameters, climate related hazards, and the yield response of major crops.

HIGHLIGHTS

- Temperatures in Pakistan have increased by 0.6°C in the past century (ADB, 2017b), and by 2080 are projected to increase between 2°C (RCP2.6) and 4.1°C (RCP6.0) depending on the emissions scenario, with higher temperature increases in the north. Heatwaves are projected to become more frequent which will negatively impact crop yields and livestock health.
- Precipitation trends in Pakistan are uncertain and vary across the country. Though an overall increase in annual precipitation of up to 9mm is projected by 2080, Punjab will experience decreases in precipitation until 2050, and KP's precipitation levels will remain relatively unchanged. Dry and wet periods are likely to become more extreme, with the increased incidence of drought (IPCC, 2022b) and heavy rainfall (IPCC, 2022a)
- Pakistan ranks 8th among the most affected countries by extreme weather events between 2000-2019 (German watch, 2021). With heavy rains, floods, and drought becoming more frequent and intense across the country, water scarcity and water excess will both threaten agricultural production. Water availability per capita is expected to decline, limiting the water resources for agriculture (GoP & PDD, 2014).
- Yields of wheat, rice, and maize (three of the most important crops for food and income) will be negatively impacted by climate change across most regions of Pakistan. Wheat yields will be the most affected by the high temperatures (IPCC, 2022a), while yield increases could be observed for rice and maize in areas of northern KP and southern Balochistan depending on water availability (S. Ali et al., 2017).
- Further negative impacts of climate change on ecosystems and natural resources of Pakistan are expected, including land degradation, higher incidence of pests and diseases, tree cover loss, and biodiversity loss, among others.

2.1 Climate impacts on agriculture to date

Rising temperatures and more frequent heat waves are suppressing the yields of wheat, maize, rice and other major crops in Pakistan. Livestock health and feed availability are also being affected. In the past century, temperatures have increased all over South Asia, with Pakistan experiencing a 0.57°C warming in annual mean temperature from 1961-2007, with the largest increases occurring during the winter and after the monsoon months (ADB, 2017b). The southern regions of Pakistan have witnessed the highest increases in winter temperature, with Punjab, Sindh and Balochistan experiencing an increase of 0.91°-1.12°C compared to a 0.52°C increase in Khyber Pakhtunkhwa (WBG & ADB, 2021). The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) notes that due to the rising temperatures and other climate change impacts, yields in Asia have decreased for maize, wheat, rice, and especially soybean (IPCC, 2022c). Furthermore, longer and more frequent heatwaves in South Asia and Pakistan are affecting both crops and livestock health (IPCC, 2022a). The valleys of the Indus basin are some of the regions of South Asia most affected by heatwaves (Im et al., 2017). The rising temperature and heatwaves in Pakistan have negatively impacted the yields of cereals and other crops by shortening the cropping seasons, increasing evapotranspiration, and increasing crop irrigation requirements (A. Ali & Erenstein, 2017). Even with appropriate levels of soil moisture, heat stress still reduces the transpiration rate of crops, ultimately reducing growth and yield of several important crops (such as maize, wheat, rice, oilseed crops, or tomato) (Fahad et al., 2017). There is limited evidence of the impacts of climate change on livestock in South Asia to date, however, weather extremes, heat stress, and reduced water availability are likely to be reducing feed availability and animal health. Globally, South Asia is the region whose livestock population shows the highest vulnerability to climate change (IPCC, 2022a).

Precipitation patters are becoming increasingly unpredictable, with consequent impacts for agricultural productivity in Pakistan. Severe floods in recent years have caused considerable damage to agriculture and livelihoods. The precipitation profile of Pakistan over the past century has been complex. Pakistan witnessed a decreasing trend in annual rainfall until 1960, after which a slight increasing trend has been observed but with considerable regional variation (WBG & ADB, 2021). Average annual rainfall along the coast and arid plains has decreased by 10-15% since 1960, contributing to the degradation of the country's wetlands and mangrove ecosystems. In the north of the country (including KP) the greatest disruptions in agriculture have been caused by irregular rainfall patterns which are becoming increasingly difficult to forecast (Babar et al., 2015). The number of heavy precipitation events has also increased since 1960, with the nine wettest days on record in KP occurring in 2010 (WBG & ADB, 2021). The resulting 2010 floods are considered one of the worst natural disasters in Pakistan's recent history (FAO, 2010; SLRC, 2012). The devastating floods were followed by further flooding events in 2011 and 2014, which collectively resulted in USD$18 billion in economic losses, impacted the livelihoods of 38million people, and damaged 4.3million ha of agricultural land across the country (GoP, 2016a). These intense rainfall events are resulting in increased agricultural losses by physically damaging crops, delaying planting and harvesting, causing oxygen deficiency in soils and nutrient leaching (Li et al., 2019).

Unpredictable rainfall, higher temperatures, and the over exploitation of water resources is increasing issues of water scarcity in Pakistan, with consequences for irrigated and rainfed agriculture. Decreasing precipitation trends in mainland South Asia have contributed to a higher incidence and severity of droughts (IPCC, 2022a). In addition to falling precipitation, higher temperatures are increasing the evapotranspiration rates, raising the water requirement of crops, and therefore compounding issues around water scarcity. Furthermore, maladaptive responses to water scarcity have seen the proliferation of tube wells which in some areas have depleted the water table to such an extent that areas are no longer available for cultivation (Ghazanfar et al., 2009). In addition to decreasing water tables, Pakistan has experienced severe droughts during the beginning of the century (e.g., 2004-2005 and 2009), and most regions have been classified as severe-to-high drought prone areas, including Punjab and KP (S. Ahmad et al., 2004). The 1998-2002 droughts, some of the longest and most severe at national scale, resulted in yield reductions of major crops by up to 10% and the death of 2 million animals (S. Ahmad et al., 2004; Waseem et al., 2021). In KP, droughts during the rabi

season have worsened in recent years, and the climate is becoming less favorable for the cultivation of wheat (Babar et al., 2015). Punjab has also suffered from severe droughts, which are shortening the growing season of wheat and maize and increasing the likelihood of poor yields. For instance, a recent study showed that maize yield was negatively affected by drought in Punjab, with drought causing 27% of maize yield variations (Waseem et al., 2022).

Climate change is driving accelerated rates of land degradation and creating conditions that are conducive to the spread of insect pests and diseases. Climate change and poor management practices have been identified as a major contributing factor to the degradation of rangelands, pastures, and forests, especially in northwestern Pakistan, reducing herd mobility and increasing pressure on natural resources (IPCC, 2022a). Unsustainable farming and grazing practices, deforestation and inadequate reforestation techniques as well as poor watershed protection and excessive water abstraction for irrigation have resulted in major environmental issues, including soil erosion and desertification (Bashir et al., 2017; A. N. Khan & Ali, 2015). With the rising temperatures, pest suitable area across SA is also increasing. In KP, 20-40% of yields are lost annually to pest infestations and outbreaks of crop diseases, something that is projected to become more common under climate change (GoP Finance Division, 2018).

BOX 1: Heatwaves and flooding severely impact agricultural livelihoods in 2022

The year 2022 has been another catastrophic year for Pakistani agriculture after being hit by a succession of extreme weather events with devastating knock-on effects. From March-May 2022, Pakistan recorded some of the highest temperatures in the country in the last 60 years, with some cities in the south reaching 51°C (The Print, 2022). The prolonged heatwaves were coupled with almost no rainfall in Balochistan, Sindh and Punjab during the spring, causing severe drought conditions and difficulting access to water for agriculture, reducing productivity (e.g. up to 20% wheat yields reductions in the south) (Kunbhar, 2022). The heatwaves were then followed by an unusual heavy monsoon, which was 68% above normal rainfall levels in Punjab and Sindh. The torrential rains have caused devastating flash floods, leaving one third of the country underwater.

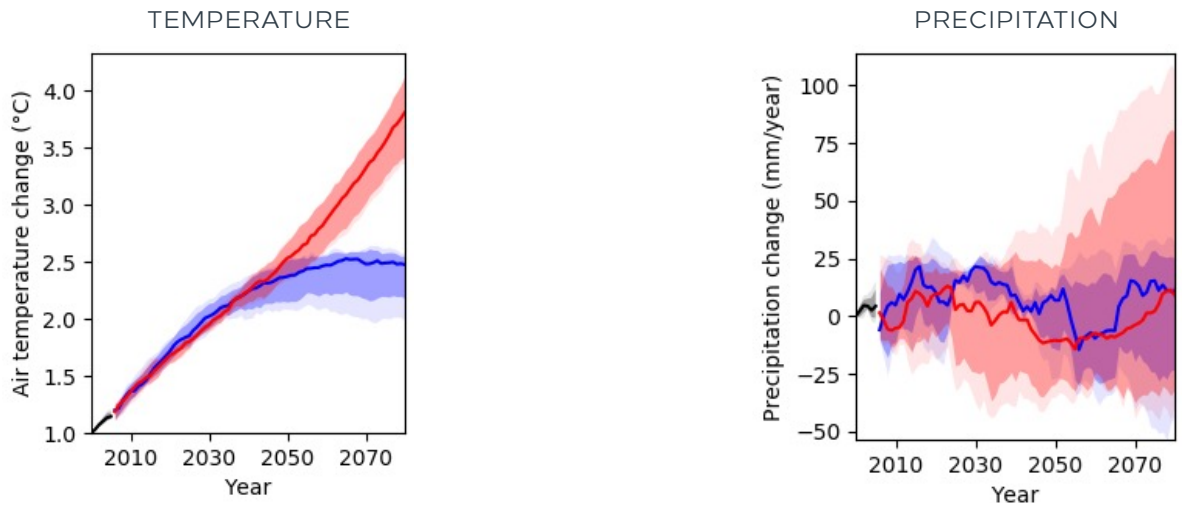
As of September 2022, 80 districts have been declared 'calamity hit': 31 in Balochistan, 23 in Sindh, 17 in KP, 6 in Gilgit-Baltistan and 3 in Punjab. Between June and September 2022, 33 million people have been displaced, there have been over 1,200 human casualties, more than 733,000 livestock deaths, around 1.46 million ha of crops and orchards affected, and over 3,000 km of roads and 145 bridges partially or completely destroyed (UN News, 2022) (UN OCHA, 2022). In Sindh alone, the floods have caused significant losses to crops such as cotton (45%), rice (31%) or dates (85%) (Kunbhar, 2022).

In KP, the combined effect of high temperatures and heavy rain also caused a glacial lake to burst further damaging infrastructure (The Print, 2022). The UN is set to launch a USD 161 million flash appeal for Pakistan to provide food and cash assistance (UN News, 2022). Repercussions from the floods will likely include a rise in water-borne diseases, higher cotton imports, compromised rice exports, rising inflation, and supply shortages for essential household food products such as meat, milk, onions or tomatoes. It is estimated that 73% of the households affected by the floods will face difficulties in accessing food (UN OCHA, 2022).

2.2 Climate projections and risk

Temperatures are projected to rise all over Pakistan by 2-4°C depending on the emissions scenario, with the highest warming projected in the north. The southern coast and plains will experience the least warming, though remaining the hottest areas. Increasing greenhouse gas concentrations will continue to cause temperatures to rise in Pakistan. Under the strong mitigation scenario RCP2.6, average temperatures in Pakistan are projected to rise by 2.0-2.6°C, whereas under the more realistic RCP6.0 scenario temperatures are projected to rise by 3.4-4.1°C by 2080 (relative to the year 1876) (Figure 3). Up to 2030, all regions are projected to experience 1°C warming, and in the second half of the century regional differences will become more pronounced, with the strongest temperature increases projected for the northern regions of Pakistan (including KP). Under RCP2.6, temperatures in northern Pakistan are projected to reach and stabilise at 2°C warming by mid-century (compared to 2000), whereas under the medium/high emission scenario RCP6.0, temperatures will continuously increase up to 3.9°C by 2080 (Figure 4). The southern coast is projected to experience the least warming, with up to 2°C temperature increases by 2080 under RCP6.0, although in absolute terms areas along the southern coast and plains (including Punjab) will remain the hottest with annual mean temperatures of over 35°C projected to increase by 2-3°C by 2080.

Figure 3: Projected changes in annual mean temperature (left) and annual mean precipitation (right) for Pakistan for two GHG emission scenarios: RCP2.6 (blue) and RCP6.0 (red). *Lines represent the best estimate (multi-model median) and shaded areas the likely range (central 66%) and the very likely range (central 90%) of all model projections.*



Annual precipitation is expected to increase in the south and north and decrease in the interior, though there is no clear long-term trend in precipitation. Under the high emissions scenario, precipitation levels in Punjab and southern KP are projected to decline by mid-century. Due to model variability and uncertainty, projections of precipitation are less certain than projections of temperature. Two climate models project decreases in mean annual precipitation in Pakistan, with the other two projecting moderate and strong precipitation increases, respectively. Model ensemble projections show a 10% increase in precipitation under RCP2.6 and a 9% increase under RCP6.0 without a clear long-term trend for either scenario. Furthermore, model predictions show considerable regional differences in precipitation trends. Under the very likely RCP6.0 scenario, annual precipitation is expected to slightly decrease by up to 15% for the whole of Punjab province and areas in northern Balochistan by 2050. Model predictions show a shift in precipitation patterns for Punjab during the 2nd half of the century, with precipitation increases by up to 20% with respect to the year 2000. Other parts of Pakistan are expected to see increases in precipitation, with Sindh showing increases up to 57% (a small increase in absolute terms considering Sindh receives on average <200mm/year) by 2080 under RCP6.0, and northern KP showing a steady increase in precipitation up to 20%.

Figure 4: Regional projections of mean air temperature for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), relative to the year 2000.

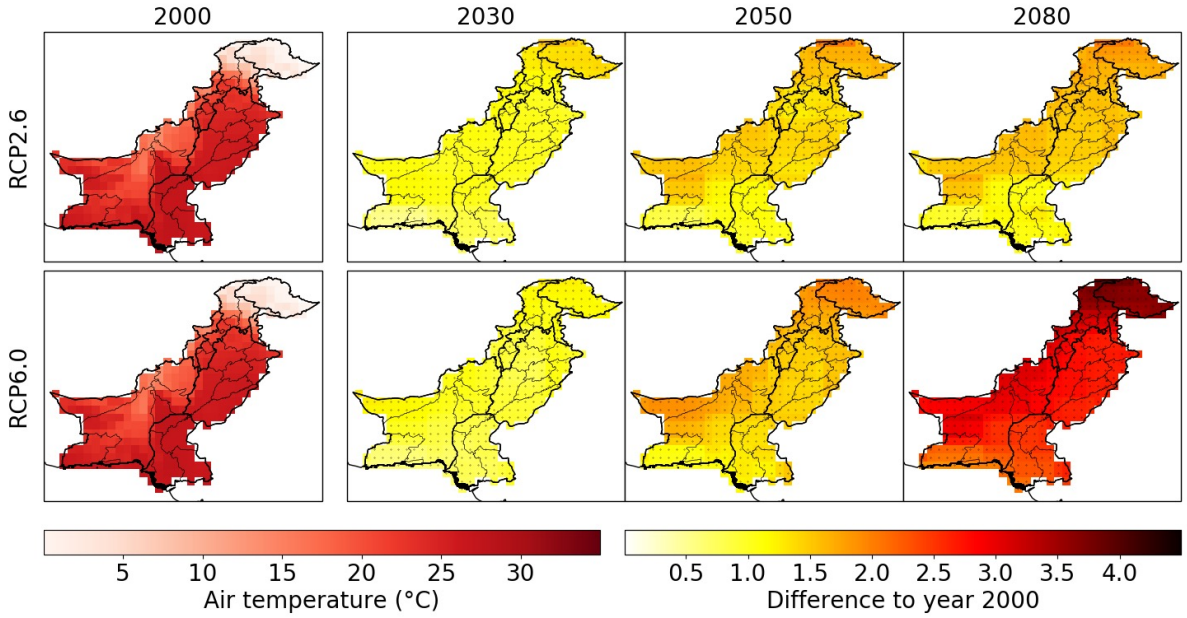
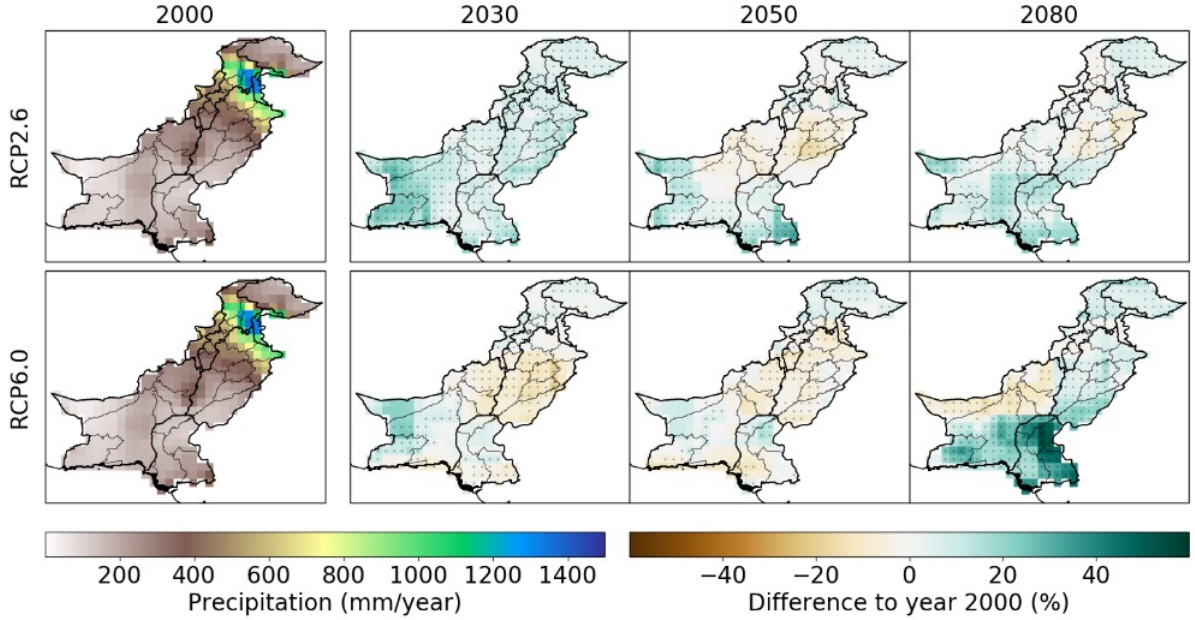


Figure 5: Regional projections of annual mean precipitation for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), relative to the year 2000.



2.3 Climate hazards detrimental to agriculture

Heatwaves are projected to become more frequent in all provinces. Heat stress will continue to suppress crop yields and affect livestock and farmers' health. The number of days with daily maximum temperature above 35°C is projected to rise dramatically and with high certainty all over Pakistan under RCP2.6 and RCP6.0, especially in northern Punjab, southern KP, western Balochistan and the southern coastline. Some parts of Pakistan, such as southern Punjab, already experience over 200 very hot days per year, which are defined as

days with mean temperatures above the threshold of 35°C, which present a threat to human and animal health, and crop productivity (Carleton & Hsiang, 2016; Christidis et al., 2019). Rising temperatures will also result in increased exposure to heatwaves and increased heat-related mortality. Under RCP6.0, the population affected by at least one heatwave per year is projected to increase from 7.8% in 2000 to 45.4% in 2080, which will particularly affect farmers or pastoralists who work outdoors exposed to the elements. Furthermore, under RCP6.0, heat-related mortality is projected to increase from 2.3 to 8.2 deaths per 100,000 people per year by 2080 compared to year 2000 levels, provided that no adaptation to hotter conditions will take place. These findings are in line with the IPCC AR6 projections for South Asia, which indicate that heatwaves have increased and will become more frequent and intense during the 21st century (IPCC, 2022b). The agricultural regions of the Indus basin will be some of the most severely affected, where heatwaves have already caused thousands of deaths to humans and livestock (Im et al., 2017). Heat stress will also negatively impact the yields of important crops in Pakistan, such as wheat, rice and maize (Fahad et al., 2017).

Higher potential evapotranspiration and lower soil moisture will negatively impact agricultural water supply at surface and groundwater levels. Potential evapotranspiration (the amount of water that would be evaporated and transpired if sufficient water was available at and below land surface) is expected to increase worldwide due to global warming. Projections for Pakistan indicate a stronger rise of potential evapotranspiration under RCP6.0 than under RCP2.6, with a 9.1% increase by 2080 compared to year 2000 under RCP6.0. The highest increases will be observed in northern Pakistan, while the southeast will continue to have the highest evapotranspiration rates in absolute terms. In addition, model projections for soil moisture (accounting for precipitation but not irrigation) show a slight decrease under both RCPs by 2080 compared to the year 2000, but without clear regional trends. Increased evaporation from the soil and transpiration from plants can lead to water losses, ultimately decreasing soil moisture, limiting the amount of water available for crops and exacerbating drought conditions (Fahad et al., 2017). Though crop sensitivity to drought can be mitigated with irrigation, surface and groundwater supplies are becoming increasingly scarce in Pakistan, which will pose a challenge for farmers to meet crop water requirements (Waseem et al., 2021).

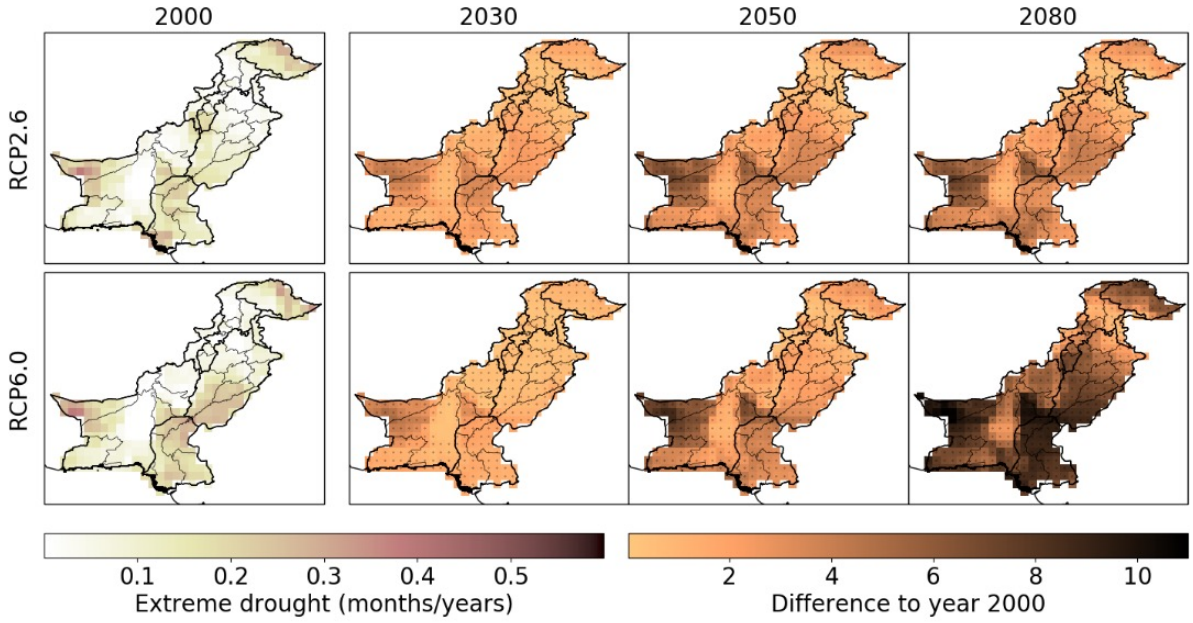
Pakistan is projected to see worsening drought conditions across the whole country, especially in the arid and semi-arid regions of the south and west. Extremely dry months are months with a strong imbalance between precipitation and evapotranspiration, without accounting for irrigation. The number of extremely dry months is projected to increase across Pakistan under both RCPs, with western Pakistan reaching on average 5 extremely dry months per year by 2030 (Figure 6). Regionally, KP is the province with the lowest projected increases in extreme drought, while most of the Punjab province is projected to reach up to 8 extremely dry months per year by 2080 under RCP6.0 (Figure 6)—this does not account for surface water resources available through the Indus basin irrigation but will impact the irrigation water requirement (see implications in next paragraph). These projections are in line with other projections for South Asia, which predict that during the 21st century droughts will become more frequent and intense in arid and semi-arid areas, such as Punjab (IPCC, 2022b). Furthermore, the national crop land area exposed to at least one drought per year is projected to increase from 0.52% in 2000 to 2.46% in 2080 under RCP6.0. The more frequent and severe droughts will threaten agricultural production, increasing the risk of food insecurity particularly for subsistence farmers (M. P. Iqbal, 2020).

Water availability per capita will drastically decrease in Pakistan due to population growth and increased water demand, particularly in Punjab. Regional differences in water availability will increase the likelihood of water competition between sectors and provinces. When accounting for population growth according to SSP2 projections[3], per capita water availability for Pakistan is projected to decline 58% under RCP2.6 and 41% under RCP6.0 by 2080 relative to the year 2000. This decline is predominantly driven by socioeconomic factors, such as population growth, increased agricultural production, and increased water abstraction for irrigation

[3] Shared Socio-economic Pathways (SSPs) outline a narrative of potential global futures, including estimates of broad characteristics such as country-level population, GDP or rate of urbanisation. Five different SSPs outline future realities according to a combination of high and low future socio-economic challenges for mitigation and adaptation. SSP2 represents the "middle of the road"-pathway.

and drinking water among others—but declining water availability will magnify these challenges (Kerres et al., 2020). These findings are in line with previous assessments of water availability in Pakistan, which project a decline of up to 1100m3 water per capita by 2025, making Pakistan a water-scarce country (GoP & PDD, 2014).

Figure 6: Regional projections of extreme drought for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), relative to the year 2000.

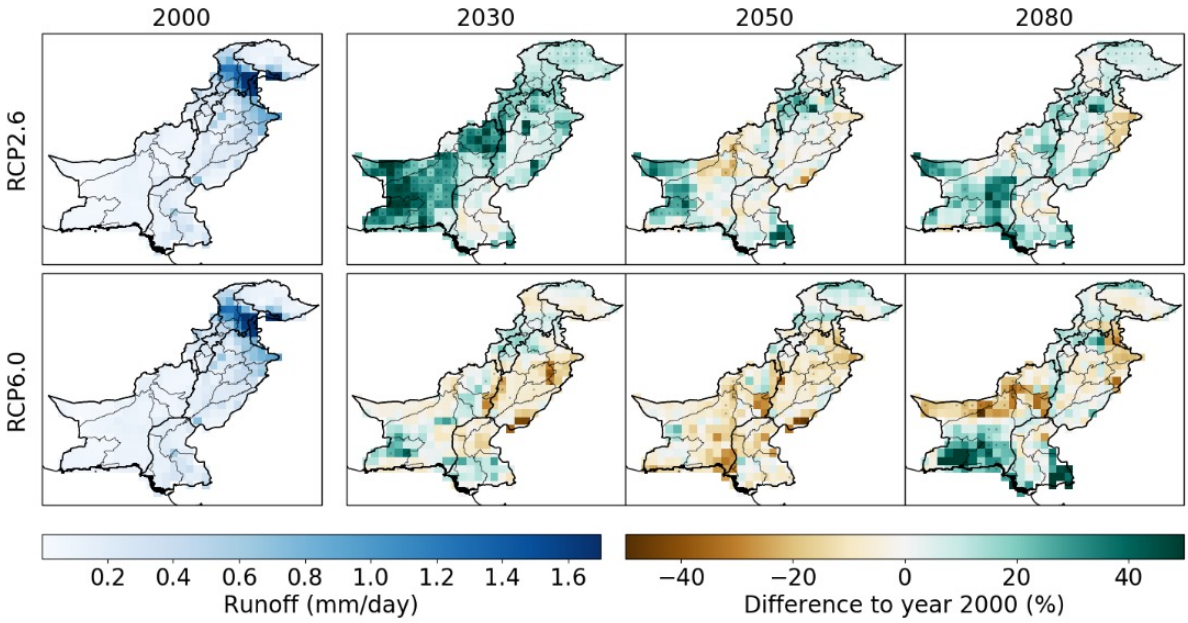


Projections of future water availability vary depending on the region and scenario (Figure 7). Under RCP6.0, only the south experiences stronger increases in water availability of up to 77 %, while other regions, such as eastern Punjab, are projected to experience decreases of up to 50%. While in the short-term, melting glaciers are providing increased water to the Indus River system, their important contribution is likely to decline in the future as shrinking glaciers contribute less melt water during the summer months (UNDP, 2017). When coupled with a higher unpredictability of the timing and strength of monsoon rains, these will have a direct effect in agriculture, especially in Punjab (ADB, 2017b; M. Z. Khan et al., 2021). In addition, increasing intersectoral water demands (e.g. for agricultural, industrial, hydropower and household use) will lead to degradation of water resources, which in some regions, are already scarce (Watto et al., 2021). Disputes over water sharing among provinces are also common, with provinces often reporting receiving less water than their entitlement during dry years, which are becoming more frequent. Although the allocation of Indus river water among the four provinces under the Water Apportionment Accord of 1991 is straightforward, it was not formulated to respond to the growing economic and social changes in the provinces nor to the upcoming changes in climatic conditions (D. Hassan et al., 2019).

Heavy precipitation events are expected to become more intense and frequent in the north, east, and south of Pakistan, increasing the likelihood of flood-related impacts in the Indus basin. Heavy rainfall events are expected to increase in intensity globally and in South Asia due to the increased water vapor holding capacity of the atmosphere under global warming (IPCC, 2022a). Nationally aggregated climate projections for Pakistan show a slight increase in the number of days with heavy precipitation events, from 7 days per year in 2000 to 8 days per year in 2080 under both RCP2.6 and RCP6.0. Regionally, under RCP6.0 the number of days with heavy precipitation will increase by up to 3.5 days per year in the north, south, and some areas of eastern Pakistan, affecting both Punjab and KP. On the contrary, the frequency of heavy rainfall in Balochistan is expected to decrease by up to 1.5 days. The projected rise in frequency of heavy precipitation events in areas of the Indus basin will likely continue to cause the Indus River to overflow, increasing the risk of flood damage

in agricultural lands. This will further aggravate the situation of millions of farmers' which have already suffered from substantial crop losses and livestock casualties due to the devastating flood events in recent years (GoP, 2016a).

Figure 7: Regional projections of water availability from precipitation (runoff) for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0).



2.4 Climate change impacts on crop production and ecosystems

Wheat yields in Pakistan are projected to decline with high levels of certainty. Punjab and Sindh will experience the largest wheat yield reductions while the east of the country could experience yield increases. Global wheat yields are expected to decline by 6.0% with each degree-Celsius increase in global mean temperature (Zhao et al., 2017). In Pakistan, projections based on nationally aggregated data of crop yields show that climate change will reduce wheat yields up to 6.0% under RCP6.0 by 2080 (Figure 8). The IPCC AR6 also estimates that wheat yields in Pakistan will decrease 5-10% by 2040, depending on the emission scenario (IPCC, 2022a). Wheat is sensitive to temperatures above 30°C, growing best around 25°C (Imran et al., 2015; Narayanan, 2018). Some regions which already have annual average temperatures of 27°C (such as Sindh and southern Punjab) will become too hot to grow wheat and are projected to experience decreases of up to 79 % by the end of the century under RCP6.0 (without accounting for irrigation) (Figure 9). In regions where annual average temperatures are lower today (such as northern Balochistan) future temperature increases will provide a more favourable climate for wheat, leading to increases of up to 58 % by the end of the century. However, projections of water scarcity in Balochistan will likely hamper yield increases.

Rice yield reductions in Pakistan will be milder than that of wheat, affecting Balochistan, Punjab and KP. Some areas in the south and north of the country could experience large yield increases in the long-term depending on water availability. Rice yields are estimated to decline 3.2% worldwide for each degree increase in global temperature (Zhao et al., 2017). Projections for rice in Pakistan show that by 2080 yields will decrease 2.6% under RCP6.0, more than under the low emissions scenario. The lower rice yield decreases under RCP6.0 compared to RCP2.6 could be explained by the CO_2 fertilisation effect: rice is a C_3 plant and its metabolic pathway benefits from higher CO_2 concentrations and tolerates higher temperatures than C_4 plants (wheat and maize) (S. Abbas & Mayo, 2021). However, rice is also a water-intensive crop (Naseer et al., 2020). Overall,

climate change impacts in Asia are not only projected to reduce rice yields but also crop quality (IPCC, 2022a). Regionally, north-western Punjab, northern Balochistan, and some areas in KP will experience decreases of up to 39% under RCP6.0 by 2080 (Figure 10). The model projects regions, such as southern Balochistan and Sindh, will see increases in rice yields under both emission scenarios, with yields potentially increasing by up to 126% under RCP6.0 by the end of the century. These results however must be viewed with caution as rice production in these areas will likely face issues linked to water availability and salinization. Other studies have also shown that the projected temperature increases in arid and semi-arid regions of Pakistan (such as Balochistan and Sindh) are expected to have a positive effect on rice yield (S. Ali et al., 2017). However, the projected increase in drought and heat stress in these areas will likely cause rice yield losses (Fahad et al., 2017).

Figure 8: Projections of crop yield changes for wheat, rice and maize for all of Pakistan for two GHG emission scenarios: RCP2.6 (blue) and RCP6.0 (red), assuming constant land use and agricultural management, relative to the year 2000. *Lines represent the best estimate (multi-model median) and shaded areas the likely range (central 66%) and the very likely range (central 90%) of all model projections.*

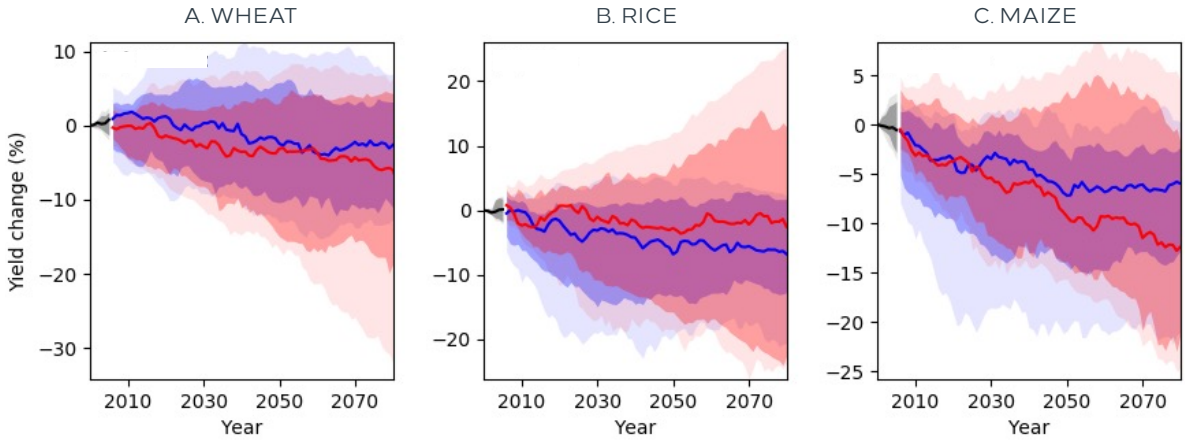


Figure 9: Regional projections of yield changes of wheat for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), assuming constant land use and agricultural management, relative to the year 2000.

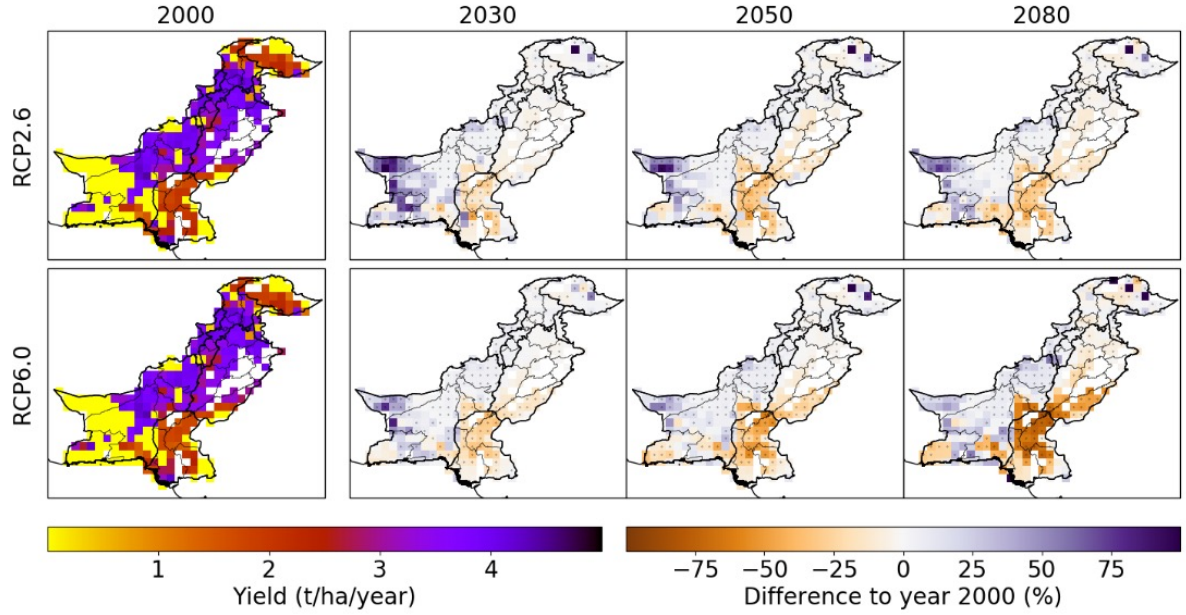
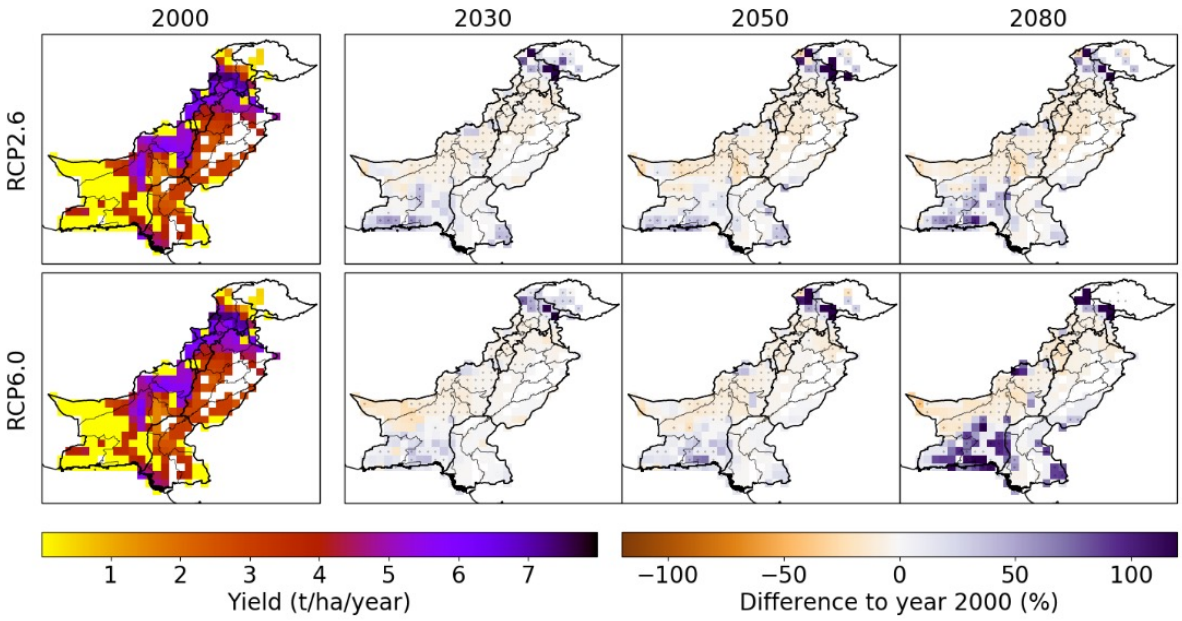


Figure 10: Regional projections of yield changes of rice for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), assuming constant land use and agricultural management, relative to the year 2000.



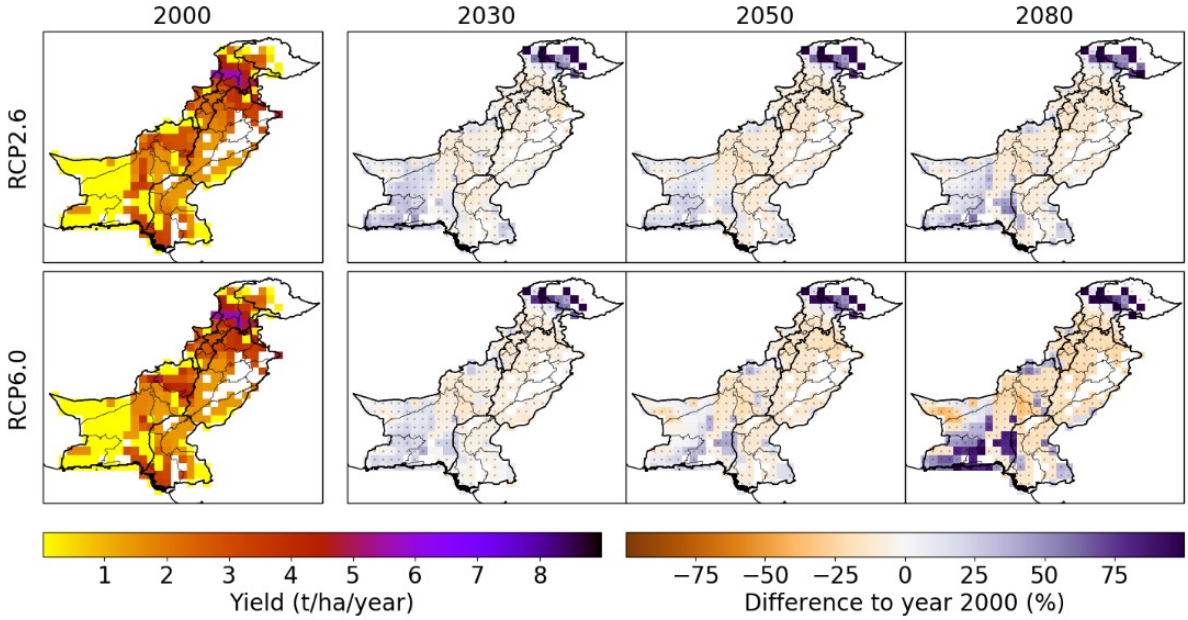
Maize yields are projected to significantly increase in northern KP in the short term, and in southern Balochistan in the long term. The interior of the country will experience maize yield reductions due to the increasingly hot and dry climate. Globally, maize yields are projected to be reduced by 7.4% with each degree increase in temperature (Zhao et al., 2017). Predictions for maize yields in Pakistan using nationally aggregated data show reductions of 12.4% by the end of the century under RCP6.0 (Figure 8). The regional distribution of climate impacts for maize is similar to that of rice. Maize yields are projected to increase in some parts of the north and south, with increases of up to 106% in northern KP and southern Balochistan by 2080 (Figure 11). The increases in maize yield in the north of KP will already be observed by 2030. However, the prevailing trend nationally is for yields to decline, especially in the north of Balochistan and the whole of Punjab province. The highest decreases are projected for northern Balochistan at 36% under RCP6.0 by the end of the century. Maize is highly sensitive to variability in precipitation and needs sufficient but not excessive soil moisture, factors that will likely constrain productivity in the future (Rashid & Rasul, 2009). Overall, adaptation strategies such as switching to improved varieties in climate change sensitive crops should be considered, yet carefully weighed against adverse outcomes, such as loss of agro-biodiversity and local crop types.

In addition to the effects in crop production, climate change is expected to significantly influence the ecology of tropical ecosystems, negatively impacting riverine and forest systems. Though the magnitude, rate and direction of ecological changes in tropical ecosystems are uncertain, negative effects are expected (Shanahan et al., 2016). With rising temperatures and increased frequency and intensity of droughts, wetlands and riverine systems are increasingly at risk of being disrupted and altered, with structural changes in plant and animal populations. Increased temperatures and droughts can also impact succession in forest systems and increase the risk of invasive species, all of which affect ecosystems. Snow and glacial melting, along with heavy precipitation in summer will expedite soil erosion in mountainous and slopy areas, leading to high levels of sedimentation in the plains, affecting the life span and efficiency of water reservoirs (Bashir et al., 2017). Soil erosion, heavy precipitation and storms, will facilitate the occurrence of landslides, threatening human lives, infrastructures and natural resources (Gilani et al., 2021; Rehman et al., 2020).

An increase in species richness is predicted in Punjab and KP, however tree cover loss is projected to continue, and manmade land use changes are likely to worsen both. Species richness (including amphibians,

birds, and mammals) was modelled for Pakistan excluding impacts on biodiversity loss from human activities, such as land use. Under RCP6.0, species richness is expected to increase in most parts of Pakistan, in particular in north-western Punjab and along the border of Punjab with KP, where increases amount to 80% compared to 2010. Only western and southern Balochistan as well as northern Pakistan will see decreases in species richness of up to 19%. However, it is important to keep in mind that human activities have been responsible for significant losses of global biodiversity in the past, and are expected to remain its main driver in the future (IPBES, 2019). Model projections for tree cover in Pakistan are more uncertain, with no clear identified trend under both RCPs. However, manmade land use changes have also accelerated deforestation: the country has lost 1.2 million ha of tree cover between 1991 and 2020, equivalent to a 25% decrease of national forest area (World Bank, 2020). Population pressure, increasing demand for firewood and poor forest management in northern Pakistan will continue to be major drivers of deforestation (Ullah et al. (S. Ullah et al., 2020).

Figure 11: Regional projections of yield changes of rice for Pakistan for two GHG emissions scenarios (RCP2.6 and RCP6.0), assuming constant land use and agricultural management, relative to the year 2000.



The following section reviews the policy and institutional framework at federal level and provincial level for Khyber Pakhtunkhwa and Punjab, along with the current programming being implemented by international organisations, development banks, and national civil society organisations. The analysis identifies the key institutions involved in climate change and agricultural programming across the provinces and their guiding policies. To support the analysis, a number of priority policy areas were identified by the research team with support from national stakeholders. Policy objectives contained within federal and provincial policy documents covering climate change, agriculture, livestock, and food security were then categorised according to these areas. Furthermore, provincial stakeholders engaged through the provincial workshops were asked to assess the importance of these policy areas, supporting the team in assessing the extent to which current policies cover the priority topics for agricultural actors in the two provinces.

Section

3

Policies, institutions and financing

HIGHLIGHTS

- The key national institutions involved in climate change and agricultural programming are the Ministry of Climate Change (MoCC), the Ministry of National Food Security and Research, and the Ministry of Planning, Development and Special Initiatives (MoPDSI), which have developed the National Climate Change Policy (2021) and Pakistan's Nationally Determined Contributions (NDCs), the National Food Security Policy (2018), and the national development plan Pakistan Vision 2025, respectively.
- The Agriculture Departments of KP and Punjab are the lead organizations for the implementation of the KP Agriculture Policy (2015-25) and Punjab Agriculture Policy (2018), respectively. Agricultural research activities are coordinated at the provincial level by the Directorate of Agriculture Research KP and the Punjab Agriculture Research Board (PARB) along with academic institutions, and the Pakistan Agricultural Research Council (PARC) provides coordination and support. The Model Farm Service Centers (MFSC) of KP provide access to inputs, mechanisation, and advisory for farmers.
- According to key stakeholders, the most important policy areas to support the agriculture sector are those targeting agriculture research and innovation, food security, value chain development, policy reform, and disaster preparedness, all of which are partly covered by the national and provincial policy frameworks.
- Public finance for development is channeled through provincial Annual Development Plans (ADPs). Public funding for agriculture through the ADPs of Punjab and KP over the last 5 years has prioritized financing irrigation infrastructure development and on-farm water management, followed by mechanisation development, and improved extension and advisory.
- The recently created Pakistan Board of Investment (BOI) has highlighted priority areas to support private sector investment in agriculture (such as increasing processing capacity for horticulture and livestock products). With the recent establishment of federal and provincial public private partnership (PPP) authorities and updated regulatory frameworks, there is a drive to unlock private sector investments for agriculture.

- Pakistan is a major recipient of bilateral and multilateral funding, mainly through official development assistance (ODA), which amounts to US$ 3,202.55 million per year. Key international donors include the World Bank Group, the US, the UK, and the Asian Development Bank (ADB). Though there is a range of bilateral and multilateral funded programs linked to CSA in place, bilateral and multilateral financing targeting agriculture-related sectors remains low.
- Opportunities lay in unlocking alternative financing options for agricultural development, for instance by mainstreaming green and climate finance in public planning and budgeting, mobilizing additional international climate finance targeting agriculture (e.g., through the Green Climate Fund) and creating an enabling environment for private sector and foreign direct investment (FDI) in climate finance.

3.1 Key institutions and supporting policies for investments in the agriculture sector

3.1.1 National institutions and policies

Following the 18th Amendment to the National Constitution in 2010, the responsibility to develop, implement, and oversee the financing of provincial activities has been decentralised from the federal government of Pakistan to the provinces. However, National policies and programming still play an important role in setting the overall direction in many key areas linked to the national climate change response and issues around food security.

The Ministry of Climate Change (MoCC) is the focal point for climate change related policies and programming at the national level. The MoCC has led the development of a number of key climate change policies including Pakistan's contribution to the United Nations Framework Convention on Climate Change (UNFCCC) through Pakistan's Nationally Determined Contributions (NDCs), and the recently updated National Climate Change Policy (GoP MoCC, 2021). Pakistan first submitted its NDC back in 2016 following the 2015 Paris Climate Accords. The document highlights that Pakistan's emissions are projected to increase by 296% from 2015-2030, with agriculture accounting for 29% of 2030 emissions. The NDC also included a commitment to reduce 2030 emissions by 20%, contingent on financial and technical support from the international community (UNFCCC, 2016). Pakistan submitted an updated NDC to the UNFCCC in 2021, with a focus on addressing current climate-induced vulnerability to support poverty alleviation and economic stability (UNFCCC, 2021). The updated NDC also increases Pakistan's cumulative ambitions to a 50% reduction on 2030 levels, with 15% committed through national resources and the remaining 35% conditional on international support (UNFCCC, 2021). These reductions are to be achieved predominantly by schemes targeting the energy and transport sectors, as well as targets linked to nature-based solutions such as the Billion Tree Tsunami Programme and Protected Areas Initiative (UNFCCC, 2021).

The National Climate Change Policy 2021 provides updates to the 2012 policy with a focus on climate change adaptation measures in sectors such as water, agriculture, forestry, coastal areas, biodiversity, and other vulnerable ecosystems (GoP MoCC, 2021). The updated climate change policy has been developed in accordance with the targets set out in the Paris Agreement, Sustainable Development Goals, and Sendai Framework for Disaster Risk Reduction. Consequently, the policy contains measures linked to decarbonization targets, institutional capacity building, technological development, and disaster preparedness (GoP MoCC, 2021).

The Ministry of National Food Security and Research is the lead institution for the National Food Security Policy (2018), with a mission to modernise Pakistan's agriculture sector to improve the availability,

access, and utilization of the nutritional foods through improved production (GoP MNFSR, 2014). The policy recognises stagnating growth within the agricultural sector and how higher food prices are causing many rural households to spend a greater proportion of their income on food, contributing to higher levels of under nutrition. The 2018 National Food Security Policy sets out a raft of measures to tackle the factors underpinning poor performance in the agricultural sector, including low levels of investment in modern practices and technologies, accessibility and affordability issues with input supply, inadequate extension and capacity building services, weak market infrastructure, trade restrictions, access to finance, and the impact of climate hazards.

In 2016, Pakistan became the first country in the world to adopt SDGs as their own national development goals through a National Assembly resolution, supporting their implementation of the 2030 agenda (VNR & GoPk, 2019). Pakistan organises its contributions to the SDGs under three core dimensions— social, economic, and environmental—with supporting policies and development plans designed to incorporate these dimensions in an interconnected way. A 2019 review of Pakistan's SDGs found that progress had been made towards agriculture linked targets for no poverty and zero hunger, although the report already highlighted how high input costs were jeopardising this progress, something that become more pronounces since the report due to the dual impact of COVID-19 and the Ukraine war (see section – Agricultural challenges). Progress on climate action was more muted, with slow progress towards low emissions production and biodiversity conservation, which is likely to worsen under the burden of a burgeoning population. Consequently, urgent action is required for anti-poverty and climate change resilience programs, otherwise Pakistan risks a knock-on effect to other areas such as poverty, health, and food security (VNR & GoPk, 2019).

Another important national institution is the Ministry of Planning, Development and Special Initiatives (MoPDSI), who with consensus of the provinces, develops Pakistan's national development plan, Pakistan Vision 2025 (GoP & PDD, 2014). Pakistan Vision 2025, identifies 7 priority pillars to Pakistan development, of which human capital development and women's empowerment (Pillar 1 – People first), sustainable, indigenous, and inclusive growth (Pillar 2 – Growth), water and food security (Pillar 4 – Security), private sector growth (Pillar 5- Entrepreneurship), and rural connectivity (Pillar 7- Connectivity), are all strongly linked to agricultural development. The policy targets to close the 40% yield gap for major crops through the application of enhanced technologies and a 50% reduction in crop losses (GoP & PDD, 2014). The policy also identifies the need to strengthen agricultural input and output markets, lower trade restrictions, increase access to advisory services, and enhance support for agricultural financing. The policy also singles out the livestock and horticulture sectors for their growth potential, with a series of enabling policies identified. The Planning Commission of the MoPDSI develops the annual Public Sector Development Program (PSDP), which is the largest national development initiative (1,843,000 million PKR for the 2021-2022 fiscal year). Agriculture linked programming in the 2021-22 PSDP include improved transport connectivity, large-scale water management, climate change adaptation, enhance agricultural productivity for food security, and the promotion of public-private partnerships through the provision of viability gap funding. Other measures include reducing regional disparities through better access to healthcare, education, and livelihood opportunities (GoP MoPDSI, 2021).

3.1.2 Provincial policy priorities and programming

In KP, the Agriculture Department is the focal point of agriculture related activities—with eleven subdivisions covering core services and sectors—including the implementation of the KP Agriculture Policy (2015-25), and the KP Livestock Policy (2018). Under Agriculture Department's agriculture research and extension wing, there is a network of 14 agriculture research stations working on seed varieties, pest management and agro-advisory implementing across KP. Climate change and natural resource management activities fall under the mandate of the Forestry, Environment & Wildlife Department of the Khyber Pakhtunkhwa Environmental Protection Agency (KPEPA), this includes the recently updated KP Climate Change Policy (EPA & GoKP, 2022). Other notable institutions in KP include the Provincial Disaster Management Authority (PDMA), who coordinate activities linked to disaster preparedness and response. Other guiding policies for the Government of Khyber

Pakhtunkhwa (GoKP) include the KP Integrated Development Strategy (2014-18) directly led by the GoKP and the KP Comprehensive Development Strategy (2010-17) from the KP Planning and Development Department, which includes multi-sectoral development plans for the province. The provincial policy frameworks must be followed by the local government system, which in Pakistan is based on three administrative divisions (districts, tehsils, and union councils). Implementing interventions related to agriculture, forestry and fishery matters and local economic development are usually functions and responsibilities of the local governments at district and sub-district level, with support from the provincial governments (Commonwealth Local Government Forum, 2018). In KP, local government functions include infrastructure and service delivery development, execution of annual development plans, market regulation, flood control protection, approval of land use plans, and monitoring service providers' performance including in agriculture. The district level offices of the Agriculture Department of KP stand devolved from provincial government, providing local government the mandate to implement agriculture-related policies (GoKP, 2019b).

Other important institutions in KP include the Model Farm Service Centers (MFSCs) and the University of Agriculture Peshawar (UAP). KPs MFSC were formed in 1999 by the provincial government but are independent entities that are *"farmer owned, financed, and managed".* About 100 MFSCs are located in 32 districts at tehsil level with 237,000 registered farmers, who benefit from improved access to inputs, mechanisation, and advisory services (H. Ahmed, personal communication, June 3, 2022). The UAP is the lead academic institution for agriculture and climate change activities in KP, including through the Universities Climate Change Center which conducts research on climate change impacts and recommended adaptation measures, including the provision of climate change related training to government and non-government actors from across KP (UAP & GoKP, n.d.).

In Punjab, the agriculture department is the lead organisation for agriculture activities, including the development and implementation of the Punjab Agriculture Policy (2018). The Punjab Agriculture policy focuses on the expansion of agricultural markets through the strengthening of value chains and Agri SMEs, improved access to quality inputs, and the promotion of climate smart and regenerative agriculture (GoPb, 2018). The Livestock and Dairy Department Punjab, provides extension service and capacity building for the livestock sector through the Punjab Livestock Policy 2015-16, with a focus on disease prevention, feed and nutrition, market development, trade liberalisation, and market information services (GoPb L&DDD, 2015). The Environmental Protection Department is the focal point for climate related activities in Punjab, including the 2017 Punjab Climate Change Policy, that covers a number of key areas linked to agriculture, natural resource management, and disaster preparedness (EPD & GoPJB, 2017). Other notable institutions in Punjab include the Provincial Disaster Management Authority (PDMA), who coordinates activities linked to disaster preparedness and response. As in KP, the local government in Punjab plays an important role in executing development plans, preparing land use plans and exercising control over land-use in agriculture, managing infrastructure and services, assisting relevant authorities in disaster management and relief activities in the event of extreme weather and natural disasters, establishing and promoting incubation centres for startups, encouraging tree afforestation, and developing linkages between public and private sector for enhancing access and quality of services (GoPb, 2022).

Research activities in Punjab are coordinated through the Punjab Agricultural Research Board (PARB), which is an autonomous body that coordinates research activities in the province for effective planning and implementation of the provincial research programme. The Ayub Agricultural Research Institute (AARI) plays a key role in supporting Punjab's agriculture, predominantly through its research into the development and introduction of new stress tolerant crop varieties. Beyond its work on crop varieties, AARI also supports the regulation of inputs through its pesticide and fertiliser testing services.

Stakeholders consulted in the two provincial stakeholder workshops were asked to assess the importance of different policy areas to support the agricultural sector in the province become more productive and resilient to climate change. Table 12 displays the ranking attributed to each of the policy areas on a scale of 1 (very low importance) to 5 (very high importance), along with the average score for both provinces. The policy priority areas were identified following a review of the previously mentioned agriculture, food security, and climate change policies at federal level and for Punjab and KP provinces. These areas were then reviewed and validated by key stakeholders in each province prior to their inclusion in the provincial workshops.

Table 12: Importance of priority policy areas for Punjab and Khyber Pakhtunkhwa, using a scale of 1=Very low importance, 2=Low importance, 3=Medium importance, 4=High importance, and 5=Very high importance.

POLICY AREAS	PUNJAB	KP	AVERAGE
Agriculture research & innovation	4.1	4.4	4.3
Food security	4.4	3.8	4.1
Value chain development	4.2	3.9	4.0
Institutional development/Policy reform	4.3	3.7	4.0
Disaster preparedness	4.0	3.9	4.0
Developing farm mechanisation	3.8	3.9	3.9
Crop production support	4.0	3.7	3.9
Water management	4.2	3.5	3.8
Agriculture financing	3.9	3.8	3.8
Seed sector development/reforms	3.7	3.6	3.6
Improved extension & advisory	3.7	3.5	3.6
Women & youth engagement	3.4	3.6	3.5
Biodiversity & conservation	3.4	3.5	3.5
Livestock sector development	3.4	3.4	3.4
Rangeland management	3.1	3.3	3.2

All of the areas assessed were classified as being of medium to very high importance, with policy objectives linked to agricultural research and innovation, food security, value chain development, institutional capacity building and policy reform, and disaster preparedness considered to be the areas of highest importance. While the order of importance for the different areas was mostly consistent across the two provinces, there were a few exceptions, with KP ranking research and innovation higher (potentially due to the large proposition of researchers in the workshop—28%), along with disaster preparedness, farm mechanisation, and agricultural financing. Punjab on the other hand ranked institutional development and policy reform along with water management as of greater relative importance.

The objectives contained with the federal and provincial polices assessed were then classified under the different policy priority areas, to evaluate the extent to which the priority areas were covered through the existing framework. The coverage by policy is outlined in Table 13[4], with the raw data accessible through the supplementary dashboard, allowing the user to filter the current framework by policy area and sector. The dashboard was used by the research team to identify supporting policies for each of the identified investment opportunities in Annex 1 and Annex 2. Overall, the existing policy framework at federal and provincial level included objectives linked to all of the identified policy priority areas. While food security was not directly

[4] PPAs are arranged in order of prioritization given by stakeholders starting with highly prioritized

referenced in a number of the policies, a number of the other areas such as crop production support, disaster preparedness, and women and your engagement will contribute to higher levels of national food security. Another key issue not extensively covered in the current policy framework is the need for reform in the seed sector to increase the availability and affordability of certified and stress tolerant seed through the formal market.

Table 13: Coverage by policy of priority areas

	NATIONAL		KHYBER PAKHTUNKHWA			PUNJAB		
	NATIONAL FOOD SECURITY POLICY 2018	NATIONAL CLIMATE CHANGE POLICY 2021	KP AGRICULTURE POLICY (2015-25)	KP CLIMATE CHANGE POLICY 2022	KP LIVESTOCK POLICY 2018	PUNJAB AGRICULTURE POLICY 2018	PUNJAB CLIMATE CHANGE POLICY 2017	PUNJAB LIVESTOCK POLICY 2015-16
Agriculture Research & Innovation	✓	✓	✓	✓	✓	✓	✓	✓
Food Security	✓	✗	✓	✗	✗	✗	✓	✗
Value Chain Development	✓	✓	✓	✓	✗	✓	✓	✓
Institutional Development /Policy Reform	✓	✓	✓	✓	✓	✓	✗	✓
Disaster Preparedness	✓	✓	✓	✓	✗	✗	✓	✓
Developing Farm Mechanisation	✓	✓	✓	✗	✗	✓	✗	✗
Crop Production Support	✓	✓	✓	✓	✗	✓	✓	✓
Water Management	✓	✓	✓	✓	✗	✓	✓	✓
Agriculture Financing	✓	✓	✓	✓	✗	✓	✗	✗
Seed Sector Development/ Reforms	✓	✗	✓	✗	✗	✗	✗	✓
Improved Extension & Advisory	✓	✓	✓	✓	✓	✓	✓	✓
Women and Youth Engagement	✓	✓	✓	✓	✗	✓	✓	✗
Biodiversity & Conservation	✓	✓	✗	✓	✗	✗	✓	✗
Livestock Sector Development	✓	✓	✓	✓	✓	✗	✓	✓
Rangeland Management	✓	✓	✓	✓	✗	✗	✓	✓

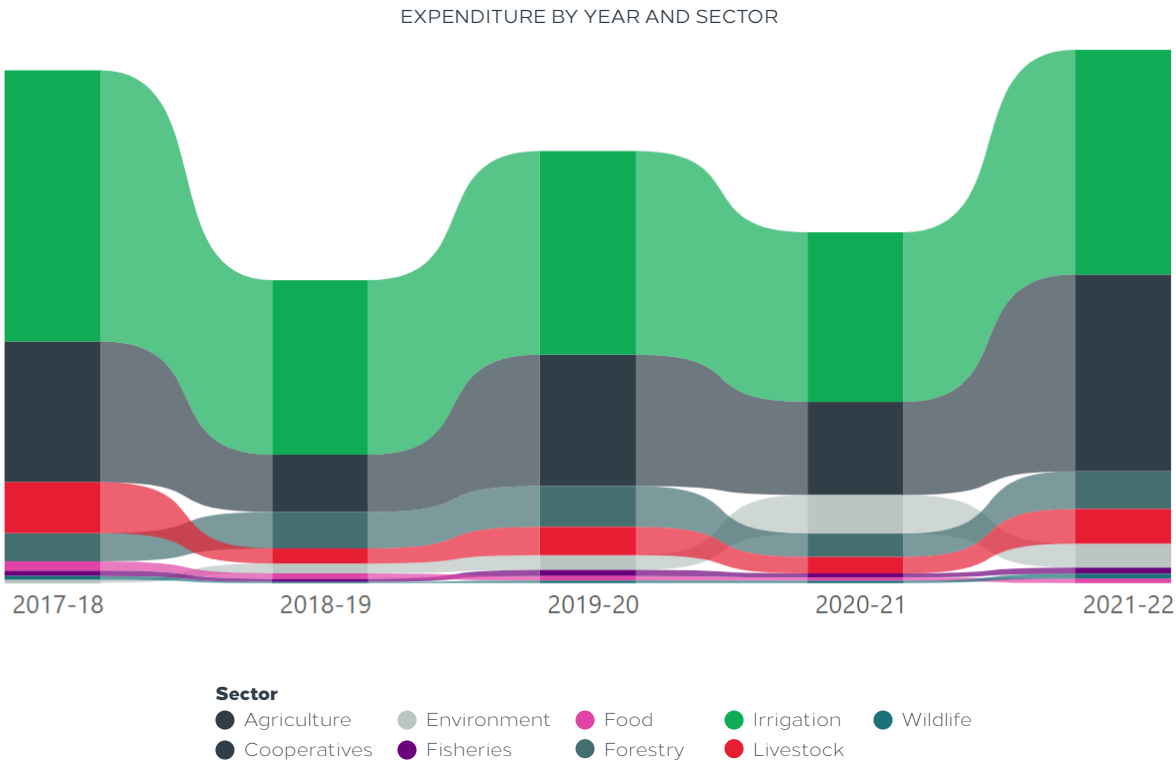
3.2 Current and potential financing sources and mechanisms for agriculture

3.2.1 Current financing through ADPs

Public sector spending on development programmes in Pakistan is mostly channelled through Annual Development Plans (ADPs). ADPs are developed at a provincial level by the planning and development departments with support from the finance department and input from other provincial departments and agencies (GIZ, 2017). ADPs are used as instruments to support the planning, execution, and monitoring of provincial spending on development related activities. Each year departments in the provinces are asked to prepare a list of ongoing and new schemes for their sectors that are aligned with the guiding principles for that year's ADPs. Schemes are mostly short term 1-3 years, with 70% of the annual allocation earmarked for ongoing projects and 30% for new programmes (GIZ, 2017). Funds are then allocated to specific schemes within the proposed portfolio, with schemes that receive counterpart funds form international organisations and those that are in response to emergencies receiving the highest priority. The final selection of ADPs comes about through a series of inter-departmental consultations hosted by the planning and development department, with final approval of provincial ADPs taking place at federal level (GIZ, 2017).

The following sections take a closer look at the types of schemes that have been funded by the ADPs in Punjab, Khyber Pakhtunkhwa, and the Newly Merged Areas, as these provide detailed insights into the areas and specific activities that are being prioritised for the allocation of public funds. The analysis uses data from the last 5 years (2017-2022), providing a first overview of expenditure by sector (focussing on those relevant to agriculture), followed by agricultural sub-sectors, and finally according to their alignment to the identified policy priority areas. The following sections support the cross analysis of the identified policy priorities and the public funding made available for different activities. In addition to the information captured in this report, an interactive ADP portal was developed, offering the user the ability to search the last 5 years of ADPs and gain insights on the types of areas prioritised for public sector funding.

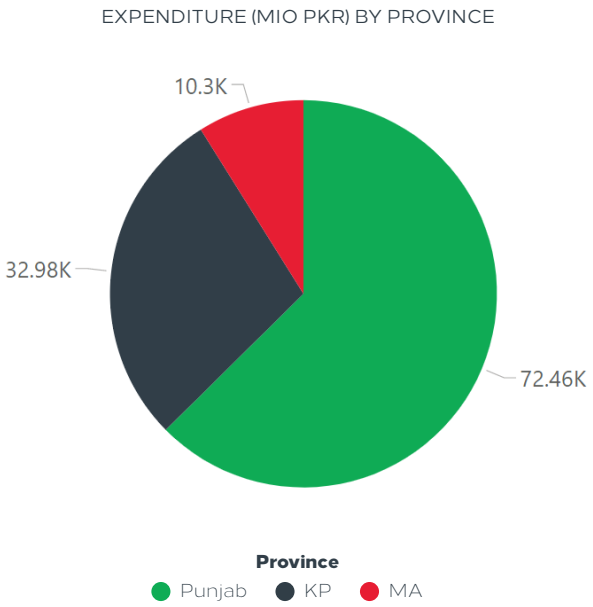
Figure 12: Expenditure on agriculture linked sectors across Punjab, Khyber Pakhtunkhwa, and the Newly Merged Areas from 2017-2022.



3.2.1.1 Expenditure by sector

Over the last five years the total expenditure in Punjab, Khyber Pakhtunkhwa, and the Newly Merged Areas on sectors linked to agriculture totals PKR 454,080 million (USD 2,225 million), with irrigation (48.5%) receiving almost half the funding, followed by agriculture (30.4%), livestock (8.0%), with number of other sectors receiving between 1 and 5% of the total allocation. The allocation of funding across the sectors remains mostly consistent for irrigation and agriculture across the different provinces/ regions, but with forestry receiving more funds in Khyber Pakhtunkhwa and the Newly Merged Areas, while Punjab had more funds targeting the livestock sector. In terms of total allocation Punjab received the most funding (59.9%), followed by Khyber Pakhtunkhwa (24.5%) and the Newly Merged Areas (15.6%). There have been some fluctuations in the year-on-year ADP allocations, with 2021-22 seeing the highest allocation at PKR 113,590 million versus only PKR 64,520 million in 2018-19 (see figure 12). However, the overall trend has reminded fairly consistent over the last 5 years.

Figure 13: Agricultural expenditure by province (2017-2022)



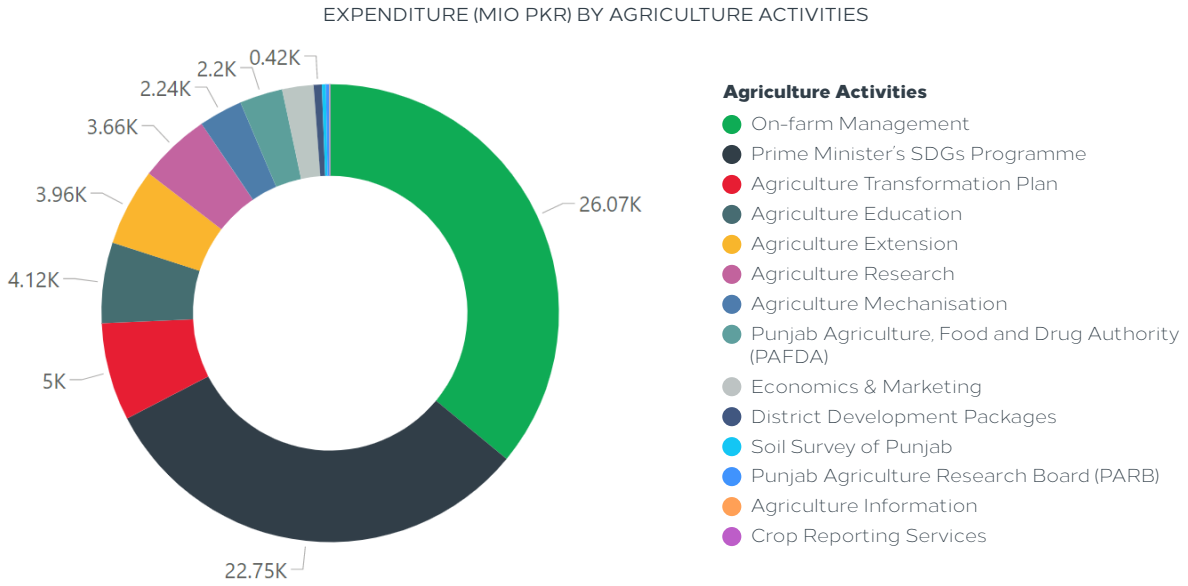
It is not uncommon for irrigation projects to be the dominant destination for agriculture related financing, due to the large infrastructure development costs linked to irrigation works. This is the case in Pakistan where the main location for irrigation funds is the construction and rehabilitation of existing barrage, dam, and canal systems. In addition to the irrigation works, the sector also includes activities linked to flood management and some smaller scale irrigation systems. However, the majority of the smaller scale irrigation and water conservation initiatives are included in the agriculture sector budget under the on-farm water management sub-sector (see next section).

3.2.1.2 Agriculture sub-sector expenditure

In terms of total agricultural expenditure[5] Punjab accounts for 62% (PKR 72,460 million), KP for 28.5% (PKR 32,980 million), and the Newly Merged Areas 8.9% (PKR 10,300 million) (see Figure 13). Assessing the destination of funding towards different agricultural sub-sectors we see that the largest proportion of funds go towards on-farm water management (36.8%), this is separated from the larger irrigation and water management investments under the irrigation sector, highlighting the scale of the funding that is targeted for water-related activities (see Figure 14). Unlike the larger irrigation infrastructure and flood defence projects, the types of investment targeted for on-farm water management include the construction of solar powered tube wells, solar drip and sprinkler irrigation systems, rainwater harvesting, and the construction of small and mini dams. Other areas that received considerable funding are the Prime Ministers SDG Programme (19.7%) which is a special initiative by the Prime Minister to support ADP schemes which contribute to the attainment of Pakistan's SDG targets. Of the ADPs reviewed, only Punjab currently had programmes falling under this scheme, with activities focussed on increasing the production of key commodities and strengthening agricultural markets. Following that funding was mostly directed towards agricultural extension (10.7%), agricultural planning (7.6%), agricultural research (5.6%), and agriculture education (4.5%). Other relevant areas that received funding are agricultural mechanisation (3.6%), soil conservation (3.1%), and economics and marketing (1.4%).

[5] Agricultural expenditure only includes schemes arranged under the agriculture sector heading in the ADPs, therefore not including schemes under forestry, livestock, environment, etc. Relevant schemes from across all sectors for the latest ADPs are assessed in the next section, classified under the policy priority areas identified as a part of this project.

Figure 14: Expenditure on agricultural sub activities across Punjab, Khyber Pakhtunkhwa, and the Newly Merged Areas from 2017-2022.



3.2.1.3 Expenditure by policy area

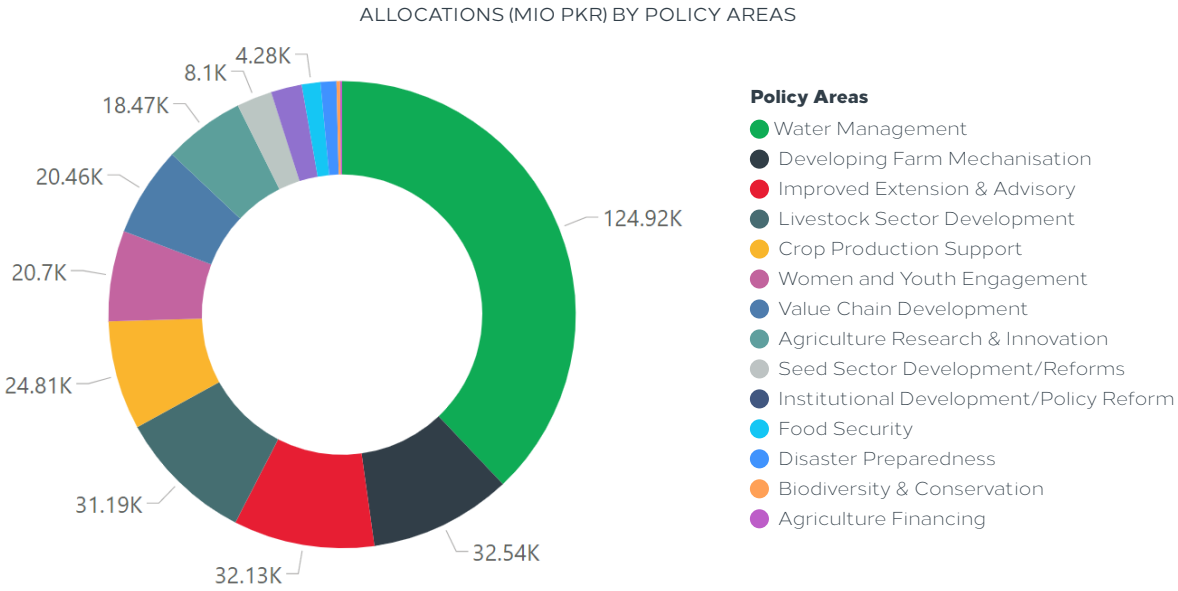
To assess the extent to which the ADPs covered the policy areas prioritised by stakeholders in each province (Table 12), the 2021-22 ADP schemes were reviewed in full, with relevant schemes categorised by policy area[6]. This also facilitated the research team in assessing the current and proposed ADPs linked to the investment opportunities prioritised for each province.

As we would expect given previous results, the largest share of ADP expenditure goes towards the water management policy area (37.9%) covering large- and small-scale water management activities (see Figure 15). The second largest destination for ADP funding is programmes supporting the development of farm mechanisation, with 100% of the PKR 32,540 million dedicated to these activities coming from the Punjab ADP (see breakdown by region in the online dashboard). The mechanisation schemes operating in Punjab cover laser land levelling, the rehabilitation of old bulldozers for landscaping, mechanisation for increased productivity, and investments in drilling equipment for tube wells. The current absence of funding for mechanisation in KP and the Newly Merged Areas is likely contributing to the low levels of mechanisation in the province, something highlighted through our research and addressed by the smallholder mechanisation investment package proposed for KP (see section 5.1). Following mechanisation, improved extension, and advisory accounts for 9.8% of the total allocation including scholarships for agriculture related courses, capacity building of extension staff, improved training on the production of key commodities, and a number of initiative focussing on modernising extension through extension services 2.0, tele farming, and database management.

Livestock sector development accounted for 9.5% of ADP expenditure, with an equal proportion coming from each of the regions covered in the analysis. When looking at the Newly Merged Areas alone, livestock development is the single largest destination for ADP funds (28.2%). Livestock development activities mostly consist of scaling artificial insemination facilities, the development of new (mobile) veterinary clinics/dispensaries/hospitals, tracking tools for zoonotic diseases, and feed storage facilities. This was followed by crop production support (7.5%), covering oilseeds, rice, wheat, and sugarcane in Punjab; oilseeds, rice, and sugarcane in KP; and olives in the Newly Merged Areas. Other key policy areas were programming on women and youth empowerment through greater skills development (6.3%), the development of agricultural value chains and markets for high value produce (6.2%), and investments in agricultural research and innovation (5.6%).

[6] This analysis includes selected ADPs from all relevant sectors. The categorisation was undertaken by the research team, which despite being reviewed by multiple team members will be inherently subjective.

Figure 15: ADP expenditure by policy area 2021-22 for Punjab, Khyber Pakhtunkhwa, and the Newly Merged Areas.



3.2.2 Private and Public-Private Investments

To support greater levels of private sector investment across all sectors of the Pakistan economy—including local and foreign direct investment (FDI)—the Pakistan Board of Investment (BOI) was established, facilitating investment through increased international competitiveness and a more conducive business environment (GoP, 2022). Food processing is identified as one of the seven priority sectors for investment in Pakistan, of the current 2500+ processing units in Pakistan, 60% are located in Punjab and only 6% in KP (Shezan Int. ltd, 2018). Priority areas for investment within the food processing sector can be found in Table 14. Further, recognizing the untapped potential of Pakistan's horticulture sector, a study was commissioned on the bottlenecks and opportunities for value added fruit and vegetable exports, focusing on citrus and juices; potatoes, fries, and chips; tomatoes, paste, and puree; bananas; and mangoes. The report found considerable export potential being unrealised due to a series of barriers including low yields due to the use of poor management practices and traditional seed varieties; weak or non-existent contract farming arrangements, creating uncertainty for processors; price distortions through government price controls; poor on-farm sanitary and phytosanitary (SPS) standards; inadequate post-harvest infrastructure; non-tariff trade barriers; and large losses from pest and disease outbreaks (Pakistan Business Council, 2020). Pakistan's 2014 inclusion in the European Unions (EU) Generalized Scheme of Preferences Plus (GSP+) removed the EUs import duties on the majority of agricultural exports, offering greater potential markets for processed agri-foods (Shezan Int. ltd, 2018).

The China Pakistan Economic Corridor (CPEC) has included food processing as a key focus, with facilities included in the plans of four Special Economic Zones. Other investments in Punjab and KP under CPEC include vegetable, fruit, and grain processing plants in Lahore and Islamabad; the construction of NPK fertiliser plant with an annual output of 800,000 tons; 6,500 acres of demonstration plots for improved seeds across Punjab; and improved transport facilities for crops (GoPb PBIT, 2018b; Shezan Int. ltd, 2018). Multi-national companies and private entities are engaged in providing agriculture services in the area of seed, fertilizers, farm machinery, farm advisory, crop protection, livestock development and agriculture processing. Table A3.1 in Annex 3 outlines some prominent companies, their geographic focus and area of specialization linked to the policy priority areas.

The Punjab Board of Investment and Trade (PBIT) published in 2018 a report titled "farm to fork cold chain solutions", including the detailed plans for a packhouse for potato, onion, turnips, and okra (GoPb PBIT, 2018a). The proposed packhouse would improve value addition and reduce post-harvest losses (currently at 30-40% for horticulture in Pakistan) through cooling, washing, cleaning, trimming, and packaging. The project is assessed to generate an Internal Rate of Return (IRR) of 31% and NPV of PKR 70,565,920, with a payback period of 5.47 years (GoPb PBIT, 2018a). Other sectors covered by PBIT include recommendations for the textile industry, fertilizer sector, and leather industry (GoPb, n.d.). A review of the types of incentives required to support the food processing sector in Punjab, mostly focused on the need to remove or reduce customs duties on capital goods used in the production, sorting, and processing of high value goods (GoPb PBIT, 2020).

The KP Board of Investment and Trade (KPBOIT) works to promote trade and investment across sectors in KP through its advocacy work for the creation of an effective enabling environment for investments, the identification of promising investment opportunities, and investment facilitation. Recent publications from KPBOIT include the Investment Promotion Strategy (2021-25) (KP-BIOT, 2021a), and the Investment Pitch Book (2021) (KP-BOIT, 2021b). The KP Investment Promotion Strategy provides an overview of the KPBOIT mandate including investment promotion and best practices (as set by the KPBOIT Act, 2015), its role coordinating investment related bodies (Industrial Policy, 2020-30), and its contributions to trade promotion (Commerce and trade strategy, 2020). The key agricultural sectors promoted by KPBOIT include investments into agribusinesses that strengthen input and output markets to improve the quantity and quality of agricultural product and generate opportunities for rural employment; along with investments into larger scale industrial food and beverage manufacturing hubs (or Special Economic Zones) to increase value addition and promote domestic and international trade for agricultural products. The report included an assessment of the attractiveness of Pakistan's priority sectors compared to competitor countries in the Asia-pacific region—based on the number of FDI projects—finding the agribusiness sector to outperform other sectors in Pakistan, especially through investments in the agro-processing of food and beverage products, and agrochemical manufacturing. However, the overall number of FDI projects remains low compared to other countries in the region—such as India, Indonesia, Thailand, and Vietnam (KP-BIOT, 2021a). Both the KP Investment Promotion Strategy (2021-25) and the Investment Pitch Book (2021) contain a number of potential Agri-investments (see Table 14).

Regulatory bodies have been established at both federal and provincial levels to facilitate public-private partnerships (PPP). The Public Private Partnership Authority was established at federal level in 2017 through the Public Private Partnership Authority Act, No. VIII of 2017, which was amended in 2021 with the Public Private Partnership Authority (Amendment) Act, 2021. The 2021 Amendment Act was introduced to strengthen the regulatory framework and make it more amenable to private sector investment in development programming (Munir, 2022). While the focus of PPPs in Pakistan has traditionally been in the energy, power generation and transportation sectors, there is scope to use the current regulatory infrastructure to support greater PPP engagement in the agriculture sector.

In addition to the federal initiative, the provinces have their own bodies with a roster of province specific projects and project opportunities. The Punjab Public–Private Partnership Authority was established in 2019, with a separate Public–Private Partnership Cell within its Planning and Development Department. In KP a Public–Private Partnership Unit was established under the Planning and Development Department through the Khyber Pakhtunkhwa Public Private Partnership Act, 2020, which is still in the process of being implemented (Munir, 2022). KP has recently established a risk management unit to monitor the governments liabilities for PPP projects. One of the main tasks of the unit will be to establish a vulnerability gap fund, that will act as a revolving fund which will pool seed money for investments that may not be fully commercially viable but offer positive social outcomes. The fins will be launched and maintained with input for the government and development partners, with winning developers required to replenish it through mandatory contributions. This program is currently being implemented through the Sustainable Energy & Economic Development (SEED) Programme, funded by the FCDO and implemented by Adam Smith International in partnership with the Government of KP. As suggested by the name the programme is currently focussed on energy and infrastructure projects

but could be replicated as a model for agricultural sector PPP investments (such as those in Table 18). In other areas the SEED programme does work with agri-business "trailblazers" to drive private sector investments into improved value chains, processing, and production technologies (SEED, n.d.). These PPP bodies should be engaged in the investment planning process for the agricultural sector to help unlock supplementary private sector finance that may currently be too risk averse to invest in the sector.

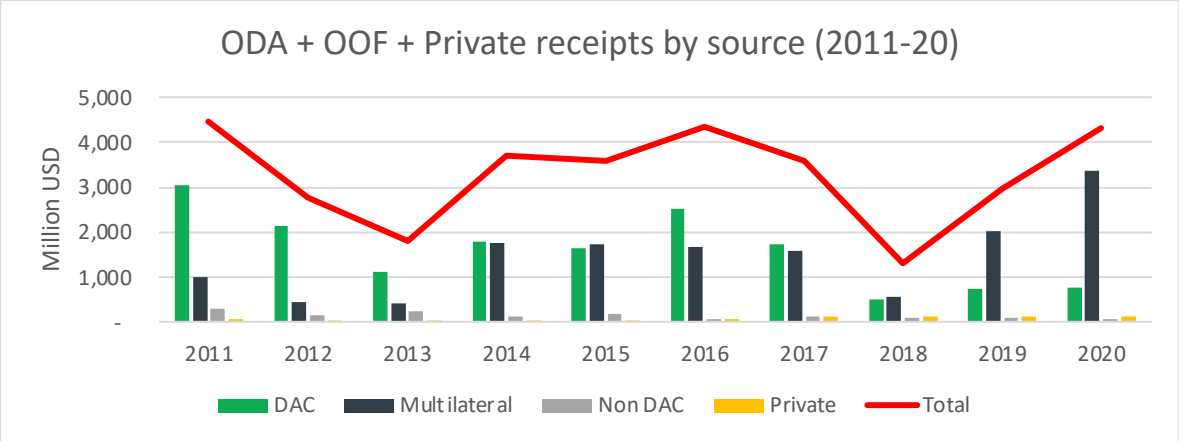
Table 14: Identified investment priorities from Pakistan, Punjab, and Khyber Pakhtunkhwa Bureaus of Investment and Trade (GoP KPBOIT, 2021b; GoPb, n.d.; GoPb PBIT, 2018a; Pakistan Business Council, 2020; Shezan Int. ltd, 2018)

PRIORITY AREAS FOR INVESTMENT – PAKISTAN-BOI	
1. Development of the dairy sector and secondary processing capacity to meet growing domestic demand and further grow their presence in export markets	
2. Value addition in fruits through increased capacity for juicing, pulping, and drying	
3. Value addition to potato through processing to fries and chips	
4. Value addition to tomatoes through processing to paste and puree	
5. Investments in Individual Quick Freezing (IQF) facilities for fruits, vegetables, meats, and seafood to access higher value international markets	
6. Olive oil extraction	
7. Halal food markets	
8. Units for the production of dehydrated potato flakes and potato powders	
9. Investments into other commodities including dates, capture fisheries, and pine nuts	
INVESTMENT OPPORTUNITY DASHBOARD – PAKISTAN-BOI	
1. Dehydrated Fruits and Vegetables (Batch Dryer) (USD $2 MIO estimated cost) – Multan, Punjab	
2. Pilot Shrimp Farming Cluster Development Project (USD $27 MIO estimated cost) – Punjab	
3. Cage Fish Culture Cluster Development Project (USD $12 MIO estimated cost) – Punjab	
4. Quality Fruit Plant Nursery Production (USD $15.48K estimated cost) – Peshawar, Khyber Pakhtunkhwa	
INVESTMENT OPTIONS – PUNJAB-BOI	
1. Fruit packhouse for potato, onion, turnips, and okra	
SPECIAL ECONOMIC ZONES – KHYBER PAKHTUNKHWA-BOIT	
SEZ – Agro food processing	- Fruit/Veg Processing (Pulp, Juices, Nectar, Pickles) - Fruit/Veg Packing - Biscuits, Bread, and other bakery products - Ice creams, Khoya, and other dairy products - Spices Bottle led water
SEZ – Non-food processing	- Seed processing & distribution - Feed Mills - Composite & other organic fertilizers - Medicinal hub processing - Chip board - Furniture
SEZ – Light engineering	- Dates dehydrators - Farm Equipment's and implements - Packaging - Hand pumps/Electric Water motors etc - Building Materials
INVESTMENT PROGRAMMES – KHYBER PAKHTUNKHWA-BOIT	
1. Establishment of large-scale dairy farms & milk processing facilities	
2. Establishment of large-scale slaughterhouse	
3. Mega food processing parks	
4. Quality fruit plant nursery production	
5. Development of Cage Fish Farming for Enhancement of Tilapia Fish Production	
6. Disease Free Zone in KP	

3.2.3 International funding

Pakistan is a major recipient of bilateral and multilateral funding. Between 2011-2020 Net total flows from Official Development Assistance (ODA)[7], Other Official Flows (OOF)[8], and private financing[9] sources covered by the OECD averaged US$ 3,202.55 million (2020 constant) per year. In recent years Pakistan has seen a decline in bilateral funding from Development Assistance Committee (DAC)[10] countries, which represented 49% of total flows over the period. A similar decline has also been observed with bilateral funding from non-DAC countries, although non-DAC countries only accounts for 4% of flows over that period. The falls in bilateral funding have mostly been offset by increases in multilateral funding, which accounted for 44% of the flows over the whole period and 78% in 2020 (see Figure 16). This gradual shift away from bilateral funding to multilateral funding is not unique to Pakistan, but reflective of a global shift towards higher proportions of multilateral funding (OECD, 2020). There has also been a gradual increase from private sector sources, although they still only represent 3% of the total flows over the period (see Figure 16).

Figure 16: ODA + OOF + Private receipts by source (2011-20)



Pakistan has also experienced a shift in the types of flows it has received. While ODA has remained the dominant form of development assistance resource flows into Pakistan between 2011-20 (84%), OOF resource flows have represented an increasing proportion in recent years (13% average, 36% in 2020). The shift towards OOF is due to an increasing share of non-concessional loans from multilateral development banks which either fail to reach the 25% grant requirement for ODA or are not primarily aimed at development. This has become an increasingly contentious issue in Pakistan over the recent years due to the ongoing sovereign debt crisis, with Pakistan's total external debt and liabilities at US$93 billion in June 2021 (34.5% of GDP), including US$5.76 billion owed to the International Monetary Fund (IMF) (Dec 2021) (SBP, 2022a). This has resulted in a growing gap between gross inflows of bilateral and multilateral support versus net flows, as an increasing proportion is used to service existing debts, with a share of between 30-65% being channelled back to funders (see figure 18). A recent example that resulted in nationwide protests and strikes, was following a US$6 billion IMF loan in 2019 that came with conditions that Pakistan run a strict austerity program, which was quickly followed by a World Bank tribunal ordering the government to pay US$5.8 billion to settle an eight-year dispute with a mining company (including compensation for lost future profits) (Tienhaara, 2019). Critics were

[7] Resource flows to countries and territories on the DAC List of ODA Recipients (developing countries) and to multilateral agencies which are: (a) undertaken by the official sector; (b) with promotion of economic development and welfare as the main objective; (c) at concessional financial terms (OECD, 2021)

[8] Transactions by the official sector with countries on the DAC List of ODA Recipients which do not meet the conditions for eligibility as Official Development Assistance, either because they are not primarily aimed at development, or because they have a grant element of less than 25 per cent (OECD, n.d.)

[9] Changes in bilateral long-term assets of the private non-monetary and monetary sectors, in particular guaranteed export credits, private direct investment, portfolio investment, and flows from the multilateral sector which are not classified as concessional (OECD, n.d.)

[10] The committee of the OECD which deals with development co-operation matters. See list of members here.

quick to point out that this payment represented one eighth of Pakistan's budget for that year and bought about no tangible improvements in the country's welfare (Tienhaara, 2019).

Figure 17: ODA + OOF + Private receipts by type (2011-20)

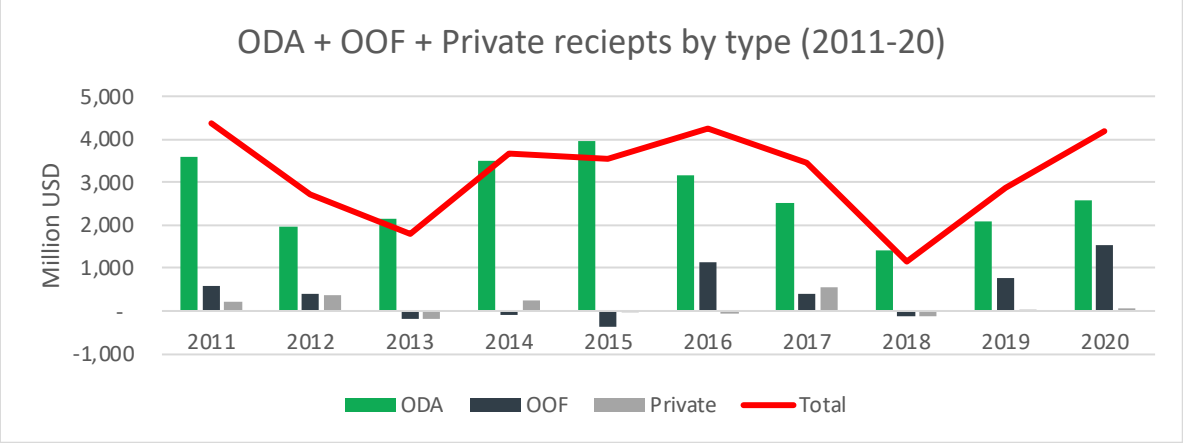
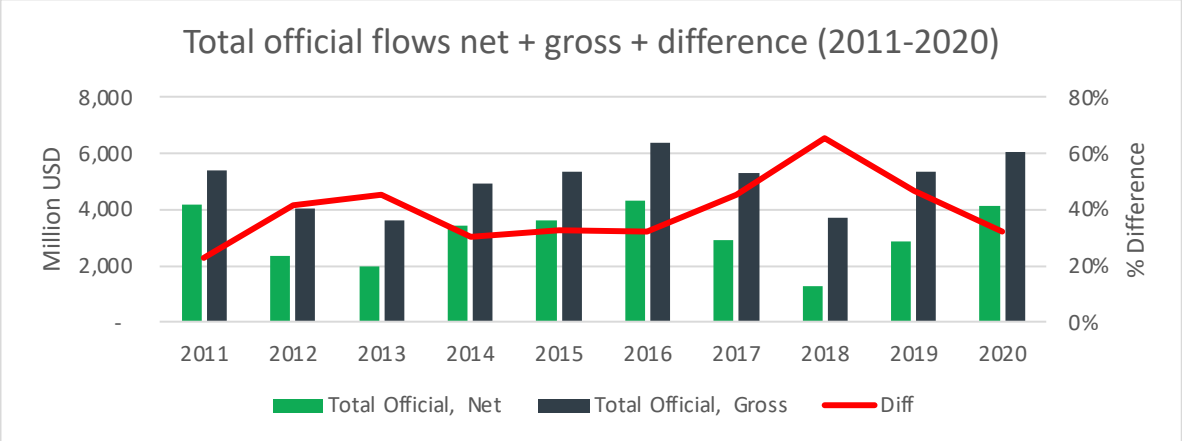


Figure 18: Net and gross total official flows and the difference as a share of gross flows (2011-20).



The World Bank Groups through its International Development Association was the largest source of financing for Pakistan, with a total net funding of US$6.6 billion (2020 constant) between 2011-2020. The United States was the second largest source and largest bilateral contributor (US$6.4 billion), followed closely by the United Kingdom (US$5.1 billion), and the Asian Development Bank (US$3.3 billion) (OECD). There is currently no record of the overall allocation of multilateral funding towards the agriculture sector, although a number of the major projects are covered in Table 15. For bilateral funding only 4% was earmarked for agriculture, forestry, and fishing as a productive sector.

Key bilateral and multilateral projects linked to Climate-Smart Agriculture are included in Table 15. This information was used to support the design of the investment opportunities (see Tables 16 & 17) along with the current policy priorities and ADP funding areas, to assure additionally and complementarity of the proposed activities.

Table 15: Key programming through bilateral and multilateral projects linked to Climate-Smart Agriculture

PROJECT	CATEGORY	DETAILS	DESCRIPTION
Strengthening Markets and Rural Transformation (SMART) (Punjab)	Value chain development; Institutional development and policy reforms; Improved extension and advisory; Livestock sector development	**Donor:** World Bank **Implementing partner:** Governments of Punjab Agriculture Department & Livestock and Dairy Development Department **Value:** US$ 300,000 **Duration:** 2017-19	• The SMART program was designed to strengthen the rural transformation process in Punjab through the support to markets and the modernization of the sector. • The program works with government institutions, providing technical backstopping for the establishment of an effective institutional and policy environment for inclusive growth withing the sector. • Key focusses of the program include agricultural extension services (including e-extension) and rural market development.
Punjab Irrigated-Agriculture Productivity Improvement Project - Revised	Water management; VC development	**Donor:** World Bank (GoP co-financing) **Implementing Partner:** GoP **Value:** 245,500,000 **Duration:** 2012-21	• The overall project development objective (PDO) is to improve water productivity i.e. producing more crop per drop. • The target was to be achieved through increasing delivery efficiency, adopting improved irrigation practices, promoting crop diversification, and effective application of non-water inputs. • The PDO would contribute to increased agricultural production, more employment opportunities in rural areas, higher incomes from the farming, better living standards of the farmers, and improved environment.
Khyber Pakhtunkhwa Irrigated Agriculture Improvement Project (Agriculture Component) under IDA	Water management; Soil fertility management	**Donor:** IDA (World Bank) **Implementing Partner:** GoKP DoA **Value:** 17,1000,000 **Duration:** 2019-25	• Khyber Pakhtunkhwa Irrigated-Agriculture Improvement Project for Pakistan is to improve the performance of irrigated agriculture for farmers in the project area.
Punjab Agriculture and Rural Transformation P4R Program	Value chain development	**Donor:** World Bank **Implementing Partner:** GoP DoA **Value:** 300,000,000 **Duration:** 2021-23	• Increase the productivity of crop and livestock farmers, improve their climate resilience, and foster agribusiness development in Punjab.
Promotion of High-Value Agriculture through the provision of Climate Smart Technology Package (Punjab)	Water management	**Donor:** ADB **Implementing Partner:** GoP DoA **Value:** 28,043,294 **Duration:** 2016-19	• Enhancement of awareness and capacity of end-users and beneficiaries on innovative water management options. • Capacity building of farmers in the operation and maintenance of solar systems and poly-tunnel farming.
Climate Adaptation and Resilience (CARE) for South Asia Project (Regional)	Climate-smart agriculture; Zoning; Policy development; Disaster preparedness	**Donor:** World Bank **Implementing Partner:** ADPC, MoPDSI **Value:** 39,500,000 **Duration:** 2020-TBC	• Climate Risk and Vulnerability Assessments (CRVA) / Hazard mapping. • Development or enhancement of existing smart agriculture zoning policy and risk management strategies.
Provincial agriculture disaster risk management operation plan and implementation guidelines-Punjab	Disaster preparedness; Institutional coordination and reform	**Donor:** FAO **Implementing Partner:** PAD, PDMA, LUMS **Value:** TBC **Duration:** 2019-20	• Explore and identify crucial knowledge gaps (including a risk assessment, drawn from contemporary information on hazards and vulnerability profiles. • Develop an action plan for DRM in Agriculture 2019-23.

PROJECT	CATEGORY	DETAILS	DESCRIPTION
Sustainable Land Management Project – Phase II (SLMP-II) (Punjab)	Land use	**Donor:** GCF **Implementing Partner:** UNDP, MoCC **Value:** TBC **Duration:** 2015-21	• Strong enabling environment at national & provincial levels supports up-scaling of SLM practices. • Effective, and adaptive implementation of SLM Land Use Planning & Decision Support System. • On-the-ground implementation of climate-resilient SLM activities is up-scaled across landscapes.
Building Disaster Resilience in Pakistan (Phase II) (National)	Value chain development; Improved extension and advisory; Disaster preparedness; Women empowerment and engagements; Livestock sector development; Strengthening farmer organizations/ groups; Water management	**Donor:** FCDO **Implementing Partner:** FAO, UNDP, WFP **Value:** 3,901,170 **Duration:** 2018-20	• BDRP (Phase II) aims to increase Pakistan's capability to reduce disaster risk though better planning, preparedness and response at the government and community levels. • The program works through two main delivery areas: (a) Community Based Disaster Risk Management (CBDRM); and (b) Strengthening disaster management bodies at the federal, provincial, district and community levels in line with the Government of Pakistan's National Disaster Management Plan (2012-2022) while contributing towards the achievement of the overall goal and outcome of the Sendai Framework for Disaster Risk Reduction. • The programme also explored the potential for CSA as a CBDRM measure for agricultural communities, recommending interventions that could build smallholder resilience.
Multi-Year Humanitarian Programme (MYHP) (National)	Strengthening farmer organizations/ groups; Women empowerment and engagements	**Donor:** FCDO **Implementing Partner:** FAO **Value:** 6,703,725 **Duration:** 2015-20	• MYHP delivered a wide range inclusive support for vulnerable communities across Pakistan supporting greater food security through improved preparedness, response, and recovery. • This was achieved through building/strengthening community-based recovery structures, to enhance resilience-building measures across the disaster affected/disaster prone areas. • Additionally, the FAO established initiatives which feature innovative, resilient and inclusive solutions for underprivileged farmers; thereby, supporting Pakistan's Sustainable Development Goals (SDGs).
Restoration of Livelihoods in FATA (Phase II) (KP-FATA)	Value chain development; Water management; Food security	**Donor:** JICA **Implementing Partner:** FAO **Value:** 4,900,000 **Duration:** 2018-21	• The project focuses on improving agricultural productivity through innovative farming practices, technologies, and value addition in agriculture through the establishment of value chains and functional markets in the FATA region of KP. • The project supported the adoption of climate smart and resilient agriculture practices for crops, livestock, and fisheries sectors. • With the decade long abandonment of land, the project is introducing water harvesting methods and rehabilitation of irrigation structures. • The project is developing agricultural and livestock value chains by establishing a linkage between farmers and market.
Restoration of Livelihoods in Khyber Pakhtunkhwa Tribal Districts (KP-FATA)	Value chain development; Water management; Natural resource management; Food security	**Donor:** JICA **Implementing Partner:** FAO, UNICEF, UNWOMEN **Value:** 13,380,000 **Duration:** 2018-20	• The project focuses on providing holistic support to the families returning to the FATA region. • This approach covers a significant range of sustainable development activities including introduction of climate smart resilient practices and technologies in return areas, value chain development, water management, Integrated Natural Resource Management, and capacity development. • Through this project, the agricultural productivity of the region will be improved through climate resilient practices and developing value chains by linking farmers with the local and national markets.

PROJECT	CATEGORY	DETAILS	DESCRIPTION
Punjab Enabling Environment Project (PEEP)	Institutional coordination and policy reforms; Agriculture financing; Value change development; Livestock sector development	**Donor:** USAID **Implementing Partner:** Chemonics **Value:** **Duration:** 2014-21	• PEEP works with the private sector, government, civil society organizations, and academia to reform policies, attract investment, and create jobs in livestock, dairy, and horticulture.
Agricultural Innovation Program (AIP) for Pakistan (National)	Agriculture research and innovation; Institutional coordination and policy reforms; Food security; Climate change adaptation; Value chain development	**Donor:** USAID **Implementing Partner:** CIMMYT; PARC; ILRI; IRRI; AVRDC; UC Davis **Value:** 2,361,905 **Duration:** 2012-21	• AIP aims to have measurable impact on agricultural growth, food security for the poor, component of climate change resilience and adaptation in Pakistan's agricultural sector. • Through the program, the governments of Pakistan and US intend to invest heavily in capacity strengthening to assist Pakistan in revitalizing its national research system and integrating the private and public sectors around pro-poor science, technology, and innovation. • The project would be a long-term, Pakistan-owned, Pakistan-led undertaking.
China-Pakistan Economic Corridor (CPEC)	Food security; Value chain development; Improved extension and advisory; Mechanisation support; Seed sector development/ reform; Water management; Disease control/ Integrated pest management	**Donor:** China **Implementing Partner:** GoP **Value:** **Duration:** 2017-30	• Agricultural Development and Poverty Alleviation in terms of cooperation in key construction areas such as biological breeding, production, processing, storage and transportation, infrastructure construction, disease prevention and control, water resources development and utilization, land development and remediation, ICT -enabled agriculture and marketing of agricultural products to promote the systematic, large-scale, standardized, and intensified construction of the agricultural industry. • This includes investments in agri-processing and value addition facilities through Special Economic Zones (SEZ) • The cooperation aims to promote the transition from traditional agriculture to modern agriculture in the regions along the CPEC to effectively boost the development of local agricultural economy and help lift farmers from poverty.
The Alternative Livelihood Option Project (KP)	Strengthening farmer organizations/ groups; Women empowerment and engagements; Value chain development	**Donor:** Bureau of International Narcotics and Law Enforcement Affairs **Implementing Partner:** FAO **Value:** 793,000 **Duration:** 2018-20	• The Alternative Livelihood Option Project explores potential alternative livelihoods options in Khyber Pakhtunkhwa by engaging the communities to develop agricultural value chains by increasing capacities of value chain actors, service providers

3.2.4 Green and climate financing instruments

Green finance refers to all types of financial flows targeted at environmental objectives. Climate finance is a subset of green finance and refers primarily to public finance that promotes multilateral efforts to combat climate change (ISO, 2021). To achieve the transition towards net zero emissions and resilient agriculture, green and climate finance flows must drastically increase globally (Climate Policy Initiative, 2021). Given that Pakistan is the 8th most vulnerable country to climate change extreme events, and its adaptation needs are estimated at USD 7.14 billion per year (until 2050) (Aslam, 2022), channeling climate finance to fund adaptation and mitigation efforts is essential. The following section reviews common green and climate financing instruments and their use to date in Pakistan.

3.2.4.1 Green bonds

Green bonds are fixed-income instruments designed specifically to support climate-related or environmental projects. Green bonds can drive down the cost of capital for large-scale projects that offer positive environmental and climate outcomes, increasing the capacity of capital markets to support governments and private actors in meeting climate targets. An emerging green bonds market can bridge the environmental, social, and governance (ESG) transparency gap in emerging markets, providing confidence to investors on the positive green impacts of projects financed and the consideration of environmental and social safeguards. (citation)

In 2021, Water and Power Development Authority (WAPDA) issued Pakistan's first green bond (Indus bond) for 10 years to raise $500 million at 7.5 per cent interest rate for funding hydroelectric power projects (Diamer Basha and Mohmand dams). The bond attracted interest from a number of international investors with offers of investments worth $3bn, six times more than its target (DAWN, 2021). The intent was to gradually increase the number of bonds based on the financial needs of the project. WAPDA delayed the issuance of the second green bond till financial year 2022-23 due to several internal and external factors increasing the interest rates.

Pakistan has thus far been unable to access climate finance on the same scale as neighbouring countries, including India and China. India as of 2021 had $18.3 billion worth of green bond transactions (Bhattacharya et al., 2022), while China's green bond market reached $200 billion (Manshu et al., 2022). The Securities and Exchange Commission of Pakistan (SECP) has guidelines for the issuance of green bonds to be utilised to finance or refinance projects related to renewable and sustainable energy, energy efficiency, pollution prevention and control, biodiversity conservation, water management, and green buildings (SECP, 2021). Compliance to globally accepted standards is necessary such as the International Capital Market Association's Green Bond Principles 2018, Climate Bond Standards and/or environmental risk management systems as well as national/international social and environmental safeguards. However, there continues to be limited access due to a number of factors outlined below:

- Lack of bankable green projects with clear mitigation and adaptation focus that can be financed or re-financed through green bonds,
- Lack of awareness among policy makers, regulators, bond issuers and investors as well as inadequate development of financial infrastructure,
- Verification of the 'green bond' status and monitoring of use of proceeds by issuers for green purposes requires costly services of second opinion or third-party assurance providers,
- High transaction costs and complexity for international investors to access local markets due to differing green bond definitions and disclosure requirements and varying measurement and reporting standards. Cross-border green bond investing is also constrained by the lack of risk hedging products such as against currency devaluation risks

The rapid growth of the international green bonds market is demonstrative of how capital market mechanisms can enlist private capital to address global climate change action and channel private sector funds to developed and emerging economies. Pakistan could enlist the support of multilateral development banks (MDB) and development financial institutions (DFI) to leverage their experiences in green bond issuances and securing their support in as providing credit enhancements and serving as anchor investors for green bonds. This could act as a catalyst for increased flows of private capital.

3.2.4.2 Nature performance bonds

The nature performance bond (NPB) is a sovereign debt instrument that links sovereign debt payments to predetermined nature-based targets (F4B, 2020). NPBs build on the experience of debt-for-nature swaps, first introduced in Latin America in the 1980s, and capitalise on the strong evidence linking natural capital to

a country's economic productivity and growth. In 2009, Pakistan signed a debt-swap agreement with Italy, pledging agriculture, health, education, and environmental projects (GoP, 2009).

NPBs have the potential to accelerate the availability of finances for achieving targets on climate adaptation, mitigation, and biodiversity conservation. Unlike debt-for-climate swaps, NPBs do not impose any restriction on the use of proceeds, thereby extending spending autonomy to the government to utilise the funds for any economic purpose, while tying them in to delivering pre-agreed outcomes. The design of financial instrument and nature performance targets is specific, reflecting the country's context and interests of creditors. Complications of normal debt negotiations are avoided if the focus is on new debt issuance. Under the terms of an NPB, issuers receive relief on both interest and principal as they achieve an agreed nature-based outcome. Dialogue needs to be continued on refining performance indicators and benchmarks for assessing performance and setting up a robust Monitoring, Reporting and Verification (MRV) system.

Efforts towards Pakistan's first NPB were recently initiated by the Finance for Biodiversity Initiative in partnership with United Nations Development Programme (UNDP). The initiative engaged with sovereign creditors – Canada, Germany, and UK – environmental and financial authorities and related organizations and experts, to develop performance indicators linked to the Ten Billion Tree Tsunami project and the restoration of national parks, with secondary development indicators such as rural employment, community participation and capacity building (Halle, 2021). Considering the overlap between the environmental and social outcomes often targeted by NPBs and the three pillars of CSA (adaptation, mitigation, and productivity), there is potential to develop NPBs with indicators linked to the widespread adoption of CSA.

3.2.4.3 Voluntary carbon offset market

The voluntary carbon offsets market allows individuals, companies, and governments to compensate for their own carbon footprint by financing projects that prevent or absorb carbon emissions elsewhere. Corporates like Apple, Microsoft, Shell, and Amazon are increasingly pledging to reduce their emissions footprint and carbon markets are becoming necessary for this transition to net zero.

Besides providing high carbon emitters with a mechanism to offset their emissions, the voluntary carbon markets make much-needed climate finance available for developing countries to invest in climate-relevant interventions. A study reveals that Pakistan's first NDC ambitions (300 $MtCO_2e$) could create a carbon offset industry worth $200M per year (Pakistan Environment Trust, 2021). One-third of this could come from nature-based projects like the Ten Billion Tree Tsunami Programme or The Restoration Initiative (TRI). Pakistan's updated NDC has committed to an even higher target - reducing 50 per cent of the country's projected emissions by 2030 (801 $MtCO_2e$) of which 35 per cent is conditional on international grant finance (UNFCCC, 2021). Moreover, the country's blue ecosystem has high carbon storage potential with a rapid assessment showing that mangrove forests and tidal marshes store approximately 21 M tonnes of organic carbon (or 76.4 $MtCO_2e$) (The World Bank, 2021). A mangrove reforestation action that removes 25 M tonnes of CO_2 by 2050 could generate a revenue of $75 million (terrestrial forest price of carbon credits of $3) or $300-500 million (aspirational blue carbon prices of $12-20), respectively.

Pakistan has made limited progress in participating in the voluntary carbon market with only 10 registered projects, compared to Nepal and Bangladesh which have 80 projects between them (Pakistan Environment Trust, 2021). None of the projects from the forestry sector are included despite the government's strong focus in the area. This is a missed opportunity because of the growing demand from offset buyers for nature-based solutions. Tapping the missed potential of the voluntary carbon market will require developing a coordinated national framework along with awareness raising and capacity building, clear institutional arrangements and developing strong MRV systems (IISD, 2018). Offset arrangements would also require third party independent entities (such as Gold Standard) to quantify and certify the impact of projects.

3.2.4.4 Impact investing

Impact investments are intended to generate social and/or environmental impact as a core objective alongside a financial return. The impact investing space in Pakistan is diverse with a range of different actors including development finance institutions (DFIs), funds or fund managers, high net-worth individuals, family offices, foundations and diversified financial institutions/banks. In Pakistan, DFIs represent the largest share of capital deployed in impact investing (92 per cent; > USD 1.8 billion) followed by funds or fund managers (8%) (GIIN, 2016). Examples of impact enterprises in the food and agriculture sector include MilkOp, Sunvolts, Microrip and Open. DFIs prefer investing in mature companies with most investments in the energy sector followed by manufacturing, infrastructure and agriculture and food processing. Non-DFI investments have gone primarily into financial services with a small share of capital going into energy, health, agriculture, and housing. Agriculture is an attractive sector for impact-oriented finance but a lack of clarity around farm ownership laws and land titles remains a key issue. Investment activity also occurs at the periphery of impact investing (called 'impact-related investment') whereby investments do not have an explicit intention of impact but they serve bottom of the pyramid population or have some intention for social and/or environmental outcomes that are not measured meaningfully (GIIN, 2016). In the case of impact-related investments, fund managers and commercial banks (receiving earmarked DFI capital) represent a significant share. Angel investors also invest in the periphery, usually tied to incubators and accelerators but with small investment size, high transaction costs, and challenges with monitoring and evaluation.

Perception of insecurity and volatility are deterrents for international investors. The overall business climate in terms of initial entry is conducive but presents challenges for private equity regulation. Beyond entry, the key challenges for investors are around screening and due diligence, structuring for investment, and exit. A nascent ecosystem of support players for investors is developing in Pakistan with the presence of incubators/accelerators, advisory services, credit rating services, and TA providers. Access to finance is a major challenge faced by enterprises in the earlier growth stages (seed & venture) who access it from informal sources or grants and donations from philanthropists or Pakistani diaspora. Entrepreneurs also face operational challenges in areas such as human resources management, corporate governance and financial management, marketing, and market access capabilities. Some prominent start-ups in the agritech space include Ricult, Bakhabar Kissan, Pak Agri Market, Crop Drop, Industrial Vision System, Aqua Agro, Agri Analytics, Qumak (National Incubation Center, 2021).

The Pakistan SDG Investment Report 2021 outlines an investment portfolio worth US$ 2 billion in SDG aligned areas including climate change related sectors (UNDP, 2021). This will form the basis of Pakistan's first SDG Investor Map, a tool that will map the intersections between country-specific development needs, policy priorities, and investor interest, translating these into actionable investment opportunity areas. These opportunities are backed by actionable data to guide investor decision-making.

3.3 Recommendations for improved policies and programming to stimulate investments in CSA

The recommendations outlined below have been developed in response to some of the challenges, bottlenecks, and opportunities identified within the institutional, policy, and financial landscape of Pakistan. The recommendations include measures targeted at both public and private actors located domestically and internationally, building on the best practices outlined in the Strategies for Financing Sustainable and Resilient Food Systems in Asia (2021) by ADB.

- **Pakistan has a comprehensive policy framework that touches on many of the areas that are important for the modernization of the agriculture sector and the adoption of CSA.** There is however a disconnect between the national and federal policies and the implementation through local government, with many issues persisting despite being the focus of previous policies. Important policy areas to support

the agriculture sector are those targeting agriculture research and innovation, food security, value chain development, policy reform, and disaster preparedness. There is a need to develop costed action plans that build on the policy objectives in these areas with measurable outcomes, clear institutions mandates, and earmarked funding.

There is a need to reorientate public finance towards agriculture sub-activities that typically receive less funding. While the large allocation of public funds towards enhancing on-farm water management practices and the upkeep of irrigation infrastructure is essential in the face of the ongoing water crisis in Pakistan, there is a need to ensure sufficient funding is channeled towards activities that will modernize the sector. Strengthening farmers' aggregation in cooperatives, providing access to agricultural information, or promoting soil conservation and soil surveys are some of the identified agricultural activities that typically receive less funding from ADPs. Increased investments in these areas will not only improve the livelihoods of farming households but offer positive sustainability outcomes for the sector.

- **Opportunities for investment lie in specific agriculture-sub sectors (such as the improved provision of inputs and the processing of horticulture and livestock products) which are supported by the existing policy frameworks but are currently acting as bottlenecks in creating growth in the sector.** Some of the key agriculture sub-sectors that need strengthening are input and output markets. For instance, the availability, accessibility, affordability, and quality of inputs has been identified by national and provincial policies as a key bottleneck preventing progress in several programs. Opportunities also lie in investing in increasing food processing capacity and value addition for high value horticulture and livestock products, which are supported by the federal and provincial boards of investment.
- **Public institutions should provide incentives to support sustainable and climate-smart agriculture production.** Currently, farmers lack incentives to pursue climate-smart agriculture and protect natural resources due to the associated high costs. Public institutions should provide incentives through introducing environmental regulations, providing public payments for environmental services and certification of sustainably produced products, among others. Better regulation would also decrease other stakeholder's risk perception to invest in the agriculture sector, allowing the scale up of investments with positive environmental impacts (ADB, 2021).
- **Public-private partnerships (PPP) engagement in the agriculture sector needs to be strengthened, to unlock private sector financing.** The private sector is key to close funding gaps in climate-smart agriculture, though generally too risk averse to invest in the sector. The recent establishment of Public Private Partnership Authorities at federal and provincial levels offers opportunities to promote PPP in agriculture, a sector which has not been prioritized in Pakistan. Developing an enabling environment for the private sector to accurately assess and mitigate the risks of investments in agriculture is essential. Blended finance can also attract commercial capital towards projects that contribute to sustainability objectives in agriculture by reducing perceived and real risks alongside providing market rate financial returns.
- **The availability of investable projects and business models that contribute to value chain addition and promote CSA could be increased** by supporting agribusinesses and SMEs which show high potential impact with the necessary technical assistance to make them attractive for investment (examples can be drawn from the innovative enterprises supported by the Pakistan ACUMEN foundry). The growing ecosystem of startups and SMEs in the agritech space of Pakistan, in addition to incubators, accelerators and other services, offer opportunities to scale impact, though access to finance is still a challenge faced by early-growth stage SMEs. Developing pipelines of bankable projects and agri-SMEs, and matchmaking these pipelines with appropriate impact investors, could scale impact and accelerate growth and resilience in Pakistani agriculture from the demand side.
- **Channeling green and climate finance from domestic and international sources and increasing its allocation to agriculture is key for adaptation.** At the domestic level, Pakistan has low capacity to finance climate adaptation and mitigation measures, since the public sector has little fiscal space and the private sector does not have sufficient incentives, making the country dependent upon foreign funds (M.

Zahid & Abedullah, 2020). At the same time, Pakistan is also a relatively new player in the international climate finance arena and has limited experience receiving or disbursing international climate finance (ADB, 2017b). There is a considerable potential to align the investment goals of public and private impact investors with the countries climate and sustainability goals, creating opportunities for green financing instruments, especially in agriculture. Pakistan has however lagged behind other countries in the region for the adoption of these instruments. To address this, green and climate finance for agriculture should be mainstreamed in government planning and budgeting processes, international climate finance from bilateral and multilateral donors should be mobilized, and an enabling environment for enhancing climate finance should be created to incentivize public and private sector institutions. This will also require the development of strong MRV systems to accurately assess the performance of these green financial instruments.

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Chapter 2

CSA Investment Prioritisation

Section

4

Introduction to prioritized CSA investment opportunities in Punjab and KP

HIGHLIGHTS

- Nine CSA Investment Opportunities were identified for Punjab and twelve for Khyber Pakhtunkhwa following an extensive assessment of the climate change and agriculture context, major risks impacting agricultural value chain, priority interventions for climate smart agricultural development, and the required enabling environment.
- Concept notes were developed for the prioritized CSA investment opportunities capturing the needs assessment, possible interventions, impact across pillars and relevance to the policy and programming landscape. A summary of concept notes is given in Table 16 and Table 17 and full versions can be found in Annex 1 and Annex 2.
- Provincial stakeholder workshops were held to support the review and evaluation of CSA investment opportunities. Stakeholders scored the investment opportunities on their potential for adaptation, mitigation, productivity, scaling potential, and investment risk. The scoring results are presented in Table 16 and Table 17.
- Four high-priority investment opportunities were selected for development into detailed investment and research packages. These packages were selected for further analysis based on the results of the expert scoring, the alignment with GIZ priorities, and additional expert consultations.
- For the investment packages a full cost benefit analysis has been conducted for the programme, while for the research packages only the costs have been assessed due to the challenges in assessing the monetary value of the non-monetary benefits.

INVESTMENT PACKAGES

5.1 Financing model for developing smallholder farm mechanisation

5.2 Enhancing biocontrol production and implementation capacity for integrated pest management

RESEARCH PACKAGES

6.1 Integrated farming with native fruit trees

6.2 Strategy development & awareness raising to counter wild boar attacks in Kurram, Orakzai, & North Waziristan

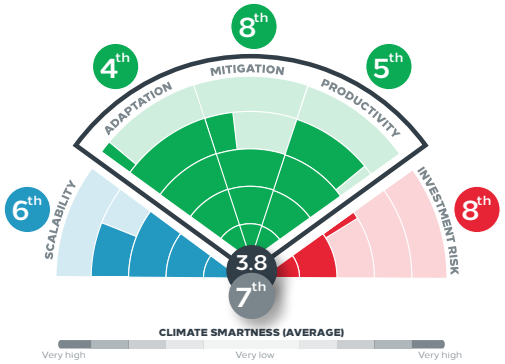
4.1 Investment opportunities

The project team undertook an extensive assessment of the current context in each of the provinces in terms of the major risks impacting agricultural production, priority interventions for climate smart agricultural development, and the required enabling environment. This was an iterative process, initiated by mining the existing data the Alliance has generated at national, provincial, district and village levels on climate hazards and priority interventions. These initial packages then went through a review process with a number of key stakeholders in each province, reviewing and refining the identified packages, and proposing additional packages that may not have emerged from the initial review. This was followed by an extensive review of the current policy framework and the programming priorities of government and non-government actors, aligning the packages with existing initiatives and avoiding duplication of activities (see Section 4 - Policies, institutions, and financing).

Through this analysis nine Investment Opportunities (IO) were identified for Punjab (see Table 16) and twelve for Khyber Pakhtunkhwa (see Table 17). These IO covered a range of different intervention types, from the scaling of climate smart interventions at farm level, to institutional capacity development for effective preparedness and response to climate change in the provinces. A core feature across the IOs is that they not only outline what needs to be done but also elaborate on how those changes are to be achieved and where they fit into the existing policy and programming landscape. Concept notes were developed for each of these investment opportunities capturing the needs assessment, possible interventions, impact across pillars, and relevance to the policy and programming landscape (see Annex 1 for KP and Annex 2 for Punjab).

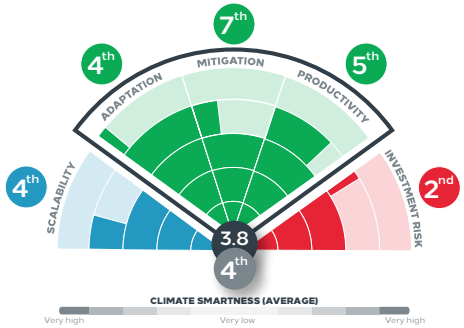
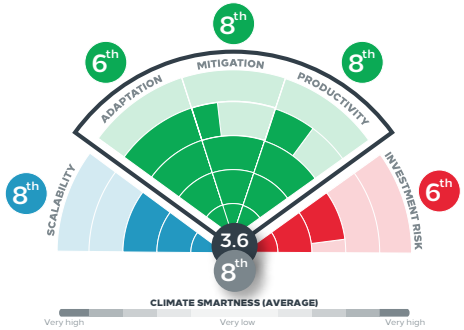
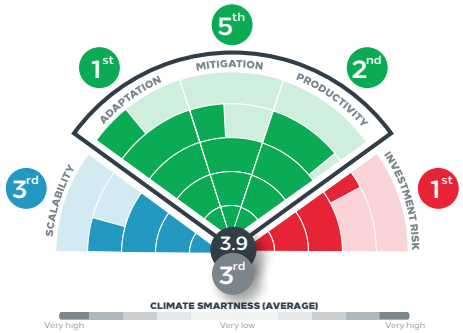
CSA scoring graphic

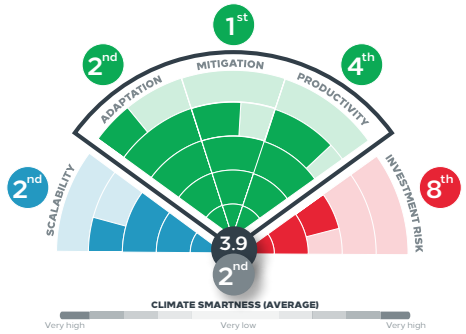
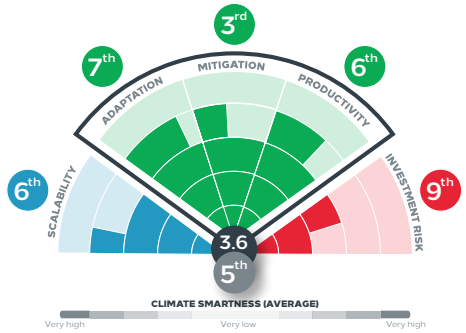
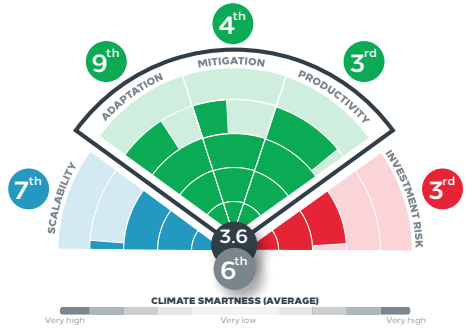
The scoring graphics presented for each investment opportunity display the results of the key stakeholder evaluations that were conducted in each province. With support of the interactive surveying tool Menti, participating stakeholders were asked to score each of the investment opportunities according to their contribution to climate change adaptation, GHG mitigation, and productivity enhancement, along with their scaling potential and investment risk, using the Likert scale from 1-5 (very low-very high).



The radar plots present the score for each of the indicators, with higher scores being favoured for all indicators except investment risk, where a lower score signifies reduced risk. The climate smartness of the package was calculated as the mean of the adaptation, mitigation, and productivity scores, seen at the bottom in dark grey. The numbers around the outside of the radar diagram signify the ranking of that indicator compared to the other packages in that province.

Table 16: Investment opportunities for Punjab

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 1: Advancing the seed sector in Punjab	• **Institutional development-** Strengthen regulatory capacity and build effective regulations within the seed sector that minimize bureaucratic procedures and incentivize compliance; mainstream the public sector seed corporations through improvements in technical expertise, seed marketing and branding, and increasing competitiveness in the market. • **Research & development-** Incentivize research and innovation in the seed sector through mainstreaming intellectual property protection and strengthening linkages between research and practice. • **Private sector engagement-** Incentivize private sector research and development in the seed sector coupled with legally binding arrangements and regulatory oversight.	**Climate change** is impacting the suitability of crops, increasing the need for improved/stress tolerant varieties. **Certified seed only accounts for 35%** of the seed used in Pakistan. With the majority of seed coming from **poorly regulated private** provides in the informal sector.	
PACKAGE 2: Strengthening the integrated management of pests	• **Research and surveillance-** Strengthen research on the distribution of pests; employ ICT and other tools for crop disease surveillance, early warning, and advisory. • **Extension capacity development-** Build the outreach and capacity of the extension system to better deliver advisory on pest management practices including pest identification, pesticide preparation & application, health hazards and biosafety; employ electronic media tools to amplify outreach of extension services. • **Regulatory capacity-** Enhance capacity of departments to improve regulation of pesticide usage and prices; improve coordination between extension department and pest warning and quality control department.	Pest and disease outbreaks are **increasing in frequency and intensity** under climate change, making them one of the major drivers of crop losses in KP and Punjab. **Poor training** on effective pest and disease management practices has resulted in farmers **overusing hazardous pesticides** which are impacting their health and the health of the environment.	
PACKAGE 3: Enhancing wheat resilience	• **Input enhancement-** Improve access to and quality of inputs to wheat production including drought and heat tolerant seed varieties, pest control tools, fertilizers, on-farm water management technologies and agriculture credit and insurance. • **Market development-** Improve connectivity of farmers to agricultural market using traditional extension as well as ICT tools to increase direct benefits to growers; enhance capacity on marketing and branding strategies. • **Technology support-** Incentivize the use of modern technology and machinery appropriate for local conditions through extension support, access to credit and linking to local manufacturers and service provides.	Wheat is heavily impacted by **climate change,** with **higher temperatures** projected to supress future **yields.** Farmers are currently not using **stress tolerant seeds** or the most suitable **management practices** to counter these losses. Wheat farmers have been found to benefit from improved access to **financial services,** high quality **inputs, storage facilities,** and **crop insurance.**	

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 4: Supporting smallholder farmers in mechanisation to improve productivity	• **Research & development-** Provide industrial extension support to local manufacturers; promote development of quality and precision local technologies by encouraging research and piloting in academic and technical institutions; investigate economic and environmental impact of various farm technologies to engage with policy makers and farmers. • **Credit support-** Improve credit support for resource constrained farmers to incentivise the use of machinery and implements appropriate to local conditions.	While Punjab has seen greater levels of farm mechanisation than other provinces, there remains **untapped productivity gains** from higher levels of **mechanisation.** Further support is needed for **low-cost, high-quality machines,** supported with **industrial extension and training.**	
PACKAGE 5: ICT based early warning, advisory and market information	• **Participatory ICT development-** Promote the development of ICT tools and services taking into consideration local needs and demands as well as principles of human-centered design. Encourage the use of interactive platforms, local languages and context-specific examples and references. • **Digital literacy and training-** Roll out digital literacy programs among farmers. Train extension officers to use ICT tools and impart skills to farmers. Monitor and evaluate the extent to which provided information & advisory is translated into action. • **Public private partnerships-** Build and strengthen partnerships with private sector and telecom providers to tap on their networks and services for greater outreach. Bundle agro-advisories with other services such as insurance and credit products.	Farmers currently lack **localised and timely information** on climate and markets. There are still **information utilization gaps** regarding **market updates** and **weather forecasts** for farmers, which can be addressed through the use of modelling, machine learning, and remote sensing technologies, to provide site-specific **advisory information.** ICT development also offers opportunities for **information intermediaries** to support service provision.	
PACKAGE 6: Agriculture financing	• **Private sector engagement-** Work with climate finance and impact investment funds to draw increased investment into Pakistan's agriculture sector. • **Investment screening-** Conduct screening and pipeline development of potential private investments considering their potential to increase agricultural productivity, adaptive capacity, and/or mitigate GHG emissions. Conduct due diligence on promising investments linking to investment KPI's. • **Training & awareness-** Provide technical assistance to investees, lowering investment risks through the inclusion of adaptive measures.	Due to resource constraints and land tenure issues smallholder farmers are unable to provide **collateral for formal loans** from commercial banks and co-operation companies. Reliance on **informal loans** often leaves farmers **trapped in debt.** Farmers and **value chain actor**s need access to financial resources to **modernise** and build their **resilience.**	

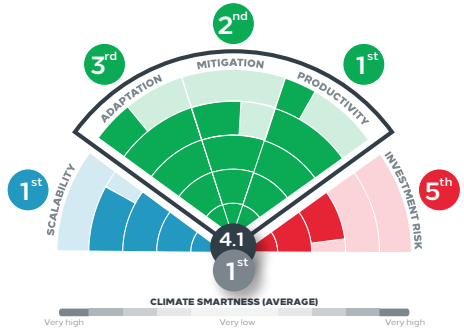
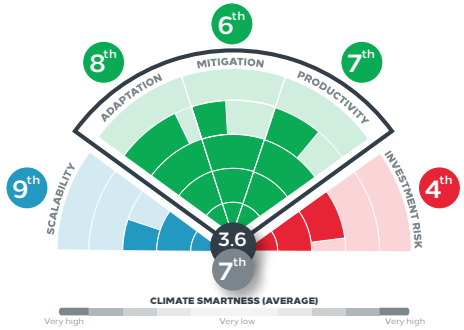
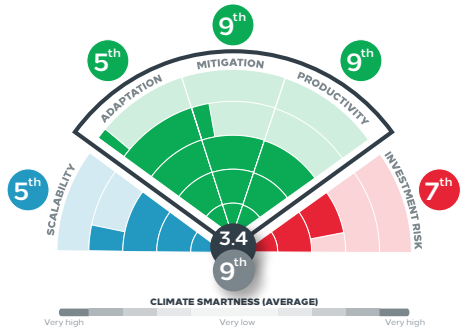
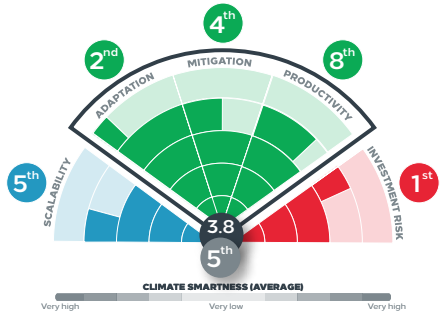
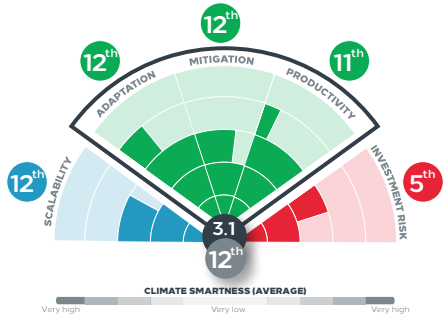
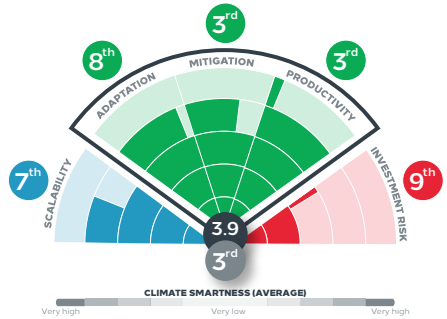
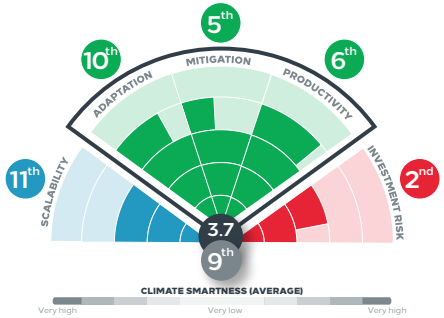
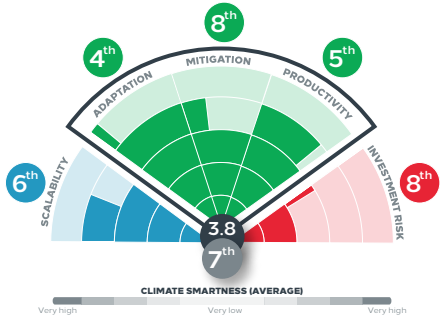
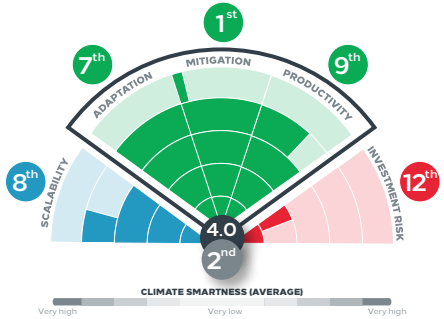
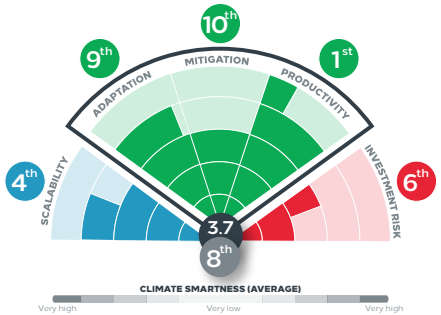
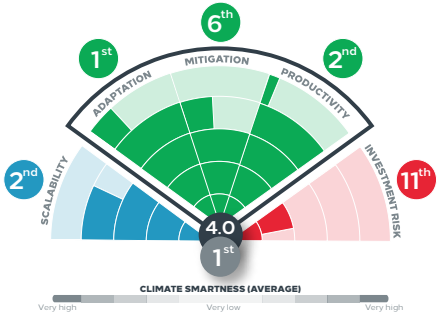
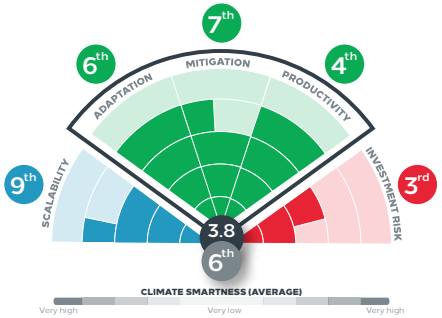
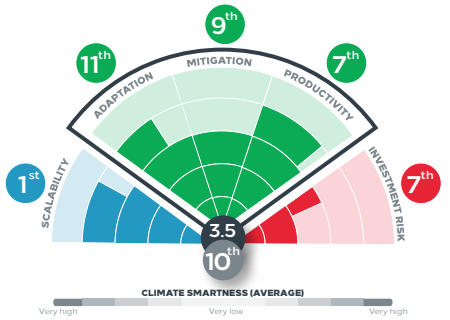
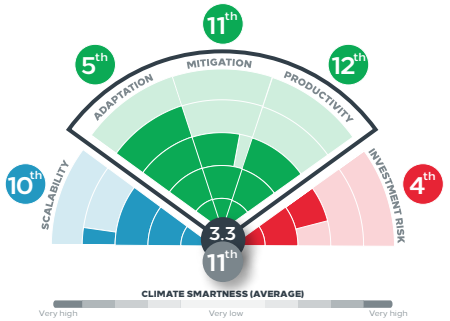
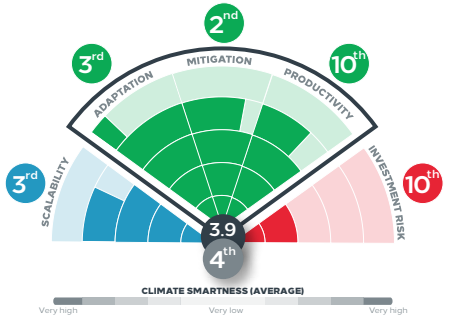
INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 7: Shifting water management strategies at farm-level	• **Training and research-** Strengthen farmer's knowledge on effects of climate change and the evolving water needs and provide training on effective water management and climate smart practices; promote research on specific water management practices to analyse their economic, social, and environmental benefits/costs such as the use of HEIS, altering cropping patterns, water user association participation; conduct test trials and pilot projects to demonstrate to farmers the benefits. • **Enabling policy environment-** Advocate for policies that support the adoption of climate smart, water management practices among the less educated & trained smallholder farmers and in particularly women farmers. • **Local water governance capacity-** Develop and strengthen water user associations for water distribution, maintenance of water courses, and for regulating water use.	**Drought** is impacting the yields of crops across Punjab (such as maize), with **irrigation requirement** expected to increase by **7-11%.** To address the issues bought about by growing water scarcity it is recommended that there is a support package for smallholder farmers to adopt **High Efficiency Irrigation Systems** (HEIS), along with **water-saving climate smart strategies** such as raised bed planting, ridge sowing, rainwater harvesting, or integrated soil fertility management. There is also a need to improve local water governance to avoid **resource conflict.**	
PACKAGE 8: Providing crop diversification and market support	• **Research & piloting-** Identify, research and pilot test diversification strategies for Punjab's different agro-ecological zones. • **Enabling environment-** Following the development of strategies, incentivize the uptake of crop diversification through input and extension support, credit access, and market development.	**Climate risks** are increasing the need for farmers to **diversify their production** to reduce their exposure to losses and support **food and nutritional security.** This involves switching to more resilient crop varieties, which requires investments **training, value chain development, and policy support.**	
PACKAGE 9: Local storage and processing capacity program	• **Modernizing local storage-** Establish modern post-harvest storage technologies in rural areas that minimize losses and risk against forces of nature. • **Agriculture processing-** Identify the economically viable products which can be processed in rural areas and build capacity of the farming households. • **Private financing-** Encourage private investors in developing and modernizing local storage and processing backed by SBP's financing facility for agricultural storage.	Pakistan's **post-harvest losses** for wheat, maize and rice are estimated at nearly **US$ 343 million per annum** due to a lack of proper drying and storage. Losses in **fruits and vegetables** due to poor value chain infrastructure and management practices stand at **30-40%.** Modern drying and silo storage facilities are not accessible for a majority of farm actors, and force farmers to **sell at harvest time when prices are at the lowest.** Traditional post-harvest practices also expose farmers, traders and other value chain actors to the uncertainties brought by **weather variability.** Building agro-processing capacity in rural areas can significantly enhance **rural incomes** and **socioeconomic development.**	

Table 17: Investment opportunities for Khyber Pakhtunkhwa

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 1: Providing market development and production support to maize growers	• **Human capital development-** Research and extension support on maize cropping calendars, pest management and other CSA practices. • **Institutional support-** Safety nets for resource poor farmers, index-based insurance, and input subsidies. • **Market support-** Research and development of high yielding/tolerant varieties, seed sector development, CBSQM, seed multiplication, improved storage and processing capacity, and output market development.	Maize is a major crop in Pakistan, for which yield reductions are projected across most of the country due to climate change. However, **northern KP** is projected to experience **yield increases** due to more favourable conditions. Capitalizing on this competitive advantage by **supporting and scaling maize production** in KP would help **meet the domestic demand (for food and animal feed).** Access to improved inputs, enhanced training and extension, and institutional and market support are needed for **value addition** in the maize value chain.	
PACKAGE 2: Strategy development & awareness raising to counter wild boar attacks in Kurram, Orakzai, & North Waziristan	• **Research-** Research on the distribution of wild boars, the factors that are driving them into conflict with farming communities, and the most effective management practices. • **Human capital development-** Support awareness raising and capacity to implement effectives measures to reduce wild boar attacks. • **Institutional support-** Focus on policy reform and service provision to reduce the physical and economic vulnerability of farmers in affected regions.	Climate change and habitat loss are driving **wild boars** into close proximity with farming areas of KP, leading to **attacks on crops** and high yield losses. A lack of awareness of **effective measures to prevent and respond** to these attacks is causing farmers to switch away from important crops or give up farming due to substantial economic losses.	
PACKAGE 3: Institutional capacity building on Integrated Soil Fertility Management	• **Institutional development-** Develop a soil management manual adapted to the different agro-ecological zones of KP through capacity development and improved coordination between the soil conservation department, research, and extension; improve the soil testing capacity of soil conservation department for rapid on-farm testing, including into the NMD's. • **Human capital development-** Provide training to input providers and FSCs; develop updated training modules for farmers on ISFM customized to specific contexts. • **Technology-** Facilitate the adoption of precision soil management practices such as the use of GIS-based soil services.	**Soil and water testing facilities** in KP are currently inadequate and services need to be more widely available through the extension system and private sector. There is also a need for **training extension workers, input providers** and farmers on best practices for integrated soil fertility management and the use of soil fertility data for decision making. **Geographical information systems for precise mapping** and testing of soil indicators have weak adoption in the agriculture sector. **Soil maps** which identify soil constraints that limit crop yield need to be **updated** and more widely available.	

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 4: Watershed management through integrated farming systems	• **Integrated farming-** Promote research on integrated farming strategies that support watersheds and reduce flooding, drought, and erosion risks - including the integrated system of contour farming soil binding fodder around native fruit tree varieties. • **Market development-** Develop native fruit trees nurseries and improve availability of fodder seed; promote a market for native fruits, increase storage and processing capacity, provide branding and advertising support. • **Water impounding & fish production-** Construct check dams and water impounding, introducing fish farming into water tanks.	KP's forested area is a critical watershed increasingly threatened by the rise in periods of **drought and intense rainfall.** Deforestation and unsustainable agricultural practices have also contributed to **watershed degradation,** causing flash floods and landslides. **Integrated farming** systems with native trees and fish farming can **enhance the health of KP's watersheds, diversifying farmer incomes** and providing access to new markets.	
PACKAGE 5: Modernizing Farmer Service Centers to improve extension, input supply, market support and farmer organization	• **FSC expansion-** Establish smaller stores closer to communities especially in remote locations; expand FSCs to newly merged districts; broaden the mandate of other related departments (soil, livestock, research etc.) to also provide training and advisory services to farmers through FSCs. • **Digital and ICT support-** Modernize and digitize inventory management to track input use and availability across FSCs. • **Farmer Organization-** Promote FSC as model for farmer organization and run outreach programs to increase membership including women farmers and farmers in remote locations.	The **Model Farm Service Centers** introduced in 2008 serve as one-window solutions for farmers to access agricultural inputs, advisory services and market information. Though showing a **promising role in agriculture service provision,** accessibility to FCSs for smallholders in remote areas is limited. Farmers would also benefit from FSCs **modernization and expansion** as well as from increased training and advisory services provided.	
PACKAGE 6: Agro-climatic zoning, updating cropping calendars & promoting alternative crops	• **Agricultural planning support-** Develop AEZ specific agricultural development plans based on recently updated AEZ's for KP; update cropping calendars for major crops and give recommendations based on the climate-adjusted zoning; identify alternative crops that improve productivity and adaptation to current and projected climate hazards. • **Capacity development-** Improve the capacity of agriculture & extension officers coupled with greater autonomy to make context specific recommendations based on localized agro-climatic conditions. • **Promote alternative crops-** Conduct research on suitable growing areas for alternative crops, run field trials, provide training and capacity to farmers, market assessment, demonstrate benefits and link farmers to input providers.	Climate change is **altering the agro-climatic zones** of KP, with implications for the cropping patterns that should be promoted. **Opportunities** lie in the promotion of alternative **high value crops** (such as saffron or olive), more resilient to the projected climatic conditions. Research on **crop area suitability and appropriate management,** along with **capacity building,** are needed to support farmers in adopting new resilient high value crops.	

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 7: Strengthening input market regulation and private sector engagement in value chain development	• **Institutional capacity development-** Build technical capacity of department staff on quality and regulatory checks in the input market; establish a task force or technical group among the existing staff to specifically oversee quality, pricing, and other regulatory checks; advocate to expand the mandate of relevant departments to include input regulation. • **Private sector engagement-** Work with climate finance and impact investment funds to draw increased investment into Pakistan's agriculture sector. Undertake screening and develop a pipeline of potential private investments across agriculture value chains considering their potential to increase agricultural productivity, adaptive capacity, and/or mitigate GHG emissions.	Providing **timely and quality inputs** assured by regulatory and price checks can lead to increased adoption of improved technologies among farmers. The capacity of the **provincial extension** department **needs to be strengthened** and the geographical coverage expanded, **for effective implementation of regulatory checks.** Government can work with the private sector, farmers, and other stakeholders to establish mutually agreed systems for quality control, inspection, and certification. **Public-private partnerships** can **modernize** the agriculture sector by screening **opportunities for investment** across agriculture value chains.	
PACKAGE 8: Promote training and implementation of integrated pest management and research effective strategies	• **Research support-** Facilitate research on effectiveness of different IPM strategies for specific crops and contexts. • **Capacity development-** Improve awareness and capacity of farmers on effective pest management, controlled/balanced chemical application on crops, higher use of bio-fertilizers, bio-pesticides & weed control practices through agriculture extension and farm service centers; deliver training to farmers on biological control measures in remote areas; train and regulate input providers to deliver effective guidance and high-quality pesticides and herbicides.	Pest and disease outbreaks are causing up to 50% crop losses in KP, and they are projected to **increase in frequency and intensity** under climate change. A lack of awareness and training on balanced pesticide application and effective pest and disease management practices has resulted in an **overuse of hazardous pesticides,** impacting farmer's health and the health of the environment.	
PACKAGE 9: Developing farm mechanisation and modifying imported farm machinery	• **Research & development-** Provide industrial extension support to local manufacturers; promote development of quality and precision local technologies by encouraging research and piloting in academic and technical institutions; investigate economic and environmental impact of various farm technologies to engage with policy makers and farmers. • **Credit support-** Improve credit support for resource constrained farmers to incentivize the use of machinery and implements appropriate to local conditions.	KP levels of **farm mechanisation remain low,** with access to machinery and credit being severely limited for smallholder farmers. Support is needed to **incentivise local manufacturing** of farm machinery adapted to local contexts, and **accessible for farmers** at a reduced cost, which could be supported by **industrial extension and training.**	

INVESTMENT OPPORTUNITY	DESCRIPTION OF ACTIVITIES	NEED	SCORING
PACKAGE 10: Strengthen livestock disease surveillance and livestock service delivery in Khyber Pakhtunkhwa	• **Data & ICT tool development-** Promote livestock disease tracking using data tools and methodologies in coordination with government and research institutes. • **Capacity development-** Facilitate vaccination & agri-vet programs and vocational courses to boost human capital; raise awareness among farmers for pest and disease management. • **Institutions-** Improve regulation of agri-vet stores and set targets for disease control in the province.	Livestock is a **key agricultural sector** in KP for poorer and landless farmers, though there is a **lack of awareness of appropriate disease management techniques.** Supporting the livestock sector **requires institutional and technical strengthening** of the livestock department. There has been **little progress in disease surveillance** at the provincial and district level using **data tools and ICT** methodologies, which could improve vaccination rates, provide a boost to the livestock sector, and improve farmers' livelihoods.	
PACKAGE 11: Promote cottage-level mushroom cultivation, value chain and market development in NMDs especially among women & youth	• **Capacity development-** Provide skills training and capacity building on mushroom cultivation as well as value chain development to women and youth in newly merged districts. • **Market development-** Stimulate market linkages connecting local producers with local and provincial markets and overall enhance consumer level awareness and demand. • **Policy engagement-** Engage provincial policy level stakeholders along with the private sector and research institutions with the aim to garner policy support as well as financial and research support for development of mushroom as a cottage industry in NMDs.	The **Newly Merged Districts of KP** are some of the most economically marginalized areas and show high food insecurity. **Mushroom cultivation** offers a **new economic opportunity** in the area occupying small plots of land. However, it has been given **insufficient attention** by the provincial government, NGOs, and development partners. Awareness on the economic potential of mushroom production for **income-generation and nutrition for women and youth,** as well as policy support would accelerate efforts on this area.	
PACKAGE 12: ICT-based agro-advisory and market information	• **Participatory ICT development-** Promote the development of ICT tools and services taking into consideration local needs and demands as well as principles of human-centered design; encourage the use of interactive platforms, local languages and context-specific examples and references. • **Digital literacy and training-** Roll out digital literacy programs among farmers as well as train extension officers to use ICT tools and impart skills to farmers; monitor and evaluate the extent to which provided information & advisory is translated into action. • **Public private partnerships-** Build and strengthen partnerships with private sector and telecom providers to tap on their networks and services for greater outreach and to incentivise technology development. Consider linking agro-advisories to other bundled services such as credit and insurance. • **Institutions-** Improve linkages between PDMA and AD on disaster early warning for agro-advisory.	Farmers currently lack **localised and timely information** on climate and markets. There are still **information utilization gaps** regarding **market updates** and **weather forecasts** for farmers, which can be addressed through the use of modelling, machine learning, and remote sensing technologies, to provide site-specific **advisory information**. ICT development also offers opportunities for **information intermediaries** to support service provision.	

Provincial workshops were held with stakeholders from Punjab and Khyber Pakhtunkhwa in March 2022, to support the review of the identified investment opportunities in each province. The workshops were hosted online, receiving participation and input from government, academia, and private sector actors. During the workshop, results of the climate modelling work conducted by PIK were shared with the participants along with the initial findings of the adaptation needs assessment led by the Alliance. The participants were presented with the long list of IO for the province.

Across the packages assessed there was generally deemed to be 'High' potential impact across the three CSA pillars (adaptation, mitigation, productivity) when using a scale from 'Very low' (1) to 'Very high' (5). There was however greater variation in the assessed scalability and investment risk for the different packages. The results of the scoring can be seen in Tables 16 and 17. Based on the expert scoring, Figures 19 & 20 were prepared, plotting the packages CSA smartness (average rating for adaptation, mitigation, and productivity) against scalability. Those packages that scored highly for both climate smartness and scalability, show the greatest potential for delivering impact at scale. The assessed investment risk is indicated by the colour of the data point from green (low) to red (high). For Punjab the most promising packages were Package 7: Shifting water management strategies at farm-level; Package 4: Supporting smallholder farmers in mechanisation to improve productivity; and Package 3: Enhancing wheat resilience. While for KP the packages prioritised were Package 8: Promote training and implementation of integrated pest management and research effective strategies; Package 12: ICT-based agro-advisory and market information; and Package 3: Institutional capacity building on Integrated Soil Fertility Management.

Figure 19: Investment Package climate smartness against scalability plot for Punjab. The data points are identified by the package numbers with investment risk indicated by the colour of the data point (green = low, navy = medium)

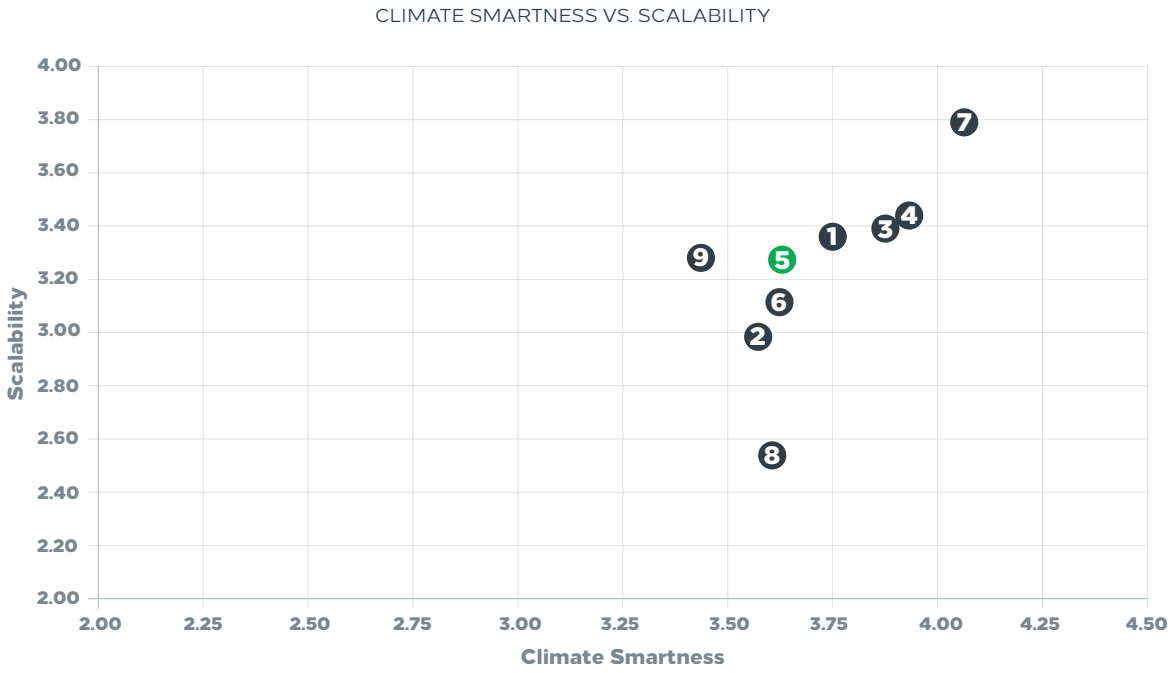
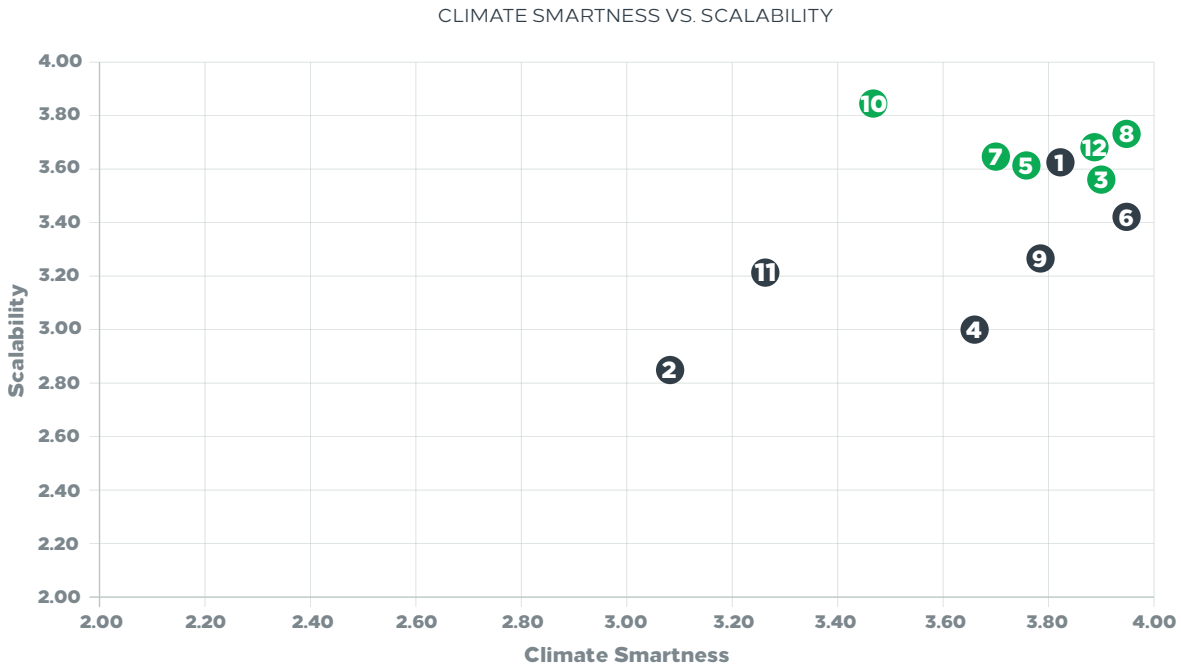


Figure 20: Investment Package climate smartness against scalability plot for Khyber Pakhtunkhwa. The data points are identified by the package numbers with investment risk indicated by the colour of the data point (green = low, navy = medium)



4.2 Investment and research packages

The prioritisation exercise with provincial experts was used to inform the further analysis and prioritisation of the packages, with the research team deciding not to base their prioritisation solely on the scoring exercise for a number of reasons:

1. While there was generally good representation of different actors at the workshop, the overall number of responses as part of the interactive session were low for some packages (especially for the latter packages).
2. Based on the feedback from the experts attending the workshop some of the packages are to be reduced in scope, combined, or adjusted to best respond to the identified needs.
3. Some packages don't lend themselves to the types of quantitative assessment to be covered in the deep dive. They will remain in the report and be identified as high priority but will not undergo a full quantitative assessment.
4. While the prioritisation exercise is reflective of the identified needs of the participants, it fails to consider the investment priorities of organisations (GIZ for example) looking to use the results to inform their investments in the two provinces. This point is particularly valid when deciding between high scoring packages.

Considering the above reasoning, additional rounds of review were conducted to review the qualitative feedback from participants during the workshop; modify the packages and narrow them down based on the expert feedback; assess the potential to conduct quantitative deep dives for the modified packages and the key elements that would be included; and share these findings with potential implementors, donors/investors, and government planners for their input. The result of the follow up sessions was the identification of two investment packages which would seek to develop financing models through public private partnerships for the scaling on improved technologies, and two research packages which are focused more on the generation of knowledge as a public good to support future provincial programming (see table 18). The

deep dive assessments on the investment packages can be accessed in section 5, and the research packages in section 6. For all packages, a detailed needs assessment has been conducted before proposing the different activities that should be conducted and the leading and supporting institutions. For the investment packages, a full cost-benefit analysis has been conducted for the programme. The cost-benefit analysis quantifies and compares the total costs and expected benefits of implementing a programme. The assessment of net present value and payback periods for investments are useful metrics to inform decision-making by potential investors (government, development partners or private sector). For the research packages, only the costs have been assessed due to the challenges in assessing the monetary value of the non-monetary benefits. These indicative costs provide a useful overview of the scope and size of the package.

Table 18: Investment and research packages

INVESTMENT PACKAGES
5.1 Financing model for developing smallholder farm mechanisation
5.2 Enhancing biocontrol production and implementation capacity for integrated pest management
RESEARCH PACKAGES
6.1 Integrated farming with native fruit trees
6.2 Strategy development & awareness raising to counter wild boar attacks in Kurram, Orakzai, & North Waziristan

Section

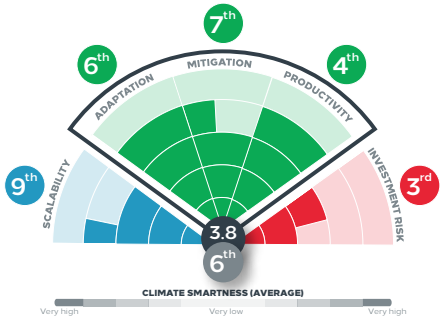
5

Investment packages

HIGHLIGHTS

- The cost benefit evaluation of the mechanisation package considers 4 types of technology – zero tillage drill, multi-crop thresher, raised bed planter and mechanical weeder. At the program level, a 10-year program on mechanisation gives a positive net present value in addition to other benefits such as increase in grain production, reduction in herbicide use, water savings and carbon sequestration. At the farmer level none of the technologies are financially feasible for purchase by farmers with 1 ha or less, while for farmers with 4 ha all but the multi-crop thresher returned a positive NPV, indicating that they are a profitable investment. Under all scenarios better returns are available if farmers choose to rent the machinery rather than purchase it, except for situations where the farmers themselves become service providers, renting the machinery to other farmers, generating a high NPV with a low payback period.
- The cost benefit analysis for the BCA enhancement and IPM implementation package also showed potential productivity gains for farmers ranging from 5-25% for the six crops evaluated (wheat, potato, peach, apple, and orange) and a 10-30% reduction in pesticide use and therefore the associated input costs. The program shows an IRR of 287% and positive NPV under two discount rate scenarios and under a 25% decrease in BCA efficiency, indicating the profitability of the program.
- In addition to the economic benefits associated with increased agricultural productivity, the two investment packages would have additional benefits for the environment such as a considerable reduction of chemical inputs. The proposed mechanisation development program would also improve soil quality, increasing water savings and soil carbon sequestration, however, GHG emissions associated with the increased farm machinery use should be considered.

5.1 Financing model for developing smallholder farm mechanisation



5.1.1 Introduction and background

Increased levels of farm mechanisation in Pakistan have been observed to have a positive impact on a number of farm operations such as land preparation, planting, watering, spraying, harvesting, and threshing, through increased productivity, reduced crop losses, and improve crop quality. The Pakistan Agriculture Research Council (PARC) has outlined a number of commercial farm machinery/implements with promising potential in terms of yield gains and labour and cost savings (GoP PARC, n.d.). Pakistan stands out among the South Asian countries (after India) having a large surge in demand for farm machinery (Aryal et al., 2021). Punjab has extended some support to farmers through the promotion of climate-smart technologies such as direct seeding drills, raised bed planters, laser land levellers and solarized high efficiency irrigation systems. An existing project by the Punjab Government (2021-26) is providing agricultural machinery and implements on a cost-sharing basis to selected service providers with the machinery and implements supplied by pre-qualified firms. KP, however, has made very limited progress in the promotion of smallholder farm mechanisation.

Research on the use of combined fertiliser and seed drills for wheat crops found grain yields to be 12% higher than with the use of conventional methods, resulting in a 7% increase in the benefit-cost ratio of production (Kashif Munir et al., 2021). Likewise, raised bed planting of wheat, cotton, and rice, were found to return yields 20%, 12%, and 30% higher than broadcast sowing, while using 43%, 39%, and 32% less water respectively (Bakhsh et al., 2018). Another study on raised bed plating for rice found that the approach could reduce N fertiliser use by 25 kg ha–1 and use 24% less irrigation water with no loss of yield (Majeed et al., 2017). Furthermore, provincial experts consulted highlighted the labour-saving capacity of mechanical threshers which are 75x faster than hand threshing, saving the average farming household 1.5 weeks of labour and reducing the drudgery of farm activities (Agriculture Engineering Department, personal communication, May 17, 2022). The labour-saving potential of farm mechanisation is particularly relevant in KP which suffers from seasonal labour shortages, with above average rates of emigration (particularly from Dir, Swat, Mardan, Peshawar, Swabi, and Mansehra) (Amjad & Arif, 2014). In addition to the aforementioned productivity and resource use efficiency benefits, a recent study in Nepal highlighted the potential for increased mechanisation in drastically reducing the work burden on women when the services are developed in such a way as to be sensitive to their needs and existing inequalities (Justice et al., 2022).

Despite these potential gains, the utilisation of farm machinery in Pakistan remains low, with a total of around 612,000 operational tractors in Pakistan, equating to 0.09 horsepower (HP) per acre, falling below the recommended 1.4 HP per acre (PES, 2021). Only about 4.5% of the tractors in Pakistan are operating in KP. Pakistan has manged to reach a point where almost 100% of land preparation activities for major crops is mechanised, mostly through tractor pulled chisel and mould board ploughs (Tanzeel ur Rehman et al., 2016). These ploughs are however found to deliver worse outcomes for long term soil health than some of the more modern land preparation implements that promote minimum/shallow tillage or direct drilling (I. Muhammad et al., 2018; A. Zahid et al., 2020). Table 19 provides a breakdown of the major types and quantity of machinery employed by farmers in KP.

Evidence on mechanisation of small-scale farms in South Asia suggests that access to credit and extension services, economic status, and training positively influence farm mechanisation (Aryal et al., 2021). In KP, 31% of landholdings are less than 1 ha and 50% are between 1 and 5 ha, with land fragmentation continuing to reduce farm sizes, making individual ownership of farm machinery unviable (KPBOS P&DD, 2021). Further constraints such as working capital, access to credit, and technical training discourage the purchase of farm machinery. Consequently, the majority of farm machinery is owned by service providers who generate an income through renting the machinery out to farmers. These service providers may be other individual farmer providers, farmer group service providers, or small and medium enterprises. In KP, ad hoc custom hiring services exist on a limited scale and for select type of machinery/implements. Some countries have promoted models for mechanisation service provision to scale up smallholder use of farm machinery. These models incentivize use of machinery through low-cost rental or service providers and hiring arrangements that reduce individual farmer's cost of purchasing, owning, and maintaining machines. Moreover, service provider arrangements enable farmers who own and operate machinery to become rural entrepreneurs by using machinery for remunerative on and off farm activities. A study on farm mechanisation service models in sub-Saharan Africa identified a number of success factors that are relevant and should be considered in the KP context: "skilful staff and leadership; diversification of mechanisation services; involvement of farmer organizations; close linkages with processors and aggregators; presence of suppliers of agricultural machinery and equipment, and relevant support services; profitability of the agri-food value chain; access to finance; and infrastructure" (Houmy et al., 2021).

Table 19: Type and quantity of machinery in KP (GoKP BOS & P&DD, 2020)

MACHINERY	2017-18	2018-19	2019-20
Tractors	27,069	27,334	27,757
Tube wells	21,359	20,904	18,863
Bulldozers	280	305	259
Wheat threshers	9,003	9,013	9,208
Rice husking machines	912	926	926
Maize shellers	3,039	3,080	3,202
Wheat harvesters	304	419	722

While membership to farmer organisations is not widespread in KP, Model Farm Service Centers (MFSC) have emerged as a form of farmer organisation, providing training and inputs to their members. A 2017 survey of 234 MFSC members producing vegetables in Charsadda district found that many of the members were accessing mechanisation through the MFSC, including cultivator (51%), rotavator (56%), mold bold plough (56%), disk plough (48%), single furrow (47%), drill (61%) and ridge maker (53%) (M. Z. Khan et al., 2017).

In terms of local machinery providers, KP has a network of local manufacturers of agricultural machinery, but they are limited in both scale and technical capacity. Tending to focus on the reverse engineering of hand implements, except for production of farm machinery (like threshers) locally in Mardan (T. Khalil, personal communication, May 23, 2022). They often lack standardization and quality in terms of the use of correct material and ensuring inter-changeability of components for easy repair/maintenance (M. A. Iqbal et al., 2015). This is due to resource issues as well as poor design, low technical skills and weak enforcement and oversight. Lack of innovation is also attributed to weak linkages between the industry and academia and research. There is diminished interest among engineering students to take up research projects on agriculture partially due to low industry prospects in the province (Z.U. Haq, personal communication, May 19, 2022). In addition to the local manufacturers, blacksmiths are often relied upon to repair broken machinery but lack the training to effectively maintain complex pieces of equipment.

The design of commercial service bundles for mechanisation requires engagement with a broad range of stakeholders. Firstly, in order to overcome prohibitively high investment thresholds for low-income farmers, agricultural financial services providers mostly offer loans that are below the average market interest rate of commercial banks. Traditional agricultural loans categorically exclude smallholder farmers since they are unable to abide to standard requirements for loan application, such as audited statements or company registrations. Alternative credit scoring systems, based on land-backed collateral or referral schemes, provide an opportunity to design inclusive products for smallholders. Post-purchase, customers should have access to warranty options, as well as insurance products that reduce actual and perceived risk of an investment. Insurance products can be provided not only for mechanical assets, but also for production in the form of index-based insurance. Bundling such kinds of financial services with innovative scaling strategies and business models has had a proven positive effect in the uptake of such innovations in other geographies.

5.1.2 Supporting policies/initiatives

EXISTING POLICIES (POLICY AREAS - DEVELOPING FARM MECHANISATION)	
KP AGRICULTURE POLICY 2015-2025. Emphasizes the role of government for creating and enforcing a legislative and regulatory framework, creating investment packages for development of farm mechanisation and modification of imported farm machinery to make them workable with local conditions and compatible with farmer resources and payment capacity.	
NATIONAL FOOD SECURITY POLICY 2018. Reducing duties and taxes on import of farm machinery in short to medium term, developing efficient farm mechanisation and processing technologies to reduce cost of production, enhancing timeliness of operations, adding value to crops and reducing post-harvest losses at farm level. Promoting aquaculture mechanisation for intensive production, processing and maintaining cold chain, incentivising industry for manufacturing quality farm machines and indigenisation of economically viable farm mechanisation.	
NATIONAL CLIMATE CHANGE POLICY 2021. Promotes energy efficient farm mechanisation to increase yields and labor saving.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The ongoing schemes on farm mechanisation include: 1) Culturable Waste Land Development in Khyber Pakhtunkhwa ($1,142,857); 2) Culturable Waste Land Development & Solarization of Existing Agriculture Tube/Open Wells in newly Merged Districts of Khyber Pakhtunkhwa – AIP ($9,471,245).	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes include: 1) Reclamation of Culturable Waste Land and Solarization of Agriculture Tube Wells ($1,714,285)

5.1.3 Proposed intervention

The purpose of this investment package is to facilitate the development and scaling of smallholder mechanisation in KP, through increased research and the formation of public-private partnerships for technology provision, and the establishment of financial support programmes for mechanisation as a service. The package was included as an investment option for the stakeholder consultations in both KP and Punjab, ranking high for climate smartness, with medium investment risk and scaling potential (see section 4.1). There was however particular interest for the package in KP where the Directorate of Agricultural Engineering under the Agriculture Department were in the process of preparing a project proposal to be submitted for review in the 2022 Annual Development Plan. The existing proposal focussed exclusively on public funding, following consultation there was an expressed interest to explore alternative blended financing models for the programme. This package has therefore been developed in close collaboration with the Department of Agricultural Engineering along with other key stakeholders, to build on the original proposal and provide

additional evidence on the investment potential and likely impact of the scheme on the agriculture sector in KP. Furthermore, considering the greater prevalence of farm mechanisation and support programmes in Punjab it was decided to focus on KP to work towards closing the gap between the two provinces.

The investment package is broken down into two components:

1. **Research & development–** to consolidate existing research and expertise on farm mechanisation and provide scaling support.
2. **Business models–** developed to increase investments in mechanisation and improved access of smallholder farmers to mechanisation services.

Component 1 focuses on strengthening the research and development of smallholder mechanisation in KP. It was noted during the consultations that while there was considerable research conducted on smallholder mechanisation in KP, there was a lack of coordination between Research, Agricultural Engineering, and Agricultural Extension, resulting in fragmented data and information. The kick-off for the program will therefore include a provincial workshop to bring together the different actors, understanding the current capacities and priorities of the different institutions and how they can better coordinate. Additional research activities will be conducted to identify location specific demand for the different technologies **[Output 1.1].** Further constraints to research on mechanisation are the low levels of engagement by students in KP on the topics of farm mechanisation, reducing the pool of trained experts to support the delivery of targeted mechanisation programmes. This will be addressed by increased funding for research and vocational courses on mechanisation **[Output 1.2]**. As highlighted above, there is also the need to strengthen the capacity of provincial manufacturing for the development of low-cost machinery in KP through the provision of industrial extension. The extension support to local manufacturers will include: market research on recent developments in farm mechanisation; assessment of the suitability of farm mechanisation implements to local context; modification of farm mechanisation to local context and manufacturing capacity; standardization and quality assurance of machinery and implements; capacity development of manufacturers through training programs and manuals; strengthening precision manufacturing techniques; trialling and showcasing implements; and assistance to other government departments for selection and procurement of machinery **[Output 1.3]**. The outcome of this component is improved coordination and capacity of institutions in KP working on mechanisation, to provide clear guidelines on priority technologies for different crops and zones.

Component 2 is focused on developing effective financing models to support the establishment of mechanisation as a service. Having reviewed existing models in Punjab and other countries in the region, along with the identified success factors it is apparent that such a system is only effective with buy-in form all the key stakeholders. This will be achieved by strengthening the partnerships between relevant stakeholders and identifying gaps in the provision of key services and expertise **[Output 2.1]**. These partnerships are then to be built on to develop effective business models to scale mechanisation trough the provision of subsidised machinery and increase capital for the development of localised manufacturing capacity. Based on consultations with provincial authorities this package will initially be targeted towards the districts of D.I. Khan, Peshawar, and Swat (see Figure 21) **[Output 2.2]**. The outcomes of component 2 include a larger number of manufacturers, trained service providers, and higher levels of mechanisation utilisation.

Figure 21: Map of target districts for mechanisation package

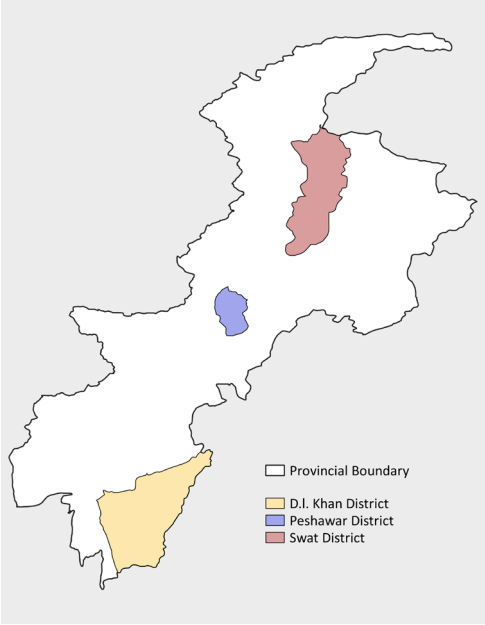


Table 20 provides a breakdown of intervention components, outcome and outputs along with indicative activity costs and timeline. The activity costs and timeline are based on similar costs for projects covering similar topics in other locations or past experience in preparing project proposals. These were also run past key stakeholders who had been consulted. In all instances, any capital investment is based on benchmarks for what is available on the market (as of May 2022), while operational costs do have more uncertainty as it is harder to find an effective baseline.

Table 20: Breakdown of intervention components, outcomes, and outputs

COMPONENT	OUTCOMES	OUTPUTS	INSTITUTIONS	INDICATIVE ACTIVITY COSTS	INDICATIVE TIMELINE
Component 1: Research & development – to consolidate existing research and expertise on farm mechanisation and provide scaling support.	**Outcome 1:** Improved coordination between institutions, and capacity, to provide priority technologies by zone. • *2 provincial multi-stakeholder workshop* • *Report on priority technologies by zone supported by evidence of impact* • *2 PhD positions sponsored at academic institutions on mechanisation in KP, with strong linkages to Ag Eng.* • *Increased capacity of local manufacturing firms*	**Output 1.1:** Provincial workshop on farm mechanisation bringing together key actors and agreeing on priority interventions.	• Agriculture Department KP (lead)	**$35,000**	Year 1
		Output 1.2: Promote development of quality and precision local technologies by encouraging research and piloting in academic and technical institutions.	• Directorate of Ag Engineering (lead) • Engineering institutes such as UET, GIK, University of Agriculture (partners)	**$26,790**	Year 2 – 4
		Output 1.3: Provide industrial extension support to local manufacturers.	• Directorate of Ag Extension (lead) • Directorate of Ag Research & Ag Engineering (partners)	**$55,000**	Year 1 – 2
Component 2: Business models – developed to increase investments in mechanisation and improved access of smallholder farmers to mechanisation services.	**Outcome 2:** Improved uptake of mechanisation through mechanisation as a service model. • *6 partnerships building workshops* • *300 new mechanisation service providers* • *200 zero tillage drills, 200 multi-crop threshers, 200 raised bed planters, 200 mechanical weeders*	**Output 2.1:** Build partnership between manufacturers, service providers, government, and financing institutions.	• Directorate of Ag Engineering (lead)	**$60,000** ($5,000 x 6 workshops)	Year 1 – 2
		Output 2.2: Develop mechanisation as a service business models to subsidise the purchase of machinery with pay as you earn model.	• Directorate of Ag Engineering (lead)	**$200,000**	Year 1 – 5
		Output 2.3: Provide financing to subsidise 30% of the purchase cost of farm machinery by service providers. Plus yearly operational costs.	• Directorate of Ag Engineering (lead)	**$318,000 + $750,000**	Year 1 – 10
Total Program Activity Costs				**$1,444,790**	

5.1.4 Potential partners

The implementing institution for this package is the *Directorate of Agriculture Engineering, Agriculture Department KP* as the lead government institution for projects on agriculture mechanisation and the provision of technical guidance to farmers on farm machinery use. To date much of the work of the Directorate of Agriculture Engineering has been focused on irrigation technologies for the reclamation of culturable waste and development of irrigation supplies such as installation of tube wells, solarizing tube wells and de-siltation of canals. The *Directorate of Agriculture Extension, Agriculture Department KP* is included in the package to support the outreach to farmers and service provides, offering technical assistance and capacity building to facilitate successful implementation and long-term continuity.

There is also a need for better linkages between the government and research institutions (national and provincial) to develop farm machinery best suited to KP's context and to conduct research on their effective implementation and potential benefits. Key research institution in KP working on Mechanisation include the *Department of Agriculture Engineering, UET Peshawar,* and the *University of Agriculture Peshawar.* Partnerships with other notable research institutes in Pakistan will facilitate technology transfer and technical backstopping. Partnerships can be strengthened with *National Agricultural Research Council (NARC), Agriculture Mechanisation Research Institute (AMRI), Punjab and the Pakistan Agriculture Research Council (federal).*

Financial institutions providing support for mechanisation uptake include Zarai Taraqiati Bank Limited, Allied Bank Limited, Askari Bank, Habib Bank Limited, Muslim Commercial Bank and Bank Al-Habib.

Table 21: Institution and names of stakeholders consulted

INSTITUTION/DEPARTMENT	CONTACT PERSON	STATUS
Directorate of Agriculture Engineering	**Engr. Kulsoom,** Deputy Director Planning	Worked closely to collaboratively develop this project; data sharing on technologies
Directorate of Agriculture Extension	**Dr. Nasir Malik,** Director Planning, Coordination and Monitoring	Supports the need for the package
UET, Peshawar	**Dr. Zia ul Haq,** Professor, Department of Agriculture Engineering	Data sharing on technologies
UET Peshawar	**Dr. Tariq Khalil,** Manager, Office of Research, Innovation, and Commercialization (ORIC)	Consulted on potential collaborations between government and academia
Model Farm Service Center	**Mr. Hussain Ahmad,** Director, Model Farm Service Center	Consulted on the current role of FSC in mechanisation provision
Fauji Fertilizer Company	**Mr. Hamid Abbasi,** Partnerships and Collaborations, Food Security and Agriculture Center of Excellence (FACE)	Consulted on their experience of running FACE in Rahim Yar Khan

5.1.5 Economic assessment

A financial analysis was conducted to assess the potential productivity gains that could be realised through the implementation of this programme. To do this a cost benefit analysis was conducted, comparing the costs of implementing the programme along with the subsidised costs incurred by the beneficiaries, to the potential gains in agricultural productivity. To do this four of the most promising items of farm machinery were selected based on their capacity to generate income for service providers, increase smallholder productivity under climate change, and increase the sustainability of farm management practices.

This section provides a cost benefit evaluation of different types of agricultural machinery proposed as part of this package. The evaluation covers the inclusion of four types of mechanisation that were prioritised for their suitability in supporting smallholder farmers in KP to improve their productivity, build resilience to identified hazards, and bring about positive environmental co-benefits through reduced chemical inputs, higher water-use efficiency, improved soil quality, and reductions in associated GHG emissions. These technologies were prioritised following extensive consultations with the Directorate of Agriculture Engineering Khyber Pakhtunkhwa. They include zero tillage drilling machines, raised bed planters, mechanical weeders, and multi crop threshing machines. At present, no information is available on the current numbers of the prioritized technologies in KP. Therefore, a benchmarking activity will be needed prior to start of project activities. Moreover, there will be scope to assess and include other machinery and/or implements once the programme is initiated.

Table 22: List of prioritized farm machinery/implements & their benefits

TECHNOLOGY	FARM OPERATION	BENEFITS
Seed cum fertilizer drill	Sowing & fertilizing	Dual seed & fertilizer application; Faster seeding, uniform seed spacing & seed depth; saves time & labour cost; Reduced soil erosion; intact soil nutrition; better weed control
Multi-crop thresher	Threshing	Efficiently thresh multiple crops including rice, wheat, maize, sorghum, barely; reduces labor cost & saves time
Raised bed planter	Land preparation	Deeper seed bed & rooting depth; reduce waterlogging; better drainage from the root zone
Mechanical weeder	Soil preparation	Saves time & labour; reduces use of herbicides
Tractor	Multiple operations	

For each of the proposed machines a number of scenarios were evaluated: 1) farmer purchases the implement and uses it on either a 1 ha or 4 ha farm, 2) farmer rents the machine from a service provider on either a 1 ha or 4 ha farm, and 3) farmer buys the implement and provides the service to other farmers over the course of a planting season. Table 23 presents the results of the cost benefit evaluation for the four pieces of prioritised farm equipment, under the three different ownership models outlined above. At the farmer level the results indicate, as expected, that farmers with 1ha would be unable to recover the costs of purchasing the equipment over their 10-year lifespan, with payback periods of between 15.4-28.6 years. That is except for the thresher where the 1ha benefit is lower than the operational and maintenance cost meaning the farmer continues to lose money. Therefore, it is not recommended that any farmers with 1ha or less purchase farm machinery outright, especially considering how under the rental model they would achieve a net present value (NPV)[11] of USD $237-350, making this a far more attractive prospect. This would also require reduced up front capital investment. However, farmers with 4ha or more may consider purchasing zero tillage drilling machines or raised bed planters as they return a similar NPV under the farmer owned and farmer rented models. Mechanical weeders return a positive NPV for the farmer owned model at 4ha, but with better returns available should farmers choose to rent the equipment. The multi crop thresher on the other hand would not recover its costs if operated by a farm with 4ha or less, with a NPV of USD -$1,938. It would however return a positive NPV of USD $839 under the rental model.

Considering the high initial capital outlay for the purchase of farm machinery, mechanisation is often provided as a service. The mechanisation as a service model makes machinery accessible to smallholder farmers who cannot afford the upfront costs associated with farm machinery and would not benefit economically from that model, also allowing machinery owners to maximize the return on their investment. The cost benefit evaluation also considered the economic incentives for such service providers, who may be farmers working

[11] Net Present Value (NPV) is the value in the present of a sum of money, in contrast to some future value it will have when it has been invested at compound interest. In this evaluation the NPV has been calculated assuming a discount rate of 10%.

their own land before renting their equipment as a service, or dedicated service providers who don't farm any of their own land. The analysis also considered a scenario where the cost of the machine was subsidised 30% by the government. The operating and maintenance costs for the service provider model were increased to 15% of the equipment cost annually to account for heavier wear and tear. All the technologies were found to be effective investments for perspective service provider with payback periods as low as a month, and NPV as high as USD $45,639 (including the 30% subsidy). Farmers looking to purchase the equipment for their farms may look to consider offering it as a service as the returns under the service delivery model are higher than those attained by farmers with 4ha who don't rent the equipment.

Table 23: Cost benefit evaluation for four pieces of farm equipment (zero tillage drilling, raised bed planter, multi crop thresher and rot weeder) under three different ownership models (owned, rented, service provider) for smallholder farmers with 1ha or 4ha.

EQUIPMENT	MODEL	1 HA		4 HA	
FARMER LEVEL		**NPV**	**PAYBACK PERIOD**	**NPV**	**PAYBACK PERIOD**
Zero Tillage Drilling	Farmer owned	-654	22.5 years	$913	3.05
	Farmer rented	$237		$948	
Raised Bed Planter	Farmer owned	-$541	15.4 years	$1,367	2.4 years
	Farmer rented	$350		$1,404	
Multi Crop Thresher	Farmer owned	-$2,936	n/a	-$1,938	27.3 years
	Farmer rented	$210		$839	
Rotary Weeder	Farmer owned	-$549	28.6 years	$546	3.5
	Farmer rented	$242		$970	
SERVICE PROVIDER LEVEL		**NPV**		**PAYBACK PERIOD**	
Zero Tillage Drilling (219ha)	Full cost	$45,369		0.1 years	
	30% subsidy	$45,639		0.1 years	
Raised Bed Planter (109ha)	Full cost	$21,712		0.2 years	
	30% subsidy	$21,982		0.2 years	
Multi Crop Thresher (211ha)	Full cost	$14,643		0.9 years	
	30% subsidy	$15,393		0.6 years	
Rotary Weeder (328ha)	Full cost	$28,886		0.1 years	
	30% subsidy	$29,096		0.1 years	

While these results paint a positive outlook for private investments in farm mechanisation, there remain a number of obstacles that constrain their uptake, which explains the low current levels of adoption in KP. Firstly, many farmers or prospective service providers lack the working capital to invest in the equipment, requiring financial support through improved access to credit services linked to mechanisation and subsidised premiums. These outlays may be even worse than calculated in the above analysis, as the evaluation has been developed considering a baseline scenario that already includes tractor ownership. Including the cost of tractor ownership in the model will increase the initial investment costs and eat into the potential earning, even considering the multiple use cases and revenue streams from tractor ownership. Furthermore, issues remain around the technical capacity of farmers to operate the machinery, the availability of farm machinery in KP, and access to servicing and repairs. All of these issues will need to be addressed to support greater uptake for farm mechanisation and remove potential investment risks.

Considering a larger program

While the previous sections have evaluated the rates of return for individual technologies, this section evaluates the economic value of a modest size program to evaluate what returns might look like when the machinery is able to be operated on a larger scale. The evaluation assumes a program that procures 200 machines each of a no-till drill, raised bed planter, multi-crop thresher, a mechanical weeder that are provided as a machinery service to producers. In contrast to the earlier evaluations, rather than being used on a 1 or 4 ha farm, it is assumed that each machine is able to run for the full period during planting or harvesting season. The area each machine can cover in a year was determined with support from provincial experts, with the figures used presented in table 23. It is also assumed that it would take time for the program to reach full potential. In the first year, the program covers 20% of total potential area, with the remaining 80% of the program being implemented in years 2 and 3.

For the cost benefit evaluation of the mechanisation program, two scenarios were evaluated: the first scenario evaluates the results of looking at the profitability of the machinery alone, while the second scenario includes estimated expenses for administration, management, and the overheads of operating the program. The results of the returns on machinery alone are contained in Table 24. Under these parameters, the program holds a net present value of $57,783,261 against a total cost for subsidising machinery purchases of $318,000. This figure represents the value the fleet of machinery could contribute to the agriculture sector in KP. However, it is probably not realistic to presume that the fleet of machinery could be set up and distributed amongst farmers without any related costs. The second analysis presumes $200,000 in program set up costs for storage and maintenance facilities and program management expenses in addition to $75,000 per year to pay for program operational expenses over the life of the project. Under this second scenario, machinery purchases, project setup, and annual operational expenses would have a total cost of $1,444,790 over a 10-year period. The net present value of the project is $56,945,629. The net present value is significantly positive even after discounting all benefits and costs over a 10-year period at a discount rate of 10 percent.

Table 24: Cost benefit evaluation of a mechanisation program procuring 200 machines each of a no-till drill, raised bed planter, multi-crop thresher, and mechanical weeder in KP.

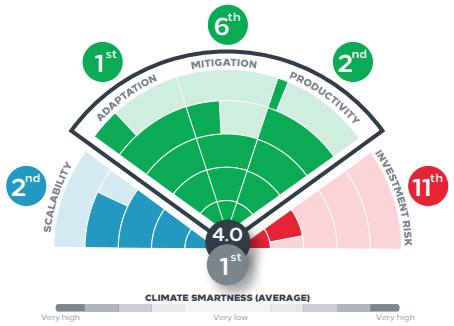
PROGRAM TYPE	NPV
Combined Program 20 Implements	**$57,783,261**
Combined Program 20 Implements + Program costs	**$56,945,629**

Table 25: Potential productivity and environmental impacts of the mechanisation program over a 10-year period (Calculated based on CottonInfo, 2015).

MEASURE	RESULT
# ha covered	1,525,920 ha over 10 years
Increase in Grain production	88,771 MT
Estimated value of herbicide reduction	$2,453,440
Estimated Water savings	96 million cubic meters
Soil Carbon Sequestered	11,563 MT
	AIRBORNE CO_2
Raised Bed Planter	2,848 MT CO_2 abated
Thresher	50,134 MT CO_2 emitted
Mechanical Weeder	7,793 MT CO_2 emitted

In addition to financial or economic benefits of the project, the table above summarises the other benefits that might be achieved by the project in terms of grain productivity/output, water savings, soil carbon, and other variables (Table 25). As set up, the project provides agricultural mechanisation services to over 1.5 million ha over a 10-year period. The total increase in grain production over the life of the project is 88,771 MT. There is an estimated $2,453,440 reduction in funds spent on herbicides. There are 96 million cubic meters of water saved through the reduced water requirements from the raised bed planter. That should be roughly equivalent to enough water to farm an additional 3,200 ha of irrigated wheat over a 10-year period. The activity is able to sequester a total of 11,563 MT of soil carbon. In terms of airborne CO_2 either abated or emitted over the course of project, the raised bed planter is able to abate 2,848 MT of CO_2 through reduced water pumping. The multi-crop thresher emits 50,134 MT of CO_2 over the project period as it requires diesel fuel to operate. Similarly, the mechanical weeder emits 7,793 MT of CO_2 over the project as it also runs on diesel fuel.

5.2 Enhancing biocontrol production and implementation capacity for integrated pest management



5.2.1 Introduction and background

Khyber Pakhtunkhwa is projected to become warmer and wetter in the coming decades (see section 2 on climate change), creating conditions that are conducive to the spread of insect pests. Changes to the climate in Khyber Pakhtunkhwa are already impacting the population size, survival rate, and geographical distribution of major pests. With experts consulted observing fruit flies earlier in the year, impacting the early maturing *"Early Grand"* peach cultivar, and thrip infestations on onion seed crops in December, both of which they believe are linked to climate change (F. Wahab, personal communication, May 12, 2022; Y. Khan, personal communication, May 18, 2022).

Major insect pests in Khyber Pakhtunkhwa include fruit flies, helicoverpa (moths), aphids, cutworms, mealy bugs, and borers (see Table 26). Those farmers who can afford them and are able to access them, rely predominantly on chemical treatments for their control. This poses a serious risk to the environment and the health of the farmers themselves, with the majority of the 49 pesticides used in KP classified as moderately hazardous (class-II of the pesticide toxicity levels) by WHO (D. Ullah & Nawab, 2019). There is also weak regulation of the quality of pesticides sold to farmers. Furthermore, limited access to government and private extension services leaves farmers with limited training on crop and location specific pesticide application, resulting in their overuse. This represents additional costs to the farmer and is detrimental to human health, soil, and water resources, and consequent export losses due to high levels of pesticide residue on crops (GoP MoPDR, 2020). Several studies have undertaken pesticide residue analysis for different crops in KP such as tomato and peach to recommend pesticide type and usage that can minimize harmful effects (Amin et al., 2022; A. U. R. Saljoqi et al., 2022).

There is considerable policy backing for the integrated pest management (IPM) approach – combining biological, cultural and chemical practices – to sustainably manage pests, reduce crop losses and address problems of chemical pesticide overuse. Key federal and provincial policy documents, including the National Agriculture and Food Security Policy Agriculture Transformation Plan, KP Agriculture Policy and KP Climate Change Policy, highlight the importance of IPM.

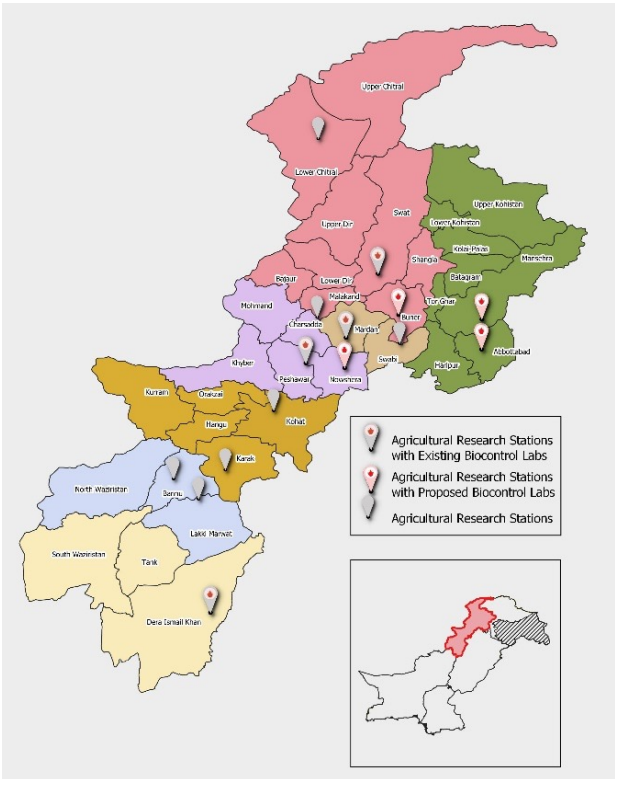
Moreover, the KP Integrated Pest Management Framework (KPIPMF) was developed in 2019 by the Directorate of On-Farm Water Management, Government of Khyber Pakhtunkhwa, under the World Bank funded Khyber Pakhtunkhwa Irrigated Agriculture Improvement Project (KPIAIP) (GoKP OFWM, 2019). The KPIPMF provides a good overview of IPM measures and current capacity in KP, however, the outcomes of the framework appear not to have been mainstreamed across government departments in KP, with most experts consulted being unaware of the existence of the document and its recommendations. Therefore, despite the strong policy backing, IPM implementation is limited in KP and in particular the use of biological control agents (BCA) to manage pest population in economically important crops.

Table 26: Major pests and host plants for KP (GoKP OFWM, 2019)

PEST	HOST PLANT	PEST STATUS
Fruit Fly	Apple, Apricot, Guava, Mango, Peach, Pear, plum, citrus fruits, melons, cucumbers, Bitterguard squashes, and many other crops.	• common & destructive in mango
***Helicoverpa* (Armiger)**	Cotton, Tomato, Tobacco, Gram, Okra, Brinjal, Beans, maize, and etc	• very serious/serious & common in cotton • common in beans & pulses • common in maize • destructive & very common in tomato
Aphids	Brassica, Cotton, Peach, Apricot, Brinjal, Maize, Peas, Potato, most vegetables, many spices & herbs, ornamentals, Roses, etc	• common & serious in potato • common & destructive in apricot/peach/plum • common in tobacco • common in oil seed crops • common in barley • common in maize • not an issue in wheat
Cutworms	Tobacco, pumpkin, Cucurbits, Peas, Maize, summer vegetables, (most spring-grown seedlings)	• serious & common in tobacco
Mealy bug	Mango, Cotton, Okra, Hibiscus, Apple, Potato, trees, Many summer vegetables	• very destructive & very widespread in mango • common in sugarcane
Borers	Sugarcane, Apple, Okra, Brinjal, Maize, Rice, Fig etc.	• common in maize • common in rice • common in sugarcane

BCA implemented as part of a holistic IPM strategy can optimize gains in yield, costs, and natural resources. When a harmful mealy bug threatened papaya crop in Sindh and Balochistan, developing resistance to chemical pesticides, *Acerophagus papaya*, a natural enemy for the mealy bug, helped control 80 per cent of the pest population in the papaya orchards (SciDevNet, 2017). Biological control of sugarcane borers has also received considerable focus over the years. Studies on managing the sugarcane stem borer have achieved positive outcomes when experimenting with the optimum levels of *Trichograma chilonis* release in combination with insecticides such as Basudin and Furadan (A.-U.-R. U. Saljoqi & Walayati, 2013; F. Ullah et al., 2012). It is important when considering effective BCA to also assess their interaction with conventional pesticides, as it will often require a holistic approach using BCA along with reduced levels of selected chemical pesticides that when applied in the correct quantity and correct time don't harm the BCA they are working in conjunction with (Haq et al., 2018). Barriers to scaling adoption of biocontrol measures in KP include weak production capacity and low awareness and extension support to farmers (GoKP OFWM, 2019). Lab facilities and technical capacity for research and rearing of natural enemies are not sufficient for commercial production of biocontrol agents. Figure 22 shows that rearing facilities (labs) for biocontrol agents are present in 4 out of the 14 agriculture research stations (Peshawar, Swat, Mardan, DI Khan) run by the KP government

Figure 22: Agricultural research station locations KP, including those that currently have IPM lab facilities.



(Y. Khan, personal communication, May 18, 2022). An assessment of barriers to biocontrol adoption by farmers identifies low levels of education and awareness, inadequate extension services, and farmer perceptions of it being time consuming and risky, with uncertainty around its effectiveness (Randhawa et al., 2015). More frequent farmer-extension contact shows a higher level of farmer knowledge on different pest management practices in KP strengthening the case for extending extension support on biological pest management (A. Ullah & Khan, 2019) . In addition, Model Farm Service Centers (MFSCs) can potentially improve adoption of biocontrol methods having demonstrated success in improved seed adoption (Israr & Khan, 2019) and farm machinery use (M. Z. Khan et al., 2017) in some areas of KP. Plantwise, a global initiative led by CABI works with national partners in Pakistan, establishing networks of plant clinics to address crop losses from pests and diseases. In Pakistan, only 0.9% of the prescription records for treating pests include BCA, this could be increased to 16.9% if plant doctors were sufficiently trained on recommended national BCA guidelines, and further increased to 96.5% with higher rates of registration for BCA in Pakistan (Dougoud et al., 2018).

Experts consulted shared that 4 biolabs hosted by the government-run agriculture research stations in KP have tested feeding potential of some natural enemies under laboratory conditions such as green lacewing (*Chrysoperla carnea*), predatory thrips (*Aleurodothrips fasciapennis – Franklin*), ladybird beetle (*Stethorus gilvifrons*) and parasitoid wasps (*Trichogramma chilonis*, *Dirhinus giffardi* & *Diachasmimorpha longicaudata*). Among these, the BCAs under rearing and production in the existing labs are *Trichogramma chilonis* (Peshawar, Mardan, DI Khan), *Dirhinus giffardi* (Swat) and *Diachasmimorpha longicaudata* (Swat) (Y. Khan, personal communication, May 18 & F. Maula, personal communication, May 31, 2022). Table 27 provides a snapshot of BCAs for major pests, their impact on yields and input use[12]. Estimates for yield increases and reduction in input use were consolidated based on expert consultations and secondary literature[13]. The productivity gains are based on approximate damage done by the pests concerned and the primary input considered is pesticide used against each pest. BCA are marked based on their production at agricultural research labs across Punjab†, labs established by CABI‡, private sugar mills in Punjab§, and the four existing labs in KP*. Due to the dearth of literature on IPM in this context, the project was required to undergo an extensive data gathering exercise with experts (see table 30) to formulate table 27.

Timely distribution of bioagent cards to farmers is critical as delays can affect the percentage hatchability. This challenge has been faced in Punjab, where a delay in distributing biocontrol agents of *Trichogramma Chilonis* and *Chrysoperla Cornea* (more than 15 days) have reduced their effectiveness (M. Asghar, personal communication, June 2, 2022). Moreover, weak contamination controls in the lab, electricity shortages and lack of trained human resources are also issues faced by the biocontrol labs in Punjab.

Capacity needs to be strengthened among extension staff and farmers to employ strategies and practices of integrated pest management, an ecosystem approach that combines growing healthy crops and minimizing the use of pesticides. Effective measures for pest management involve a combination of biological, cultural, and chemical practices that improve agricultural production and per hectare productivity. ICT tools have the potential to support decision-making through pest surveillance, early warning and advisory.

[12] It should be noted that the variation in percent yield increase and percent reduction in inputs may vary according to the climatic conditions.

[13] The secondary sources consulted were: Book on "Control of Pests and Weeds by Natural Enemies, An Introduction to Biological Control"; Book on "biological control of crop pests & weeds"; Book on "Biological Control of Insect Pests Using Egg Parasitoids; Monthly agriculture bulletins; and published papers

Table 27: BCAs for major pests and impact on yields and input use (Source: expert consultations)

CROPS	PEST	BIOLOGICAL CONTROL AGENT (BCA)	INCREASED YIELD (%)	REDUCED INPUTS (%)
Maize	Maize stem borer, *Chilo partellus*	Parasitoid wasps: *Trichogramma chilonis*†*	8-10	10-15
Sugarcane	Root borer, Stem borer, Top borer, Gurdaspur borer	Parasitoid wasps: *Trichogramma chilonis*†*	5-10	10-15
		Green lacewing: *Chrysoperla carnea*†*	2-5	Around 5
Wheat	Wheat aphid, *Sitobion avenae;*	Green lacewing: *Chrysoperla carnea*†	2-5	5-10
		Lady beetle: *Hippodamia convergens*	10-15	Around 10
	Green bug, *Rhopalosiphum padi;*	Green lacewing: *Chrysoperla carnea*†	3-5	5-8
Vegetables	Melon Fruit Fly, *Bactrocera cucurbitae*	Parasitoid wasps: *Dirhinus giffardi**	20-25	Around 30
	Cabbag caterpillar *(Pieris brassicae)*	Parasitoid wasps: *Trichogramma brassicae* (E)	5-10	10-15
Fruits	Peachfruit fly, *Bactrocera zonata* (Saunders)	Parasitoid wasps: *Diachasmimorpha longicaudata **	20-25	Around 30
	Oriental fruit fly, *Bactrocera dorsalis*	Parasitoid wasps: *Diachasmimorpha longicaudata **	20-30	More than 30
	Wooly apple aphid, *Eriosoma lanigerum*	Brown lacewing: *Micromus tasmaniae* (Walker)	Around 10	10-15
	Citrus Whitefly, *Dialeurodes citri*	Green lacewing: *Chrysoperla carnea*†	5-10	10-13
		Brown lacewing: *Micromus tasmaniae* (Walker)	Around 10	10-15
Potato & Tomato	Potato tuber moth, *Phthorimaea operculella*	Green lacewing: *Chrysoperla carnea*†	Around 10	10-15
	Potato cutworm, *Agrotis ipsilon*	Parasitoid wasps: *Trichogramma*	Around 10	Around 15
	Tomato fruit borer, *Helicovera armigera*	Parasitoid wasps: *Trichogramma evanescens*	5-10	Around 15
	Aphids	Green lacewing: *Chrysoperla carnea*†	Around 10	10-15
		Ladybird beetles, coccinilids	10-15	Around 10
Rice	Rice stem borer, yellow stem borer, *Scirpohaga incertulas* (Walker)	Parasitoid wasps: *Trichogramma*	5-10	Around 15
		Lady beetle: *Coccinellidae*	5-10	Around 15

5.2.2 Supporting policies/initiatives

EXISTING POLICIES (POLICY AREAS - AGRICULTURE RESEARCH AND INNOVATION; IMPROVED EXTENSION AND ADVISORY)	
KP AGRICULTURE POLICY 2015-2025. Promotes bio-safety measures through lowering the use of chemical fertilizers and pesticides as well as integrated pest management.	
KP INTEGRATED PEST MANAGEMENT FRAMEWORK. Enhance the scale of the biological control activities by public institutions as well as involvement of private sector in rearing and release of such beneficial insects. Promote awareness and education of the farmers regarding identification and conservation of beneficial bioagents. Development of biological control lab/ facilities are an integral part of IPM.	
NATIONAL FOOD SECURITY POLICY 2018. Provide facilitation to institutionalize Farmer Field School (FFS) led Integrated Pest Management (IPM) approach in the research and extension system of Pakistan	
NATIONAL CLIMATE CHANGE POLICY 2021. Promote IPM practices, ensure biological control of forest pests by maintaining viable populations of predatory birds and insects.	
CONVENTION ON BIOLOGICAL DIVERSITY 1993. Ensure compliance to the Convention on Biological Diversity (CBD) of which Pakistan became a signatory in 1994. A supplementary agreement to the CBD is the Nagoya Protocol that provides a framework for access and benefit sharing of genetic resources including biological control agents.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The existing schemes include: 1) Surveillance on Pesticide and Fertilizer Adulteration in Khyber Pakhtunkhwa ($1,336,588).	

5.2.3 Proposed intervention

The purpose of this package is to increase the production capacity of labs in KP for BCA, and further mainstream IPM measures in the province. The package on integrated pest management was included in the consultations for both KP and Punjab. The package was ranked higher in KP—high climate smartness and scalability potential and low investment risk—than in Punjab, which is linked to the lower levels of investment in IPM activities in KP and relatively more progress made in Punjab (7 government biocontrol labs along with some private providers) to promote IPM and biocontrol methods. In particular, respondents during the workshop highlighted the need for investments to enhance lab capacity and farmers' knowledge on BCA and broader IPM activities.

The investment package is broken down into three components:

1. **Research support-** facilitate research on effectiveness of different IPM strategies for specific crops and contexts, with a focus on BCA.
2. **Capital investment-** increase lab capacity for reproduction of biocontrol agents.
3. **Capacity development-** Support lab staff in development of natural predators and extension for their successful release.

Component 1 focusses on improving the understanding of major pests and their impacts across KP, along with the effectiveness of different IPM measures. There is currently some work conducted on this by the 4 research stations with lab facilities (Peshawar, Swat, Mardan, DI Khan), however the low spatial coverage of the stations and issues around data sharing and publication mean they are insufficient to provide an effective evidence base for a holistic IPM strategy in KP. Therefore, this component intends to conduct a stocktaking on the different IPM resources and skills in the province to act as a benchmark for the programme. Fortunately,

some of the required information has been gathered under the KP IPM Framework that needs to be built further and validated. To avoid further issues with data sharing and availability the investment would look to equip existing and proposed IPM research centres with digital tools for pest tracking **[Output 1.1]**.

Digital tools have also been developed to support the real time identification of pests, such as Trapview (funded through the European Commission Horizon 2020 programme) which is an artificial intelligence-based pest monitoring and forecasting platform. The low-cost platform uses image recognition to identify insects that get trapped in real time, providing farmers and government actors with continuous data on pest populations and dynamics. The Trapview technology is already being made available in Pakistan through Efficient Farming Solution in Lahore (Farm Dynamics Pakistan, 2019). Another initiative utilising digital tools for pest monitoring is the AgriSmart application developed by the Punjab Public Management Reform Programme (PPMRP) under the $300 million World Bank Strengthening Markets for Agriculture and Rural Transformation in Punjab (SMART Punjab) Program (World Bank, 2018). The application is used by as many as 2,724 field workers across Punjab to support extension activities, where it was found to reduce their time on departmental tasks by 15%, increasing their time spent with farmers (GoPb PITB, n.d.). There is however, very little documentation of the success of the scheme, with some experts consulted highlighting issues with the technical capacity of field staff and pushback on the tracking of their activities. While digital technologies have been found to face issues in widespread adoption, there is scope to integrate them in a limited capacity to support experimenting and reporting on pest distribution and BCA effectiveness. The digital tools will be co-developed with target users and key stakeholders to ensure usability and uptake for higher impact and scalability **[Output 1.2]**. Data on current pest outbreaks coupled with improved climate modelling could also be used to develop predictive models of future pest distributions, to inform proactive policy making and programming in the different AEZs of KP. The monitoring of pest distribution will consider the possible risk of transboundary migration of pests from KP to other provinces. To mitigate this, a risk assessment will be done prior to implementation to assess the threat levels for crops grown in neighbouring districts outside of KP along with ensuring close coordination with agriculture departments of neighbouring provinces **[Output 1.3]**. All of the above outputs will need to be supported through increased investments in agricultural research on BCA effectiveness. This will require the establishment of randomised control trials to ensure the effectiveness of the different BCA and broader IPM measures, avoiding maladaptive measures that risk exposing farmers to greater risks and threatening the credibility of IPM and an effective pest management solution for farmers in KP **[Output 1.4]**. These activities will focus on the districts with existing labs and those identified as priority locations for new labs.

Component 2 is focused on the capital investment required to increase the lab capacity in KP for the production of priority BCAs identified in component 1. An initial assessment shows that the existing network of 4 labs (out of 14 research stations) is insufficient to cater to all of KP. These labs have low production and technical capacity for commercial purposes. Production is often limited to only one type of BCA due to the risk of cross-contamination because of a lack of proper equipment and weak implementation of protocols. There are limited training opportunities for the lab staff on latest production methods and proper safety regulations. Moreover, these labs are testing BCA effectiveness based only on field trials and therefore, require the technical support to pilot the BCAs on farmer fields. The process of increasing lab capacity will be kicked of with site visits to the existing labs (in Peshawar, Swat, Mardan, DI Khan) to assess their current facilities and production capacity. In addition to the existing labs, agricultural research stations without an existing lab will be visited with the view to establish new labs **[Output 2.1]**. Following the recommendations of the output 1, upgrades will be made to the 4 existing labs **[Output 2.2]**, and 4 new labs built based on the need for BCA in the area and their capacity to successfully install and manage a lab **[Output 2.3]**. Based on stocktaking of existing lab capacity and analysis of production across major crops, Table 28 gives the potential locations (research stations) for the proposed labs and the BCA that will be prioritized for output 2. In addition, see Figure 22 that gives a map for the existing labs and proposed labs in KP.

Table 28: Selected BCA to be produced in each of the selected research stations based on alignment with major crops in that division.

DIVISION (DISTRICT)	BCA	CROPS
Peshawar D (Nowshera)	Green lacewing: *Chrysoperla carnea*†	Sugarcane; Wheat; Fruit; Potato
	Brown lacewing: *Micromus tasmaniae* (Walker)	Fruits
Malakand D (Buner)	Parasitoid wasps: *Diachasmimorpha longicaudata**	Fruits
	Lady beetle: *Stethorus gilvifrons**	Rice; Potato; Tomato; Wheat
	Parasitoid wasps: *Dirhinus giffardi**	Vegetables
Hazara D (Mansehra)	Parasitoid wasps: *Trichogramma chilonis*†	Maize
Hazara D (Abbottabad)	Green lacewing: *Chrysoperla carnea*†	Wheat; Fruit; Potato

Component 3 is to ensure that that there is sufficient capacity amongst the staff at the labs to effectively manage the reproduction of BCAs. This includes training lab staff on biosafety, health and safety and waste disposal protocols along with briefing on licensing requirements for biocontrol production **[Output 3.1]**, the extension staff to effectively recommend and deliver IPM treatments including BCAs **[Output 3.2]**, and input providers to be conscious of the recommended application rates of chemical treatments **[Output 3.3]**. Capacity building for the uptake of IPM by local smallholder farmers has the potential to be developed into commercially viable business models, either by new market entrants or existing ones that expand their service portfolio. Advisory on the effective use of IPM, including both application and awareness-raising on prospective commercial benefits, can be provided as a value-added service to the distribution of bio-control agents. Pest-treatment distributors with existing distribution networks and connections to local stakeholder groups such as farmer associations can be trained to provide such agronomic best-practices. Various channels have proven successful in other contexts, for example the provision of info brochures or digital content such as emails and social media messages. However, it is challenging to operationalize such strategies given the lack of awareness and subsequent low willingness to pay by the low-income target group. Another opportunity to disseminate information on IPM is to tap into existing information providers of agronomic best-practices, such as news or radio channels. Schemes exist in which subsidized partnerships between distributors and media agents provide locally targeted information to specific audiences.

A breakdown of intervention components, outcome and outputs along with indicative activity costs and timeline is provided in Table 29. The activity costs and timeline are based on similar costs for projects covering similar topics in other locations or past experience in preparing project proposals. These were also run past key stakeholders who had been consulted. In all instances, any capital investment is based on benchmarks for what is available on the market, while operational costs do have more uncertainty as it is harder to find an effective baseline.

Table 29: Breakdown of intervention components, outcomes, and outputs

COMPONENT	OUTCOMES	OUTPUTS	INSTITUTIONS	INDICATIVE ACTIVITY COST*	TIMELINE
Component 1: Research support – facilitate research on effectiveness of different IPM strategies for specific crops and contexts, with a focus on biological control agents.	**Outcome 1.1:** Improved understanding amongst researchers and extension staff of the spatial distribution of major pests and effective treatments. • *Research and extension staff trained on the application of digital tools for pest tracking and early warning.* • *Research institute trained in pest distribution modelling.*	**Output 1.1:** Research report on the current distribution and impact of major pests across KP.	• Alliance • CABI	**$100,000**	Year 1
		Output 1.2: Development of digital tools to support pest identification, tracking, and early warning by extension staff.	• Alliance	**$300,000**	Year 1
		Output 1.3: Develop models to assess future distribution of pests under climate change.	• Alliance	**$80,000**	Year 2
		Output 1.4: Research on effectiveness of different bio-control treatments and complementary recommendations for chemical pesticide use.	• CABI • Directorate of Agriculture Research	**$250,000**	Year 2 – 5
Component 2: Capital investment – increase lab capacity for reproduction of biocontrol agents.	**Outcome 2:** Increased lab capacity for the production of bio-control agents in KP. • *4 labs modernised* • *4 new labs constructed*	**Output 2.1:** Detailed review of existing lab capacity in for bio-control production in KP.	Alliance	**$30,000**	Year 1
		Output 2.2: Capital costs of upgrading 4 existing labs and constructing 4 new labs.	• Directorate of Agriculture Research	**$161,680**[14]	Year 1 – 5
		Output 2.3: Operational and HR costs of establishing and running IPM labs.	• Directorate of Agriculture Research	**$2,246,384**[15]	Year 2 – 5
Component 3: Capacity development – provide training and capacity development to researchers, extension staff, and input suppliers.	**Outcome 3:** Provincial staff are trained in the production and release of bio-control agents. • *8 lab staff trained* • *Extension staff from 8 districts trained* • *5-25% reduction in losses* • *10-30% reduction in the use of chemical pesticides*	**Output 3.1:** Train lab staff in the production of bio-control agents.	• CABI	**$36,000** (3,000 x 12 trainings)	Year 1 – 5
		Output 3.2: Train extension staff on the use of bio-control agents.	• CABI	**$20,000** ($500 x 8 districts x 5 years)	Year 1 – 5
		Output 3.3: Train input providers to provide suitable recommendations for pesticide sale and application.	• Directorate of Agriculture Extension	**$40,000** ($1,000 x 8 districts x 5 years)	Year 1 – 5
Total Program Activity Costs				**$3,264,061**	

[14] Capital cost per new lab = $22,470; Capital cost per upgrade lab = $17,950

[15] HR & Ops cost for new lab/year = $81,200; HR & Ops cost for upgrade lab/year = $58,400

5.2.4 Potential partners

The implementing institution for this package is *Directorate of Agriculture Research, Agriculture Department KP*, who has the mandate for development of integrated pest and disease management strategies. Directorate of Agriculture Research has 14 research stations operational across the province. The *Directorate of Agriculture Extension* is included in the project to support the outreach to farmers, provide technical assistance and capacity building on biocontrol measures and the distribution of BCA cards. The network of *Model Farm Service Centers (MFSC)* can also provide support in the provision/distribution of bioagent cards and instruction for use to farmers.

A key technical partner for the project is *Centre for Agriculture and Bio-Sciences International (CABI)* bringing in their expertise on IPM implementation across Pakistan. Research partners are *University of Agriculture, Peshawar* and *University of Swabi* who will provide a rich resource pool of trained entomologists and agriculturists to support the activities.

Table 30: Institution and names of stakeholders consulted

INSTITUTION	FOCAL PERSON	STATUS
Directorate of Agriculture Research, Agri Department KP	**Dr. Rauf,** DG Agriculture Research	Knows about the project and gave approval to his team for data sharing
Agriculture Research Institute, Tarnab, Peshawar	**Mr. Fazli Wahab,** Director Agriculture Research (Merged Areas)	Coordinated with plant protection experts from his team & shared feedback
Agriculture Research Institute, Mingora, Swat	**Dr. Fazal Maula,** PRO	Shared data on crop losses & lab results on predation potential of biocontrol agents
Agriculture Research Institute, Tarnab, Peshawar	**Mr. Younas,** SRO	Shared feedback and data on lab costs
University of Swabi, KP	**Dr. Muhammad Saeed,** Associate Professor, Department of Agriculture	Helped compile and review data on crop losses by pest, effective biocontrol agents
CABI	**Mr. Sabyan Honey**	Gave feedback and validation project design and data
Agriculture Department Punjab	**Dr. Muhammad Asghar,** Director Agri Extension (IPM)	Shared progress and details of the biocontrol labs in Punjab

5.2.5 Economic assessment

This section outlines the costs and benefits of an Integrated Pest Management (IPM) program, that scales the production for BCA labs across KP. The commodities evaluated for the program are wheat, tomato, potato, peach, apple, and orange as these were identified as being some of the major crops afflicted by pest outbreaks. These are also crops identified as being amenable or responsive to the application of BCA treatments. Estimate of gross revenues for each of these crops is contained in the table below. Yields and prices for the crops were obtained from the government of Pakistan either through the Pakistan Agricultural Research Council or the Pakistan Agriculture Marketing Information Service (Directorate of Agriculture Punjab, 2022; Ministry of National Food Security and Research, 2022). The potential productivity gain or loss eliminated from an IPM program are listed in the far right-hand column, these were gathered through extensive expert consultations and secondary literature. For the analysis, onions and potatoes were evaluated as an average as they have similar gross revenues. Similarly, apples, peaches, and oranges where aggregated as they also show similar agro-economic characteristics for the evaluation. The area covered is split evenly between these crop categories wheat, tomatoes, potatoes/onion, and tree crops. It is expected that the program is run over a period of 15 years.

Table 31: Economic summary of crops evaluated for the IPM program

	YIELD	UNIT	PRICE	UNIT	PRICE US$ (XR 200 RUP PER $)	REV PER HA	POTENTIAL PRODUCTIVITY GAIN, BCA TREATMENT
Wheat	1.7	MT/Ha	6,000	Rup/100kg	300	510	5%
Tomato	11.4	MT/Ha	6,000	Rup/100kg	300	3,429	10%
Potato	22	MT/Ha	5,000	Rup/100kg	250	5,500	10%
Peach	7.2	MT/Ha	14,000	Rup/100kg	700	5,040	20-25%
Apple	8.3	MT/Ha	12,000	Rup/100kg	600	4,980	10%
Oranges	11	MT/Ha	15,000	Rup/100kg	750	8,250	5-10%

Estimates on the costs of upgrading and developing new labs, along with the staff and operational costs were compiled with support from CABI and the Punjab biocontrol labs. This included the identification of necessary equipment and human resources. The cost estimates were taken for equipment, human resources and operations and maintenance for a lab producing a single biological control agent as that was considered best practice to avoid cross-contamination. Discussions with sector specialists in Pakistan indicated that IPM programs could reduce pesticide expenditures up to 30 percent. It was not possible to obtain cost information for all relevant pesticides in Pakistan to come up with an accurate estimate of what the savings would be in Rupees or dollars on a per hectare basis. However, Rahman et al. 2018 found that surveyed vegetable farmers in Bangladesh spent an average of $25.40 per ha on pesticides. 30 percent of this value would be US$8.46 per ha, which is the value used for the analysis. It seems that an effective IPM program ought to be able to offset pesticide expenditure by at least this value and as such this should be viewed as a relatively conservative estimate of this type of benefit.

The total costs of running a program of this size over the full 15 years is USD $8,848,021, although if the funding were to only cover the set up and operation for the first 5 years this could be reduced to USD $3,264,061 with the remainder covered through government co-financing (USD $558,396/year). The model assumes that the labs will be installed over a number of years with 3 existing labs upgraded in year 0, the remaining lab upgraded in the first year with two new labs constructed, and the two remaining new labs built in the second year. Once fully up and running the program will produce enough BCA to treat an area of 5,678ha per season, with a total area of 79,492ha treated for a season over the course of the programme. The programme performs well under the cost benefit evaluation, with a calculated Internal Rate of Return (IRR)[16] of 104% which shows that every $1 invested in the programme gets back $2 for farmers in KP. This profitability is measured when comparing the private benefits of farmer beneficiaries (reduced losses and pesticide costs) with the programme costs, it does not however return a profit to the programme implementers. The programme is therefore assessed as having a positive net present value of USD $8,745,066. The assessment also included a sensitivity analysis looking at two scenarios, an increase in the discount rate to 20%, or a fall in BCA efficiency by 25%. Evaluating the sensitivity of this package to changes in the discount rate, showed it still achieving a positive NPV with the higher 20% rate. Furthermore, were the efficiency of the BCA treatments to be 25% lower than originally modelled, the program would also maintain a positive NPV.

[16] Internal Rate of Return (IRR) is a measure of profitability. In this assessment a discount rate of 10% has been applied.

Table 32: Cost benefit evaluation of the IPM program, including the costs of capital investment, HR and operational costs, versus the economic benefits of increased productivity and associated environmental benefits. Operational considerations have also been included.

TYPE	FACTOR	VALUE	SOURCE
COST BENEFIT EVALUATION			
Cost – Capital investment	Upgrading 4 existing labs	$17,950.00/lab	CABI; KP Ag Research
	Installing 4 new labs	$22,470.00/lab	CABI; KP Ag Research
Cost – HR & Operations	**Existing –** Staff; operations; maintenance; transport	$68,400.00/year/lab	CABI; KP Ag Research
	New – Staff; operations; maintenance; transport	$91,200.00/year/lab	CABI; KP Ag Research
Cost – Program	Research and program implementation (excluding lab construction and running)	$856,000	Table 29
Benefits – Productivity	Yield	See Table 31 productivity gains	KP Ag Research; various literature; monthly bulletins
Benefits – Environmental	Pesticide reduction	30% (calculated as $8.46 per ha)	KP Ag Research; Rahman et al. 2018
OPERATIONAL CONSIDERATIONS			
Volume	Production volume of BCA	10,000 cards per month per lab	Punjab Ag research lab operators
Coverage	Ha treated per lab	20-40 cards per ha replaced every 14 days = 167ha per month	Punjab Ag research lab operators

Table 33: Cost benefit evaluation of the IPM program under two different discount rate scenarios (10% and 20%) and under a 25% fall in BCA efficiency.

MEASURE	RESULT
Internal Rate of Return (IRR)	104%
Net Present Value (NPV) – 10% Discount rate	$8,745,066
Net Present Value (NPV) – 20% Discount rate	$4,644,473
Net Present Value (NPV) – 75% Efficiency	$5,513,446

Section

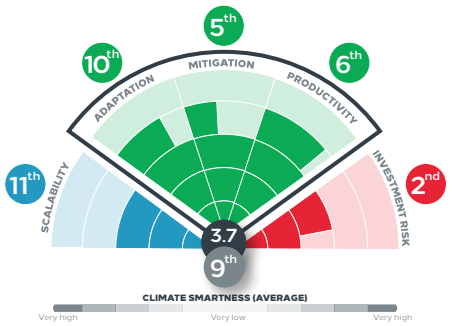
6

Research packages

HIGHLIGHTS

- For the proposed research packages, only the costs have been assessed due to the challenges in assessing the monetary value of the non-monetary benefits, however, the positive environmental and social impacts of both packages would be substantial.
- The integration of native fruit trees package would complement existing forest restoration initiatives in KP by mainstreaming agroforestry in local farming systems. The interventions would enhance water holding capacity in the watersheds and build resilience against flash floods and landslides, which are becoming increasingly common in KP due to the increase in heavy precipitation.
- Integrating native fruit trees and fish production in farming systems of KP would also create new economic opportunities for farmers, however, input and output markets need to be strengthened to effectively commercialize these new agricultural products.
- The wild boar strategy development package aims to develop research and institutional capacities to find effective measures to respond to wild boar attacks affecting farming communities of KP, which are becoming more common. Research on best management practices and capacity development of extension agents and farmers are some of the proposed interventions that could reduce human-wildlife conflicts, and protect farmers against losses of economically important crops.

6.1 Integrated farming with native fruit trees



6.1.1 Introduction and background

KP is exposed to both periods of intense rainfall and drought. Due to its mountainous topography, intense rainfall in KP often results in flash flooding, as surface runoff is channelled down steep slopes, overwhelming the river system with high peak flow rates. This process also accelerates the rate of soil erosion and in extreme circumstances trigger landslides. Experts consulted in KP considered that in many areas of the province topsoil are still to recover from the impact of the 2010 floods, with a contingent effect on soil fertility. Future climate projections are also worrisome. Overall, KP will experience a rise in the frequency of heavy precipitation events with northern KP seeing an increase by up to 3.5 heavy precipitation days per year under RCP6.0 (PIK, 2022). Drought projections also show a positive trend in the number of extremely dry days per year in KP under RCP 2.6 and 6.0 (PIK, 2022). Moreover, hazard mapping across 5 districts and 24 villages in KP identified flooding and drought incidents as occurring every second year with moderate severity (10-30% losses)(FAO & The Alliance of Bioversity International & CIAT, 2020).

KP's forested area, which makes up 14.8 per cent of the province, plays a critical role in regulating water flows and aquifer recharge (KP Dev Statistics, 2021). The forest area also serves soil conservation and carbon sequestration functions. It is estimated that these forests hold soil organic carbon of about 59.4 x 106 t, of which 69 per cent is present in the temperate forests (A. Ali, Ashraf, et al., 2020). Deforestation weakens the watershed function of the forest as it is unable to regulate water flows from heavy precipitation events, increasing the risk of flooding.

Deforestation, unsustainable agricultural practices and removal of vegetation on steep slopes in KP has accelerated soil erosion and increased the incidence of landslides and the risk of flash floods (S. Muhammad et al., 2016). Disruptions from flooding and landslides can damage irrigation systems, storage facilities and farm to market roads. Accelerated soil erosion causes soil degradation and loss of nutrients which can have catastrophic impacts for growing crops in arid regions (Siddiqui & Ali, 2010). Moreover, degraded watersheds offer lower rates of water holding capacity, increasing the speed of onset and severity of water stress following dry spells.

Recognising the important role forests play in regulating ecosystem services in KP, the government launched the One Billion Tree Tsunami Afforestation Project (2014-19) under their Green Growth Initiative. The project provided training to residents on forest preservation and climate change adaptation, along with planting materials, with the aim of increasing the provinces forest cover by 6.3% (FAO, 2019b). Leading into the UN Decade on Ecosystem Restoration (2021-2030), the programme was expanded in 2018 to become the "Ten Billion Tree Tsunami Programme" with phase-I running from 2019-2023 (GoP MoCC, 2019). The original One Billion Tree Tsunami Afforestation Project has come under some criticism, with Usman. A (2019) observing issues around the revocation of grazing rights and land tenure agreements for herders as landowners received higher use value contracting with the forest department; the exclusion and marginalisation of tenant and landless households leading to worsening inequality in areas engaged in the programme; and the reinforcement of local power structures through the interaction of ethnic and class interests with issues around land ownership and forest access (U. Ashraf, 2019).

The most recent independent audit of the One Billion Tree Tsunami Afforestation Project conducted by WWF in 2017, found that by the end of June 2017 the KP Forest Department had planted 872.3 million seedlings, of which 88.75% had survived, growing the provinces forested area by 350,000 hectares. The species composition of the trees planted under Phase-I & II of the project included Char (21%), Eucalyptus (19%), Kail (14%), Sanitha (7%), Phulai (6%), and Poplar (5%) (WWF, 2017). A further special audit of the Ten Billion Tree Tsunami Project is due this year (2022), with news sources suggesting the programme has now planted up to 2.5 billion trees (TheNews, 2022). There are also concerns about the future of the Ten Billion Tree Tsunami Project following the removal of ex-prime minister Imran Khan from office (Climate News, 2022). Another restoration programme operating in KP is The Restoration Initiative (TRI), which is a multi-country programme launched in support of the Bonn Challenge. In Pakistan the programme is implemented by the FAO with USD $4 million of funding from the Green Environment Facility (GEF), focusing on the sustainable management of chilgoza forests[17] in four locations.

Experts consulted during the course of the development of this report highlighted the potential to strengthen the long-term sustainability of tree planting initiatives in KP through the integration of native fruit and nut species. Furthermore, the promotion of integrated farming systems with fodder grown between trees would ease the conflict between herder communities and plantation projects, while also acting as a form of Ecosystem-based Adaptation (EbA) considering the multiple benefits linked to reduced flooding and erosion risks and increased water holding capacity. There is also potential to market native fruits and nuts as an alternative income source for farming communities.

Where suitable it has also been recommended that the project can support the installation of small-scale fish farms for the production of trout and carp, helping to manage the flow of water through the watershed and generating income and food sources for communities. Fish farming has recently emerged as a promising income source for farmers in KP (Sir Biland Khan et al., 2018), with research showing that it is predominantly practiced by young, educated farmers who are able to make use of existing government support in the form of financing, training, and information (A. Hassan et al., 2021) . It has however, been noted that to expand fish farming there is a need for greater support from Government and international institutions, building the capacity of the Fishery Department and providing financial support through subsidies or direct financing (A. Hassan et al., 2021).

Native trees are also of significant cultural importance to tribal communities and their traditional food systems, who make use of the fruits, leaves, and other parts of the tree for various ethnobotanical purposes (S. M. Khan & Abdullah, 2020). Marwat et al. conducted a study in D.I. Khan on the ethnobotanical uses of native fruit trees (see Table 34), finding the trees to still play an important role for communities in the province especially in time of drought when they are relied upon as a substitute food source for cultivated crops (Marwat et al., 2011).

A study on the effectiveness of agroforestry systems in KP, found that they were being adopted by farmers for a range of environmental benefits including for windbreaks, erosion prevention, rain attraction, composting, and their aesthetic impact on the landscape (Zada et al., 2022). This was in addition to the productive benefits derived from the use and sale of forest products, diversifying farmer incomes with fewer inputs (see table 35). The study did however identify a raft of barriers that are frustrating the effective implementation of agroforestry systems in KP, including the small plot size, poor training on effective plantation management which resulted in outbreaks of pests and diseases, the lack of water for irrigation, theft of fruit, and trouble accessing seeds and seedlings. Thus, calling for improved extension outreach on orchard management and the promotion of local seed nurseries for promising agroforestry species (Zada et al., 2022).

[17] Chilgoza forests are managed for the production of the chilgoza nut that is both sold locally and on international markets.

Table 34: Native fruit trees in D.I Khan and their ethnobotanical uses (Marwat et al., 2011).

S/N	BOTANICAL NAME	LOCAL NAME	HABIT AND HABITAT	FLOWERING PERIOD	INDIGENOUS ETHNOBOTANICAL USES
1	*Capparis decidua*	Kira (P), Karir, Dela (U), Kreeta (S)	Shrub common in desert parts of the area	May-Jul	Camels browse the young branches of the plant, the wood is used in making of agricultural tools. The dried plant is used for fuel purpose. The ripe fruit is eaten by the local inhabitants.
2	*Cordia dichotoma*	Lasuri (S) Lasora (P)	A polygamo-dioecious tree	Mar-Apr	Leaves are used as fodder. Fruit is eaten. The dried branches are used as fuel.
3	*Cordia myxa*	Lasora (P)	A polygamo-dioecious tree	Mar-Apr	Leaves are used as fodder. Fruit is eaten. The dried branches are used as fuel.
4	*Grewia tenax*	Anzirai (P) gunghi (S)	Small, depressed shrub, found in and semi-arid plains and hills arid	Feb-Aug	The leaves are used as fodder for cattle, especially for goats. The dried plant is used as fuel wood species.
5	*Monotheca buxifolia*	Gur Gura	Small shrub found in hilly area	Apr-May	It is honey bee, fuel wood species. Browsed by camels and goats. Fruits are eaten by local people and birds.
6	*Nannorrhops ritchiana*	Patha, Mazri (U), Mazairay (P)	Perennial, gregarious, usually small tufted palm, found in sandy hilly areas.	Jul-Oct	The leaves are used for making rope used for weaving bedstead (charpayee), tray (Skor), hand fan (Bozay), small prayer mat (Musalla), large prayer mat (Suff), Grain bins (Puzai) – for storage of grains, hot pot (Chabbal/ Chabbi), hat (Topee), grooms (Jharu) and basket (Tokrai/Tokris). Fruit is eaten, dried plant is used for fuel purposes.
7	*Nelumbo nucifera*	Kanwal, Behi	Perennial submerged herb	Sep-Nov	The rhizome (Bhen) of *Nelumbo nucifera* is used as vegetable and seeds are eaten.
8	*Salvadora oleoides*	Jhal, Khabbar, Pilu	Shrub or small tree found in rocky slopes and sandy area	Mar-Jun	Wood is used as fuel. Branches and leaves serve as camel fodder. The sweet fruits are eaten.
9	*Salvadora persica*	hal (S), Plaman (P), Pilu (U)	Shrub or small tree found in rocky slopes and sandy area	Mar-Jun	The dried parts are used as fuel, wood is also used in making of agricultural implements. Miswak (toothbrush) is made from its root. Branches and leaves serve as fodder. The ripe fruits are eaten.
10	*Zizyphus mauritiana*	Ber (S,U), Bera (P)	Cultivated and self sown throughout the district in arid and semi-arid area	Jul-Sep	The wood is used in making of bedsteads, agricultural implements, house poles, tool handles, yokes, household utensils, also valued as firewood, a source of charcoal, branches used for fencing and hedges, leaves used as fodder, fruit is edible.
11	*Zizyphus numularia*	Jher Beri (S,U), Karkanra	Shrub or small tree found in arid and semi-arid region usually in hilly area	Mar-Jun	It is firewood and honey bee species, branches are used for hedging and fencing; leaves browsed by goats and camels. Wood is used in making of agricultural tools. The fruit is edible.

Key: P = Pushto; S = Seraiki; U = Urdu

Table 35: Types of agroforestry trees in KP and their benefits (Zada et al., 2022)

MAJOR PLANTS	INCOME	CONSTRUCTION	FOOD	FODDER	FIREWOOD	MEDICINE	TIMBER
Poplar	23	6	-	-	2	-	0
Oriental plane	6	-	-	-	-	-	4
Persimmon	17	2	7	-	6	0	9
Black persimmon	13	0	9	5	8	0	5
Plum	6	5	6	-	5	2	3
Apple	12	2	5	-	0	3	-

MAJOR PLANTS	INCOME	CONSTRUCTION	FOOD	FODDER	FIREWOOD	MEDICINE	TIMBER
Peach	16	-	8	0	5	1	-
Acacia Keekar	10	7	-	5	6	0	5
Fig	5	-	6	3	4	2	0
Pear	8	-	7	-	5	1	0
Walnuts	7	-	4	-	3	3	5
Apricot	4	0	5	0	3	2	-
Melia	7	5	-	3	4	-	2
Morus	5	3	-	2	2	3	3
TOTAL	**139**	**30**	**57**	**18**	**53**	**17**	**36**

Scientific name: *Populus, Platanus orientalis, Diospyros virginiana, Diospyros texana, Prunus domestica, Malus, Prunus persica, Acacia, Ficus carica, Pyrus, Juglans, Prunus armeniaca, Melia azedarach and Morus alba.*

6.1.2 Supporting policies/initiatives

EXISTING POLICIES (POLICY AREAS - WATER MANAGEMENT; AGRICULTURE RESEARCH AND INNOVATION)	
KP AGRICULTURE POLICY 2015-2025. Strengthen capacity of the Agricultural Engineering Department and Soil and Water Conservation Department for the development and promotion of watershed-based soil and water conservation practices. Indigenisation and promotion of production system based low-cost farm machinery & tools along with soil and water conservation technologies/practices (e.g. range land development, olive, forages, and forest management).	
KP CLIMATE CHANGE POLICY 2022. Identify and declare vulnerable uphill fragile watershed areas as sensitive, and place them under specific silvicultural management by incorporating local populations in order to prevent floods and siltation of water reservoirs. The entire watershed area of Khyber Pakhtunkhwa needs to be treated simultaneously through the mechanism of complete valley treatment instead of patch plantation approach.	
NATIONAL FOOD SECURITY POLICY 2018. Promotion of integrated watershed management for livelihood improvement in mountainous areas. Climate smart innovations for the promotion of agroforestry to conserve natural resources.	
NATIONAL CLIMATE CHANGE POLICY 2021. Promote integrated watershed management including ecological conservation practices in uphill watersheds. Identify and declare uphill fragile watershed areas as sensitive and bring them under special silvicultural management to check floods and siltation of water reservoirs, Ensure minimal exploitation of water shed areas declared as sensitive.	
NATIONAL WATER POLICY 2018. Improve watershed management through extensive soil conservation, catchment area treatment, preservation of forests and increasing forest cover.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The existing schemes include: 1) Billion Tree Afforestation Project in Khyber Pakhtunkhwa Phase-III ($36,102,440); 2) 0-BTTP Up-Scaling Green Pakistan Program, Revival of Forestry Resources in Khyber Pakhtunkhwa – ADP & PSDP Funded ($78113428); 3) Collection and Storage of Seeds of Forest Species, Operationalization of Seed Storages and Up-gradation of Seeds Testing Laboratory Phase-II ($228,571).	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes include: 1) Billion Tree Afforestation – Support Project – BTASP assisted by KFW ($14,994,285).

6.1.3 Proposed intervention

The proposed package of interventions aims to address a range of socio-cultural, environmental, and economic challenges in KP through the adoption of a holistic package of landscape (watershed) level EbA measures. The proposed interventions combine cultural practices with diversified income sources in a way that builds the resilience of farming communities to climate change, improves their income generating potential, and addresses emerging resource conflicts over grazing land.

The research package is broken down into three components:

1. **Research –** to better map priority watersheds, the appropriate distribution of native fruit trees, and assess the feasibility of different agroforestry systems.
2. **Market development –** for the supply of inputs and training for native fruit trees and the sale of produce.
3. **Fish farming –** sites identified for the promotion of small-scale trout and carp farms.

Component 1 will be used to create an effective evidence base for investments in integrated framing systems that target vulnerable micro watersheds. The first activity will be to conduct a watershed and micro watershed mapping for the province, assessing the health of different watersheds and their risk of flooding, erosion, and landslides. This activity will be conducted using GIS mapping technologies coupled with filed visits to validate the findings **[Output 1.1]**. To achieve the targets of preventing, halting, and reversing degradation for the United Nations Decade on Ecosystem Restoration (2021-2030) (FAO & UNEP, n.d.), there has been an identified need to support fit-for-purpose and resilient native tree seed systems that can contribute to the attainment of global forest and landscape restoration targets (The Alliance of Bioversity International and CIAT, 2022). One of the available tools to support this transition is the diversity for restoration tool developed by the Alliance of Bioversity International and CIAT (D4R & The Alliance of Bioversity International and CIAT, 2022) **[Output 1.2]**. The tool has been developed to help decision makers identify appropriate tree species for restoration purposes, and to support the development of effective seed systems targeted for the needs of the local context. Within the tool it is possible to introduce parameters linked to the restoration objectives of the programme, which in this instance would be linked to soil binding and agroforestry potential. The output of the tool will have relevance outside of this programme, providing information that could have broader implications for the tree species composition used under the much larger Ten Billion Tree Tsunami Programme. To validate the outputs of the two modelling exercises with ground data, trial sites that are already implementing the prioritised integrated farming systems (or can easily be modified to do so without having to wait for trees to reach maturity) will be identified and evaluated for their effectiveness and scaling potential **[Output 1.3]**.

Component 2 aims to support the development of effective input and output markets. Effective seed selection and seed sourcing strategies are critical determinants of success for ecological restoration projects (The Alliance of Bioversity International and CIAT, 2022), along with the development of nursery capacity for seedling production **[Output 2.1]**. To build the capacity of farmers in orchard management and integrated farming, demonstration plots will be established **[Output 2.2]**. Through the training farmers will be equipped to counter the existing challenges that have been afflicting agroforestry systems in KP. To further enhance the effectiveness of the system in erosion avoidance, farmers will be trained in contour farming approaches, whereby trees and crops are planted following the contour lines which reduces the levels of surface run-off and in turn lowers the rate of erosion as topsoil's are trapped by the horizontal lines of vegetation. The programme will also support the development of well-functioning output markets to ensure farmers can generate good value for their produce and are not impacted with post-harvest losses. This will be achieved through investments in localised storage and processing facilities as needed, along with branding and marketing support for produce for greater value addition and access to higher value markets **[Output 2.3]**.

Component 3 aims to increase the provincial farmed fish market which has been shown to be an effective revenue generating activity in KP with the production of trout and carp. Locations for farms will be located

in each of the target watersheds **[Output 3.1]**, with interested farmers provided financing support for the establishment of the pond system and purchase of inputs **[Output 3.2]**. Technical training will be provided to the fisheries department to better equip them to provide training and capacity building to fish farmers in the priority watersheds, reducing the prevalence of disease outbreaks and the pollution of local water resources **[Output 3.3]**.

Table 36: Breakdown of intervention components, outcomes, and outputs

COMPONENT	OUTCOMES	OUTPUTS	INSTITUTIONS	INDICATIVE ACTIVITY COST*	TIMELINE
Component 1: Research – to better map priority watersheds, the appropriate distribution of native fruit trees, and assess the feasibility of different integrated farming systems.	**Outcome 1:** Evidence for decision making on location specific integrated farming systems. • *GIS maps developed for watersheds and potential tree distribution* • *2 priority micro watersheds identified* • *8 trial sites identified to assess effectiveness and scaling potential of existing agroforestry initiatives*	**Output 1.1:** Conduct GIS mapping of the watershed and micro watersheds in KP.	• IWMI	**$150,000**	Year 1
		Output 1.2: Conduct mapping of the possible distribution of native and introduced trees with agroforestry potential.	• Alliance	**$100,000**	Year 1
		Output 1.3: Run trials of different integrated farming systems and their socio-cultural, environmental, and economic potential.	• Forestry, Environment and Wildlife Department (FEWD); • Alliance (technical backstopping)	**$200,000**	Year 2-3
Component 2: Market development – for the supply of inputs and training for native fruit trees and the sale of produce.	**Outcome 2:** Integrated farming systems scaled across micro watershed with input and output markets strengthened. • *70% of agroforestry introduced is in areas highly prone to erosion and landslides.* • *8 new nurseries established, along with 6 new storage and processing plants.*	**Output 2.1:** Conduct seed selection, sourcing and nursery development for native fruit tree species and fodder crops tailored to each micro watershed	• FWED; • Agriculture Department; • Pakistan Forest Institute	**$1,500,000**	Year 2-5
		Output 2.2: Use the existing trial sites as training sites for farmers to learn appropriate management practices	• Directorate of Extension	**$150,000**	Year 2-5
		Output 2.3: Develop output markets for fruits, increasing local storage and processing capacity and marketing. Also providing advertising and branding support.	• Agriculture Department; • FEWD	**$300,000**	Year 2-5
Component 3: Fish farming – sites identified for the promotion of small-scale trout and carp farms.	**Outcome 3:** New small-scale trout and carp farms established. • *6 new trout and carp farms established.*	**Output 3.1:** Identification of sites for small-scale fish farms.	• Department of fisheries	**$15,000**	Year 1
		Output 3.2: Financial support for the establishment of new farms.	• Department of fisheries	**$30,000**	Year 1-5
		Output 3.3: Technical training on fish production, disease management, and marketing.	• Department of fisheries	**$15,000**	Year 1-5
Total Program Activity Costs				**$2,460,000**	

6.1.4 Potential Partners

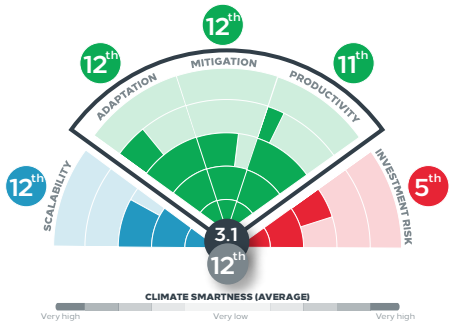
The *Forest, Environment and Wildlife Department (FEWD)* KP will be a key stakeholder and partner in the project responsible for piloting and scaling up of integrated farming systems across micro-watersheds and strengthening input and output markets. FEWD can be supported by the *Pakistan Forest Institute* to provide research services and trained manpower for testing and scaling up integrated farming systems including seed selection, sourcing and nursery development for native fruit tree species and fodder crops tailored to each micro watershed. *Directorate of Agriculture Extension* can provide extension support to *FEWD* by using trial sites to train farmers on appropriate management practices.

The research component can be led by *Alliance of Bioversity International & CIAT* and *International Water Management Institute (IWMI)* to generate evidence for decision making on location specific integrated farming systems. IWMI can contribute to generating evidence by using GIS technology to map watersheds and micro watersheds in KP. *Alliance* can undertake mapping of possible distribution of native and introduced trees with agroforestry potential on selected watersheds. *Alliance* can also provide technical backstopping to government departments and research institutes in setting and scaling up trial sites.

***Directorate of Fisheries* is the provincial department for the regulation and development of fisheries sector.** The department can play a role in providing extension services for the promotion and development of fish farming and fish hatcheries. This can include identification of sites for small-scale fish farmers and giving technical training on fish production, disease management and marketing.

***FEWD* and *Department of Agriculture* can jointly work towards strengthening the input and output markets for fruits and increasing local storage and processing capacity.** Support for effective marketing, advertising and branding can also be provided to farmers.

6.2 Strategy development & awareness raising to counter wild boar attacks in Kurram, Orakzai, & North Waziristan



6.2.1 Introduction and background

The wild boar, *sus scrofa*, is a species that has a wide global distribution, throughout Europe and Asia. In Pakistan, the wild boar mostly occurs at an elevations up to and lower than 1,000 m above sea level (Roberts, 1997). Previous studies have associated wild boars with the Indus Basin's riparian areas having thick vegetation (Virk, 1991). However, this species have been found to be highly adaptable, and often propagates in almost all types of habitats, including plains, swamps, mountains, coastal areas, and almost all kinds of forests (Durio et al., 1995; Gerard et al., 1991). In sampled studies in Nowshera, KP, researchers found the wild boar as the most frequently occurring and uniformly distributed wild mammal (Khattak et al., 2022).

Several causes have been attributed to the expansion in wild boar populations in Pakistan. Firstly, reductions in predators such as wolves and tigers have allowed for wild boar populations to increase without natural control. Secondly, the species thrives in fragmented ecosystems, where dense bushes, forests, and marshes provide cover, combined with a high abundance of food as a result of agricultural development (I. Ashraf et al., 2013). The development of the irrigation canal system in Pakistan has increased the habitat for wild boars. Originally, the species were restricted to riverain habitats, which provided them dense cover, abundant water and seclusion. Once agriculture spread beyond the riverain zones in the Punjab and Sindh due to canal network, a variety of suitable habitats for wild boars appeared in isolated patches all over the Indus plain (Beg & Khan, 1982). Thirdly, changing climatic conditions are driving wild boar to areas of KP that were traditionally out of their natural range. Warmer temperatures seem to be the reason behind their movement to temperate regions (Saeed, 2020). Lastly, while in other countries, management practices such as hunting the boar for meat has helped to limit boar populations, strict religious prohibitions in Pakistan regarding consumption of pork have barred this as a possible activity. This immunity has favoured the exponential increase in the wild boar population across study areas in Nowshera, KP, and the country as a whole (Khattak et al., 2022).

Wild boars are considered a significant pest both in Pakistan and globally due to the damage they cause to crops. The species has been found to consume 80-100% of vegetable matter as their diet (I. Ashraf et al., 2013). Schön (2013) suggested that damages are especially severe where the agricultural landscape is made up of fragmented small fields, due to the nature of the boars often foraging near agricultural field edges in order to easily escape. In sampled areas across Nowshera, KP, the wild boar and Indian porcupine species were found to cause substantial crop damage, where the boars contributed to 81% of the damage, translating into an economic loss of USD 18,000 (USD 9000 per year, USD 18.07 per household) (Khattak et al., 2021). Wild Boars were also identified by villagers as a critical hazard to farmer's subsistence and livelihood in Kurram, Orakzai and North Waziristan districts. (FAO & The Alliance of Bioversity International & CIAT, 2020). More severe attacks were reported on grain crops (maize, rice and wheat) along with vegetables and fruit orchards from

Figure 23: Analysis of suitable habitats for wild boar populations in Pakistan (author's own analysis). Methodology for analysis based on Bosch et al.'s (2016), which categorised GLOBCOVER 2009 land cover data according to suitable habitats for wild boars.

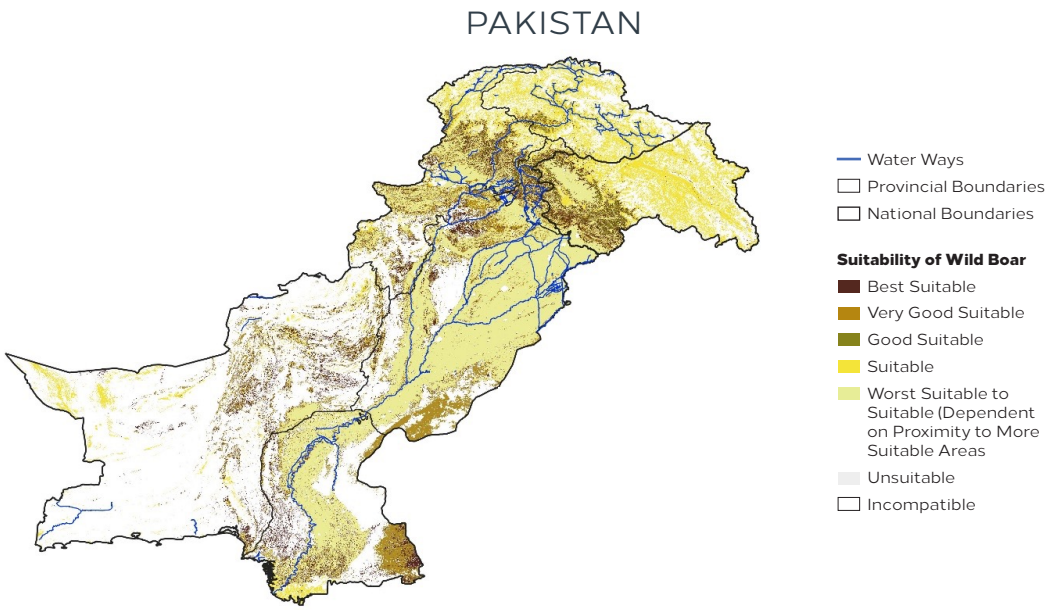
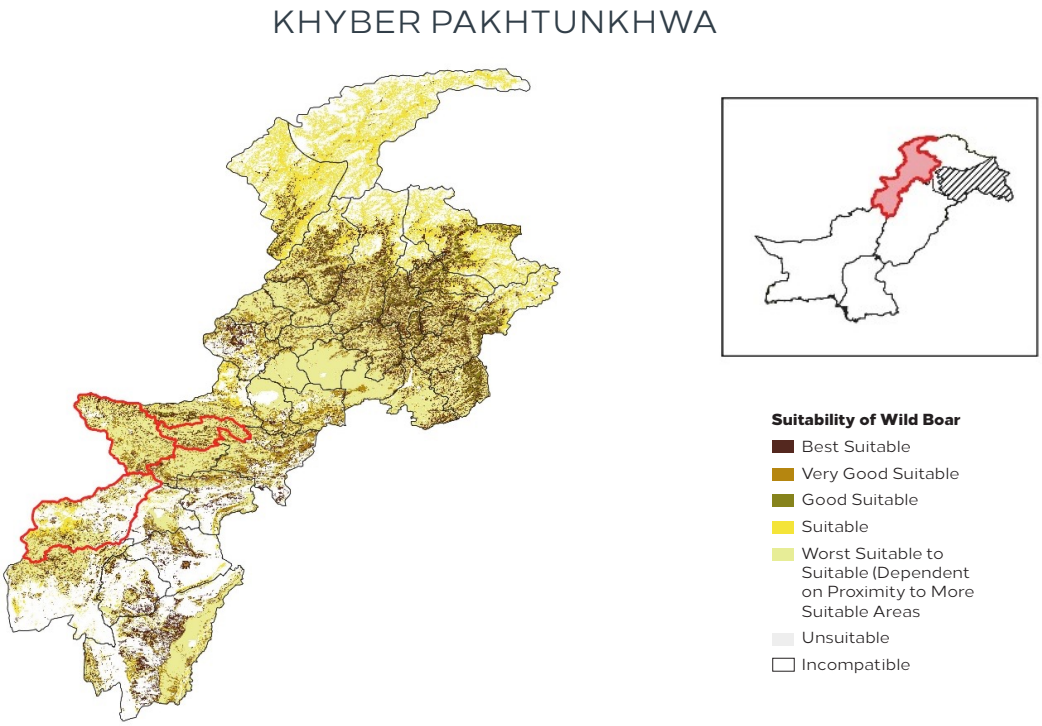


Figure 24: Analysis of suitable habitats for wild boar populations in KP province, Pakistan (author's own analysis). Highlighted districts in red are Kurram, Orakzai, & North Waziristan. Methodology for analysis based on Bosch et al.'s (2016), which categorised GLOBCOVER 2009 land cover data according to suitable habitats for wild boars



April to October, resulting in yield losses estimated at 15-80% during the 2019-2020 growing season (FAO & The Alliance of Bioversity International & CIAT, 2020). Khan and Noureen (2021) research in Haripur district found that farmers reported crop damage events due to wild boards in maize, wheat, and pea. These incidences peak in summer and early autumn, with lessor activity during spring and winter seasons. This period coincides with peak breeding seasons of the wild boar (Virk, 1991). In the most severe cases, farmers have reportedly gave up on farming altogether due to significant economic losses (Saeed, 2020). Aside from damages to crops, wild boar are also carriers of diseases that can be passed on to humans (such as tuberculosis, hepatitis E and influenza A) and livestock (such as swine fever, trichinosis and vesicular stomatitis, and foot-and-mouth disease – FMD).

Control methods for wild boar in Pakistan are mostly conducted by individual or groups of farmers. At landscape scale, the government has only initiated sporadic eradication programmes, due to a lack of funding and research on wild boar populations and control methods. Experts assessed that the wildlife department has not initiated any such program due to lack of coordination between agriculture department, farmers, and the wildlife department. While sport hunting of wild boar is practiced in some areas of Pakistan, such as Punjab, where wild boars are not under the protected species category, these activities do not match the reproductive rate of the animal. In KP province, there is a complaint response mechanism in Wildlife department, when they receive any complaint from community, the department forms a committee, consisting of 2 Govt officials and 2-3 Community representatives, to gather data, make assessments about the damages, plan out the hunting, and ensure public announcements before the hunting activity.

Rural farmers have adopted a range of physical control measures to protect their fields and orchards from wild boars. In a study in Haripur district, researchers found that farmers frequently used catch dogs, along with loud noises, such as cracker blasts, personal loud calls, and drumbeats, to scare away boars. A smaller population of farmers were also found to be using electric wires during night-time, as well as poisonous chemicals. However, non-lethal methods have been found to be only somewhat effective in controlling boar activity. In a survey of effectiveness of control methods of wild boar in Faislabad division, farmers assessed that chemical control methods such as poison baiting was the only highly effective method to kill wild boars, followed by shooting (M. Abbas et al., 2004). The usage of chemical poising, however, is a highly controversial method, as it can kill other species that feed on the bait or contaminated boar carcasses, causing significant ecosystem damage as the poison travels through the food chain.

These control methods can bare significant labour, financial and opportunity costs to farmers. In some cases they may even exceed the potential damage incurred by wild boards. A study in Rajasthan, India, found that annual economic loss to farmers from crop damage due to wild boars is about US$2,500-3,000 from 25 farms. However, the cost of crop protection for each farm ranged between US$200-250 per year, totalling US$5,000-6,250 annually for the 25 farms (Chhangani & Mohnot, 2004).

Aside from the physical control of wild boars, farmers have also been found to use nature-based methods to deter wild boar from entering the field. In some cases, in KP province, experts reported witnessing farmers adopting strategies likewise growing Sun hemp, Okra and Guar as boarder crops for maize and vegetables to protect from Boar entrance (KP experts, 2021). As previous research has found that wild boar damage incidences mostly occur at field edges, the use of multiple rows of fencing crops can protect higher-value crops grown in field. In other cases, farmers have also switched production systems from crops susceptible to wild boar consumption, such as wheat, maize, to less-desirable crops, such as mustard. However, this practice can significantly reduce the income generated by farmers. As one anecdotal report of a farmer in Kashmir suggests, the difference in profit between cultivating mustard and potato can be up to 252 USD per hectare (Saeed, 2020).

Despite these management efforts by farmers, global evidence suggests that these sporadic and un-coordinated efforts may not be able to control the population of wild boars. Eradication efforts often have greatest opportunity for success in areas where boar populations are just beginning to become established.

In poor habitats, it has been found that recreational hunting that remove mostly adults can reduce population sizes (West et al., 2009). However, in areas where there are favorable habitat conditions and abundant food, depopulating boars is extremely difficult and will require a coordinated effort among farmers and government institutions. During periods of abundant food, the breeding between juvenile boars can contribute more to population growth than breeding of adult (Bieber & Ruf, 2005). Under these conditions, even a mortality rate of 90 to 100% of adult females may not cause a population decline, as juvenile female breeding can still sustain the population size (West et al., 2009). As a result, recreational hunting, which normally removes mostly adult pigs, is usually ineffective as a population control method in good habitat (Hanson et al., 2009). Hence, boar management programs need to consider using multiple approaches to ensure sufficient population control. Choquenot et al., (1993) for example, found that an intense trapping program can reduce populations by 80 to 90%. These findings concur with previous studies conducted in Pakistan, where (Hafeez et al., 2007) found that panel of traps have been found to effectively capture wild boars. However, as boars are highly intelligent creatures, some individuals are resistant to trapping. Thus, without effective and coordinated control measures on a large scale, combined with agricultural extension to raise farmer awareness on deterring boars, farmers in KP and Pakistan may be expected to incur more serious agricultural costs due to wild boars in the future.

6.2.2 Supporting policies/initiatives

EXISTING POLICIES (POLICY AREAS – CROP PRODUCTION SUPPORT)	
NATIONAL CLIMATE CHANGE POLICY 2021. Ensure involvement of local communities in conservation of mountain biodiversity; Effect on mountain species due to climate change may be overcome by preventing human– wildlife conflicts	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**

6.2.3 Proposed intervention

The research package is broken down into three components:

1. **Research –** Research on the distribution of wild boars, the factors that are driving them into conflict with farming communities, and the most effective management practices.
2. **Human capital development –** Support awareness raising and capacity to implement effective measures to reduce wild boar attacks.
3. **Institutional support –** Focus on policy reform and service provision to reduce the physical and economic vulnerability of farmers in affected regions.

Component 1 focuses on generating evidence on the distribution of wild boar population, factors driving them into conflict with farming and the most effective management practices. There is an absence of any wide scale study on the boar population in Pakistan and on the economic damage that this species causes. These assessments are essential in development of an appropriate management program for the boar population. In any depopulation program, it is important to conduct ongoing population surveys to assess the success of the program and the degree of population reduction (West et al., 2009). This package will develop wild boar populations distribution maps for KP **[Output 1.1]**. Information from the maps will be validated through field visits to high-risk areas and reporting on the wild boar related economic losses **[Output 1.2]**. The key institutional stakeholders with mandate of crop protection from wildlife are the Agriculture Department, particularly agriculture research and extension units, and the Forestry, Wildlife and Environmental Department. These and additional stakeholders will be engaged to share the evidence gathered on the growing vulnerability of farmers to wild boar attacks **[Output 1.3]**.

Component 2 focuses on enhancing human capital for effectively implementing the wild boar control measures. This includes training on nature-based solutions and cost-effective methods to deter boars from entering fields. The first phase of this component will be the establishment of a series of pilot sites to test the effectiveness of different control measures **[Output 2.1]**. Following that local extension providers will receive training on the most effective methods for their communities and receive support on how best to coordinate their activities **[Output 2.2]**. Finally, a manual will be prepared taking on board the findings from the pilot and recommendations from extension staff, this manual will support extension staff to provide training and awareness raising through Farmer Field Schools (FFS) and can be used directly by farmers **[Output 2.3]**.

Component 3 calls for a focus on policy reform and service provision to reduce the physical and economic vulnerability of farmers in affected regions. Several rounds of multi-stakeholder consultations will be held to determine the most effective strategies informed by the evidence generated on wild boar population and trends **[Output 3.1]**. This will lead to the development of a holistic programme and implementation framework to reduce damage by wild boars agreed upon by the key implementing stakeholders **[Output 3.2]**. At present, there is no institutional support for boar control and farmers have to bear the cost of agricultural damage and control costs. The wild boar control programme development process will also explore the willingness of stakeholders to introduce innovative schemes to control boar populations and reduce damage costs such as expansion of boar trophy hunting programme for tourists, where profits will only be used for non-Muslim populations and the compensation of agricultural damage through wildlife repayment scheme.

6.2.4 Potential Partners

Forest, Environment and Wildlife Department (FEWD) **is the leading provincial department responsible for environment and wildlife in KP.** *FEWD* will be a key stakeholder in the policy reform process and custodian of the wild boar eradication programme and implementation framework. *FEWD* can support research teams in providing field-level data on vulnerable areas, extent of losses and existing practices for wild boar control.

The ***Directorate of Agriculture Extension*** **has a key role in agriculture advisory and dissemination of best practices to farmers.** The department can use the field manual to provide awareness raising and training on wild boar control directly to farmers through the farmer field schools (FFS).

Alliance of Bioversity International & CIAT **can provide research support and technical backstopping to the project partners.** Alliance will use digital technologies to develop wild boar distribution maps for KP and identify trail sites. Alliance will steer the policy engagement process to identify potential strategies for wild boar control and formulate an eradication programme in coordination with key stakeholders. *Alliance* will provide training to extension officers on effective control measures followed by the development of a training manual for the Farmer Field Schools.

WWF-Pakistan **will be the key implementation partner in the project.** *WWF-Pakistan* will validate research findings from Alliance through field visits to at risk sites to assess the physical and economic costs due to wild boar attacks. *WWF-Pakistan* will support FEWD in establishing pilot sites to test the effectiveness of the different control measures. *WWF-Pakistan* will also be a key stakeholder in the policy reform process.

Table 37: Breakdown of intervention components, outcomes, and outputs

COMPONENT	OUTCOMES	OUTPUTS	INSTITUTIONS	INDICATIVE ACTIVITY COST*	TIMELINE
Component 1: Research on the distribution of wild boars, the factors that are driving them into conflict with farming communities, and the most effective management practices.	**Outcome 1:** Evidence for boar population distribution and economic damage to agriculture production. • *Population distribution maps developed* • *Areas for the wild boar control programme identified* • *Evidence shared with stakeholders in 2 number of consultations*	**Output 1.1:** Use digital technologies to develop wild boar population distribution maps	• Alliance	**$80,000**	Year 1-2
		Output 1.2: Conduct field visits to at risk sites to assess the physical and economic costs due to wild boar attacks.	• WWF-Pakistan	**$45,000**	Year 1
		Output 1.3: Engage key stakeholders to share the evidence on wild boar distribution and economic damage	• Alliance	**$10,000**	Year 1
Component 2: Support awareness raising and capacity to implement effective measures to reduce wild boar attacks.	**Outcome 2:** Human capital developed for effective understanding and implementation of control measures • *30 number of extension staff & forest and wildlife officers trained* • *6,000 number of farmers trained* • *400 number of FFS awareness raising sessions delivered*	**Output 2.1:** Establish pilot sites to test the effectiveness of different control methods.	• WWF-Pakistan • Forestry, Environment & Wildlife Department (FEWD)	**$50,000**	Year 2
		Output 2.2: Train extension officials on the most effective control measures	• Alliance • WWF-Pakistan	**$25,000**	Year 1-2
		Output 2.3: Field manual developed for FFS sessions	• Alliance • Directorate of Agriculture Extension	**$15,000**	Year 2
Component 3: Facilitate policy reform and service provision to reduce the physical and economic vulnerability of farmers in affected regions.	**Outcome 3:** Wild boar eradication programme developed in coordination with relevant stakeholders • *2 number of multi-stakeholder consultations held* • *Innovative schemes for wild boar population control proposed to the policy actors* • *A holistic eradication programme for wild boars developed and agreed on by key actors*	**Output 3.1:** Hold multi-stakeholder consultations to discuss potential strategies to control wild boar attacks	• Alliance • WWF-Pakistan	**$15,000**	Year 2
		Output 3.2: Formulate a holistic wild boar eradication programme and implementation framework	• FEWD • Alliance • WWF-Pakistan	**$160,000**	Year 2-4
Total Program Activity Costs				**$400,000**	

Annex

1

Concept notes for investment opportunities Khyber Pakhtunkhwa

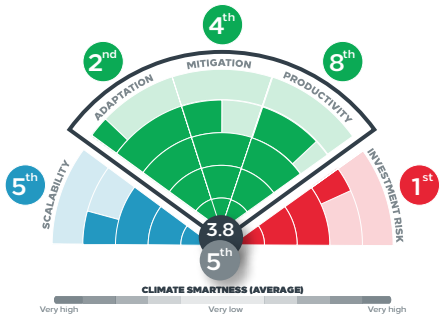
CONCEPT NOTES

- **Package 1:** Providing market development and production support to maize growers
- **Package 3:** Institutional capacity building on Integrated Soil Fertility Management
- **Package 5:** Modernizing Farmer Service Centers to improve extension, input supply, market support and farmer organization
- **Package 6:** Agro-climatic zoning, updating cropping calendars & promoting alternative crops
- **Package 7:** Strengthening input market regulation and private sector engagement in value chain development
- **Package 10:** Strengthen livestock disease surveillance and livestock service delivery in Khyber Pakhtunkhwa
- **Package 11:** Promote cottage-level mushroom cultivation, value chain and market development in NMDs especially among women & youth
- **Package 12:** ICT-based agro-advisory and market information

Note: Package # 2, 4, 8 and 9 are covered in more detail in section 5 and 6 as full investment and research packages

PACKAGE 1:

Providing market development and production support to maize growers



POSSIBLE INTERVENTIONS

- **Human capital development-** Research and extension support on maize cropping calendars, pest management and other CSA practices.
- **Institutional support-** Safety nets for resource poor farmers, index-based insurance, and input subsidies.
- **Market support**- Research and development of high yielding/tolerant varieties, seed sector development, CBSQM, seed multiplication, improved storage and processing capacity, and output market development.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Increases total production and productivity per unit area. • Market support and improvements in value addition increases incomes.	• Planting times better suited to prevailing climatic conditions reduces losses from climate hazards. • Improved varieties are selected for their resilience to localised climatic hazards (drought, cold, blight), reducing losses associated with extreme events. • Crop rotation reduces the risk of total crop failure due to diversification of crops under unfavourable weather conditions.	• Crop rotation protects soil structure and organic carbon reserves. • Leguminous species integration reduces the need of nitrogen-based synthetic fertilizers. • Small improvements in nutrient use efficiency and plant biomass.

NEEDS ASSESSMENT

Maize is a major crop for KP behind sugarcane & wheat, with production concentrated in Swat, Mansehra, Mardan & Buner (GoKP BOS & P&DD, 2021). It holds nutritional and economic importance as food for humans, livestock and poultry and as a major ingredient for bread, corn flakes and corn oil. In the last 3 years, maize production and area cultivated have remained mostly constant (GoKP BOS & P&DD, 2021).

Climate change is projected to negatively impact maize production in the country, with shifting weather patterns altering planting times. Robinson et al. projects that by 2050 yields will be 11.7% lower than the projected 2050 value if climate change had not occurred (Robinson et al., 2015). PIK modelling results indicate a similar projection–a decline of 12.4% in maize yields by 2070 under RCP6.0 (PIK, 2022). However, climate modelling also shows that northern most region in KP will experience increasing yields of maize in 2030, 2050 and 2080 under both RCP 2.6 and RCP 6.0 scenarios as conditions become more favorable for maize production (PIK, 2022). Therefore, this package is intended

to support areas of Northern KP to capitalize on this competitive advantage, scaling the production of maize to meet the domestic demand.

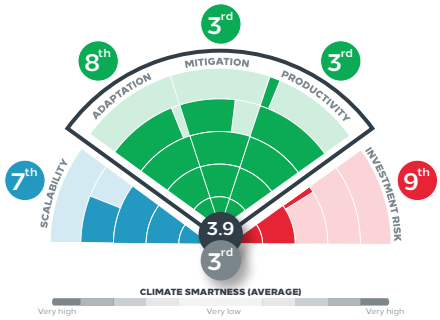
CCRI KP has worked on the development of several hybrid and OPV varieties of maize seed such as Baber, Azam, Iqbal, Pahari and Edhi, however, commercialization of these varieties remains a major challenge. With research department's mandate to produce Breeder Nucleus Stock (BNS) and pre-basic seed, linkages between research department and seed companies can help commercialize and market the improved seed varieties (M. Naseer, personal communication, April 29, 2022). There is a need for innovative models for scaling access to improved seeds especially for resource poor farmers and demonstration of yield and adaptation benefits from new varieties. Resource poor farmers are willing to pay less for hybrid seeds compared to wealthy farmers and the adoption of hybrid seeds is higher among farmers with more human and physical capital (A. Ali, Beshir Issa, et al., 2020). Access to quality inputs and training to maize farmers can be extended using the model farm service model that has shown some promising results and has great potential for further improvement. Furthermore, pest and disease incidence is incurring yield losses as maize is prone to pests such as Helicoverpa, Termites, Aphids, Vertebrate pests and Borers. There is untapped potential for improved marketing potential and value addition along the value chain.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – CROP PRODUCTION SUPPORT; VALUE CHAIN DEVELOPMENT; IMPROVED EXTENSION AND ADVISORY)	
KP AGRICULTURE POLICY 2015-2025. Recommends enhancing production, processing and marketing of key major commodities including Maize. Introduce wide range of innovative products (insurance, leasing, investment loans etc.), combinations of financial service providers (banks, micro finance, community banks etc.) and other services including building vertical linkages in the financial services to achieve profitable and competitive value chain development of major commodities including wheat and maize.	
NATIONAL FOOD SECURITY POLICY 2018: The supply of certified seed in the country is limited to only few major crops like wheat, rice and cotton; whereas, the availability of certified seed is almost non-existing for minor crops like fodder, pulses, and vegetables. Hybrid seed of maize, vegetables, oilseeds and fodders remained on the import list. Moreover, production of rice, maize, cotton, sugarcane, vegetables and fruit remain partially mechanised with constraints such as low local manufacturing, low access of farm machinery to smallholder farmers and slow adoption rate.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: None on Maize. **OTHER GOVERNMENT PROGRAMS:** 1) National Coordinated Maize, Millet, Sorghum Research Program. Pakistan Agriculture Research Council (PARC) working to develop early/medium maturity maize varieties and hybrids for specific climatic conditions – development of low-cost effective production technology for farmers.	

PACKAGE 3:

Institutional capacity building on Integrated Soil Fertility Management



POSSIBLE INTERVENTIONS

- **Institutional development-** Develop a soil management manual adapted to the different agro-ecological zones of KP through capacity development and improved coordination between the soil conservation department, research, and extension; improve the soil testing capacity of soil conservation department for rapid on-farm testing, including into the NMD's.
- **Human capital development-** Provide training to input providers and FSCs; develop updated training modules for farmers on ISFM customized to specific contexts.
- **Technology-** Facilitate the adoption of precision soil management practices such as the use of GIS-based soil services.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• ISFM generates sustainable increases of crop productivity and input use efficiency which ultimately benefit the livelihood of farmers with minimal impact on the environment.	• ISFM enhances soil quality, water retention and soil functions, increasing the system's potential to overcome climate shocks as well as increasing the possibility of farming in degraded soils.	• ISFM reduces the need of synthetic fertilizers, pesticides and fungicides use, thus reducing related GHG emissions during their production and use. ISFM also helps to conserve Soil Organic Matter (SOM) and reduces nitrate leaching.

NEEDS ASSESSMENT

Several man-made and climate change induced factors affect soil fertility crucial for productive agriculture. Intensive cultivation and unsustainable soil management practices harm soil health including over application and unbalanced use of fertilizers that also contribute to GHG emissions. Snow and glacial melting, along with heavy precipitation and flooding events can expedite soil erosion especially in mountainous and sloping areas of KP. Poor soil structure and health reduce the water holding capacity of agriculture systems increasing their vulnerability to rising dry spells and drought.

An assessment carried out with more than 1,500 farmers in KP revealed that soil and water related constraints weighted more than 71% in the constraint matrix for hampering crop productivity (Ahmad et al., 2018). A larger proportion were constrained by water scarcity followed by soil salinity and soil sodicity constraints (Ahmad et al., 2018). Integrated management of soil fertility that combines agronomic practices relating to crops, mineral fertilizers, organic inputs and other amendments has the potential to address weak soil fertility management. These practices can be tailored

for a wide range of cropping systems, soil fertility status and socioeconomic profiles in order to maximize on nutrient use efficiency and improve crop productivity (Roobroeck et al., 2015).

In order to implement practices for integrated soil fertility management, there are capacity challenges at the end of extension workers and farmers to adopt the best strategies suited to their soil fertility status and cropping system. There is a need for rigorous training and capacity building of extension workers, input providers and farmers on best practices for integrated soil fertility management and the use of soil fertility data for decision making

Services for soil fertility testing need to be more widely available through the extension system as well as the private sector. At present, soil and water testing laboratories in KP are inadequate. The map below gives the overview of agriculture extension, soil and water testing facilities in KP. An assessment with farmers in 2018 revealed that only 20% farmers were conducting soil tests while only 8% were doing water tests (Ahmad et al., 2018). The same assessment identified that not a single soil and water testing laboratory of the private sector was functional even in the economically important crop production zones of the province. Outreach linkages with the farmers need to be strengthened for extensive surveys/assessments at the farm level.

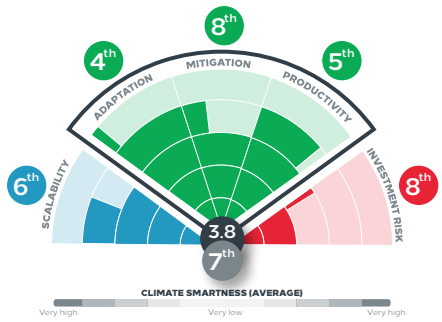
Moreover, technology-driven developments such as the use of geographical information systems for precise mapping and testing of soil indicators have weak adoption in the agriculture sector thus far. Important soil indicators include macronutrients, micronutrients, soil reaction (pH), salinity carbon content, organic matter (OM), soil electrical conductivity (EC), plant available phosphorous (P) and extractable potassium (K). Availability of updated soil maps to identify soil constraints that limit crop yield in the consistently poor performing areas may be helpful.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – IMPROVED EXTENSION AND ADVISORY; AGRICULTURE RESEARCH AND INNOVATION)	
NATIONAL FOOD SECURITY POLICY 2018. Promotion of innovative practices that increase yields and soil fertility (e.g. Precision/Hydroponic Agriculture) for profitable production. Emphasize establishing and strengthening accredited soil fertility laboratories by provinces. Ensure best coordination towards the availability of appropriate fertilizers at affordable prices. Deliver sustainable soil management information to farmers and policy makers.	
NATIONAL CLIMATE CHANGE POLICY 2021. Promote wide-scale adaptation of better management practices with a reduction in the use of chemical fertilizer, water, and pesticides; Explore methods to reduce nitrous oxide release from agricultural soils, E.g., by changing the mix of chemical fertilizers commonly used; Promote use of green manure, better manure storage and management.	
KP AGRICULTURE POLICY 2015-2025. In the case of areas under intensive horticulture, there is a need to progressively move to an input regime that is based on a lower use of chemical fertilizers and pesticides as well as integrated pest management. This would not only conserve biodiversity but also reduce costs and ensure that soil and water resources are not damaged through pollution.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The on-going schemes include: 1) Establishment of Soil and Water Testing Labs in Tribal Districts i.e. Merged Areas ($410,262).	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes include: Soil Fertility Mapping of Khyber Pakhtunkhwa ($1,714,285).
SOIL FERTILITY MAPPING OF KHYBER PAKHTUNKHWA (2021) Under the new project of (Annual development programming of KP) the nature of fertility of agricultural land in Khyber Pakhtunkhwa will be determined. 450,000 land samples will be tested in a year. Farmers will be registered on Android application.	

PACKAGE 5:

Modernizing Farmer Service Centers to improve extension, input supply, market support and farmer organization



POSSIBLE INTERVENTIONS

- **MFSC expansion-** Establish smaller stores closer to communities especially in remote locations; expand MFSCs to newly merged districts; broaden the mandate of other related departments (soil, livestock, research etc.) to also provide training and advisory services to farmers through MFSCs.
- **Digital and ICT support-** Modernize and digitize inventory management to track input use and availability across MFSCs.
- **Farmer Organization-** Promote MFSC as model for farmer organization and run outreach programs to increase membership including women farmers and farmers in remote locations.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Improved training & advisory, & access to better quality inputs can increase productivity and farm incomes.	• Farmers have increased awareness of climate hazards and effective adaptation measures, reducing their vulnerability to climate shocks.	

NEEDS ASSESSMENT

Model Farm Service Centers were introduced in 2008 and constituted under a provincial act in 2014 (amended in 2015) to provide a semi-autonomous extension solution to farmers. The vision was that farmer-elected bodies would run the MFSCs and resources will be pooled by member farmers along with government funding. MFSC in essence was introduced as one-window solution for the farmers to access agricultural inputs, advisory services and market information.

The envisioned role of the MFSC has great potential for benefiting smallholder famers provided some crucial issues are addressed. Evaluation studies in different parts of KP have highlighted MFSCs promising role in agriculture service provision as well as some important challenges. MFSC membership was an important determinant of improved wheat seed technology adoption in some areas of KP (Israr & Khan, 2019). MFSC members from district Swat, DI Khan, Mardan and Abbottabad were found to be more prudent in farm input usage and enjoyed higher yield across a variety of crops compared to non-members (Shah et al., 2021b). Peach growers in Swat district registered with the MFSC for

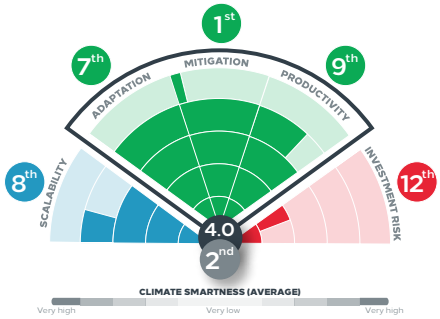
a longer period were doing better in peach production compared to growers who registered later (Zafarullah Khan et al., 2019). In terms of challenges, physical accessibility of the centers by smallholder farmers especially in difficult terrains (such as Chitral) continues to be an issue. There are low financial resources with the MFSC and more power with the government facilitator instead of the farmer-elected bodies (J. Muhammad, personal communication, April 25, 2022; F. Wahab, personal communication, April 23, 2022). The number of staff providing services is also limited due to budget and resource constraints. There are reports of limited farmer participation in the general body meeting and MFSC elections which is crucial to build farmer trust and ownership (M. Z. Khan et al., 2017). The process of sourcing seeds, fertilizers and other inputs is not always effectively managed, creating challenges for members to access them. For example, it was noted that a majority of MFSC members did not procure their seeds from the centers (M. Z. Khan et al., 2017; R. U. Ullah et al., 2016). While MFSCs rented out farm machinery to member farmers, there were problems such as outdated machinery, complicated booking process, costly rental prices and less utilization duration (R. U. Ullah et al., 2016). Moreover, there is potential to diversify the role of MFSC to include mandates such as collective marketing, market information system, cooperative farming and group micro loan lending (M. Wahab, personal communication, April 23, 2022). To expand the coverage of services to farmers, departments other than extension such as research, livestock, and soil conservation can play a positive role in terms of resources and training support to farmers. Efforts to facilitate and encourage farmers' registration in MFSC are also needed if they are to maximize benefit from MFSC services.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – IMPROVED EXTENSION AND ADVISORY)	
KP AGRICULTURE POLICY 2015-2025. The farmer organizations would be getting technical backstopping from the public sector and developing linkages with the private sector for community business initiatives through Model Farm Services Centers (MFSC) while ensuring inclusiveness of the small farmers in the value chain; These MFSCs, which are registered under the Co-operative Societies Act (1925), would facilitate access to markets, services, technology, and credit working in close collaboration with Governmental and non-Governmental organization; MFSCs are to play a greater role in services as well as input supply, farm machinery, marketing and credit from formal institutions with increasing reliance on own savings/revolving funds.	
KP FARM SERVICE CENTER ACT 2014. Act defines the role of MFSC to (a) safeguard farmers rights and interests; (b) enhance farmers knowledge and skills; (c) boost the modernization of agriculture; (d) increase crop yields; (e) improve farmers livelihood; (f) develop rural economy; (g) purchase certified seed, fertilizers, animal husbandry services, quality veterinary health care services and medicines, farm machinery, expertise and technology for the provision to the members who are registered with the center on affordable rates in comparison to open market rates; (h) provide or extend the facility of loan to the members, subject to the availability of fund, from its own resources on such terms and conditions as may be prescribed by Board. (i) facilitate its members to avail the facilities of laboratories established and maintained by Government on such charges as may be prescribed from time to time by Government; and (j) make marketing arrangements for all types of surplus produce at Centers.	
NATIONAL FOOD SECURITY POLICY 2018: Under mechanisation, the policy recommends the establishment of machinery pools as farm-services centers by provinces in private sector.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The on-going schemes include: 1) Strengthening and Capacity Building of Agriculture Extension in FATA/Newly Merged Areas ($1,164,668).	

PACKAGE 6:

Agro-climatic zoning, updating cropping calendars & promoting alternative crops



POSSIBLE INTERVENTIONS

- **Agricultural planning support-** Develop AEZ specific agricultural development plans based on recently updated AEZ's for KP; update cropping calendars for major crops and give recommendations based on the climate-adjusted zoning; identify alternative crops that improve productivity and adaptation to current and projected climate hazards.
- **Capacity development-** Improve the capacity of agriculture & extension officers coupled with greater autonomy to make context specific recommendations based on localized agro-climatic conditions.
- **Promote alternative crops-** Conduct research on suitable growing areas for alternative crops, run field trials, provide training and capacity to farmers, market assessment, demonstrate benefits and link farmers to input providers.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Timely planting and management practices using climatic zoning and cropping calendars can increase productivity and overall yields.	• Following climatic zoning and cropping calendars can reduce uncertainty and risk posed due to changing environmental and climatic patterns.	

NEEDS ASSESSMENT

Climate change is altering the agro-climatic zones of KP, with implications for the cropping patterns that should be promoted in the different zones of the province. In response to these changes, it is recommended that agricultural planning be orientated around the updated AEZ developed by Helvetas Pakistan, the Climate Change Center at the University of Agriculture Peshawar, and the Pakistan Meteorological Department[18]. The zoning divides the province into 5 zones and 9 sub-zones based on temperature, rainfall, topography and altitude (GoKP, n.d.-a). It needs to be further refined to micro-climate level to more effectively support agriculture planning (F. Wahab, personal communication, April 23, 2022). The updated AEZ should be considered when proposing alternative cropping systems that are more productive and resilient to current and projected climatic conditions, and the modification of cropping calendars for optimal planting and harvesting times. For example, apple, cherry, and pear crops need to move higher due to warmer climate in existing areas and require seed varieties for warmer temperatures (M. Naseer, personal communication, August 4, 2021). In lower Chitral, as weather patterns shift, the onion seed crop is increasingly exposed to purple blight, disrupting its production in the region (M. Naseer, personal communication, August 4, 2021).

[18] The research team are aware that this initiative has taken place and have seen some provisional results but have been unable to access a digital copy of the report to verify the robustness of the methodology used for its development. This would need to be reviewed before deciding to base the package on updated AEZ.

Based on the updated agro-ecological conditions in KP there will be opportunities to promote alternative high value crops in the region. Saffron, olives and horticulture, for example, can provide a high economic value option for diversification of agricultural incomes. Encouraging farmers to adopt alternative high value crops would require awareness raising on their financial benefits and suitability to KP's climate and topography. In the case of saffron, some efforts have been made piloting the crop, but it will require additional government and private sector support to be grown on a wider scale. Even if the first step is Saffron promotion at a domestic level, the government can take lessons and best practices from global market players in Saffron such as Iran, India, Spain and Greece that use production & post-harvest technologies and genetic enhancement for high income productivity (Nehvi et al., 2007). Learning from the Afghanistan's experience in saffron promotion, a saffron production promotion policy can include provision of required machinery services, long-term loans, multiple small but easy to access saffron promotion service centres (Azimy et al., 2020).

Moreover, olive cultivation has gained traction for few years with significant potential for further growth. The KP government intends to graft 40 million of the 70 million wild olive trees existing in KP and the Newly Merged Areas in five years (Recorder, 2021). A PSDP funded project (2021-26) will focus on olive plantation across the country including in KP. A primary focus of the KP government is developing the Newly Merged Areas for olive cultivation due to their suitable climate and soil. Alongside plantation drives it is crucially important to develop the olive value chain including processing, storage, packaging, standardization and marketing, in order to increase competitiveness in the international markets.

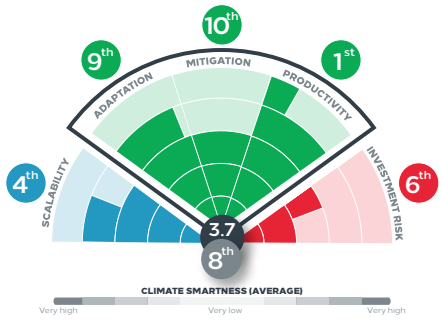
Provision of ICT-based agro-advisory and market information will incentivize farmers to mitigate risks early and capture market benefits. Real-time alerts for weather forecast, crop sowing, harvesting, and other vegetation suitability and pest attacks may be predicted and communicated using observed weather data from each climatic zones and simulation models (J. Muhammad, personal communication, April 25, 2022).

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – AGRICULTURE RESEARCH AND INNOVATION; CROP PRODUCTION SUPPORT; IMPROVED EXTENSION AND ADVISORY)	
KP AGRICULTURE POLICY 2015-2025. Develop production hubs by district and zone based on cropping patterns and seasonal production cycles of select commodities.	
KP CLIMATE CHANGE POLICY 2022. Develop high-quality datasets on crops, soil, and climate-related parameters in order to find optimal cropping patterns for each zone and to support research work on climate change impact assessment and productivity projection studies.	
NATIONAL CLIMATE CHANGE POLICY 2021. Develop appropriate digital simulation models for assessment of climate change impacts on physical, chemical, biological and financial aspects of agricultural production systems in various agro-ecological zones.	
NATIONAL FOOD SECURITY POLICY 2018. Contractual production linkages of alternative crops with private sector food chains and public sector food departments including utility stores and CSDs.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The existing schemes include: 1) Adaptive Research on vegetables and cereal hybrids and OPVs in Tribal Districts/Newly Merged Areas ($96,000); 2) Development and Promotion of Organic Food Products from Argunja (Wild Cherry Plants) and research on Cold Tolerant Rice in District Kurram in Newly Merged Areas ($109,657); 3) Preservation and Promotion of Indigenous Beans, Pulses, Ground Nuts and Medicinal Herbs of Newly Merged Areas and Fruit Fly control in Kurram, North Waziristan and South Waziristan Districts in Newly Merged Areas ($211,428); 4) Promotion of New Fruit Cultivars in FATA/Newly Merged Areas ($159,554).	Agriculture Extension Department along with Agriculture Research and Forestry departments have planned a 4-year project on climate resilience and horticulture with the support of Ministry of Climate Change and National Disaster Risk Management Fund.

PACKAGE 7:

Strengthening input market regulation and private sector engagement in value chain development



POSSIBLE INTERVENTIONS

- **Institutional capacity development-** Build technical capacity of department staff on quality and regulatory checks in the input market; establish a task force or technical group among the existing staff to specifically oversee quality, pricing, and other regulatory checks; advocate to expand the mandate of relevant departments to include input regulation.
- **Private sector engagement-** Work with climate finance and impact investment funds to draw increased investment into Pakistan's agriculture sector. Undertake screening and develop a pipeline of potential private investments across agriculture value chains considering their potential to increase agricultural productivity, adaptive capacity, and/or mitigate GHG emissions.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Access to better quality and timely agricultural inputs can improve yields per hectare and farm incomes.	• Better quality & timely inputs especially for smallholder farmers can increase their resilience to shocks and climate stresses	• Balanced and controlled use of GHG emitting inputs (such as fertilizers) can help reduce carbon emissions

NEEDS ASSESSMENT

Functioning and transparent input markets comprising of a mix of government, private actors, and farmers demand robust regulatory mechanisms and their effective implementation. Regulatory checks are needed on pricing, quality and delivery of inputs in the agriculture market such as seeds, fertilizers, pesticides and machinery and implements. Ensuring transparent and equal information sharing among farmers engaged in input markets and providing timely and quality inputs assured by regulatory and price checks can lead to increased adoption of innovation & technology among farmers and can boost agricultural productivity (A. Ullah et al., 2020).

The provincial extension department has the mandate for quality control and regulation of agricultural inputs (GoKP, n.d.-b). However, monitoring the quality of inputs and ensuring standards are met for the different inputs is a technical and extensive task. Specific experts or task forces within the existing specialized departments are required to conduct more thorough quality control. It can be helpful to broaden the mandates of specialized departments (soil, livestock, seed certification etc.) to include quality assurance of inputs, given that the necessary technical training is provided to the staff. A campaign against adulteration of agriculture inputs, mirroring the example of Punjab, is needed to in KP to ensure better quality and controlled pricing of essential inputs for farmer. The capacity of the extension staff

also needs to be strengthened for effective implementation of regulatory checks. The geographical coverage of input regulating departments needs to be expanded. Moreover, government can work with the private sector, farmers and other stakeholders to establish mutually agreed systems for quality control, inspection and certification in order to incentivize actors to uphold the systems (FAO & GoKP, 2015).

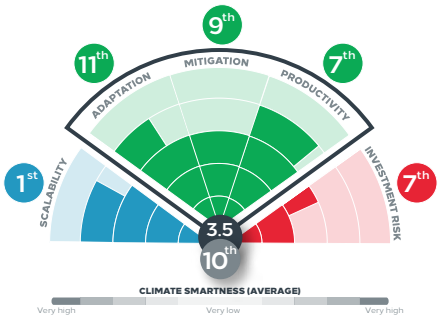
There is great potential for private sector investment to modernize and technologize the agriculture sector. Screening of opportunities for investment across agriculture value chain – credit sourcing, inputs, production, storage, processing, and distribution – based on their potential contribution to productivity, climate change adaptation, and mitigation can help increase private sector engagement. However, private sector stimulation in the agriculture sector should come through in an environment of effective regulation as competitive providers of high-quality goods can build overall trust and transparency in the market. This process should include a consultation with private enterprise to determine the effectiveness of existing policies and programming in KP for supporting increased private sector investment and the formation of public-private partnerships.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – INSTITUTIONAL DEVELOPMENT; VALUE CHAIN DEVELOPMENT)	
KP AGRICULTURE POLICY 2015-2025. Envisages private industry linkages and academia involvement into Model Farms Service Centers (MFSCs) activities. Work with the private sector to establish mutually agreed systems for quality control, inspection, certification. Help the private sector within KP to increase its awareness of opportunities in both national and international markets through study tours, participation in trade fairs and trail shipments. Link new emerging market chains and supermarket stores with the farmers through MFSC with social and legal coverage for investment for contract farming would help the small farm economy of Khyber Pakhtunkhwa.	
KP COMPREHENSIVE DEVELOPMENT STRATEGY 2010-2017. Improve efficiency of agricultural markets and maximize incentives for farmers, with prioritized public private investment in market, processing and storage facilities. Increase commercialization of the sector through the establishment of joint ventures with the private sector and the establishment of milk, meat and egg processing industries through local and foreign investment, and creation of a Livestock Commercialization Board and Network.	
NATIONAL FOOD SECURITY POLICY 2018. Policies relating to pricing and subsidies of agricultural inputs and outputs need more in-depth treatment to ensure competitiveness of agriculture sector at national and international levels. Develop requisite legislative and regulatory support system for development of modern seed industry. Curtail the indiscriminate use of pesticides. Strengthen and restructure Federal Seed Certification and Registration Department (FSC&RD) and pesticide import and registration sections in Department of Plant Protection (DPP). Establish and/or strengthen accredited fertilizers testing laboratories by provinces. Development of a model of value chain financing for major crop and livestock products and investment portfolios for public-private partnerships. Provide incentives for food processing/value addition at farm level through cluster approach under public-private partnership arrangements. Give incentives to invest in infrastructure such as storage and processing facilities, reliable energy supply and transport facilities.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**

PACKAGE 10:

Strengthen livestock disease surveillance and livestock service delivery in Khyber Pakhtunkhwa



POSSIBLE INTERVENTIONS

- **Data & ICT tool development-** Promote livestock disease tracking using data tools and methodologies in coordination with government and research institutes.
- **Capacity development-** Facilitate vaccination & agri-vet programs and vocational courses to boost human capital; raise awareness among farmers for pest and disease management.
- **Institutions-** Improve regulation of agri-vet stores and set targets for disease control in the province.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Disease tracking and improved extension delivery will improve livestock heath and reduce mortality and health costs leading to more livelihoods security and better production.	• Livestock is important for the poorest farmers who are highly vulnerable to extreme weather events and disaster impacts. Better disease monitoring, extension delivery and advisory will improve livestock resilience and farmer preparedness to shocks.	

NEEDS ASSESSMENT

Livestock is a key agricultural sector in the province particularly crucial for poorer and landless farmers. Approximately 20% of the net income of farm households and land-less families is generated from animal husbandry (Shah et al., 2021a). Improvement in disease surveillance and livestock service delivery including during disasters can provide a boost to the livestock sector and improve farmer livelihoods.

The increasing severity and frequency of natural disasters in KP has made livestock and farmer livelihoods more precarious. Flooding increases livestock morbidity and mortality due to depleted fodder and grazing, the destruction of livestock shelters, disease outbreak and difficulty in accessing vets for medical support. Responding to disaster emergencies, especially in remote areas, and addressing the demand for livestock support requires institutional and technical strengthening of the livestock department. Existing training for the vets in not sufficient to meet the demand and scale of livestock services (M. Naseer, personal communication, August 4, 2022). In 2019-20, the province overall

had a capacity of 150 veterinary hospitals, 795 dispensaries and 814 centres for 49 million livestock in the province (GoKP BOS & P&DD, 2021). In the last 3 years, the increase in hospitals and dispensaries has been insignificant and the number of centres has declined (GoKP BOS & P&DD, 2021). Weak regulation of the services provided by the livestock department has created issues with transparency and over charging. A study of livestock activities in Model Farm Services Centers in Swat, Mardan, Abbotabad and Dera Ismail Khan highlighted issues such as lack of participation of farmers in developmental programs, long distance of these Centers, lack of proper facilities and high charges of treatment (Shah et al., 2021b). Availability of fully-equipped mobile clinics and laboratories can improve access to treatment in far-off locations.

Moreover, there has been little progress in disease surveillance at the provincial and district level using data tools and ICT methodologies. Improved disease tracking can help the department proactively respond to medical needs as well as improve vaccination rates in the province. Farming communities also lack awareness on disease management techniques, and the potential risk to human health through zoonotic pathogens (Nieto et al., 2012). Disease tracking can ensure targeted training, knowledge and awareness is given to farmers to address and handle disease cases. The federal government has shown interest in establishing disease information and surveillance system to eradicate the highly prevalent and contagious foot and mouth disease among livestock (Z. Ali, 2020). The surveillance system along with effective action can be instrumental in improving livestock quality and thus, countering the losses and bans on export of meat and dairy to high-end markets.

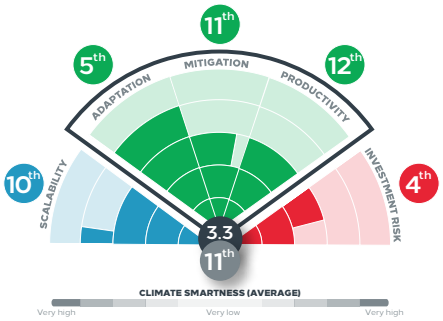
POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – LIVESTOCK AND POULTRY DEVELOPMENT)
KP LIVESTOCK POLICY 2016. Animal health policy of Livestock and Dairy Development (L&DD) Department will be modified and lay greater emphasis on surveillance, control of dangerous pathogens and biosecurity; Establishment of centre of epidemiology unit with the broad spectrum of required skills for restructuring of animal health services; Training of official veterinarians in epidemiology, disease surveillance, investigation and diagnoses, and control as well as re-orientation of animal health services; Improving veterinary-farmer cooperation through extending farmer field schools; Establishment of forum for improving relationships between livestock health services, migratory livestock keepers, traders, and market administration; Develop a system of mobile SMS based digital reporting to increase the timeliness of disease reporting.
KP AGRICULTURE POLICY 2015-2025. Trainings of farmers in livestock management, promotion of best management practices along with improved breeding, awareness of herd health management and supply of veterinary services along with disease monitoring and control in transhumant herds.
KP CLIMATE CHANGE POLICY 2022. Develop and promote biotechnology in terms of improved breeds (less prone to heat stress, and are drought tolerant), and livestock production through genetic engineering. Enhance veterinary extension services, research technology development and training on diversification, fodder conservation, preparation of feed supplements, animal husbandry, and disease prevention.
NATIONAL FOOD SECURITY POLICY 2018. Emphasize diversification of income and nutrition, patronization and certification of potential private livestock breeding farms and their investment in dairy production, promotion of improved breeds, disease control, capacity building of farmers, export of animals and products.
NATIONAL CLIMATE CHANGE POLICY 2021. Promotion of feed conservation technologies and fodder banks in arable areas, disease monitoring and surveillance at district level and local and hybrid breeds.

EXISTING PROGRAMMING	PROPOSED PROGRAMMING
ANNUAL DEVELOPMENT PLANS: There are 67 existing schemes related to livestock and poultry with a total value of $94,432,782. 61 out of the 67 existing schemes are focused in the Newly Merged Areas representing 79% of the total funding. The schemes cover a range of sub-themes within livestock and poultry development sector including veterinary services, infrastructure development for veterinary dispensaries and centres, artificial insemination, mass vaccinations, model dairy farms, breed improvement and capacity building of staff. Following are the existing schemes with the highest funding allocation: 1) Opening of 41 Veterinary Centres, 22 AICs and Upgradation of 01 CVD to CVH Status in South Waziristan ($24,738,800); 2) Integrated livestock development in Newly Merged Areas ($17,822,754); 3) Save the Calf Program in Khyber Pakhtunkhwa - Provincial Share-PM's Agriculture Emergency Program ($7,104,085).	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes include: Genetic Improvement of Non-Descript indigenous cattle through cross breeding with exotic improved cattle breeds in Khyber Pakhtunkhwa ($13,714,285); Community dairy and meat development in Khyber Pakhtunkhwa. ($5,714,285); Feasibility & Establishment of Veterinary University in Khyber Pakhtunkhwa ($5,714,285); Establishment of Civil Veterinary Dispensaries in rented Building in Khyber Pakhtunkhwa ($2,285,714).

PACKAGE 11:

Promote cottage-level mushroom cultivation, value chain and market development in NMDs especially among women & youth



POSSIBLE INTERVENTIONS

- **Capacity development-** Provide skills training and capacity building on mushroom cultivation as well as value chain development to women and youth in newly merged districts.
- **Market development-** Stimulate market linkages connecting local producers with local and provincial markets and overall enhance consumer level awareness and demand.
- **Policy engagement-** Engage provincial policy level stakeholders along with the private sector and research institutions with the aim to garner policy support as well as financial and research support for development of mushroom as a cottage industry in NMDs.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Comparatively low costs and high returns. Great potential for cottage level farming and higher women and youth participation.	• Diversification of agricultural incomes of resource constrained & vulnerable farmers. Mushroom has great nutritional value for consumption by local population.	• Environmentally friendly as they use bio agricultural waste for cultivation.

NEEDS ASSESSMENT

The Newly Merged Districts (previously 13 semi-autonomous districts) became a part of KP in 2018. These are some of the most economically marginalized areas with low human development and food insecurity and have experienced the direct and indirect effects of prolonged regional conflicts. The KP government is working towards integration and uplift of the Newly Merged Areas and opening new economic opportunities in the area.

Mushroom's economic importance lies in its nutritional value as a food source (rich in protein, vitamins, folic acid, iron) & medicinal use. Its cultivation depends minimally on land availability and climatic factors can be reasonably controlled. This makes it a high priority area for off-farm income for resource constrained households in Newly Merged Areas. Women and youth can play a key role in cottage-level mushroom farming that offers good economic returns provided initial support is given in terms of kits and spawns, training and linkages to the market. Agriculture Research Station,

Tarnab Peshawar has a mushroom unit providing facilities for capacity building and spawn production (F. Wahab, personal communication, April 23, 2022). One kg of mushroom production that takes about 35 days can bring an income of USD 49 to USD 59 to the household and a household set-up can conveniently produce 500 kg mushrooms at one time (Associated Press of Pakistan, 2021). This can potentially be a low-cost and high-income substitute to poppy cultivation. Mushroom cultivation can use agricultural straw waste (e.g. wheat, paddy, barley, oat and gram straw, sugarcane and maize leaves) as substrate (medium) for cultivation available at low cost in Pakistan (A. Abbas, 2016).

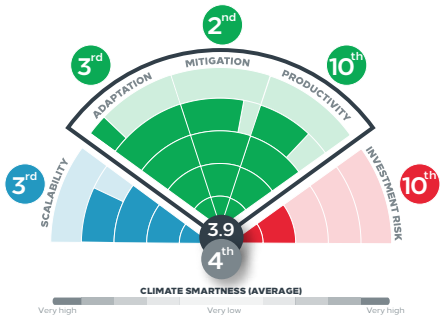
Mushroom cultivation has been given some but insufficient attention by the provincial government, NGOs and development partners. Learnings and conclusions from existing pilot interventions need to be consolidated and built further. At the farmer end, awareness on the economic potential of mushroom and knowledge and training on mushroom cultivation is lacking especially among women and youth. The consumer end lacks awareness about the nutritional and medicinal value that can boost food security. Additional policy level direction at the provincial level is needed to accelerate efforts on this priority area.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – AGRICULTURE RESEARCH AND INNOVATION; VALUE CHAIN DEVELOPMENT)	
NATIONAL FOOD SECURITY POLICY 2018. Emphasize Increasing productivity of major crops for diverting saved natural resources for the production of other high value crops. Provide incentives for food processing/ value addition at farm level through a cluster approach under public private partnership arrangements. Greater emphasis on post-harvest research and technology and consumer awareness especially women and youth on improved techniques for the household level storage.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
	ANNUAL DEVELOPMENT PLANS: The new schemes include: 1) Agriculture Transformation in the Newly Merged Areas ($11,428,571).

PACKAGE 12:

ICT-based agro-advisory and market information



POSSIBLE INTERVENTIONS

- **Participatory ICT development-** Promote the development of ICT tools and services taking into consideration local needs and demands as well as principles of human-centred design; encourage the use of interactive platforms, local languages and context-specific examples and references.
- **Digital literacy and training-** Roll out digital literacy programs among farmers as well as train extension officers to use ICT tools and impart skills to farmers; monitor and evaluate the extent to which provided information & advisory is translated into action.
- **Public private partnerships-** Build and strengthen partnerships with private sector and telecom providers to tap on their networks and services for greater outreach and to incentivise technology development. Consider linking agro-advisories to other bundled services such as credit and insurance.
- **Institutions-** Improve linkages between PDMA and AD on disaster early warning for agro-advisory.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Wider availability of precise information & advisory related to input use, forecasts and market can enable farmers make accurate and appropriate farming decisions leading to advances in productivity.	• Availability of up-to-date and precise information to farmers can help them respond timely to variability in weather conditions and extreme events and mitigate risk to lives and livelihood.	• Up-to-date information and advisory on pest and disease management and fertilizer use can deter over use.

NEEDS ASSESSMENT

ICT tools can be employed to provide agriculture advisory and disaster early warning services directly to farmers to enable timely decision making. They also add value to the existing extension system and can help bridge some of its limitations. Timely forecasting and projections can support the extension workers in delivering advice for implementing effective protection measures. In a research study in KP, wheat farmers indicated that extension services were not able to effectively address farmers' needs to improve their farming methods including strong disagreement on extension agents being able to provide timely suggestions about crop protection measures (Al-Zahrani et al., 2019).

Evaluations of existing ICT-based advisory interventions in KP and other provinces provide useful insights for understanding ICT adoption. Mobile/cell phone based ICT tools are the most effective (N. A. Khan et al., 2019, 2020;

Luqman et al., 2019), with farmers preferring voice-based content compared to the SMS-based information (N. A. Khan et al., 2019). Preference of voice-based content can be attributed to low literacy levels impacting consumption of written messages and the greater availability of voice messages in local languages. Younger farmers, educated farmers and farming families with more educated members have higher adoption of ICTs (N. A. Khan et al., 2019, 2020; Luqman et al., 2019). Infrastructural development for improved connectivity is key to expanding the outreach of ICT-based services particularly in remote areas of KP. Issues with internet connectivity, weak television and radio signals and electricity shortages can disrupt the flow of agriculture information (Aziz & Khan, 2021).

Application of the advisory information received through ICT tools is another issue. Age and education of the respondent has a significant relationship with application of information received through radio and TV (Aldosari et al., 2019). Evaluation of an ICT advisory intervention in Punjab shows that utilization of information for decision-making on crop production is weak while uptake of market information is promising (N. A. Khan et al., 2020).

The extension system has a critical role in promoting the adoption of ICT-based services by farmers. There agriculture extension and disaster management departments can co-develop early warning, market information and agro-advisory systems by building on extension department's existing network of registered users (N. Malik, personal communication, March 29, 2022). Extension system's role involves creating awareness and educating farmers on the use of ICT-based services and identifying barriers to the adoption of ICT tools and application of the information received. Many extension workers maybe ill-equipped to play this role and may not have exposure to modern ICT tools and therefore require necessary in-service trainings and capacity building programs (Aldosari et al., 2019).

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – AGRICULTURE RESEARCH AND INNOVATION)	
KP AGRICULTURE POLICY 2015-2015. Agriculture extension and Livestock department KP to enhance use of ICT in knowledge dissemination through establishment of ICT centre and use of digital video and electric tools.	
KP INTEGRATED DEVELOPMENT STRATEGY 2014-18. Improve extension services to farmers including information and agri-techno support to increase agriculture productivity.	
KP LIVESTOCK POLICY 2018. Establish collaboration of extension department with academia and introduce modern extension techniques.	
KP CLIMATE CHANGE POLICY 2022. Promote extension services, Farmer field schools, linkages with environmental agencies. Share knowledge of local agricultural practices, yields, landholding size, and other relevant information with farmers and departments responsible for social welfare, safety nets and poverty alleviation, to make poor agricultural households more resilient.	
NATIONAL FOOD SECURITY POLICY 2018. Promote the use of ICTs to transfer market information to producers. Facilitate provinces for strengthening the extension services, promoting cropping pattern and climate smart agriculture practices with maximum water productivity.	
NATIONAL CLIMATE CHANGE POLICY 2021. Improve the extension system and enhance use of the media to allow effective and timely communication of climatic predictions and corresponding advice to farming communities	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The existing scheme includes: 1) Database Development through Information & Communication Technology (ICT) in Crop Reporting Service, KP ($1,219,931).	**ANNUAL DEVELOPMENT PLANS:** The new schemes include: 1) Tele-Farming and Digital Services Platform ($20,000,000)

Annex

2

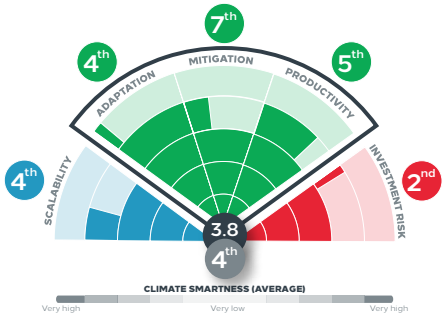
Concept notes for investment opportunities Punjab

CONCEPT NOTES

- **Package 1:** Advancing the seed sector in Punjab
- **Package 2:** Strengthening the integrated management of pests
- **Package 3:** Enhancing wheat resilience
- **Package 4:** Supporting smallholder farmers in mechanisation to improve productivity
- **Package 5:** ICT based early warning, advisory and market information
- **Package 6:** Agriculture financing
- **Package 7:** Shifting water management strategies at farm-level
- **Package 8:** Providing crop diversification and market support
- **Package 9:** Local storage and processing capacity programme

PACKAGE 1:

Advancing the seed sector in Punjab



POSSIBLE INTERVENTIONS

- **Institutional development-** strengthen regulatory capacity and build effective regulations within the seed sector that minimize bureaucratic procedures and incentivize compliance; mainstream the public sector seed corporations through improvements in technical expertise, seed marketing and branding, and increasing competitiveness in the market.
- **Research & development-** incentivize research and innovation in the seed sector through mainstreaming intellectual property protection and strengthening linkages between research and practice.
- **Private sector engagement-** incentivize private sector research and development in the seed sector coupled with legally binding arrangements and regulatory oversight.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Improved varieties increase yields.	• Seed varieties adapted to extreme conditions such as heat stress, drought, floods, and frost along with disease and pest resistant varieties can increase resilience to climate change and its impacts.	

NEEDS ASSESSMENT

The changing climate and extreme climatic conditions including droughts, floods, heat stress and frost as well as disease and pest incidence has amplified the need for improved seed varieties. For example, for wheat in rainfed areas, farmers need early drought tolerant varieties while seed varieties resistant to terminal heat stress are needed across the province (A. Nawaz, personal communication, April 28, 2022). Timely availability of quality seed has the potential to enhance agriculture productivity. Seed is procured either from formal sources including seed companies and public sector organizations (such as Punjab Seed Corporation) or informal sources including farmer-farmer exchange and small-scale seed providers who multiply seed from various sources (Agriculture Department GoP, 2015). The informal seed market is substantial, almost entirely unregulated, and dominated by traditional varieties of mixed quality (Hussain et al., 2017).

The legislative provisions available to guide the seed sector presuppose the presence of infrastructure, strong monitoring and regulatory mechanisms, and trained personnel, all of which are currently not available at the level

required (Yazdani & Ali, 2017). The Federal Seed Certification & Registration Department (FSC&RD), an attached department of Ministry of National Food Security & Research has the mandate of assuring quality of seed through seed certification and the registration of seed varieties. It provides services as and when requested by public & private seed agencies and has a yearly plan for field crop inspection and seed testing. However, the workforce is too limited (27 seed inspectors for the whole country) to effectively exercise this task, with seed production often taking place without regulatory oversight (Rana, 2014). FSC&RD administration is working on improving seed certification services by strengthening their field offices (PES, 2021).

The availability and quality of early generation seed including pre-basic and basic seed is one of the major constraints of the seed sector (I. Afzal, personal communication, April 27, 2022). The role of public sector has considerably diminished in the provision of quality and improved certified seeds. Overall, public sources only provide 5.24 per cent of the total seed available in Pakistan (PES, 2021). The Punjab Seed Corporation is the only public entity supplying certified seed in Punjab. It faces several challenges including a lack of research and development expertise and trained professionals, weak marketing and branding, and stringent internal policies due to compliance to government rules that makes it difficult to compete in the market. On the other hand, private sources constitute 70.4 percent of the total seed availability in the country (GoP Finance Division, 2021). With over 500 seed companies registered in Punjab, the seed sector requires improvements in existing seed certification and registration process, maintenance of seed quality throughout the supply chain and marketing the seed to smallholder farmers (I. Afzal, personal communication, April 27, 2022). However, regulation and oversight in the private seed market is not effective and efficient. The private sector regards the field inspections by FSC&RD as intrusive, time-consuming and unnecessary. By law, seed variety approvals are compulsory but approvals don't ensure intellectual property protection, and bypassing the law does not entail FSC&RD recourse (Rana, 2014). Therefore, private companies have incentive to release the variety directly in the market without FSC&RD's approval. At the moment, certified seed in Pakistan is only 35% (I. Afzal, personal communication, April 27, 2022). Bt cotton is an example of an unapproved variety that is widely promoted by the government and private actors for use across Punjab and Sindh, highlighting the limitations of the formal seed sector (Rana, 2014).

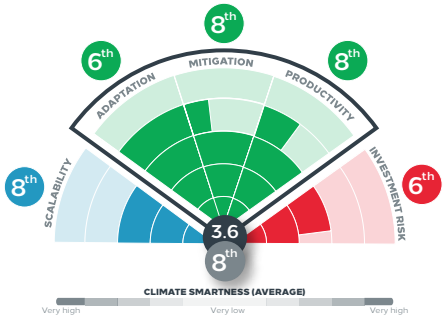
The seed sector requires advanced research, upgradation of seed production and processing facilities and storage infrastructure and improve seed multiplication to farmers. Public and private sector partnerships in research, varietal development, certification and marketing can help to increase productivity and resilience of the seed sector (H.U. Rehman, personal communication, April 27, 2022). The weak implementation of intellectual property rights protection discourages the private sector from innovation, research, and development in the seed sector. There is potential to boost availability of improved seed through public-private partnerships, swift availability of pre-basic seed to well established private seed companies and introduction of legally-binding arrangements between public and private entities (Hussain et al., 2017), in addition to the extension of intellectual property rights protection.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – SEED SECTOR DEVELOPMENT/REFORM)	
PUNJAB AGRICULTURE POLICY 2018. Policy proposes to increase farmer profitability through reducing the cost of inputs including seed, increasing access to quality seed and certified varieties/ nurseries, providing subsidies on oilseeds (Canola & sunflower) and cotton and permit companies either government or private, those have passed regulatory sieve, to sell their seeds under truth in labelling regime. Under the truth in labelling the obligation to maintain seed quality will be shifted to private companies to develop and test varieties and self-report their characteristics on label. Policy recommends that overall regulation of the seed sector remains with the Federal Government (FSC&RD), and the institutional capacities are built for effective nationwide regulations of seed. However, this policy advocates a provincial role in implementation of the regulatory function, such as collection of samples from point of sale, testing of samples, registration of seed dealers, training, etc.	
PUNJAB LIVESTOCK POLICY 2016. Make timely availability of fodder seed and its multiplication in the respective areas, having demonstration plots, the Punjab Seed Corporation can play a pivotal role.	
NATIONAL FOOD SECURITY POLICY 2018. Develop village-based seed enterprises, seed banks and fruit plant nurseries, strengthen research facilities for the development of hybrids of potential crops e.g., vegetables, oil seeds, food grain and fodder crops. Establish Seed Technology Research and Training Institute. Develop requisite legislative and regulatory support system for development of modern seed industry. Strengthen Punjab and Sindh Seed Corporations, and establish Foundation Seed Cells (FSCs) at major research institutes.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: On-going development schemes in the seed development sector include: (1) National Oil Seed Enhancement Program ($17,810,382), (2) Promotion of Fruit Production in Punjab through Provision of Certified Seed 2019-20 to 2022-23 ($2,059,045) & (3) Development of Hybrid and OPVs in Vegetables Resilient to Climate Change 2019-20 to 2021-22 ($1,428,571).	**ANNUAL DEVELOPMENT PLANS:** A number of new schemes are in the pipeline including: 1) Program for Quality Seed Production and Dissemination ($25,434,285); 2) National Crop Genomics and Speed Breeding Center for Agriculture Sustainability ($2,571,428); 3) Establishment of Foundation Seed Cell to Strengthen the Seed Production Facilities at Research Institute of Punjab ($2,285,714). Another two proposed schemes focus on model farms for cotton seed and development of fodder germplasm resistant to biotic and abiotic stresses.
NATIONAL PROGRAMS: National Program for Enhancing Profitability through Productivity Enhancement of Wheat (under Prime Minister Agriculture Emergency Program) under which one component is to promote certified and Treated Wheat Seed of rust tolerant varieties provided to farmers on 50% subsidy (Punjab share: $52,182,320).	

PACKAGE 2:

Strengthening the integrated management of pests



POSSIBLE INTERVENTIONS

- **Research and surveillance-** Strengthen research on the distribution of pests; employ ICT and other tools for crop disease surveillance, early warning, and advisory.
- **Extension capacity development-** Build the outreach and capacity of the extension system to better deliver advisory on pest management practices including pest identification, pesticide preparation & application, health hazards and biosafety; employ electronic media tools to amplify outreach of extension services.
- **Regulatory capacity-** Enhance capacity of departments to improve regulation of pesticide usage and prices; improve coordination between extension department and pest warning and quality control department.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• IPM practices increases crop yields and productivity, nutrient efficiency and reduced expenditure on pesticides. IPM leads to effective and cost-efficient management of crop pests, thereby reducing crop losses and increasing both food security and farmers' incomes.	• IPM represents an ecological alternative for pest control hence reduces crop losses even during moisture stress conditions. IPM decreases negative impacts on the broader ecosystem, making farming systems more resilient to climate change.	• IPM reduces emissions from excess inorganic fertiliser application and increase organic carbon sequestration in soil and biomass. By reducing reliance on synthetic pesticides IPM also reduces GHG emissions.

NEEDS ASSESSMENT

Climate change can create conditions detrimental for crop health and conducive to the spread of pests and diseases, thereby increasing the frequency and severity of these outbreaks. Effective measures for pest management involve a combination of biological, cultural and chemical practices that improve agricultural production and per hectare productivity. The over and unsafe use of insecticides plus poor handling leads to the development of resistance, the outbreak of secondary pests, and hazardous impacts on environment (Bakhtawer & Afsheen, 2021). A study on pesticide use in the cotton belt of Punjab reveals that most of these active ingredients are classified as moderately hazardous (55%) or highly hazardous (23%) according to WHO classification (Khan et al., 2015). High pesticide residues are not only detrimental to health but also threaten export potential (A. Nawaz, personal communication, April 28, 2022).

Export of basmati rice has been threatened due to crossing permissible level of maximum residue level of pesticides (Associated Press of Pakistan, 2021; Butt, 2021).

There is limited knowledge among farmers about biological methods of pest control and poor outreach of training by extension officers (Bakhtawer & Afsheen, 2021). Commercial availability of bio-pesticide and bio-control agents is limited. The balanced use of pesticide is more likely among farmers that are more educated and/or have received better training (Khan & Damalas, 2015a). Farmers face difficulty in preparing required doses and reading and understanding the label instructions that are not local languages (Bakhtawer & Afsheen, 2021; Khan & Damalas, 2015b; Mubushar et al., 2019). They also find it difficult to distinguish between the different species, diseases (except leaf curl), and natural enemies for cotton pests (Khan & Damalas, 2015b).

Moreover, biosafety measures such as use of protective gear, face mask, respirators and proper disposal of pesticide containers are severely lacking (Bakhtawer & Afsheen, 2021; Khan & Damalas, 2014). With a dearth of trainings on pesticide use, biosafety and integrated pest management delivered by extension officers (Aldosari et al., 2019; Bakhtawer & Afsheen, 2021). In the absence of extension system outreach, farmers seek advice from neighboring farmers (Mubushar et al., 2019) reinforcing the need to provide training as it can have a cascading effect. The perception of risk posed by pesticide use to the environment and health is also low (Khan et al., 2015). Awareness raising, training and education can help elevate farmers' risk perceptions about pesticide use and their understanding of integrated pest management (Mehmood et al., 2021; Mubushar et al., 2019).

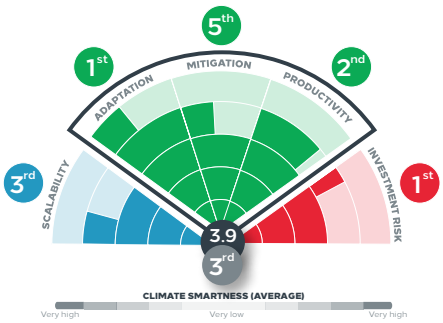
An outdated extension system and weak regulatory oversight in pesticide provision creates barriers to integrated pest management from the side of the government (Khan & Damalas, 2015a). A priority concern is the extent of outreach of the existing extension system and how it can be improved. The use of electronic media (TV, radio, helpline, internet, mobile) for advanced information about agriculture production techniques can be promoted, with a significant relationship found between the age and education of farmer and the application of information received through TV and radio (Aldosari et al., 2019).

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – AGRICULTURE RESEARCH AND INNOVATION)	
PUNJAB CLIMATE CHANGE POLICY 2017. Proposes improved access of poor communities/ farmers to appropriate and integrated pest management practices in order to protect from crop losses and uplift socio-economic condition of agriculture community.	
NATIONAL FOOD SECURITY POLICY 2018. Provide facilitation to institutionalize Farmer Field School (FFS) led Integrated Pest Management (IPM) approach in the research and extension system of Pakistan	
NATIONAL CLIMATE CHANGE POLICY 2021. Promote IPM practices, ensure biological control of forest pests by maintaining viable populations of predatory birds and insects.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
	ANNUAL DEVELOPMENT PLANS: A proposed scheme on integrated pest management focuses on Strengthening of Analytical Capabilities of Pesticide Quality Control Labs in Punjab ($1,021,714)

PACKAGE 3:

Enhancing wheat resilience



POSSIBLE INTERVENTIONS

- **Input enhancement-** Improve access to and quality of inputs to wheat production including drought and heat tolerant seed varieties, pest control tools, fertilizers, on-farm water management technologies and agriculture credit and insurance.
- **Market development-** Improve connectivity of farmers to agricultural market using traditional extension as well as ICT tools to increase direct benefits to growers; enhance capacity on marketing and branding strategies.
- **Technology support-** Incentivize the use of modern technology and machinery appropriate for local conditions through extension support, access to credit and linking to local manufacturers and service providers.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Enhances productivity and links farmers to the market resulting in higher farmer income & profits.	• Drought and heat tolerant seed varieties, climate smart technology adoption & access to agricultural credit helps adapt to the changes in climate and reduce risk posed by extreme events. CSA practices such as crop rotation, intercropping and no or minimum tillage help reduce soil erosion, reduce pests, weeds & diseases	• CA practices in wheat systems can mitigate climate change by increasing carbon sequestration in the soil.

NEEDS ASSESSMENT

Wheat is a staple food that also holds great economic value in Punjab's economy. 75.5 per cent of Pakistan's wheat production comes from Punjab. Based on yield and production data for Punjab from 2013-14 to 2020-21, wheat production has increased by 0.05 and yield by 4.15 per cent (GoPJB CRS, 2021). Changes in climatic conditions and increases in the frequency and severity of extreme events can undermine wheat yield and productivity. By 2050, annual mean temperatures in Punjab are projected to have risen by 2.3-2.5°C above current levels, with precipitation increasing by 4-13% (CIAT & FAO, 2018). A large increase in the number of days with temperatures over 35°C is projected for some districts in the wheat growing (Rabi) season (FAO & Alliance, 2020).

Improving access to quality inputs will be important in enhancing wheat production and productivity in the province, with more productive, climate- and heat-resilient wheat varieties required. 18-22% of all wheat seed sown in Punjab is certified while the rest comes from the informal market (Hussain et al., 2017). There is potential to increase independence and capacity of public sector seed entities, engage private sector in R&D, improve regulatory

mechanisms for seed quality, and make institutional and legislative environment conducive to innovation. Subhani 2021, MH-2021, Dilkash-2021, Bhakkar-20 and MA-2020 are examples of stress-tolerant and disease-resistant wheat varieties released by agriculture research stations and CIMMYT for different production environments in Punjab (Tiwari, 2021; H.U. Rehman, personal communication, April 27, 2022). Fast-track seed multiplication programs are required to improve replacement rates because quality seeds are rarely available at the right time, location, quantity, and price for smallholders. Marketing and training efforts need to be improved for women, who are mostly responsible for household-level seed production and seed care (Tiwari, 2021).

Weed eradication during production and reduced post-harvest losses due to mishandling of wheat in the process of shifting from fields to markets are crucial (Ahmed, 2015). Access to credit on favorable interest rates can have a positive effect on wheat productivity. While short-term loans (from formal credit institutions) show a stronger effect on productivity, maybe owing to higher usage of inputs such as fertilizer and improved seed, longer term loans show higher investments in land preparation, irrigation and plant protection, which may lead to higher wheat production in the future (Chandio et al., 2021). Developing, testing, and implementing effective agricultural insurance mechanisms can enable wheat farmers to minimize the risk associated with climate change, promoting higher levels of investment into improved production methods.

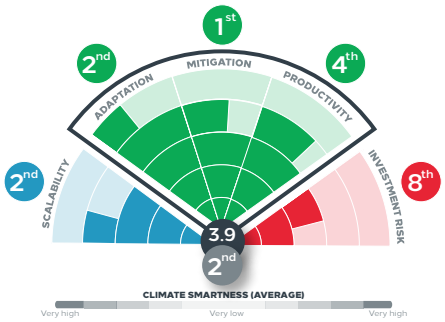
Particularly in the rain-fed regions, early drought is a major problem so breeding should be done for early drought tolerance. There is potential for wheat farmers to adopt the conservation agriculture approach including practices such as no till or minimum tillage, direct seeding, crop rotations, and intercropping. Crop rotation and intercropping, for example, helps reduce presence of weeds, pests and diseases with legumes often recommended as the rotation crop for their nitrogen fixing functions. In Punjab, no-till rice-wheat systems are increasingly being adopted whereby wheat is planted immediately following the rice harvest without tilling the land. Improving local grain storage technologies and their access to smallholder farmers will reduce post-harvest losses.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – CROP PRODUCTION SUPPORT; VALUE CHAIN DEVELOPMENT; SEED SECTOR DEVELOPMENT/REFORMS; DEVELOPING FARM MECHANISATION)	
PUNJAB AGRICULTURE POLICY 2018. Ensure subsidy on wheat procurement.	
PUNJAB CLIMATE CHANGE POLICY 2017. Policy proposes enabling conditions for use of climate resilient and high yielding inputs, and sustainable agricultural practices for major crops like wheat, cotton and sugarcane. It also emphasizes increasing self-reliance on crops & agricultural inputs, and improving food security.	
NATIONAL FOOD SECURITY POLICY 2018. Provision of food subsidy on wheat flour and its transportation to the poor people of far-flung areas. The current procurement policy and support price of wheat should be revisited, and may be phased out gradually. Identify exit strategies that benefit small holders and the most vulnerable.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: The on-going schemes directly linked to enhancing wheat resilience include: 1) National Program for Enhancing Profitability through Increasing Productivity of Wheat ($53,976,640); 2) Establishment of Centres of Excellence for Wheat, Rice, Sugarcane, Maize & Millets ($56,668,800).	
OTHER GOVERNMENT PROGRAMS: Establishment of Food Grain SILOS In Punjab on 19 sites (10 years project) by the Government of Punjab to expand its wheat storage capacity by constructing two (02) million MT Near Farm Wheat Silos of 10,000 MT storage capacity each based on Punjab Food Department guaranteed storage volumes and annual payments of service charges for a period of ten years ($23,600,000).	

PACKAGE 4:

Supporting smallholder farmers in mechanisation to improve productivity



POSSIBLE INTERVENTIONS

- **Research & development-** Provide industrial extension support to local manufacturers; promote development of quality and precision local technologies by encouraging research and piloting in academic and technical institutions; investigate economic and environmental impact of various farm technologies to engage with policy makers and farmers.
- **Credit support-** Improve credit support for resource constrained farmers to incentivise the use of machinery and implements appropriate to local conditions.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Improves crop quality and increases efficiency and timeliness of agriculture processes leading to higher productivity.	• Increases adaptation capacity with the use of technology and practices that build resilience to climate change and reduce natural resource depletion.	• Enhances the efficiency of energy and water use on the farm.

NEEDS ASSESSMENT

Increased levels of farm mechanisation in Pakistan have been observed to have a positive impact on a number of farm operations such as land preparation, planting, watering, spraying, harvesting, and threshing, through increased productivity, reduced crop losses, and improve crop quality. The Pakistan Agriculture Research Council (PARC) has outlined a number of commercial farm machinery/implements with promising potential in terms of yield gains and labour and cost savings (ABEI commercial products). An average increase of 2.181 mounds per acre of wheat was observed as a result of an agriculture mechanisation project in Punjab that promoted the use of subsidized machinery/ implements (rotavator, disc harrow, seed drill & chisel plough) (Ashraf & Khan, 2020). Adoption of raised bed planting in three different cropping zones of Punjab gave yields that were 19.9, 12.1 and 29.9 percent higher in wheat, cotton and rice respectively compared to flat sowing (Allah Bakhsh et al., 2018). Research on the use of combined fertiliser and seed drills for wheat crops found grain yields to be 12% higher than with the use of conventional methods, resulting in a 7% increase in the benefit-cost ratio of production (Kashif Munir et al., 2021).

Individual ownership of farm machinery is not viable in Pakistan due to a majority of smallholder farms. The average farm size in Punjab is 2.26 ha - 90.8 per cent of farms are smaller than 5ha and 41.9 per cent are smaller than 1 ha (Phambra et al., 2020). Pakistan has managed to reach a point where almost 100 per cent of land preparation activities for major crops are mechanised (Tanzeel ur Rehman et al., 2016). Overall, there are around 612,000 operational tractors

in the country amounting to per acre horsepower (HP) of 0.09 against the required power of 1.4 HP per acre (GoP Finance Division, 2021). Table A2.4.1 gives a breakdown of major types and quantity of machinery employed by farmers in Punjab.

Table A2.4.1: Major types and quantity of machinery in Punjab (GoP BOS & P&D, 2020)

MACHINERY TYPE	NUMBERS (2018-19)
Threshers	145,304
Self-propelled combined harvesters	7,503
Tractor drawn combine harvester	921
Tractor mounted reapers/harvester	43,980
Cutter binders	4,550
Sprayers (all kinds)	743,112
Drills (all kinds)	135,701
Other implements	811,683

Higher rates of mechanisation have the potential to increase the efficiency of on farm processes and support the adoption of improved management practices such as laser land levelling and zero till. Evidence shows that resource rich farmers are more likely to take up mechanisation on their farms. For example, Akram et al. finds that in Punjab, farm machinery ownership is positively correlated with capital assets, civil infrastructure, alternative sources of power, and credit facility (Akram et al., 2020). Research results from Southern Punjab show that large farm size, access to credit and off-farm income positively affects farm mechanisation (Determinants of Farm Mechanisation among Arable Farmers in South Punjab, Pakistan, 2019). The same study also reveals that land owners are comparatively richer in terms of farm mechanisation than tenants. Therefore, concrete steps need to be taken to improve the access of tenant and resource constrained farmers to farm mechanisation, through schemes that promote a competitive market for agricultural service providers. Some countries have promoted models for mechanisation service provision to scale up smallholder use of farm machinery through low-cost rental or service providers and hiring arrangements that reduce individual farmer's cost of purchasing, owning, and maintaining machines.

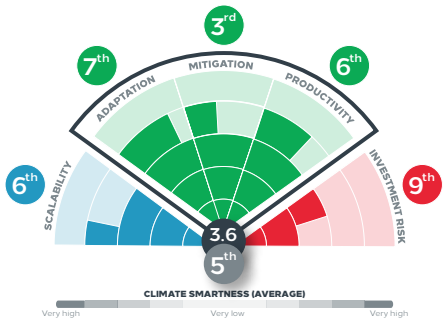
To improve smallholder access to farm machinery it is critical to strengthen the local manufacturing of machine and farm implements. Often these lack standardization and quality in terms of use of correct material and ensuring inter-changeability of components for easy repair/maintenance (Iqbal et al., 2015). This is due to resource issues as well as poor design, low technical skills and weak enforcement and oversight. Mechanisation support entails strengthening of R&D and enabling an environment for the local manufacturing of low-cost, good quality, and standardized and precise machinery and implements. Providing industrial extension service to local manufacturers can better equip them to compete in the market and meet local demand. On the farmers' side, establishment of service centers under the guidance of manufacturers for the repair and overhaul of machines and availability of spare parts can help them efficiently use equipment.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – DEVELOPING FARM MECHANISATION; AGRICULTURAL RESEARCH AND INNOVATION)	
PUNJAB AGRICULTURE POLICY 2018. The policy aims to strengthen Agriculture Mechanisation Research Institute (AMRI) to play a constructive role in R&D of mechanisation technologies by being responsive to market demands and development needs of the agriculture sector. The policy recommends significantly increasing the institutional capacities at AMRI and supporting it with an increase in spending for R&D on farm mechanisation. A private sector-led governance structure with strong monitoring and impact- based performance management of AMRI is recommended to ensure value for money. The bank loans through eCredits scheme can be offered on purchase of farm implements to the registered mechanisation service providers, with special consideration for rural youth. The demand for mechanisation service can be promoted by offering direct-to-farmers subsidy on rental charges through Kissan Card.	
NATIONAL FOOD SECURITY POLICY 2018. Reducing duties and taxes on import of farm machinery in short to medium term, developing efficient farm mechanisation and processing technologies to reduce cost of production, enhancing timeliness of operations, adding value to crops and reducing post-harvest losses at farm level. Promoting aquaculture mechanisation for intensive production, processing and maintaining cold chain, incentivizing industry for manufacturing quality farm machines and indigenisation of economically viable farm mechanisation.	
NATIONAL CLIMATE CHANGE POLICY 2021. Promote energy efficient farm mechanisation to increase yields and labor saving.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: Existing schemes on developing farm mechanisation include: 1) Horizontal Land Development in South Punjab - 2019-20 to 2021-22 ($11,428,571); 2) Strengthening of Well Drilling Services Through Procurement of Power Drilling Rigs -2019-20 to 2021-22 ($3,428,571); 3) Strengthening of AMRI Research and Development capabilities in collaboration with UAF for Fabrication of cost effective and efficient small agriculture implements for small farmers - 2019-20 to 2022-23 ($2,644,320); 4) Mechanized Management of Rice Crop Residue - 2019-20 to 2021-22 ($1,594,285)	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes on farm mechanisation include: 1) Promotion of Mechanized Agriculture for Increasing Crop Productivity ($160,000,000); 2) Rehabilitation of Old Bulldozers for Sustainable Land Development Work to Ensure Food Security ($6,857,412).
INTERNATIONAL FUNDING: China-Pakistan Economic Corridor (CPEC) (2017-2030) Strengthen technical exchange and cooperation in the mechanisation demonstration and ICT-enabled agriculture.	

PACKAGE 5:

ICT based early warning, advisory and market information



POSSIBLE INTERVENTIONS

- **Participatory ICT development-** Promote the development of ICT tools and services taking into consideration local needs and demands as well as principles of human-centred design. Encourage the use of interactive platforms, local languages and context-specific examples and references.
- **Digital literacy and training-** Roll out digital literacy programs among farmers. Train extension officers to use ICT tools and impart skills to farmers. Monitor and evaluate the extent to which provided information & advisory is translated into action.
- **Public private partnerships-** Build and strengthen partnerships with private sector and telecom providers to tap on their networks and services for greater outreach. Bundle agro-advisories with other services such as insurance and credit products.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Wider availability of precise information & advisory related to input use, forecasts and market can enable farmers make accurate and appropriate farming decisions leading to advances in productivity.	• Availability of up-to-date and precise information to farmers can help them respond timely to variability in weather conditions and extreme events and mitigate risk to lives and livelihood.	• Up-to-date information and advisory on pest and disease management and fertilizer use can deter over use.

NEEDS ASSESSMENT

ICT-based tools are being used by the public and private sector for their potential to support agricultural decision making, improve market access and empower the farming communities. The Connected Agricultural Platform Punjab (CAPP) application by the provincial government, Telenor and PITB provides an interface between farmers and agricultural experts, real-time weather data, best practice & instructional videos as well as a platform to apply for agri-loans. The Agriculture Marketing Information System provides a portal for sharing local and international commodity prices, quantity arrivals reports, crop and import/export data and other information (Agriculture Department, n.d.). Farmers and agriculture actors can benefit from a similar portal for livestock sector hosted by the livestock department of any private entity (K. Mushtaq, personal communication, April 26, 2022).

Evaluations of different ICT-based services and their utilization by farmers provides useful insights. Mobile/cell phone based ICT tools are the most effective (Khan et al., 2019, 2020; Luqman et al., 2019), with farmers preferring voice-

based content compared to the SMS-based information (Khan et al., 2019). Preference of voice-based content can be attributed to low literacy levels impacting consumption of written messages and the greater availability of voice messages in local languages. Younger farmers, educated farmers and farming families with more educated members have higher adoption of ICTs (Khan et al., 2019, 2020; Luqman et al., 2019). Digital literacy and training programs and access to ICT tools are key entry points in enabling the use of technology in farming. Telecom and private sector farmer advisory services play a key role with significant partnership potential for the government (Khan et al., 2019).

There are gaps in access to information and taking practical action based on that information. The information utilization gap is lowest in market updates and highest in weather forecasts, which is in line with the farmers' perceived effectiveness ranking, highest for reduced transportation cost and lowest for avoiding potential crop damages (Khan et al., 2020). These results reveal a gap in practical action especially pertaining to decision-making around crop production. This gap can be addressed if the advisory information is precise and site/area specific made available through utilizing modelling, machine learning and remote sensing technologies (A. Wakeel, personal communication, April 25, 2022).

The development process of ICT tools and services is not always centred around the needs of the farmers on the ground with location-specific information and has the tendency to sideline the needs of smallholders, women, and youth (Bell & Shahbaz, 2016). There are also credibility, reliability & relevancy issues with the information being provided and sometimes credibility issue with the delivery agent (Bell & Shahbaz, 2016). In addition to providing an interface with the farmers, ICT offers the opportunity to strengthen information intermediaries i.e. enhance coordination between service providers as well as build capacity of service providers and extension workers (Bell & Shahbaz, 2016).

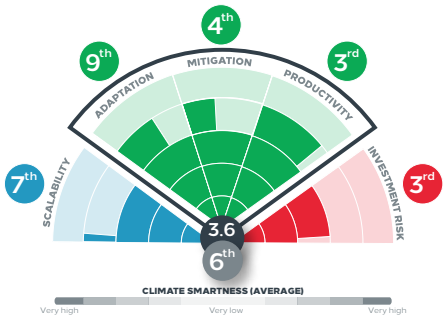
POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – AGRICULTURE RESEARCH AND INNOVATION; DISASTER PREPAREDNESS; IMPROVED EXTENSION AND ADVISORY)
PUNJAB CLIMATE CHANGE POLICY 2017. Policy recommends the mitigation measures including preparation of an integrated natural hazard zoning map of the province, including layers of physical, biological, social, and demographic vulnerabilities, develop strategies for disaster risk management (including evacuation plans, local flood forecasting & early warning system, drought monitoring, strengthening and enhancement of barrages capacity, retarding basins and providing escape channels etc.)
PUNJAB AGRICULTURE POLICY 2018. The policy proposes improved availability of information and advisory services to farmers so they can adopt good agriculture practices.
PUNJAB LIVESTOCK POLICY 2015-16. Policy recommends the ICT intervention of L&DD will provide real time bulk data for major interventions for the livestock sector. The L&DD will develop analysis tools for the interpretation of the data. The Government will provide this data to research institutions as well. L&DD will build standing capacity and capability to conduct a survey/ census of the livestock in the province through the use of its ICT based platform.
NATIONAL FOOD SECURITY POLICY 2018. Promoting the use of ICTs to transfer market information to producers. Facilitate provinces for strengthening the extension services, promoting cropping pattern and climate smart agriculture practices with maximum water productivity.
NATIONAL CLIMATE CHANGE POLICY 2021. Improve the extension system and enhance use of the media to allow effective and timely communication of climatic predictions and corresponding advice to farming communities.

EXISTING PROGRAMMING	PROPOSED PROGRAMMING
ANNUAL DEVELOPMENT PLANS: The development schemes relevant to ICT based early warning, advisory and market information include: 1) Extension Service 2.0 farmer facilitation through modernized extension - 2015-16 to 2021-22 ($23,455,651)	
INTERNATIONAL PROGRAMS: China-Pakistan Economic Corridor (CPEC) (2017-2030) has committed support to strengthening technical exchange and cooperation on ICT-enabled agriculture.	

PACKAGE 6:

Agriculture financing



POSSIBLE INTERVENTIONS

- **Private sector engagement-** Work with climate finance and impact investment funds to draw increased investment into Pakistan's agriculture sector.
- **Investment screening-** Conduct screening and pipeline development of potential private investments considering their potential to increase agricultural productivity, adaptive capacity, and/or mitigate GHG emissions. Conduct due diligence on promising investments linking to investment KPI's.
- **Training & awareness-** Provide technical assistance to investees, lowering investment risks through the inclusion of adaptive measures.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Increased levels of targeted investment into Punjab's agriculture sector will increase the adoption of productive and climate-smart practices, and reduce losses and inefficiencies across the value chain.	• Evidence driven investments into climate resilient practices and technologies will reduce climate related losses.	• Impact investing funds that target GHG mitigation KPI's can support greater levels of investment into mitigation measures.

NEEDS ASSESSMENT

Finance is required by farmers and other value chain actors to improve the productivity and climate resilience of Punjab's agriculture sector. The adaptation and mitigation co-benefits of CSA creates an opportunity for climate finance and impact investors to make sound investments which contribute to their KPI's/ESG's. There is however, a lack of information and data on the types of investments they should be targeting and the likely impacts they will have. This package supports investments targeted towards value chain actors or farmers' organizations that increase the availability of climate-smart inputs and services, or increase the credit available to farmers to invest in improved management practices. Investing along the agriculture value chain, both downstream and upstream, generates employment, boosts economic growth and advances food security.

Climate change leads to an increase in incidence of extreme events and diseases and uncertainty in agricultural processes, making farmers more vulnerable. Access to credit for smallholder farmers becomes essential to invest in inputs, mitigate risk and increase productivity. Credit demand by farmers is determined by a mix of environment and socioeconomic factors including education, income, farm size, dependent children, input price risk, flood risk, disease risk and borrowed amount (Rizwan et al., 2019). Agricultural credit had a favorable impact on productivity of wheat crop in district Sargodha but the study found a small credit coefficient as only 30% of credit was used for agricultural inputs compared to 70% used for other reasons (Shabir et al., 2020). Rice farmers in Punjab did not completely invest the

acquired agricultural credit amount in the agricultural sector: 64.8% was invested in the agricultural sector, while 25.5% and 9.7% of the credit was used to manage their livelihood and business activities, respectively (Rizwan et al., 2019).

Financing options for farmers are available from formal and informal sources. Financial institutions like Zarai Taraqiati Bank Limited (ZTBL), commercial banks, and co-operation companies are the largest formal source of loans (Shabir et al., 2020). State Bank of Pakistan's regulatory framework has encouraged commercial banks to launch production and development loans and innovative financing schemes for value chain development, contract farming and most recently electronic ware-house receipt (K. Mushtaq, personal communication, April 26, 2022). For example, Habib Bank Limited (HBL) has a diversified portfolio of rural banking products for farmers *(HBL | Business | Rural Banking, n.d.)*. Mechanisms for farmer feedback, assessment of loan effectiveness and regulatory checks on loan disbursement should be encouraged.

Due to resource constraints and lack of land ownership smallholder farmers are unable to provide collateral for formal loans. The middlemen (also called *Artees*) have long responded to agricultural and personal financial needs of farmers, passing on the system from one generation to the next, often placing farmers in perpetual debt. An informal crop-livestock integrated system is also practiced where by farmers sell livestock to buy crop inputs and sell crop output to buy livestock (K. Mushtaq, personal communication, April 26, 2022). There are also some formal sources based on group lending approach are available such as the State Bank's financing scheme for smallholder farmers. The scheme aims to support small agriculture related activities like livestock, dairy, poultry, fisheries and horticulture. Moreover, the Punjab Agriculture Department started the interest free e-credit scheme for farmers having landholding up to 2.5 acres of land and tenants/sharecroppers of up to 5 acres in selected districts of Punjab *(E-Kissan | Empowerment of Kissan through Digital & Financial Inclusion, n.d.)*. The e-credit option makes the loaning process shorter and less cumbersome while also increasing the outreach of formal and digital financial services. Sources of informal loans are family and friends as well as middlemen/agents.

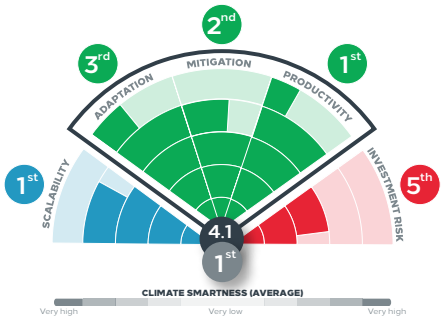
POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – FARMER-ORIENTED FINANCE)
PUNJAB AGRICULTURE POLICY 2018. Improved availability of bank loans to farmers through ICT-based systems development. Proposal for an innovative agriculture (warehouse receipt) financing system where farmers' produce will be accepted as collateral for formal financing by banks and shall be regulated by the Government through collateral management company regulations
PUNJAB LIVESTOCK POLICY 2015-16. Encourage the lending institutions, business entities, NGOs, individuals and higher education institutes to research and design such financial products that could compete with the middleman in the market to provide 73% un-banked population access to the banking market.
NATIONAL FOOD SECURITY POLICY 2018. Assessment of regions specific innovative financial products for strengthening rural businesses, extending outreach of credit among the participating communities on the recommendation of NARS, development of a model of value chain financing on major crop livestock products. Promotion of low-cost microfinance among rural populations through one window operation.
NATIONAL CLIMATE CHANGE POLICY 2021. Ensure an enabling financial environment for farmers to invest in and adopt the relevant technologies to overcome climate related stresses. Ensure the access and effective use of opportunities available internationally for adaptation and mitigation efforts, e.g. through the Green Climate Fund (GCF), Clean Development Mechanism (CDM), Adaptation Fund (AF), Global Environmental Facility (GEF), World Bank's Forest Carbon Partnership Facility (FCPF) and Carbon credit trading. Establish a "Pakistan Climate Change Fund" for financing climate change related projects.

EXISTING PROGRAMMING	PROPOSED PROGRAMMING
OTHER GOVERNMENT PROGRAMS: 1) Empowerment of Kissan through Financial and Digital Inclusion (E-Credit) 2016 -2021 funded by Government of Punjab provides interest free loans to small farmers (up to 12.5 acres are eligible but interest subsidy will be provided up to 5 acres only) are being provided to small farmers though two Commercial Banks - ZTBL and –NBP - and three Micro Finance Institutions (MFIs) - Telenor Micro Finance Bank, NRSP and Akhuwat Islamic Microfinance; 2) Punjab Fasal Bema Program 2019-2022 funded by Government of Punjab ensures crop yield loss protection of the farmers of 27 districts of Punjab during Kharif 2021 & Rabi 2022 seasons covering Cotton, Rice, Wheat, Canola & Sunflower Crops.	

PACKAGE 7:

Shifting water management strategies at farm-level



POSSIBLE INTERVENTIONS

- **Training and research-** Strengthen farmer's knowledge on effects of climate change and the evolving water needs and provide training on effective water management and climate smart practices; promote research on specific water management practices to analyse their economic, social, and environmental benefits/costs such as the use of HEIS, altering cropping patterns, water user association participation; conduct test trials and pilot projects to demonstrate to farmers the benefits.
- **Enabling policy environment-** Advocate for policies that support the adoption of climate smart, water management practices among the less educated & trained smallholder farmers and in particularly women farmers.
- **Local water governance capacity-** Develop and strengthen water user associations for water distribution, maintenance of water courses, and for regulating water use.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• More efficient water management practices and technology will increase yields and improve water and crop productivity.	• Improved adaptive capacity to counter impacts of high irrigation losses, drought, heavy rain, flooding and soil erosion.	• Use of renewable energy in irrigation systems such as solar power HEIS will reduce carbon emissions.

NEEDS ASSESSMENT

Punjab is experiencing periods of heavy rains and flooding as well as droughts. Unsustainable land management, deforestation, and high intensity rainfall have accelerated soil erosion. Some areas are expected to be more water scarce compared to others. Irrigation efficiency is weak and losses are high. Climate change is predicted to increase the irrigation requirements by 7%–11% in the region due to fluctuations in temperature and rainfall (Awan et al., 2016). Drought impacts are also affecting yields and expected to further stress the irrigation system. Maize yield variability between 2001-2020, for example, has been impacted by meteorological drought, particularly short-term drought (1-3 months) at the critical growth stage in South and Central Punjab (Waseem et al., 2021). In this context, appropriate water management practices for improving conservation and efficiency need to be adopted.

The pricing system for agricultural water consumption is not efficient - it costs more to collect water-charges from farmers compared to the water-charges received - delaying the maintenance of the irrigation systems which exacerbates water losses (Afzal, 2021). Inefficient on-farm irrigation practices and poor maintenance lead to unnecessary losses.

High efficiency irrigation systems (HEIS) including sprinkler and drip irrigation have been promoted in different parts of Punjab. HEIS has potential of higher gross margins and high water productivity among adopters compared to non-adopters but adoption is higher among large farmers (Razzaq et al., 2018). Another demographic profile more likely to adopt HEIS are young farmers with higher education levels (M. A. A. Khan et al., 2021). Therefore, policy needs to be directed at improving adoption among small farmers, providing better access to credit, increasing knowledge and education on HEIS and pushing for crop & location specific irrigation solutions.

Changes in cropping pattern can be beneficial to water and soil conservation. Punjab's key crops including sugarcane, cotton, and rice are highly water intensive. Research shows that average water consumption reduces by up to 35% through optimizing cropping patterns of the existing crops (moving from more to less water intensive crops) with the current irrigation settings and even by up to 50% through the combined implementation of optimal cropping patterns and improved irrigation technologies (Muzammil et al., 2020). Other climate smart practices for water and soil conservation include raised bed planting, ridge sowing, seasonally adopted planting times, rainwater harvesting, integrated soil fertility management and crop rotation. There is a need to better understand the economic impact of these water-saving and climate-smart strategies and engage with policy makers and farmers.

Theoretically, the role of the watercourse-level institutions is significant for effective on-farm water management and water distribution. Improving the management of surface water through functioning watercourse-level institutions can increase use efficiency across water, energy and land resources (Mekonnen et al., 2015). Absence of water user associations can disrupt effective water distribution in the region (Afzal, 2021). On the contrary, formalization of water-user association model in Punjab has revealed gaps and increased disputes among farmers (Stakeholder workshop, personal communication, March 30, 2022).

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – DEVELOPING FARM MECHANISATION; AGRICULTURAL RESEARCH AND INNOVATION)
PUNJAB AGRICULTURE POLICY 2018. Policy underlines the significance of effective water management, both for surface and underground water, shifts from flood agriculture to water efficient technologies, encouraging rain harvesting and water storage, discouraging water intensive crops and improving water pricing mechanisms, which should all lead towards the sustainable management of water.
PUNJAB CLIMATE CHANGE POLICY 2017. Improve water-use practices in agriculture. Enhance water efficiency and productivity, incentivize use of efficient devices, incentivize & expand drip irrigation technology deployment, deploy rain water harvesting systems, rehabilitate irrigation infrastructure, remove sedimentation, construct breeches, and upgrade the distribution system. Prepare a comprehensive inventory of all water resources, including surface and groundwater. Develop and implement water conservation and water demand management strategy including financial incentives and fiscal instruments to promote water use efficiency especially in agriculture and industry sectors. Make centralized provincial water policy for the next 5 years which takes into account variation in water availability and quality due to climate change impacts

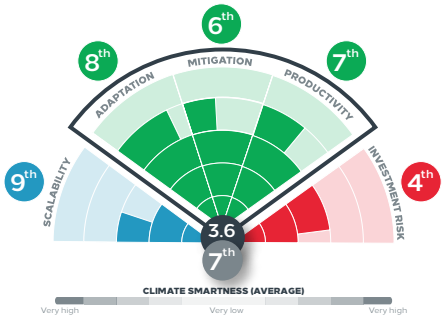
NATIONAL FOOD SECURITY POLICY 2018. Emphasize actions to promote water management by promoting efficient use through applying alternate sources of energy, promoting sustainable solar based pumping systems in shallow water areas like riverine areas, mini dams, ponds, rivers and dug-wells, invest in the construction of small and mini dams, water ponds, on farm storage in Rod-Kohi and water harvesting in rain-fed areas. Support replication of successful water conservation technologies/models by the provinces. Develop and enforce required legislative and regulatory framework to protect groundwater resources through provincial governments, protect groundwater through management and technical measures like artificial recharge for threatened aquifers through provincial governments. Promote efficient utilization of land and water resources by adopting appropriate techniques and measures like high efficiency irrigation systems, laser land leveling and watercourse improvement. Develop a knowledge sharing network with regions and other countries to improve water availability. Promote efficient water distribution according to needs through using remote sensing technology. Promote sustainable intensification of crop and livestock systems, while conserving water resources and averting degradation of natural resources including arable lands, forest, pastures and rangelands. Promote treatment of waste water and its use in agriculture. Promote integrated watershed management for livelihood improvement in mountainous areas. Take measures for flood water utilization in agriculture sector and strategic measures for the control of land degradation (soil erosion, water logging and salinity).

NATIONAL CLIMATE CHANGE POLICY 2021. Assess and address the needs for additional water storage and distribution infrastructure. Ensure early rehabilitation, remodeling and upgrading of the existing irrigation infrastructure in the country to make it resilient to climate change related extreme events. Identify new potential dam sites to keep the option open to develop new dams, should they be needed. Protect groundwater through management and technical measures such as regulatory frameworks, water licensing, slow action dams, artificial recharge especially for threatened aquifers, and adoption of integrated water resource management concepts.

EXISTING PROGRAMMING	PROPOSED PROGRAMMING
ANNUAL DEVELOPMENT PLANS: Development schemes related water management at farm level include: 1) The World Bank assisted Punjab irrigated agriculture productivity improvement project (PIPIP) ($238,502,571); 2) National program for improvement of watercourses in Pakistan Phase-II - 2019-20 to 2023-24 ($104,760,308); 3) Promotion of High value Agriculture through Solarization of Drip & sprinkler Irrigation Systems ($11,020,451); 4) Pilot testing of Innovative Technologies to improve water use efficiency ($5,028).	**ANNUAL DEVELOPMENT PLANS:** Proposed schemes include: 1) Command Area Development (CAD) Component of Greater Thal Canal (GTC) Project Phase-II in Bhakkar,Khushab,Layyah ($97,646,800); 2) Transforming the Indus basin with climate resilient agriculture and climate-smart water management supported by FAO in Dera Ghazi Khan, Khanewal, Lodhran, Multan & Muzaffargarh ($7,285,714); 3) Agricultural Tubewell Pumping Efficiency Improvement Programme – Pilot Project ($1,714,285); 4) Development of Groundwater Resources with 3d-ERM & Geo-Logging Technology ($1,714,285).
INTERNATIONAL FUNDING: 1) World Bank supported Command Area Development of Jalalpur Irrigation Project (CAD-JIP) - 2019-2023 for Khushab and Jhelum helps to develop the culturable waste land for agriculture in Jalalpur Canal command and promote irrigated agriculture with efficient utilization of limited water resources being made available from new canal system through sustainable infrastructure development at the farm level	

PACKAGE 8:

Providing crop diversification and market support



POSSIBLE INTERVENTIONS

- **Research & piloting-** Identify, research and pilot test diversification strategies for Punjab's different agro-ecological zones.
- **Enabling environment-** Following the development of strategies, incentivize the uptake of crop diversification through input and extension support, credit access, and market development.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Adopting crop diversification with good market potential will increase incomes of farmer households and optimizing cropping patterns for more than one crop will increase productivity of land.	• Crop diversification will improve community resilience by addressing the risks posed to agriculture by changes in climate, extreme events, disease incidence and declining soil fertility.	

NEEDS ASSESSMENT

Crop diversification can be an effective strategy for building community resilience and adapting to the risks posed by climate change. Crop diversification helps smallholder farmers break out of the poverty cycles by earning more and spending more on nutritious food items (Rose et al., 2020). In rural Punjab, crop diversification was found to be statistically significant with food consumption and negatively associated with food insecurity (Munawar et al., 2021). Given the changing climate and its implications on water resource availability, rising intensity and frequency of extreme events, deteriorating soil health and increasing disease incidence, the risk of food insecurity is even greater if farmers depend on a small number of major crops.

Diversification involves identifying cropping systems that are more resilient to climate change and adopting strategies such as mixed cropping, inter-cropping and crop rotation. The identification of more resilient and diversified cropping systems requires scientific testing and analysis and rigorous trials to demonstrate the effectiveness to farming households. In Punjab, research and development on alternative crops – such as quinoa, chia and buckwheat – has made some headway with efforts to enhance their value chains and encourage exports (H.U. Rehman, personal communication, April 27, 2022). The first quinoa variety was registered in 2019 and chia variety is expected to be registered next year with over 35 companies introducing their products in the market (I. Afzal, personal communication, April 27, 2022). Farmers should be encouraged to grow rabi pulses and oilseed crops as they are lucrative alternative options (K. Mushtaq, personal communication, April 26, 2022).

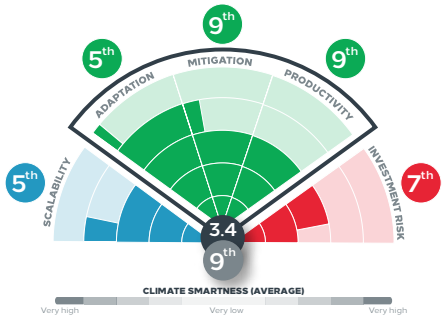
Policy support from the government and extension support for the farmers is required for promoting the adoption of diversified cropping systems and for them to generate tangible benefits for the farmers (Kiani et al., 2021). The Pakistan Agriculture Marketing Regulatory Authority Act 2020, for example, mandates the "emergence of non-traditional market channels such as supermarkets, virtual markets, and farmer markets, changes the power structure of the market, and enhances financial efficiency and transparency" (Li & Janssen, 2020). Farmers require support in terms of access to technology, training and extension support, availability & multiplication of improved and climate resilient seed varieties, and opportunities to avail credit on reasonable rates.

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – DEVELOPING FARM MECHANISATION; AGRICULTURAL RESEARCH AND INNOVATION)	
PUNJAB AGRICULTURE POLICY 2018. Emphasize product diversification, quality and value chain and embrace a wider range of clients beyond farmers.	
PUNJAB CLIMATE CHANGE POLICY 2017. Actions to reduce migration to urban areas by providing farmers and communities localized agriculture and crop diversification options.	
NATIONAL FOOD SECURITY POLICY 2018. Policy supports increasing productivity of major crops for diverting saved natural resources for the production of other high value crops, bridging the yield gaps and ensuring farm profitability, promotion of cultivation and utilization of pulses and oilseeds as alternate crops for import substitution, contractual production linkages of alternative crops with private sector food chains and public sector food departments including utility stores and CSDs, Introduction of new species of high value fruit crops like olive, pistachio, almond, kiwi, grapes and dates, Development of processing clusters of high value crops, livestock and fisheries for producing diverse high value products to reduce post-harvest losses, increase availability during off seasons and to promote rural businesses.	
EXISTING PROGRAMMING	**PROPOSED PROGRAMMING**
ANNUAL DEVELOPMENT PLANS: Development schemes related to crop diversification & market support include: 1) Establishment of Centre of Excellence for olive Research and Training (CEFORT) at Barani Agriculture Research Institute Chakwal 2019-20 to 2022-23 ($1,617,834); 2) Enhancement of honey production by using modern techniques ($131,428); 3) Promotion of fruits production in Punjab through provision of certified plants 2019-20 to 2022-23 ($2,059,045). 4) The World Bank assisted Punjab irrigated agriculture productivity improvement project (PIPIP) ($238,502,571)	**ANNUAL DEVELOPMENT PLANS:** The proposed schemes include: 1) Research & Development on Fruit Crops in South Punjab through Establishment of Fruit Research Institute at Bahawalpur ($914,285); 2) Establishment of Mango Research Station, Rahim Yar Khan ($1,142,857).

PACKAGE 9:

Local storage and processing capacity programme



POSSIBLE INTERVENTIONS

- **Modernizing local storage-** Establish modern post-harvest storage technologies in rural areas that minimize losses and risk against forces of nature.
- **Agriculture processing-** Identify the economically viable products which can be processed in rural areas and build capacity of the farming households.
- **Private financing-** Encourage private investors in developing and modernizing local storage and processing backed by SBP's financing facility for agricultural storage.

IMPACT ACROSS PILLARS

PRODUCTIVITY	ADAPTATION	MITIGATION
• Modernizing and improving storage technologies will reduce losses across the value chain and enhancing agriculture processing will improve farm incomes.	• Improving storage post-harvest will protect against uncertainties in temperature and rain. Strengthening agro-processing at the rural level will diversify sources of income and build resilience.	

NEEDS ASSESSMENT

A lack of proper storage, warehousing and processing facilities impose a major cost on the agriculture sector. Post-harvest losses of agricultural commodities cause both reductions in quality (in terms of change in nutrient composition, acceptability, and edibility) and quantity. Pakistan's post-harvest losses for wheat, maize and rice are estimated at nearly US$ 343 million per annum in quantity and quality due to a lack of proper drying and storage (Saeed et al., 2020). Losses in fruits and vegetables due to poor value chain infrastructure and management practices stand at 30 to 40 per (Ali, 2020).

Modern drying and silo storage facilities are not accessible for a majority of farm actors including farmers, traders and small to medium size millers. Dependence on the traditional practice of sun drying maize and rice paddy before storage and lack of access to mechanical drying facilities can alter grain quality as well as force farmers to make 'distress sales' at harvest time when prices are at the lowest (Saeed et al., 2020). There is limited access to affordable storage technologies such as hermetic storage systems. The storage landscape is monopolized by corporate players and large farmers (Stakeholder workshop, personal communication, April 30, 2022). Traditional post-harvest practices and lack of silo storage expose farmers, traders and other value chain actors to the uncertainties brought by climatic factors. In

the case of rice paddy and winter-harvested maize for example, the drying process before storage can be hampered by fog, smog, and possible winter rains that reduce contact of the grains with sunlight leading to losses. Similarly, for summer-harvested maize, the risks posed by untimely pre-monsoon rains and the prospect of monsoon can cause significant uncertainty and loss to maize farmers.

Globally, agricultural economies have made progress in the adoption of electronic warehouse receipt system to enable farmers to desist from distress sales immediately after harvest, attain higher prices for their produce, and consequently, improved returns. In 2014, State Bank of Pakistan (SBP) developed a mechanism for EWR financing and in 2017, the Security Exchange Commission of Pakistan (SECP) formulated the collateral management and warehousing regulations. However, the implementation of this system and its benefit to smallholder farmers faces multiple challenges despite progress on the regulatory and legislative front. Smallholder farmers have limited access to storage infrastructure and scarcely use formal sources of financing with increasing dependence on the *arthee* system (Safdar et al., 2019). They lack awareness and technical knowledge to engage in the system. Lack of crop grading and standardization and absence of commodity testing labs create a bottleneck in materializing agricultural trading (Saeed et al., 2020). There is weak incentive for investments in the warehousing landscape due to incomplete regulatory and legislative framework and absence of collateral management companies. SBP has introduced a financing facility to encourage private sector to establish silos, warehouse and cold storages available at a markup of 6 per cent for period of 10 years capped at PKR 500 million per project (SBP, n.d.). The EWR system is still nascent and need of more regulatory, legislative, institutional, and infrastructural support to make an impact for the smallholder farmer.

Building agro-processing capacity in rural areas can play a significant role in enhancing rural incomes and socioeconomic development (Ali, 2020). Agro-processing in the rural landscape can absorb the oversupply of various fruits and vegetables, diversify agricultural production, bring value addition to primary commodities and create employment for rural labour. There is a potential for village level processing started as cottage industry, to mature and transform into processing industry or alternatively develop forward integration with large scale industries in urban and peri-urban centres (Ali, 2020).

POLICIES AND PROGRAMMING

EXISTING POLICIES (POLICY AREAS – VALUE CHAIN DEVELOPMENT)
PUNJAB AGRICULTURE POLICY 2018. Expand local storage capacity, reduce post-harvest losses, establish warehouse receipt financing.
PUNJAB LIVESTOCK POLICY 2015-16. Develop livestock processing industry over next 10 years, particularly in the South.
NATIONAL FOOD SECURITY POLICY 2018. Provide incentives for food processing/value addition at farm level through cluster approach under public private partnership arrangements. Give incentive to invest in infrastructure such as storage and processing facilities, reliable energy supply and transport facilities. Take measures to support smallholders that yield economies of scale and allow them to move towards high value activities in the food supply chain. Support to design and introduce procedures to ensure higher corporate accountability standards to monitor reductions in losses in the food processing and retailing sectors. Develop skilled human resources in fruit and vegetable processing sector.

PAGE 156

EXISTING PROGRAMMING	PROPOSED PROGRAMMING
ANNUAL DEVELOPMENT PLANS: The on-going schemes linked to developing local storage and processing capacity include: 1) Establishment of model farms linked with improved supply chain and value addition - 2016-17 to 2022-23 ($12,445,382); 2) Provision of Missing Infrastructure in 10 Agriculture Produce Markets ($1,141,405); 3) PM's Package - Acquisition of Land for Establishment of Model Markets at Rawalpindi and D.G. Khan ($2,171,428).	**ANNUAL DEVELOPMENT PLANS:** The proposed scheme includes: PM Package - Program for Establishment of Model Markets in Dera Ghazi Khan, Lahore, Rawalpindi, Punjab ($85,714,285).
OTHER PROGRAMS: 1) Establishment of Food Grain SILOS In Punjab on 19 sites (10 years project) by the Government of Punjab to expand its wheat storage capacity by constructing two (02) million MT Near Farm Wheat Silos of 10,000 MT storage capacity each ($23,600,000); 2) State Bank of Pakistan's Financing Facility for Storage of Agricultural Produce (FFSAP) to encourage private sector to establish silos, warehouse and cold storages in order to enhance storage capacity and develop agricultural produce marketing with mark up of 6% per annum for a maximum period of 10 years with a maximum of PKR 500 million available for a single project; 3) Under the *Electronic Warehouse Receipt (EWR)* regime, an accreditation entity called Naymat Collateral has been licensed by SECP (corporate regulator) to accredit warehouses and warehouse operators and run a software system in which warehouse operators will be able to issue electronic warehouse receipts (transferable and tradeable) against stock which pass regime-wide testing criteria for each crop and enter storage at the accredited warehouse.	
INTERNATIONAL FUNDING: China-Pakistan Economic Corridor (CPEC) (2017-2030) has proposed to help improve post-harvest handling, storage and transportation of agricultural products; and, innovating in marketing and sales models.	

PAGE 157

Annex

3

Multi-national and private entities providing agriculture services in KP and Punjab

Table A3.1: Multi-national and private entities providing agriculture services in KP and Punjab

COMPANY	GEOGRAPHIC COVERAGE	AREA OF SPECIALIZATION	POLICY PRIORITY AREAS
Engro Fertilizers	Pakistan	Fertilizer manufacturing and marketing company having a portfolio of fertilizer products (such as Engro Zarkhez, Zingro, Engro DAP and Envy) with a focus on balanced crop nutrition and increased yield.	Crop production support
Engro Eximp Agriproducts (EEAP)	Punjab	Operates an integrated plant for processing rice - 65 acres of plant coverage; 70,000 Tons capability of rice export	Value chain development
FrieslandCampina Engro Pakistan Limited	Punjab and Sindh	Manufacturing, processing and marketing of dairy products and frozen desserts. Products include Olper's, Omoré, and Tarang.	Value chain development; livestock sector development
Fauji Fertilizer Bin-Qasim Limited	Pakistan	Operates a modern Granular Urea and Di-Ammonium Phosphate (DAP) fertilizers manufacturing complex.	Crop production support
Fauji Fertilizer Company Limited (FFC)	Punjab and Sindh	5 Farm Advisory Centers and Regional Agri. Services Officers in Punjab and Sindh	Improved extension and advisory
Fauji Fresh n Freeze Limited	Pakistan	Produces premium quality fruit and vegetable products from Pakistan. Cultivated in prime agricultural lands spread over 200,000 sq. km	Value chain development
Bayer Pakistan (Pvt) Limited	Pakistan	High-quality seeds and crop protection products that enable efficient and sustainable agriculture. Engages in farmer education and digital innovations in agriculture	Seed sector development; crop production support; improved extension and advisory
Syngenta Pakistan	Pakistan	Portfolio includes insecticides, herbicides, fungicides, bio-stimulants, seed protection and other crop enhancement products as well as hybrid seeds for crops including (but not restricted to) Cotton, Wheat, Rice, Sugarcane, Corn, Vegetables and Fruits.	Crop production support; seed sector development
ICI Pakistan Limited	Pakistan	The Animal Health Division provides complete farm-management solution to livestock and poultry stakeholders across Pakistan. The Agri Sciences Division provides the highest quality seeds, agrochemicals and micronutrients that ensure high yields and greater value for money.	Livestock sector development; seed sector development; crop production support

COMPANY	GEOGRAPHIC COVERAGE	AREA OF SPECIALIZATION	POLICY PRIORITY AREAS
Haji Sons	Punjab and Sindh	Provides integrated agricultural solutions on seed, seedling, irrigation, fertilizers, pesticides and post-harvest technologies (drying, storage, transport)	Seed sector development; water management; value chain development; crop production support
Four Brothers Seeds Corporation Pakistan Pvt. Ltd.	Pakistan	Four Brothers provides wide range of agricultural services including farm advisory, seeds, agrichemicals, HEIS, tractors & corn silage for dairy cows	; water management; developing farm mechanisation; improved extension and advisory
Jullundur Private Limited (JPL)	Pakistan	Produces agrochemicals, seeds, hybrid seeds and fodders	Seed sector development; livestock sector development; crop production support
Ramzan & Haseeb Agricultural Mechanical Engineers	Punjab	Manufacturing a variety of agri farm machinery and processing units	Developing farm mechanisation
Noorani industries Pvt. ltd	Punjab	Manufacturing a variety of agri farm machinery and processing units	Developing farm mechanisation
Ch Manzoor Karim Impex Company	Punjab	Manufacturing a variety of agri farm machinery	Developing farm mechanisation
Iftikhar Brothers	KP	Manufacturing a variety of agri farm machinery and aquaculture equipment	Developing farm mechanisation
Seed Companies	KP	19 seed companies in KP are registered with the national ministry for provision of seed for various crops (Federal Seed Certification and Registration Department, 2020)	Seed sector development/ reforms
Seed Companies	Punjab	552 seed companies in Punjab are registered with the national ministry for provision of seed for various crops (Federal Seed Certification and Registration Department, 2020)	Seed sector development/ reforms

Annex

4

Biocontrol lab development costs

Table A4.1: Biocontrol lab development costs (Source: CABI)

	PER UNIT COST ($)	QUANTITY	TOTAL COST ($)
EQUIPMENT			
Incubator (80 litre capacity)	800	1	800
Growth Chamber	6,000	1	6,000
Humidifier	120	2	240
Electric aspirator	25	6	150
Microscope	3,000	1	3,000
Freezers	350	1	350
Rearing cages	50	10	500
Jars	2	400	800
Sieves	2	20	40
Racks	110	8	880
Refrigerators	300	1	300
Diet ingredients	Lumpsum	Lumpsum	1,500
Diet Mixer	50	1	50
Chemicals	Lumpsum	Lumpsum	3,000
Air conditioner (Invertor 1T) for Cooling and heating	400	2	800
Generator (5-10 KVA)	3,200	1	3,200
Working station (including sitting chairs)	80	5	400
Table lamps	15	8	120
Humidity and temperature meter	30	2	60
Ice box	100	2	200
Water dispenser	80	1	80
TOTAL			**22,470**
RECURRING COSTS (PER MONTH) - HR & OPERATIONAL			
Biocontrol Specialist	1,200	1	1,200
Trained entomologist	400	1	400
Lab support staff	300	3	900
Staff for delivery and installation	200	3	600
Operational costs (consumables, utilities, fuel etc.)	Lumpsum	Lumpsum	2,000
TOTAL			**5,100**
RECURRING COST (PER YEAR)			
infrastructure maintainence (white wash, wall sealings, repair etc.)	Lumpsum/per year	Lumpsum	10,000
TOTAL			**10,000**
RECURRING COST (PER SEASON)			
vehicle and fuel cost (field visits for insect collection & releasing etc.)	Lumpsum/per season	Lumpsum	5,000
TOTAL			**5,000**

Annex

5

Stakeholders consulted for investment opportunities in Punjab

NAME	ORGANIZATION
Yasir Hayat	WFP
Saeed Ahmad Asad	COMSATS
Umer Farooq	SAWiE
Muhammad Hasan Ali Baig	Arid Agriculture University
Yasir Gul Khan	MoPDSI
Hafeez ur Rehman	University of Agriculture Faisalabad
Sarah Parvez	USAID
Irfan Afzal	University of Agriculture Faisalabad
Muhammad Khalid Bashir	University of Agriculture Faisalabad
Masood Khan	WWF
Kamran Niazi	USAID
Nazim Ali	USAID
Alyna Nawab	GIZ
Gulfam Younus	
Abdul Wajid Rana	IFPRI - Pakistan
Saima Younis	University of Agriculture Faisalabad
Abdul Khaliq	University of Agriculture Faisalabad
Ms. Anam Shabbir Rathor	GIZ
Ms. Sobiah Becker	FCDO
Ms. Asma Asif	GIZ
Mariam S. Khan	WCS
Waqar Ud Din	EPD
Fouad Bajwa	Agriculture Republic
Tasneem	University of Agriculture Faisalabad
Iqra Asghar	WWF
Malik Muhammad Akram	OFWM Punjab
Mubshar Hussain	Bahauddin Zakariya University - BZU
Abid Niaz	
Kashif Salik	SDPI
Rana Mahmood	Agriculture Department, Punjab
Bunchingiv Bazartseren	UN
Ali Akbar Abbas	LUMS
Hafiz Zahid Mahmood	COMSATS
Arif Goheer	GCISC

NAME	ORGANIZATION
Rabeya Yasmeen	Environment Department Punjab
Mushtaq Gill	Government of Punjab
Khalid Mahmood	Director, SAWiE
Tahir Iqbal	Arid Agriculture University
Dr. Mukhtar Ahmed	Arid Agriculture University
Mr. Syed Irshad Shah	FAO
Khalid Mushtaq	University of Agriculture Faisalabad
Ayesha Sadaf	GIZ
Amnah Jaral	SAWiE
Muhammad Irfan	WWF
Fahad Saeed	Climate Analytics
Hamid Abbasi	Food Security and Agriculture Center of Excellence (FACE), Fauji Fertilizer Company
Abdul Rauf	Directorate of Agriculture Research KP
Muhammad Asghar	IPM, Agriculture Department Punjab
Abdul Wakeel	University of Agriculture Faisalabad
Ahmad Nawaz	Bahauddin Zakariya University - BZU
Mohsin Hafeez	IWMI

Annex

6

Stakeholders consulted for investment opportunities in Khyber Pakhtunkhwa

NAME	ORGANIZATION
Mansoor Khan Khattak	University of Agricultural Peshawar
Afaq Ahmad Khan	
Ismail Khan	PDMA-KP
Inayat Ullah	Director Federal Seed Certification & Registration Department (FSC&RD)
Jan Muhammad	District Director, Agriculture Extension Department, District Shangla.
Muhammad Yasir Khan	Cereal Crop Research Institute (Nowshera)
Aftab Alam Khan	Resilient Future Int
Nathan A. Rive	ADB
Alyna Nawab	GIZ
Khadija Bano	GIZ
Mohsin Rose	USAID
Anam Shabbir Rathor	GIZ
Zubair Shah	Central Cotton Research Institute
Sobiah Becker	FCDO
Farhan Ali	Cereal Crop Research Institute (Nowshera)
Abdul Wajid Rana	IFPRI
Jan Muhammad	Directorate of Agricultue Extension, KP
Maryam Bibi	CEO, Khwendo Kor
Arif Goheer	Head Agriculture, Forestry & Land Use, GCISC, MoCC/ Steering committee member
Asma Asif	GIZ
Fayaz Ahmad	EPA KP
Kulsoom	Directorate of Agriculture Engineering
Yousaf Noor	The University of Agriculture, Peshawar
Irfan Ullah Khan	Central Cotton Research Institute
Mr. Bashir Ahmad	PARC
Maria Daud	WFP
Muhammad Naseer	Directorate of Agriculture Research KP
Pervaiz Khan	
Hamid	
Fazli Wahab	Directorate of Agriculture Research KP
Abdul Nasir Malik	Directorate of Agriculture Extension KP
Fazal Maula	Directorate of Agriculture Research KP
Younas	Directorate of Agriculture Research KP
Muhammad Saeed	University of Swabi KP

NAME	ORGANIZATION
Sabyan Honey	CABI
Bashir Ullah	Directorate of Agriculture Research
Yasir Hayat	WFP
Timothy Joseph Krupnik	CIMMYT
Riina Jalonen	Alliance of Bioversity International & CIAT
Hauke Dahl	IWMI
Zia ul Haq	UET, Peshawar
Tariq Khalil	UET, Peshawar
Hussain Ahmed	Model Farm Service Center
Rab Nawaz	WWF

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CLIMATE SMART AGRICULTURE INVESTMENT PLAN
PUNJAB AND KHYBER PAKHTUNKHWA

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