The Pakistan Business Council
FOSTERING ECONOMIC GROWTH

# THE STATE OF PAKISTAN'S AGRICULTURE 2023

## Setting agriculture on the path of growth

# THE STATE OF PAKISTAN'S AGRICULTURE 2023

## Setting agriculture on the path of growth

Kazim Saeed

March 2023

PAKISTAN AGRICULTURAL COALITION
PAC

The Pakistan Business Council
FOSTERING ECONOMIC GROWTH

# Acknowledgments

This report has been developed by Kazim Saeed (Strategy Advisor, Pakistan Agricultural Coalition, kazimsaeed@gmail.com) under the aegis of a joint initiative for agricultural growth by **Pakistan Business Council** and Pakistan Agricultural Coalition. The author would like to express special gratitude to Mr. Abrar Hasan (Chief Executive Officer, National Foods), Mr. Khalil Sattar (Chief Executive Officer, K&N's), Mr. Ehsan Malik (Chief Executive Officer, Pakistan Business Council), Mr. Ali Khan (Managing Director, Friesland Campina Engro Pakistan), and Mr. Arif Nadeem (Chief Executive Officer, Pakistan Agricultural Coalition), for their generous support and guidance towards this report. Invaluable contributions were made towards the chapters of this report by Mr. Shan E Ahmed (financing, technology, and seed), Mr. Jamal Jaffer (water), Mr. Hasaan Anwar (animal disease management), and Mr. Danish Ahmed Khan. The author would also like to thank Mr. Masood Ahmed and Mr. Chaudhry Ashraff for their insightful suggestions for the water chapter.

The Pakistan Business Council (PBC) is a research-based business policy advocacy platform, supported by over 100 private sector companies, local and multinational, that have significant and long-term commitment to sustainable growth of the country. They come from 17 major sectors of the formal economy, generate 40% of annual exports, contribute a third of Pakistan's total tax revenues and employ three million. Their combined sales represent every 9$^{th}$ Rupee of Pakistan's GDP. PBC's major thrust is **"Make-in-Pakistan"** with three pillars: "Grow More/Grow Better", "Make More/Make Better" and "Serve More/Serve Better," all with the objective of generating jobs, promoting exports and reducing imports. This study is under the "Grow More/Grow Better" pillar. (www.pbc.org.pk)

The Pakistan Agricultural Coalition (PAC) develops commercially scalable business models and provides policy/strategy advice for growth in Pakistan's agriculture sector. PAC is supported by 17 of Pakistan's leading business and financial groups representing a diverse range of sectors and a combined revenue of over US$ 10 billion. PAC's vision for Pakistan's agriculture sector is that it should be private sector-led, technology-driven, entrepreneurial, and globally competitive with higher grower profitability. (www.pac.com.pk)

Major funding for this report was provided by the Pakistan Business Council.

# The Pakistan Business Council: An Overview:

The Pakistan Business Council (PBC) is a business policy advocacy platform, established in 2005 and now composed of over 100 of Pakistan's largest private-sector businesses and conglomerates, including multinationals. PBC businesses cover nearly all sectors of the formal economy.

The PBC is a not-for-profit entity, registered under Section 42 of the Companies Ordinance 1984. It is a pan-industry advocacy group, not a trade body, nor does it advocate for any specific business sector. Rather, its key advocacy thrust is on easing barriers to allow Pakistani businesses to compete in regional and global arenas. The PBC conducts research and holds conferences and seminars to facilitate the flow of relevant information to all stakeholders in order to help create an informed view on the major issues faced by Pakistan.

The PBC works closely with relevant government departments, ministries, regulators and institutions, as well as other stakeholders including professional bodies, to develop consensus on major issues which impact the conduct of business in and from Pakistan. It has submitted key position papers and recommendations to the government on legislation and other government policies affecting businesses. It also serves on various task forces and committees of the Government of Pakistan as well as those of the State Bank, the SECP, and other regulators with the objective to provide policy assistance on new initiatives and reforms.

# The PBC's Founding Objectives

The major objectives of the PBC as stated in its founding documents are:

- To provide for the formation and exchange of views on any question connected with the conduct of business in and from Pakistan.
- To conduct, organize, set up, administer and manage campaigns, surveys, focus groups, workshops, seminars and field works for carrying out research and raising awareness in regard to matters affecting businesses in Pakistan.
- To acquire, collect, compile, analyze, publish and provide statistics, data analysis and other information relating to businesses of any kind, nature or description and on opportunities for such businesses within and outside Pakistan.
- To promote and facilitate the integration of businesses in Pakistan into the World economy and to encourage in the development and growth of Pakistani multinationals.
- To interact with governments in the economic development of Pakistan and to facilitate, foster and further the economic, social and human resource development of Pakistan.

The PBC is a Section 42 not-for-profit Company Limited by Guarantee. Its working is overseen by a Board of Directors. More information on the PBC, its members, and its workings, can be found on its website: www.pbc.org.pk

# The PBC Member Companies

ABACUS
Abbott A Promise for Life
AIRLINK
AkzoNobel
AlliedBank
AMRELI STEELS Building for Life
ARCHROMA LIFE ENHANCED
Artistic Milliners DENIM COMPANY OF THE FUTURE
Atlas
Bank Alfalah
Bata
BAYER
CENTRAL DEPOSITORY COMPANY
CHERAT CEMENT
CHANGAN AUTO
Coca-Cola
COLGATE-PALMOLIVE
COTTON WEB LIMITED
Dalda
daraz
Dawlance
Dawood Hercules
DESCON
EBM
efu GENERAL
EMAAR PAKISTAN
engro corp
faysalbank
FEROZSONS LABORATORIES LIMITED
FORWARD
FrieslandCampina Engro Pakistan Limited
GATRON
Getz pharma
gsk do more feel better live longer
GulAhmed
HASCOL
HBL
Hilton PHARMA
HUBCO
HUTCHISONPORTS PAKISTAN
INDUS GROUP
INTERLOOP
International Industries Ltd.

Ismail Industries Limited
Jazz
JS BANK
Jubilee General Insurance
K&N's
KE
KHAADI
KSB
LIBERTY
LIPTON Teas and Infusions
LOTTE
LUCKY CEMENT
MACPAC FILMS
MAHMOOD GROUP
Martin Dow
MASOOD ROOMI
mayfair The little joys of life
MEGA MEGA CONGLOMERATE
National Foods
NAVEENA GROUP
Nestlé Good food, Good life
NIMIR
OLP
Packages Limited
pakarab Fertilizers Limited
PEPSICO
PM
PSL PAKISTAN SERVICES LTD.
PSX PAKISTAN STOCK EXCHANGE LIMITED
ptcl
reckitt
SAIF GROUP
Sapphire
Servis
Shan
SICPA
SIEMENS
Soneri Bank
SOORTY
SPEL Synthetic Products Enterprises Limited
Standard Chartered
systems
TAPAL
TATA PAKISTAN
TCS WE MOVE YOU
Tetra Pak PROTECTS WHAT'S GOOD
TG
TOYOTA INDUS MOTOR COMPANY LTD
TPL
TTE
Tufail Chemical Industries Ltd.
UBL where you come first
Unilever

# The PBC Affiliates

HINUCON Private Limited

International Steels Limited
Shaping Tomorrow

LMC Lucky Motor Corporation

Pakistan Cables

LCI
Lucky Core Industries

# Table of Contents


**Introduction** ........ **2**

**I. Higher agriculture growth through technology** ........ **6**

Traceable and sustainable cotton through two industrial revolutions ........ 7

Service providers can deliver technology to Pakistan's farmers: The case of rice ........ 8

Building the backbone for Pakistan's fragmented fruit and vegetable value chains ........ 11

Pakistan's poultry sector is a success story of growth through technology ........ 12

Welcoming the fourth industrial revolution ........ 14

Conclusions and policy priorities ........ 14

**II. Water for equitable growth** ........ **17**

Water productivity is key ........ 17

Pakistan's key water-related challenge is the wastage of water ........ 19

The irrigation system is supply-driven rather than demand-driven ........ 21

Groundwater from the Indus aquifer is critical for Pakistan's agriculture ........ 21

Drainage and water quality are critical issues to address ........ 23

Climate change is expected to seriously impact Pakistan's water resources ........ 24

Conclusion and policy priorities ........ 24

**III. The Seed of Growth** ........ **28**

What is good quality seed? ........ 28

Pakistan's success story with hybrid maize seed ........ 29

Sad state of cotton seed in Pakistan ........ 30

Pakistan's seed system is not organized to provide quality seed to all farmers ........ 33

Policy priorities to the address legal and regulatory constraints to growth ........ 35

Conclusions ........ 37

**IV. Financing growth in agriculture** ........ **39**

Credit ........ 41

Equity ........ 45

Insurance ........ 46

Government support ........ 47

Conclusions and policy priorities ........ 48

**V. Mitigating animal disease to support growth** ........ **51**

Case study of disease management: outbreak of lumpy skin disease in Pakistan ........ 51

The contradiction in regulation: over-regulate the formal few, ignore the rest ........ 52

Mapping the stakeholders ........ 53

Surveillance ........ 54

Disease-free zones ........ 55

Pakistan needs to expand vaccination with a path to domestic production of vaccines ........ 56

Conclusions and policy priorities ........ 57

**VI. Better feed for higher livestock growth** ........ **60**
Feed 101 ........ 61
How the economics of feed impacts the farmer's choice of feed ........ 65
State of Pakistan's feed industry ........ 66
Can Pakistan produce the feed required in the coming decade? ........ 67
How can domestic production of feed rise to meet demand? ........ 68
Feed quality ........ 70
Conclusions and policy priorities ........ 70
**VII. Policy priorities for growth in agriculture** ........ **73**
**Annexures** ........ **77**
Annex A. Understanding poultry technology ........ 77
Annex B. Pakistan's freshwater resources ........ 78
Annex C. Basics of seed technology ........ 80
Annex D. Area Yield Index Insurance (AYII) ........ 82
Annex E. Common livestock diseases in Pakistan ........ 84

# Tables

**Table 1:** Lumpy skin disease in Pakistan ........ 52

# Figures

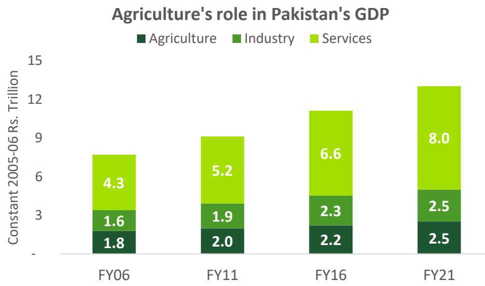
**Figure 1:** Agriculture has slowed growth.......... 2
**Figure 2:** Low growth within agriculture .......... 2
**Figure 3:** Net food importer even before Covid .......... 3
**Figure 4:** Pakistan's agriculture: Yet to mechanize .......... 6
**Figure 5:** Best to water the cotton plant through the soil .......... 7
**Figure 6:** Shifting rice from manual to mechanical.......... 9
**Figure 7:** A good crop can die at the mandi .......... 11
**Figure 8:** The past and (possible) future of Pakistan's poultry sector .......... 12
**Figure 9:** With technology, the real price of poultry has fallen .......... 13
**Figure 10:** Pakistan must create more value from its water.......... 17
**Figure 11:** Policy priority: Fruits and veg are highest .......... 18
**Figure 12:** Farmer preference: Sugarcane is highest .......... 18
**Figure 13:** Every drop counts: water loss at each stage .......... 19
**Figure 14:** Pakistan withdraws more of its water .......... 21
**Figure 15:** Which district has more effective drainage? .......... 23
**Figure 16:** China: Rise in vegetables led to fall in water use .......... 25
**Figure 17:** Good cotton seed has high germination, uniform cotton variety, and same plant height .......... 29
**Figure 18:** Introduction of hybrid maize seed in 2001 has led to a maize revolution in Pakistan .......... 30
**Figure 19:** Pakistan's cotton yield: From stagnant to falling .......... 31
**Figure 20:** Tale of two cotton producers .......... 32
**Figure 21:** Pakistan's farmers have a large unmet demand for quality seed .......... 33
**Figure 22:** Pakistan's seed provision system.......... 34
**Figure 23:** The private sector is the main supplier of seed .......... 34
**Figure 24:** The jump to precision agriculture .......... 39
**Figure 25:** Understanding financial needs in the agriculture sector .......... 40
**Figure 26:** Four different routes for bank credit (and speculator money) to reach farmers .......... 43
**Figure 27:** Lending: crop vs. end-product (FY22).......... 43
**Figure 28:** Cultivated area dominated by larger farms .......... 45
**Figure 29:** Livestock has been rising with poultry dominating by number.......... 52
**Figure 30:** Disease management: Stakeholders, key factors .......... 53
**Figure 31:** Tracking outbreaks .......... 54
**Figure 32:** Dairy feed in Pakistan Conventional feed sources.......... 61
**Figure 33:** Soybean meal, oil and soybeans .......... 63
**Figure 34:** Traditional storage of wheat straw.......... 63
**Figure 35:** Rising use of oil seed meal in Pakistan .......... 64
**Figure 36:** Better feed requires better genes .......... 65
**Figure 37:** Maize demand projections.......... 67
**Figure 38:** Wheat projections for Pakistan .......... 69

# INTRODUCTION

# Introduction

**It is time for agriculture to drive Pakistan's growth.** Figure 1 shows the components of Pakistan's GDP in *real* (i.e., inflation-adjusted) terms over a 15-year period. The agriculture sector stands out as the component dragging down growth. As a primary sector, agriculture should drive economic growth in its associated sectors and indeed the rest of the economy. But in this period, agriculture's real growth has been restricted to the range of 2.2 to 2.6 percent per annum while industry and services have driven Pakistan's economic growth. Given the dire needs of the Pakistani economy, it is now time to reverse this trend.

Figure 1: Agriculture has slowed growth

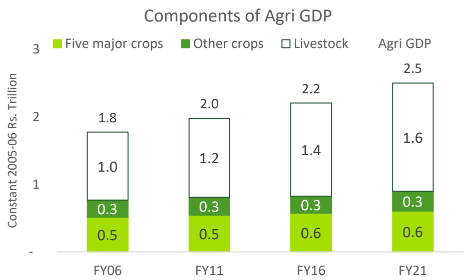



**Real GDP growth in 5-year periods**

| CAGR | Agriculture | Industry | Services | GDP |
|---|---|---|---|---|
| FY06-FY11 | 2.2% | 3.7% | 3.8% | 4.6% |
| FY11-FY16 | 2.2% | 3.7% | 4.8% | 4.0% |
| FY16-FY21 | 2.6% | 1.4% | 4.1% | 3.2% |

Within the agriculture sector (figure 2), the livestock sector (mainly dairy and poultry) has driven agricultural growth while the five major crops—wheat, cotton, maize, sugarcane, and rice—have held sector growth back by growing at around 1.1 percent per annum in real terms for nearly two decades. As this report outlines, these five crops are taking the majority of Pakistan's agricultural assets (land, water, labour, etc.) but not delivering what Pakistanis deserve in growth and prosperity. Among 'other crops', mainly fruits and vegetables, there has been erratic but slow growth during this period.

Figure 2: Low growth within agriculture




**Real Agri GDP growth in 5-year periods**

| CAGR | Five major crops | Other crops | Livestock | Agri GDP |
|---|---|---|---|---|
| FY06-FY11 | 1.2% | 0.6% | 3.0% | 2.2% |
| FY11-FY16 | 1.1% | -1.1% | 3.4% | 2.2% |
| FY16-FY21 | 1.1% | 3.1% | 3.0% | 2.6% |

*Source: Economic Survey of Pakistan*

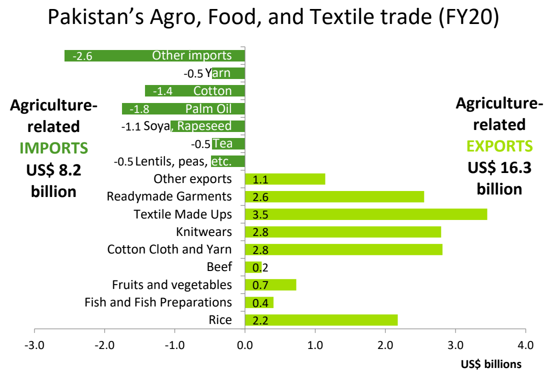
The glass is half empty but also half full. Today, Pakistan's economy needs a path towards rapidly increasing exports without a massive increase in imports. It also needs sources of sustained, year-on-year economic growth which creates good jobs particularly in Pakistan's rural areas where poverty resides in its millions. Agriculture has the potential to address all these needs.

**Climate of change** Pakistan is one of the top ten most vulnerable countries from climate change. Crop performance is highly sensitive to the elements: water availability, heat, flood and drought, wind, rain, etc. Today, it is increasingly being accepted that, with climate change, the frequency of catastrophic events that can impact crop yields is rising. According to the ADB, the number of heat wave days increased by 31 days during 1980 and 2007 with rainfall in arid plains/coastal areas decreasing by 10-15 percent. The year 2022 saw a historic heatwave across Pakistan in March-April followed by 'biblical floods' and rains in August-September. Even when these events are not catastrophic, they reduce the crop's ability to defend itself against pests and diseases. This reduces yields and therefore farmer profitability.

Pakistan's farmers have been reporting changes in weather patterns for over a decade. And, even in normal years, agriculture accounts for 93 percent of Pakistan's freshwater resources. So, the agriculture sector is where the issues of climate change and environmental sustainability really hit home in Pakistan.

**A great food insecurity is coming.** Figure 3 shows that Pakistan was already a net importer of food before Covid hit. The massive rise in global commodity prices since then has brought a wave of inflation to Pakistan turbo-charged with sharp depreciations in the value of the rupee. As a result, food inflation has persisted at historic highs and rendered food less accessible to the poor. This comes in the context of two factors that have been eating away at Pakistan's food security over the years: (i) rising population means a rising food and feed requirement, while (ii) yields have stagnated in many crops and in livestock where the genetic potential remains poor (for reasons outlined in this report). This has necessitated imports of food commodities that have been grown here for decades, if not centuries, such as wheat. Today, Pakistan's perilous shortage of foreign reserves piles on top of global commodity price levels and transport congestion to raise the specter of a great food insecurity in the years to come—tougher for the poor.

Figure 3: Net food importer even before Covid




*Source: Trade Development Authority of Pakistan*

**Pakistan cannot tackle the issues of the 2020s with the institutional and commercial mechanisms of the 1960s.** No crop typifies agriculture's issues better than wheat. Wheat is the only crop that the government actually purchases in Pakistan. The government announces a support price at which it will purchase wheat 'from farmers' each season. But this purchase process is captured by middlemen so most farmers do not get the full support price. The government borrows hundreds of billions of rupees to purchase this wheat—the original circular debt—and store it in government go-downs. This wheat is later sold to flour millers in the name of cheap flour for the poor. But enforcement is weak so the government ends up attempting to subsidized flour at its utility stores as well.

This institutional mechanism was put in place in the 1960s to help Pakistan achieve self-sufficiency in wheat. Pakistan achieved this self-sufficiency in the 1980s and, since then, this mechanism has become a source of economic stagnation for Pakistan's agriculture sector. The capture by middlemen is so strong that efforts to transition this rigid system to a more market-based wheat value chain have all floundered. The most unfortunate outcome is that the system neither rewards wheat quality nor greater yield. So, wheat yields have stagnated close to 3 tons per hectare (30 maunds per acre) when progressive farmers within Pakistan are achieving 4.5 tons per hectare and other countries are achieving even more. As a result, despite so much government involvement in the crop, no serious investment in wheat seed development, mechanization, storage, and processing stands on the ground. In fact, wheat imports have become common. A sharp contrast is seen in the maize and rice crops which have hardly any government intervention: maize yields have tripled over the past two decades completely on the steam of the private sector. In rice, exporters have brought high-yielding hybrid seed to farmers and invested in mechanization.

**The scale of business opportunities in agriculture is enormous.** Just three crops—wheat, rice paddy, and maize—have a farm-gate value of about $12 billion of which nearly $1 billion is lost in quality and quantity due to traditional drying practices, sub-optimal warehousing, unfair market practices, and traditional logistics. For such business opportunities to be realized, agriculture's business model has to change: from government-driven to private sector-driven, from rigid to entrepreneurial, from traditional to technology-based, and from patronage to global competition. None of this is possible if the solutions proposed do not increase profitability of farms and of farmers.

# HIGHER AGRICULTURE GROWTH THROUGH TECHNOLOGY

# I. Higher agriculture growth through technology

**As Pakistan tries to embrace the third industrial revolution, the fourth has arrived!** The advance of technology in the modern era is marked by four industrial revolutions[1]:

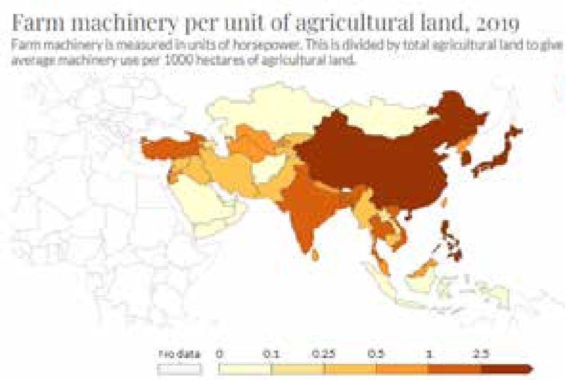
I. *The first industrial revolution* is placed in the late 18th century when the introduction of the steam engine and the harnessing of water power led to the mechanization of manufacturing;

II. *The second industrial revolution* is placed in the late 19th century to early 20th century when electricity catapulted mass production. In agriculture, these developments saw the global shift from manual work on farms through traditional tools and dependence on animal power to mechanical power on farms and mass-produced chemical inputs for farming. In Pakistan, this wave arrived in the form of the green revolution in the 1960s and 1970s which brought tractorization, mass-produced chemical fertilizers and agro-chemicals complemented by advancements in seed which led to new varieties and higher yields.

III. *The third industrial revolution* of the late 20th century rode on the development of electronics. This brought automated production using electronics, particularly programmable logic controllers, advanced IT systems, and robotics. From the early 1990s, this wave brought the development of precision agriculture through yield monitoring, guidance systems for farming, and variable rate application of agri-inputs on each portion of the farm based on its need.

IV. *The fourth industrial revolution* of the early 21st century is riding on big data, artificial intelligence, the Internet of Things, etc. This has begun to allow autonomous decision-making by cyber-physical machines using machine learning. In agriculture, this is beginning to allow autonomous farming using ubiquitous sensors.

Figure 4: Pakistan's agriculture: Yet to mechanize




*Source: United States Department for Agriculture (USDA) Economic Research Service OurWorldInData.org/employment-in-agriculture • CC BY*

Figure 4 uses a simple measure of mechanization to show that, while Pakistan has broadly embraced the second revolution, it is yet to fully embrace the third and fourth industrial revolutions. As a proxy for mechanization, figure 4 takes the estimated farm machinery in each country (measured in horsepower) divided by its total agricultural land.

1 Marco Brini (2023). *Digital Agriculture e-book.*

The features of Pakistan's agriculture sector today demand mechanization. The low yields per acre and small scale of farming operations lead to inefficient use of resources and higher unit costs. This means higher end-consumer prices despite low farmer profitability. The lack of modern drying, storage, and logistics infrastructure means higher post-harvest losses of commodity and the use of bags for grain storage and transport entails high labour costs. All this means higher costs for end-consumers. Finally, growers continue to lack the capacity to adopt better farming practices which are complemented by modern technology. **This chapter lays out how technology can be scaled up to bring higher growth to Pakistan's agriculture based on reduced inefficiencies and increased productivity.**

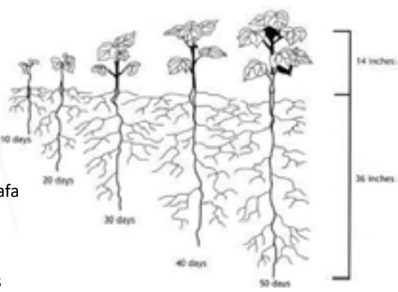
## Traceable and sustainable cotton through two industrial revolutions

The rise in modern consumers' commitment to environmental sustainability and social standards has led to a shift in the global fashion industry. This has placed new demands on the global textile industry. Traceability and sustainability goals have increasingly become a requirement of global brands. Over fifty leading brands have signed the Textile Exchange's 2025 Sustainable Cotton Challenge to source 100 percent of their cotton from the most sustainable sources by 2025. Similar pledges have been made by other global brands. Therefore, Pakistan's textile industry is also beginning to look for traceability and sustainability in its cotton sourcing and processing. This is where a combination of technology from the third and fourth industrial revolutions can deliver.

In Pakistan a simple example modern technology enabling traceability and sustainability goals involves the practice of water delivery to cotton plants. A widespread issue across Pakistan's agriculture sector is the low power of Pakistan's locally-built tractors. This industry was given protection from imports some decades ago with the policy goal of indigenization of tractor production. Despite decades of this protection and direct government support to farmers for purchase of these tractors, Pakistan's most common tractors operate in the range of 50 horsepower. To put this in perspective, the Toyota Corolla Altis 1600cc model is marketed as capable of 120 horsepower at 6,000rpm (Indus Motors website 2023). The result of this low traction is that soil is typically ploughed to a maximum of about 18 inches by these tractors. This means that on most farms in Pakistan, soil compaction is usually found at 15- to 18-inch depth. This is called the 'hard pan' which must be broken for the cotton plant to grow sustainably.

Figure 5: Best to water the cotton plant through the soil

Cotton plant, Mustafa Farms, Rahim Yar Khan (April 2022) – hard pan broken by John Deere tractors




Typical soil profile at most cotton farms in Pakistan

As the middle panel in figure 5 shows, the cotton plant sets its root far deeper reaching over four feet and is best watered through its roots using the water retained by the soil it grows in. The photograph on the left shows the cotton plants at Mustafa Farms, Rahim Yar Khan, in April 2022 which were sown by Monosem pneumatic planters at consistent plant-to-plant and row-to-row distance to achieve higher plant population per acre. Before planting, the hard pan was broken down to four feet with John Deere tractors of up to 145 horsepower using a chisel plow. This means that the water retained by the soil is feeding the plants. That is why the surface gives a parched look but, despite this, the plant looks healthy. No surface water is being held which avoids a humid environment around the plants conducive for pests.

By contrast, the photograph on the right shows the hard pan (no cotton plant shown) which means that the roots of the typical cotton plant in Pakistan are found to turn at right angles at the depth of around 18 inches, sometimes even less. The natural need of the cotton plant is not being met because of inadequate farm machinery used season after season after season. This means that, instead of watering the cotton plant through the soil, excessive surface watering is commonly practiced in Pakistan. This provides a home to insects. This leads to a higher use of insecticides resulting in lack of compliance with global sustainability standards. Instead, if the correct farm machinery is used, less surface water will mean less insects, less insecticide sprays and greater sustainability.

The traceability and sustainability goals can be achieved on Pakistan's farms by combining multiple industrial revolutions: using appropriate machinery with accurate measurement through modern sensors using the Internet of Things. This can help Pakistan's processors in becoming more competitive in global markets. This is why Indus Dyeing, Mahmood Group, and Dynamic Sportswear have sponsored this project at Mustafa Farms in District Rahim Yar Khan with Farmonix as the machinery service provider and Mehrgarh Kasht as the project developer. A key question arises here: modern farm machinery is generally intended for a larger scale of cultivation—how can we get this machinery to the majority of Pakistan's smallholder farmers.

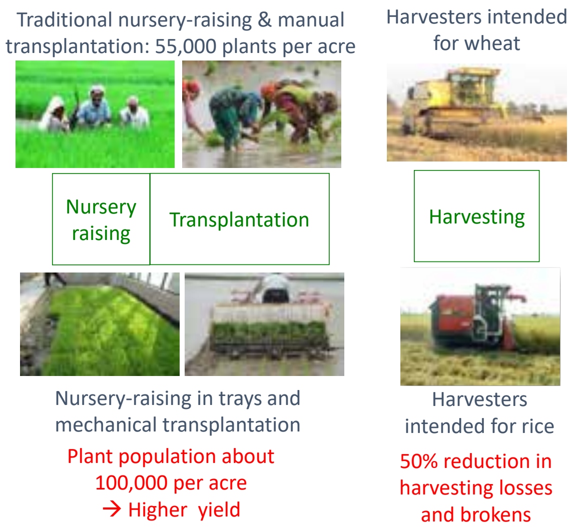
## Service providers can deliver technology to Pakistan's farmers: The case of rice

**The state of mechanization in Pakistan:** In Pakistan, farm mechanization is taking place most commonly through informal service providers who import scrap machines from the Far East (China, Thailand, Vietnam, etc.). These machines have typically run their use life already and hardly any duty has to be paid for them. The import of the farm machines is generally through a registered company but the sales of these services to farmers are in cash and without any encumbrances of taxes paid to the government.

The skill of the machine operator makes or breaks the service delivered to farmers. And even in this landscape, there are expert machine operators who can also play the role of on-farm mechanics. This is important because the scrap machines meet frequent on-farm breakdowns while these services are being provided. The lack of parts inventory for these machines means delays in harvesting or sowing for farmers—these are parts of the cultivation cycle when time is literally money.

**Globally, mechanization has been driven by the shortage of labour.** The geographical regions where agriculture depends on wage labour (such as northern Punjab and lower Sindh) are already embracing mechanization of harvesting and, more gradually, mechanization of sowing. The shortage of labour during the harvest period is facilitating mechanization. For example, in northeastern Punjab's Kalar Tract—the Basmati region—rice harvesting has completely shifted to mechanical harvesters which has reduced the harvest period from 5-6 weeks down to a mere twenty days. This changes the commercial dynamics significantly for farmers preparing for the next crop as well as for traders. Similarly, lower Sindh faces serious shortages of labour particularly rice-growing areas around Karachi from which labour shifts to urban areas. Mechanization of the rice crop is also finding a home in this area. By contrast, upper Sindh and parts of southern Punjab where the sharecropping system dominates and labour is bound to the land, mechanization is not making much progress.

Figure 6: Shifting rice from manual to mechanical




**The need to upgrade machinery-based service providers:** The shortage of labour is only one key driver of mechanization. Advancing the example of the rice sector, whose exports have stagnated in the range of US$ 2-2.5 billion over the past decade, the modernization of harvesting and sowing is a need of both farmers and exporters to get higher yield from the same cultivated area. Pakistan's Basmati rice crop is now harvested mechanically but the harvesters used are old and mostly intended for wheat. According to a NARC study[2], yellow-colored New Holland combine harvesters seen across Pakistan during the harvest season led to rice grain losses of 5-19 percent while the scrap rice harvesters have grain losses of 2.2-5%. By comparison, a 2020 ADB study measured grain losses of new harvesters to be significantly lower: Thinker (1-2.5%), Kubota (0.8-3%). Grain breakage was also much lower for the new rice-only machines.

The adoption of imported hybrid seed in rice has increased yields but not to the level it can—mainly because sowing is not mechanized. Rice sowing is typically done in two stages: nursery-raising and transplantation. Since rice plants are highly vulnerable in the first 2 to 3 weeks after sowing, they are planted in a concentrated 'nursery' on half an acre to eventually cultivate fifty acres. After this initial period, the traditional method is to manually uproot these seedlings and transplant them all over the 50 acres. As figure 6 shows, this is back-breaking work done mostly by female labour while standing in the sweltering heat of June in about eight inches of standing water—the traditional practice of flood irrigation. An increase in Pakistan's rice exports clearly requires a shift from traditional nursery raising and manual transplantation of seedlings to nursery-raising in trays which allows transplantation by machines.

2 National Agricultural Research Center (2017). Factors causing low head rice recovery in combine-harvested paddy, Tanveer Ahmed, Zulfiqar Ali, and Hafiz Sultan Mahmood. https://inis.iaea.org/search/search.aspx?orig_q=RN:50046429

**Traditionally, government policy focused on machine ownership by individual farmers.** But machine ownership requires scale. A rice transplanter achieves eight acres a day and 88% of Pakistan's farms are less than 12.5 acres. Modern machines are complex and require daily maintenance which means that properly trained operators are essential. For applications such as transplantation, the interaction between machines and the soil and conditions in each agro-climatic zone need to be understood for achieving results. This requires trained agronomists and entomologists. Finally, an inventory of frequently atrophied parts is needed to rapidly address on-farm breakdowns. All this needs capital and scale. This is why existing informal service providers need help to upgrade; new service providers are required in the formal sector.

**The trajectory of rice mechanization in Vietnam in the past two decades[3].** At the turn of the 21st century, Vietnam's farmers were using imported second-hand combined harvesters from Japan, China and Thailand, as Pakistan's farmers are doing today. During the first decade of this century, some 15 Vietnamese companies were competing to produce their own designs. In parallel, small service providers were importing cheap Chinese machines and offering services to farmers. By the end of the decade, with vigorous incentivization of rice exports by the government, a massive rise in rented machinery services took place both among large farmer and small farmers while ownership of machines by farmers stagnated at a low level. With the shift towards quality machines for service provision, the Japanese brands Kubota and Yanmar had 95 percent of market share by 2015 with only 2 local brands operating. With the expansion of the market for new machines, Kubota has started manufacturing combine harvesters in Vietnam. The availability of appropriate technology for small farmers has allowed them to stay competitive as farm wages rose. Vietnam's small farmers also 'aggregated' their farm holdings under the 'small farm, large field' model to gain scale. The Government of Vietnam also required rice exporters to purchase 10 percent of their rice paddy directly from farmers rather than middlemen. This incentivized rice exporters to support the upgrade of farmers' cultivation methods.

**The need for modern service providers has been understood by leading rice exporters of Pakistan.** Investment has been made in farm mechanization by companies like Jaffer Brothers, Meskay & Femtee Trading, Garibsons, MM Commodities, Conwill Pakistan, RBI, etc. In parallel, global rice machinery brands have also appointed agencies in Pakistan: Kubota of Japan, Fuerdai of China, TYM of South Korea, etc. But mechanization demands scale. As done in Vietnam, Pakistan needs to transition towards local manufacturing of modern farm machinery. This will require building a national fleet of new machines that justifies machine manufacturing in Pakistan. Government and donor institutions must support large-scale training of farmers, machine operators, helpers, mechanics, and agronomist to populate this eco-system. The import of machines older than a certain number of years must be gradually phased out. The service providers in the informal sector must be facilitated to upgrade their machinery fleets as well as staff expertise to be able to provide better services to farmers.

3 IFPRI (2018). *Evolution of Agricultural Mechanization in Vietnam.*

## Building the backbone for Pakistan's fragmented fruit and vegetable value chains

Figure 7: A good crop can die at the mandi


**The fragmented structure of Pakistan's fruit and vegetable value chains destroys value from end to end.** At the production level, small holder farmers dominate with limited scientific and technical knowledge of their crops. More importantly, they have low awareness of the requirements of export markets. The wholesale markets are also fragmented with intermediaries taking a short-term 'trader mindset'. This part of the chain has opportunistic players with few long-term relationships. There is hardly any investment in quality at these markets and little value addition associated with them. Next, there are a limited number of processors—with few direct links with farmers—with some export. Ninety percent of Pakistan's fruit and vegetable output is consumed domestically. The links between wholesale markets and end-consumers are mostly small, traditional retailers with informal quality standards. The produce that is exported is typically through fragmented, small exporters who deliver mixed quality and mixed branding for Pakistan as a source. The lack of cool chain infrastructure causes post-harvest losses of 2 to 4 times higher than good practice in other countries.

The main constraint to realizing the growth potential of this sub-sector is the broken link between growers and export markets. This vicious cycle of low investment, low productivity, and low profits results in poor branding: Pakistani produce fetches lower prices in export markets than comparator countries. Therefore, yields are often forty percent lower than comparator countries. At the core of this under-performance is weak demand pull for quality produce in larger quantities. If there is one element that can completely change the landscape for these perishable commodities, it is investment in cool chain infrastructure. But, as in other cases presented in this paper, the introduction of technology requires a different commercial arrangement which aligns the incentives for investment in technology. Growers also clearly articulate their need for an off-take guarantee to start making on-farm investments.

The commercial driver for this development is guarantee off-take of not only the fruit and vegetables but also of the cool chain infrastructure's services. No serious investment in an entire cool chain can be justified without a significant off-take commitment to ensure adequate capacity utilization. And since only a small portion of Pakistan's local markets and end-consumers for fruits and vegetables value quality and pay extra for it, an off-take commitment linked to the global export markets is what will fit the bill.

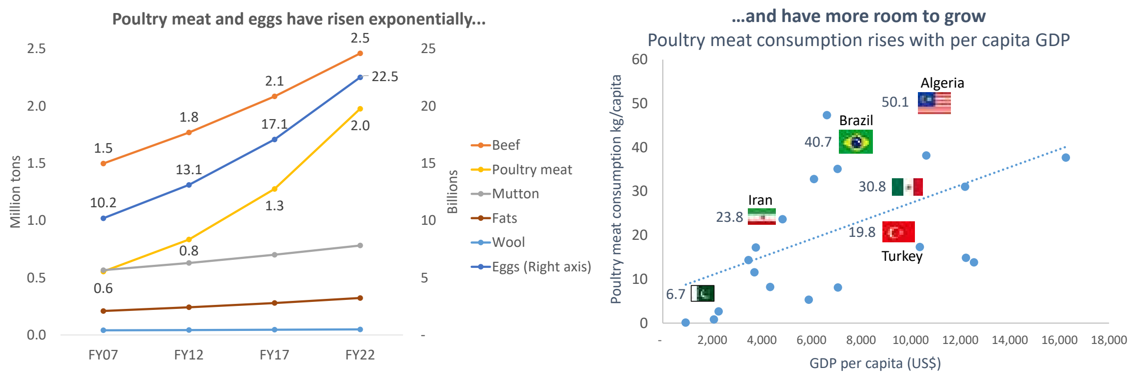
**Global players are needed to upgrade Pakistan's fruit and vegetable value chains.** Food majors need to be attracted to Pakistan under an arrangement of off-take guarantees for global export markets to justify the investments in cool chain infrastructure. The same off-take guarantees can be extended back-to-back to farmers to incentivize their on-farm investments and delivery of produce. Many larger farmers express interest in developing collection points on their premises by hosting pack houses, but only if the requisite off-take guarantee and some capacity building can be offered.

## Pakistan's poultry sector is a success story of growth through technology

Pakistan is the 11th largest producer of poultry in the world with 1.7 million poultry birds which have quadrupled in the past 15 years. In 2022, the output of these birds was 22.5 billion eggs and about 2 million tons of poultry meat. This poultry farming sector is globally competitive on quality. State-of-the-art facilities are installed at some 70 percent of the parent stock farms and about 60 percent of broiler farms (see Annex A for explanation).

**The rise of poultry in Pakistan is founded on the introduction of technologies right along the value chain.** This made continued growth possible. Two technologies stand out: controlled sheds introduced in the mid-1980s (see Annex A) and hybrid maize seed introduced in 2001. Controlled sheds were a game-changer because the poultry feed conversion (or feed-to-meat) ratio deteriorates if temperatures are outside the recommended comfort zone for chickens. Controlled sheds provide the optimum environment to obtain better feed conversion ratio, uniform air movement, lower medication cost, and lower bird mortality. All are critical for the profitability of poultry farming.

Figure 8: The past and (possible) future of Pakistan's poultry sector




*Source: Economic Survey of Pakistan 2022*

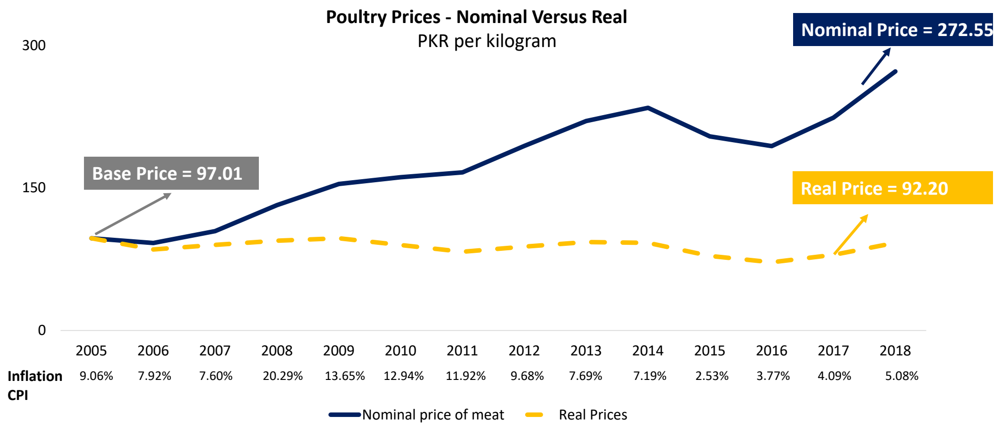
*Source: OECD 2022*

Poultry feed is a significant component of the cost of poultry farming. Modern poultry feed typically comprises some forty five percent maize, twenty percent soybean meal, and the rest is agriculture and livestock residue and by-products. The rising adoption of hybrid maize seed since 2001 has led to a tripling of maize yields from 18 maunds per acre nationally to 60 maunds per acre according to the Economic Survey of Pakistan (mechanization of maize cultivation can increase it further). And, as farmers continued to switch to maize, the area under this crop has also continued to increase. Maize farmer's profitability has risen with this. Today, more than 70% of the maize grown in Pakistan goes towards poultry feed mills. Import of soybean (which began in 1984) has also improved the feed mix given to poultry which has improved the productivity of the sector. This sector is the largest consumer of agriculture and livestock residue and by-products: oilseed meal, wheat bran, rice polish, broken rice, etc. In 2018-19, residues made up ten million tons of poultry feed. So, the rise of poultry has also lifted other sectors with it.

A thriving poultry value chain can convert imported grandparents into exportable processed poultry products. Import of chicken with high genetic potential has made this growth possible. Some 95 percent of Pakistan's poultry is now grown on commercial farms. These birds have the genetics that can respond to this modern nutrition. The traditional 'desi' chickens would not gain weight from the same nutrition since they do not have the suitable gene pool for it. The scale-up of poultry production through technology has actually allowed the price of poultry meat to fall in real terms, i.e., after eliminating the rise due to general inflation (figure 9). This is the way to identify the change in prices due to factors internal to the poultry sector rather than changes in the general level of prices.

The success story of poultry bears lessons for growth in the wider agriculture sector. First, for sustained growth, technology additions have to be facilitated right along the value chain, not just in one link of the chain. Second, import of genetic material is critical for high productivity. And, equally important, scale-up in production levels can make the end-product more affordable for the public.

Figure 9: With technology, the real price of poultry has fallen




*Source: World Bank, IndexMundi*

## Welcoming the fourth industrial revolution

In recent years, a number of start-ups have begun to develop agri-tech solutions to solve problems in Pakistan's agriculture sector. A few broad categories of 21$^{st}$ century agri-tech are arriving in Pakistan. One category operates in digital financial services. An example is Ricult: a company which uses agronomy and profile data to assess farmer affordability for financial services. The data helps develop financial products that fit farming cycles better and provide improved risk management for banks and institutions with better financial access for farmers. Another category is focused on aggregating inputs and outputs. For example, Jiye Technologies operates a platform that provides farm inputs, yield enhancement advisory, information on market prices, farming contracts, and trade agreements to farmers and also helps link the farmers to retailers. A third category aims to bring efficiency in 'last mile' deliveries between the 'mandi' and the end-consumer. The most celebrated among these is Tazah Technologies which started in late 2021 to bring efficiency in the last mile of horticulture value chains. However, they subsequently pivoted to trading of grains under their brand Tazah Global. Another focus is precision agriculture: Sapphire is offering drone-based spraying solutions. It is often argued that agri-tech ideally performs in tandem with the technologies of the third industrial revolution, not just the second industrial revolution. The jury is still out on this.

## Conclusions and policy priorities

For growth in agriculture through technology, the most important conclusion is that a shift in the technology of production is ideally driven by the demand side. In Pakistan, the demand for greater environmental and social sustainability with fully traceable sourcing of cotton is becoming a driver for leading textile players to invest in mechanized cotton cultivation. Rising demand in global rice markets has driven leading rice exporters to bring hybrid rice seed to Pakistan and invest in farm machinery service providers. The ability of such investments in technology to bring scale, reduce cost, make agri-commodities more affordable for the public, and make exports competitive has been demonstrated amply by Pakistan's poultry industry. But introduction of technology usually requires new commercial relations.

Processors who have invested deeply in 'backward integration' to form deeper connections with farmers through contract farming have already set good examples: Rafhan in maize, JDW in sugarcane, Nestle in milk, etc. But scaling up the adoption of technology across Pakistan's small-to-medium-sized farms requires another type of entity: the farm machinery service provider. Service providers large and small, formal and informal, must be supported actively to upgrade cultivation at both large and small farms. Service providers are the entities which can facilitate farmers' shift to cultivation practices that complement mechanization. A shift from scrap machines to a national fleet of new machines is needed to move Pakistan towards local manufacturing of globally competitive farm machinery. Training is a must.

For sustained growth, technology additions need to be facilitated right along the value chain. The poultry sector's growth bears the examples of controlled sheds introduced in the mid-1980s and hybrid maize seed introduced in 2001. Invariably, the continuous introduction of better genetic material, whether in the form of seed for crops or grandparent stock for poultry, is the fulcrum of growth in productivity.

Some segments of the agriculture sector (such as the fruit & vegetables supply chains) require the introduction of global players that can ensure guaranteed off-take for global export markets. This assured market makes larger investments in cool chain infrastructure and on-farm technologies more feasible.

Overall, the 'pull factor' from processors and the existence of service providers may not translate into a nation-wide wave. The international experience indicates that the cost of agricultural labour is a more important determinant of the demand for mechanization than cost of capital.[4] The movement of labour to industry typically drives labour shortages in rural areas which create the need for mechanization. This is already visible in large parts of Pakistan's agriculture landscape. But complementing this trend, a transformation of the agriculture sector is required from supply chains dominated by government decisions and 'permanent winners' towards more competition and market-based commercial relations.

The international experience shows that in countries where agricultural wages are low and the reform is not taking place (in markets for farm inputs on one end and agri-commodities on the other), policies to increase farm mechanization based on subsidized finance to reduce the cost of capital are likely to have limited impact on agricultural growth. Mechanization alone cannot solve the broader problems of agriculture such as lack of reform in inputs and agri-commodity markets, weak financial systems, and poor business environments. A broader will to infuse competition and higher growth is critical for catapulting agriculture to the next level. Long-standing protections to key domestic industries like tractors must go!

4 The World Bank (2010). F*arm Mechanization: A New Challenge for Agriculture in Low and Middle Income Countries of Europe and Central Asia,* World Bank Working Paper No. 53318-SAS, page 59.

# WATER FOR EQUITABLE GROWTH

# II. Water for equitable growth

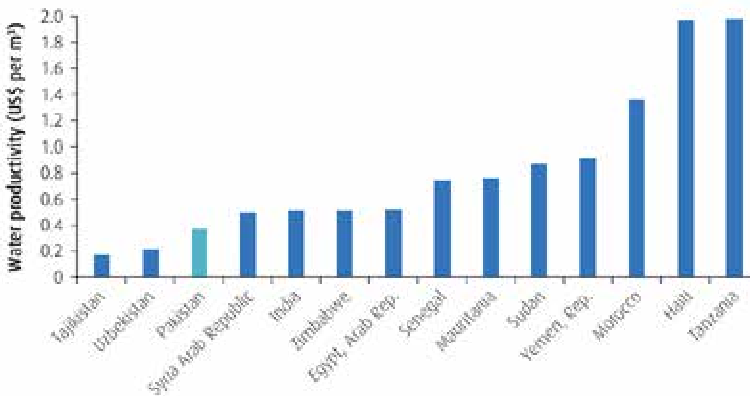
Contrary to popular perception, Pakistan is not running out of water—not just yet. The common refrain about Pakistan's water resources is that 'freshwater available *per capita*' is falling. But, as Annex B explains, the available freshwater has generally remained constant over the past decades. It is the population that has been rising—hence the fall in per capita freshwater available. **This chapter focuses on utilizing Pakistan's water resources in the agriculture sector to maximize economic growth.** In doing so, it outlines the real water-related challenges when it comes to the agriculture sector: serious water wastage, the state and management of the irrigation system, unrestrained withdrawals of groundwater, deteriorating water quality, and the coming impact of climate change on Pakistan's water resources.

## Water productivity is key

**For growth, water productivity (i.e., value created from each unit of water) is more important than water availability per capita.** Figure 10 shows that Pakistan is creating little value from its water even compared to a cohort of countries with comparable levels of water availability, low GDP per capita, high proportion of water used in agriculture, and importance of agriculture in GDP.

**Pakistan is among the few countries where more than 90 percent of the freshwater used by the country is devoted to agriculture.** To put this in perspective, on average, the countries of the world have the following distribution of the freshwater they use: 70 percent in agriculture, 20 percent in industry, and 10 percent in municipal uses (drinking water, public uses in towns, etc.). Pakistan's distribution is 93 percent in agriculture, 6 percent in industry, and 1 percent in municipal uses. The question of low water productivity is mostly a question of low productivity of water in agriculture.

Figure 10: Pakistan must create more value from its water




Countries with (i) >80% water used in agri, (ii) agri > 10% of GDP, (iii) water available per capita <3,000 $m^3$ per annum, (iv) GDP per capita: US$800-4,000

*Source: World Bank 2019*

**Within agriculture, the five major field crops dominate water consumption.** Pakistan's farmers predominantly follow a two-harvest system for field crops: a summer cultivation season called '*kharif*' and a winter cultivation season called '*rabi*'. During *rabi* (winter), wheat is cultivated on more than 80 percent of Pakistan's farms while during *kharif* (summer), generally four major crops compete for acreage: cotton, sugarcane, rice, and corn (maize). During *rabi* (winter), wheat accounts for 79 percent of water consumption. During *kharif* (summer), cotton, sugarcane, rice, and corn consume 94 percent of water.

In the past two decades, the area under wheat, the main rabi (winter) crop, has risen by 11 percent to reach about 22 million acres in FY22. Of the crops cultivated during kharif (summer), a momentous expansion has been witnessed in rice (up 49 percent to 8.7 million acres), maize (up 75 percent to 4 million acres), and sugarcane (up 31 percent to 3.1 million acres). These enormous increases have been at the expense of the area under cotton (down 34 percent to 4.8 million acres). While some agro-climatic zones are more suited to some of these crops than others, over the past couple of decades, multiple failures have led to a sub-optimal distribution of crops by geographic area. But this depends on farmers' crop choices.

**Like any entrepreneur, the Pakistani farmer makes business choices based not only on profitability but also the risk calculus.** Figure 11 presents the value of water from the policy point of view compared to the farmer's business point of view (figure 12). The policy priority is that the highest value is generated from each drop of freshwater used in Pakistan. Figure 12 shows that a farmer can earn more per acre by growing sugarcane, but because of a higher water requirement, the productivity is lower than cotton.

From the farmer's business point of view, the value generated per acre is the priority. On this count, the opposite result appears for sugarcane as it emerges the most preferable while rice paddy (averaged between Basmati, IRRI, and hybrid varieties) emerges at the bottom. The clear winner, though, is horticulture which generates many times more value per drop even with conventional irrigation—and more value per drop by an order of magnitude with high efficiency irrigation system such as drip irrigation.

Figure 11: Policy priority: Fruits and veg are highest

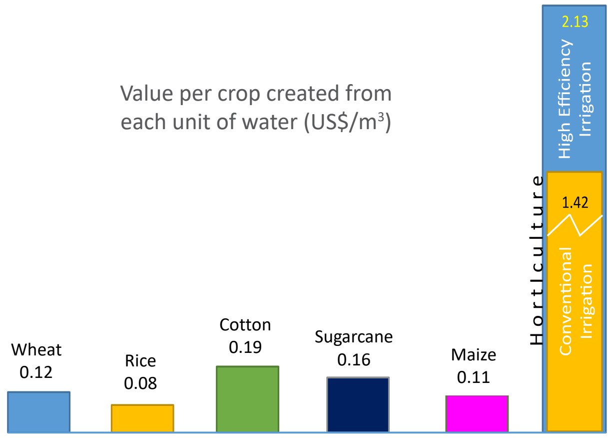
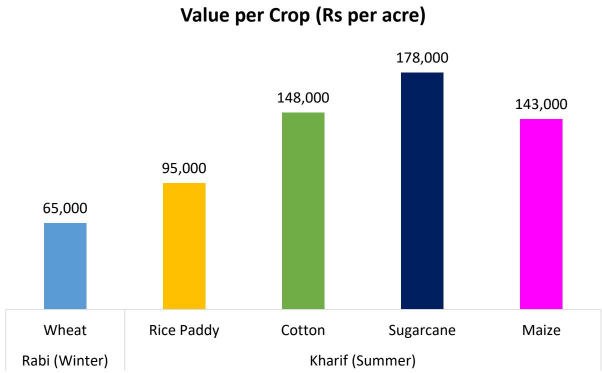



Figure 12: Farmer preference: Sugarcane is highest




*Source: FAO 2020*

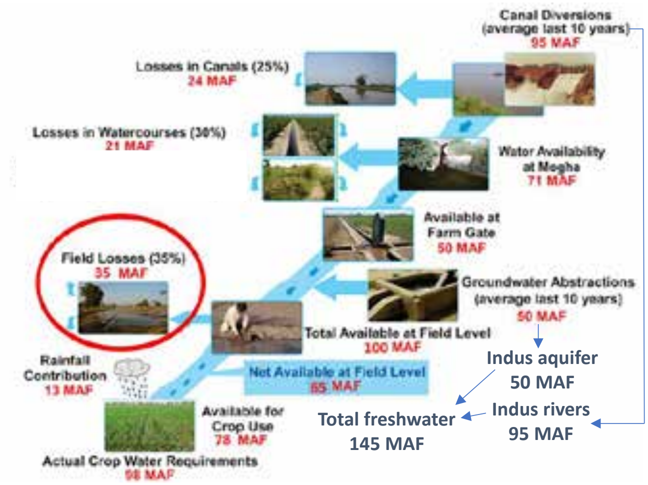
**Farmers' views on profitability and risk associated with each crop are shifting them towards crops that consume more water per unit of farmland (e.g., sugarcane) while the policy priority of 'more value per drop' favors cotton.** This situation illustrates the classic challenge of economic policy: to incentivize business decisions to align with national policy priorities.

In such situations, the obvious measure of economic policy is to increase the price of water in a way that the farmer's profitability is impacted in favor of cotton and maize in areas where they can replace sugarcane. But farmers' crop choices are unlikely to change in this way if other major risk factors are not addressed. For example, the reduction in the area under cotton in favor of other crops, particularly in the cotton heartland in southern Punjab, is a critical issue for Pakistan. Figure 11 suggests that, from a policy point of view, farmers should be incentivized to shift from sugarcane to cotton. But farmers have seen serious uncertainties associated with the cotton crop, particularly, the vulnerability to pink bollworm in the absence of modern seed, untimely and excessive rains with unsuitable drainage on farms, etc. This has rendered the cotton crop financially unviable for many farmers.

## Pakistan's key water-related challenge is the wastage of water

While available freshwater resources have remained stable (see Annex B), Pakistan's water consumption has remained constant in proportion with withdrawals showing little improvement in water use efficiency. To reduce the amount of water withdrawn for agriculture, improvements to the productivity of water must be addressed. Water productivity is basically the amount of GDP created per drop of water. Pakistan's current water productivity is the eighth lowest in the world at $1.38 per cubic meter of water withdrawn from the Indus River Basin and the Indus aquifer (see Annex B). The total water withdrawals are the fifth highest in the world (World Bank, 2019).

Figure 13: Every drop counts: water loss at each stage




The main source of low productivity stems from inefficiencies within the delivery system of water from the Indus Basin Irrigation System to the farm gate and from the on-farm application of that water to the crop root. Figure 13 demonstrates that only a fraction of the water that is diverted from the Indus River System reaches the crop. Conveyance losses within the canal system account for an average of 25 percent losses to the watercourse outlet to the farm-gate. These have been estimated at 30 percent too (Jacoby et al., 2018). This means that, of the 95 million acre-feet (MAF) of water diverted from the Indus River System 24 MAF is lost in canals through seepage and evapotranspiration. This leaves 71 MAF at the canal outlet (*mogha*) level. From there, an estimated 30 percent is lost in tertiary watercourses leading to farms—these are often unlined. This means that of the 71 MAF available at canal outlets, another 21 MAF are lost till the farm-gate. But each farm has multiple fields within it which receive water for cultivation.

**Of the 95 MAF diverted from the Indus River System to the irrigation system, only 50 MAF is available at the farm-gate.** Farmers draw about the same amount of water from the Indus aquifer through tube wells. But field losses are in the range of 35 percent so only 65 MAF is available to farmers. Traditionally, water is applied through flood irrigation methods. Lack of laser land levelling is a key reason for over-watering in large parts of Pakistan's agriculture landscape. If the land is not suitably levelled, the plants in a trough on the surface will suffocate with too much water and the plants on a crest on the land will have low water availability. Farmers typically water their fields to the level required by the plants on any trough. This and other reasons for flood irrigation can result in further losses estimated at 40-60 percent in many cases (Akbar et al., 2016; Sajid et al., 2022). The monsoons add about 13 million acre-feet of water to the 65 MAF available to farmers from the irrigation network and groundwater (the Indus aquifer).

Farmers get 78 MAF for farming against an estimated crop requirement of 98 MAF. This shows that Pakistan's irrigation system is highly inefficient and requires major improvements of these delivery systems to improve water use productivity and support economic growth.

**This low water use efficiency is attributed first to the state and management of irrigation infrastructure.** This system is often flaunted as the world's largest contiguous irrigation network. But the operation and maintenance of this infrastructure is far from adequate. Celebrated water expert John Briscoe famously wrote that Pakistan's business model for its irrigation system is the 'BNR model': the Build-Neglect-Rebuild model (Briscoe & Qamar 2006). Much of the infrastructure is not being maintained and functions at low performance. For example, Pakistan largely missed the opportunity to remove the sediment getting deposited in the reservoir of Tarbela Dam. As is often quoted, Pakistan has a very low capacity for water storage. The Indus River System can barely hold 30 days of average flow compared to over 900 days for the Colorado River in the USA and the Murray-Darling system in Australia.

Tarbela Dam and Mangla Dam have reduced capacity by 29 percent and 21 percent respectively due to silting and sedimentation (Haq & Abbas 2012). The volume of sediment accumulated in the reservoir is now too large for removal to be practical. The result is that the dams can store less water stored for the dry season than the original design capacity and they can overflow during monsoons. Adequate maintenance expenditure would have maintained the storage levels close to the original level. The cost to remediate sedimentation in Tarbela Dam would have been a fraction of the total annual maintenance cost of Pakistan's irrigation system. Today, the sedimentation is too large for practical removal. The more viable solution to relieve sediment build up now would be to finish construction of the upstream Diamer Bhasha Dam (World Bank, 2019).

**Flood irrigation is often used on-farm because water delivery is unpredictable** ("fill up while it's flowing!") or to keep weeds from growing right after sowing (as in rice paddy) or because soils are suffering from salinity. The result is that, it has often been observed that reductions in the amount of water typically used during irrigation actually improved water use efficiency and they could grow more by using less. In Dera Ghazi Khan, cutting water from 500mm to 250mm only decreased yields by 5-16 percent, while greatest water use efficiency was at 153mm (Jabeen et al., 2021). But the unpredictability of water for farmer is linked to the approach of Pakistan's irrigation system to water delivery.

## The irrigation system is supply-driven rather than demand-driven

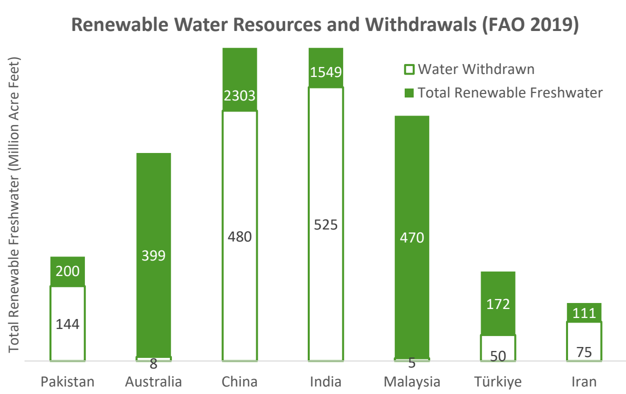
In agriculture, water delayed in water denied. If plants do not receive water at the times they require water (and fertilizer which is delivered with water), they cannot grow optimally. This impacts yields and therefore growth in agriculture. The *warabandi* system of fixed-turn water allocation allows farmers to take a certain amount of water at a certain time of the day once every week (or every 10.5 days). The amount of water available to withdraw is proportional to the size of the farm, not to the demand of that farm based on the requirements of its crop. Gravity-driven water distribution in the canals is often inadequate at the tail ends which, on average, only receive 60 percent of designed supply (Mirjat et al., 2017). This is not only because of technical reasons but also due to water theft by more powerful farmers in connivance with irrigation officials. Canals typically perform less adequately in early-summer low-flow situations averaging 25 percent less than their designed supply. Farmers that require frequent watering to support different stages of crop growth or who are at the canal tail are then forced to address demand by pumping groundwater, which is not regulated under *warabandi*.

An example from the canal tail illustrates this point. Pakistan's capital of red chili cultivation is Kunri, in Sindh's District Umerkot, where the uniquely round *dandicut* (or *longi*) variety of red chilies are grown because growing conditions are ideal. But water is the limiting factor. When seedlings are transplanted onto the field, they require frequent watering to establish roots, more frequently than *warabundi* currently provides (Pakistan Planning Commission, 2020). In the drought conditions of 2018, mistiming of water supply compounded with low flows at the canal tail end which left red chilli farmers with no ability to achieve their expected yields. With no reliable groundwater in the District Umerkot area to compensate for the lack of canal supply, cropped area was reduced to 40 percent (Daily Dawn, 2018).

## Groundwater from the Indus aquifer is critical for Pakistan's agriculture

Pakistan has an estimated 200 million acre-feet of total renewable freshwater including groundwater sources. As figure 14 shows, Pakistan withdraws over 70 percent of these freshwater resources each year which is among the highest among comparator countries in the world (FAO AQUASTAT 2019). China and the India both withdraw more water every year than Pakistan, but only 21 percent and 36 percent of their total freshwater resources, respectively. With an enormous proportion of water being withdrawn for Pakistan's agriculture, water use efficiency in both irrigation and agriculture must be prioritized.

Figure 14: Pakistan withdraws more of its water



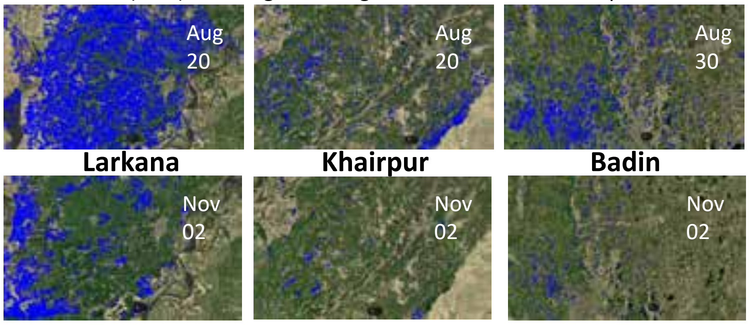
In the areas that are now Pakistan, modern irrigation started in the 1860s. Over the subsequent decades, substantial amounts of water seeped through the canals and added to the Indus aquifer. Over time, the groundwater table rose from over fifty feet below the ground surface to ten feet below the surface causing issues of waterlogging and salinity in the 1960s. These issues were addressed through the Salinity Control and Reclamation Project (SCARP) which introduced over 12,000 public drainage tube wells to control the groundwater table and release the freshwater back into the canal system. This was an ingenious way to draw water out of the Indus aquifer while putting it to good use. The program succeeded in reclaiming waterlogged lands and simultaneously increased the water supply which improved cropping intensity. In the 1970s, performance issues of the public wells and increasing operational costs forced the program to transition towards subsidizing the installation of private tube wells for farmers. There was already growing interest from farmers who wanted continuous access to the very shallow aquifer at that time. This sent the pendulum swinging far in the other direction leading to a rise in the number of tube wells in Pakistan from 30,000 in the late 1960s to over 1.2 million in 2020 (Qureshi, 2020). Today, Both Pakistan and India are drawing water from the Indus aquifer faster than the rate of water re-charge back into the aquifer. This is leading to a lowering of the water table. Neither the Indus Water Treaty of 1960 with India nor Pakistan's inter-provincial Water Accord of 1991 deal with the allocation of groundwater from the Indus aquifer. Both instruments should be upgraded to make them comprehensive.

**Farmers are protesting against rising electricity tariffs for tube wells because groundwater is nearly half of farmers' water supply today.** Pakistan is the world's fourth largest user of groundwater and meets nearly half of the irrigation requirement with groundwater (Khalid & Qaisrani, 2018). Nearly 90 percent of the tube wells are in Punjab due to lower salinity and relatively higher water quality. Most of Sindh has saline groundwater which means that any water that flows into the aquifer is lost forever. However, the relentless pumping of groundwater has now lowered the water table back to or below pre-colonial times. Canal tail users are caught in a feedback loop of increased reliance on groundwater when canal water is insufficient, but also are farming in the reaches of the aquifer that are least fed by seepage. The cost of pumping from a shallow well (less than five meters) is US$4.5 per thousand cubic meters versus US$15 from a deep well (more than twenty meters). The cost of installation of an electric deep well is ten thousand dollars versus one thousand dollars required for a shallow well. Increasing fuel and energy prices have also increased operational costs, straining the farmers' ability to withdraw needed water.

**Irrigation is not just about delivering good water—it is equally about removing bad water safely so that soils are healthy for the next crop.** But effective drainage is a challenge in Pakistan. The failure of the cotton crop in 2020 was caused by a combination of pink bollworm attacks and excessive, untimely rains. The lack of drainage meant that rainwater stood and devastated crops.

Figure 15: Which district has more effective drainage?

Water (blue) standing after August 2022 floods in Sindh province




*Source: Satellite images from Pula Advisors (2022)*

Fields that do have drainage infrastructure have, in some cases, released agricultural run-off into key water bodies that have been rendered unusable. The most extreme example is Manchar Lake in Sindh province which has been so polluted by the Right Bank Outflow Drain that fish populations have plummeted, and the health of the local people has suffered (Mahesar et al., 2019). Fields that do not have drainage or have been impacted with secondary salinity require contaminant flushing through irrigation, pumping of unusable water, or abandonment of the field.

## Drainage and water quality are critical issues to address

**Neglected water quality is harming health and is a threat to agricultural exports.** Surface and groundwater downstream of tanneries on the Sutlej River have shown severe levels of water quality degradation thereby affecting human health, ecology, and local agricultural production (Atique et al. 2020). Effluent from leather tanning production re-enters soil and surface waters as recycled water from the wastewater treatment plant (Abbas et al. 2012). This contaminated groundwater has led to increased cases of water-borne diseases such as typhoid, cholera, cancer, kidney failure, and more (Ali et al. 2022).

Pumped groundwater is increasingly drawn for household and drinking use, particularly where water supply is limited or because it is safe from microbiological contamination. However, this groundwater often contains unsafe concentrations of total dissolved solids and heavy metals. Water quality indices show that groundwater in Sindh is most often unsuitable for drinking purposes based on WHO standards from Larkana to the Thar Desert (Lanjwani et al., 2022; Jamali et al., 2022; Khuwahar et al., 2019). Surface water quality is also deteriorating, caused by untreated effluent from industry and agriculture.

The Chenab River, for example, receives waste from the industrialized city of Faisalabad, agricultural run-off from adjoining agricultural districts. The downstream stretches of this river are highly polluted. The poor quality of the Chenab's water is particularly acute during low flows, when concentrations of effluent are much higher relative to freshwater input (Kausar et al. 2019). With less flow in the river due to upstream withdrawals, this can harm those who use the nearby water, illustrating another reason why appropriate management of canal diversions is crucial.

## Climate change is expected to seriously impact Pakistan's water resources

The flow of the Indus River System is controlled for much of the year by glacier (permafrost) melt and snow melt, while fluctuation in monsoon strength has a large impact on peak flows in summer months. Climate change will have varying effects on both natural inputs, increasing glacier melt and altering the predictability of monsoonal rainfall. The projections of glacier melt are not yet an exact science but there is emerging consensus that melting glaciers may increase flows in the short-term, but flows may decrease 30-40 percent in the later part of the 21st century (Habib & Wahaj. FAO. 2021). Projections for rain indicate large year-on-year variability suggesting increased volume of rainfall on fewer rainy days (Parry et al. 2017), as is already evident by recent intense drought and heatwave periods followed by flooding. Sindh had received 30 percent of the usual rain during the monsoon season in 2018. Just four years later in 2022 the province received rainfall that was more than 500 percent above the average for the monsoon season (Pakistan Meteorological Department). An added challenge to water resource management will be: how to adapt to the changing conditions of extreme weather events given the state of glacier and snow melt.

## Conclusion and policy priorities

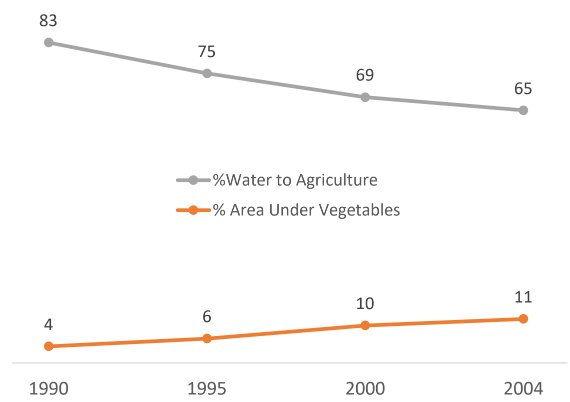
**The highest priority of this decade must be to reduce water wastage** both in the irrigation system and on-farm. The focus of Pakistan's public discourse on water has been dominated by the construction of dams. While adding more water storage is critical, the more mundane activities need to be performed with care and integrity.

**Pakistan's irrigation system needs a serious upgrade.** Pakistan's overall water productivity is low because of the massive water losses in canals, tertiary watercourses, and on the farms. The major challenge of conveyance losses from canal delivery will require substantial interventions in policy, governance, and infrastructure improvement for these on-farm actions to succeed. Farmer choices to flood irrigate, overdraw groundwater, and plant crops with low water productivity is highly influenced by the unreliability and low financial performance of current irrigation system. Priorities are needed to improve lining and drainage where the most benefit can be achieved from waterlogged and saline areas. Canal lining efforts have proved successful, for example, in Mirpur Khas where cultivated land nearly doubled off some watercourses after canals were improved (Zaidi et al., 2022). Increasing the value of canal water will require a comprehensive water monitoring and metering system that can properly account for the movement of water within the system. To recuperate operation and maintenance costs, an equitable pricing system will need to be developed based on transparent and precise quantities of water delivered to farms, particularly small farms and farms at the canal tail. Better governance of irrigation is the key.

For each crop, the water productivity is low partly because of low crop yields but also because of the significant on-farm wastage of water primarily through flood irrigation. Water pricing is unlikely to shift the crop choices of farmers without resolution of major challenges in crops like cotton. But it is reasonable that water pricing is set to at least collect the operational and maintenance costs of the irrigation system. The fact is that farmers' opposition to even this level of increase in the price of canal water is because they do not earn enough from their crops. The yields are too low for Pakistan to charge a reasonable price.

**Pakistan's acreage under horticulture (fruits & vegetables) must rise from 5 percent to 15 percent.** The domination of Pakistan's cultivable acreage by only five field crops means that these crops significantly dominate not only land but also water, human resources, etc., as well. China's historic shift between 1990 and 2004 from four percent of its acreage under horticulture to 11 percent of its acreage under horticulture created a global boom in the production of dozens of fruits and vegetables. This period saw China's water devoted to agriculture fall from 83 percent to 65 percent. Pakistan must increase the proportion of its cultivable acreage under horticulture from 5 percent to 15 percent within this decade. The introduction of high efficiency irrigation systems on these orchards must be supported financially.

Figure 16: China: Rise in vegetables led to fall in water use




*Source: World Bank, FAO*

**High efficiency irrigation systems must spread further to generate more value per drop.** These systems include drip irrigation, sprinkler irrigation, center-pivot irrigation, etc., which have application efficiencies and yields much greater than flood irrigation. For example, drip irrigation applies water and fertilizers close to the crop roots as per the plant's requirement, wetting only a fraction of soil surface therefore reducing water lost to evaporation. Application efficiency for drip is consistently above 90 percent and increases yields between 20 and 40 percent for cotton, sugarcane, and wheat (Sajid et al., 2022; Baksh et al., 2015, Singandhupe et al., 2008; Aujla et al., 2005). Cost and know-how are the largest barriers to adoption of high efficiency irrigation though, with World Bank support, Punjab and Sindh have developed their own provincial projects to subsidize costs.

**Laser levelling must become a norm across Pakistan's cultivated area.** Laser levelling is a crucial step in preparing efficient fields such that water is evenly distributed without pooling or major runoff. In Sargodha, laser levelling improved water use efficiency by 33-38 percent, increased yields 6-10 percent, and supplemented incomes by 32 percent after including costs (Ashraf et al., 2017). Laser levelling in upper Sindh is critical to save water but even the initial earth moving works have not been conducted on farms there after which laser levelling can start its work. This initial activity must be encouraged so that. On farm storage developments accumulate excess water and help farmers address water insecurity for farmers when canal flows are low. They may also help with addressing water quality by draining excess water during heavy rain, controlling soil erosion, and recharging groundwater in the nearby vicinity.

**The Indus aquifer must be safeguarded.** The withdrawals from the Indus aquifer are faster than the water re-charge to it. The Indus Water Treaty of 1960 with India and Pakistan's inter-provincial Water Accord of 1991 must be upgraded to deal with the allocation of groundwater from the Indus aquifer.

# THE SEED OF GROWTH

# III. The Seed of Growth

**Seed can make or break a crop.** The bedrock of a thriving agriculture sector is good quality seed. Seed determines more than any other element what results a crop can achieve. All other factors like crop management, application of inputs and their quality, and weather events come second. Low yield potential of a seed will not deliver high yields despite the best machinery, crop care, inputs, etc. Most of the explanation for Pakistan's low yields starts with poor quality seed. And the small farmer is typically the biggest loser due to poor quality seed.

**Good quality seed is 'agriculture's great equalizer' because it gives the small farmer a shot at the same results that large farmers have.** This chapter first illustrates how seed can make or break a crop through the maize success story and the cotton horror story. It then outlines how Pakistan's seed provision system is not organized to deliver good quality seed to all farmers. Finally, it shows how the legal and regulatory regime for seed is strangulating growth in the seed sector and identifies policy priorities for unleashing its potential for growth in agriculture.

## What is good quality seed?

In lay terms, good quality seed refers to seeds that have been produced, processed, and stored under appropriate conditions ensuring, at the minimum, three basic requirements:

- *High germination rate:* Good quality seeds will have a high percentage of viable seeds that sprout and grow into healthy plants. A high germination rate means farmers need to apply an appropriate number of seeds. Globally, a germination rate of 85 percent is considered the minimum acceptable. In Pakistan, the average cotton seed available hovers in the vicinity of 44 percent germination. This means 44 out of every 100 seeds sprout, all others are duds! The result is that farmers typically apply 16 kg of seed per acre which have uneven germination across a field (with good quality seed, only 8kg per acre would be required). So, one hill may have no plants while another hill has four plants—four plants feeding on the nutrition intended for one plant. These additional plants are pulled out by hiring labour later in the season—an added expense.

- *Varietal purity:* Good quality seeds will be uniform and true-to-type, i.e., all seeds in a bag are of the same variety (see Annex C for explanation of variety). This means that a bag of a certain variety of seed purchased for sowing can be trusted to be at 99 percent or more of the same variety, not contaminated with other plant varieties. A uniform crop is much easier to manage requiring less labor and leads to an easier transition to mechanization. Keeping with the cotton seed example, compared to a cotton crop cultivated with good quality seed (right panel in figure 17), a cotton crop cultivated with poor quality seed results in uneven plant height which is a nightmare for agronomy. Lack of purity also results in non-uniform fiber characteristics which is not desirable for the textile industry and translates into a lower price.

- *Strong vigor:* Good quality seeds will produce plants that have strong roots, healthy leaves, and are able to tolerate stressors such as drought, pests, or disease. This reduces input costs as a healthy crop requires less synthetic nutrients or crop protection products.

Figure 17: Good cotton seed has high germination, uniform cotton variety, and same plant height

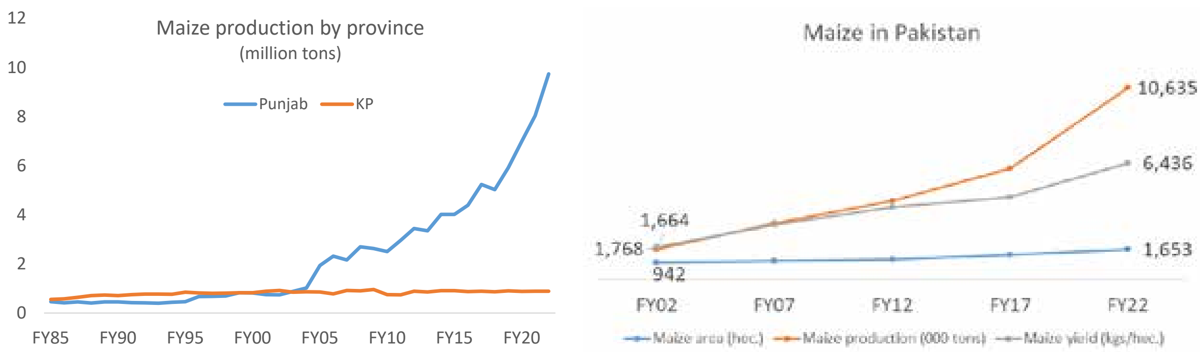

Reduced input costs, increased yields, and simplified maintenance practices lead to greater profitability for farmers. Farmers also tend to select crops that have a readily available supply of high-quality seed. The expansion of the more expensive hybrid maize seed (see Annex C for explanation of *hybrids)* across Punjab over the past two decades demonstrates that farmers are willing to pay for good quality seed.

## Pakistan's success story with hybrid maize seed

Over the past two decades, maize cultivation in Pakistan has experienced remarkable growth. Between FY02 and FY22, maize production surged more than six-fold from a mere 1.6 million tons to 10.6 million tons. This is partly because a number of farmers have shifted to cultivating maize resulting in an increase by 75 percent in area under maize during this period. However, the bulk of this increase comes from the increasing average yields (maize produced per acre) which have more than *tripled* in the last twenty years!

The government decision to allow hybrid maize seeds in 2001 has been the primary driver of this surge in maize production. This shift in production is evident in the change in the geographical distribution of maize cultivation. In 1995, KP province was the largest maize producer in Pakistan, accounting for 64 percent of the total maize produced with Punjab producing only 35 percent. However, by FY03, Punjab had overtaken KP, producing more than half of the country's maize. Today, Punjab is the major hybrid maize-producing province in Pakistan, responsible for over 90 percent of Pakistan's maize production with maize yields almost 4 times the average yields achieved in KP province. Unlike Punjab, where most of the poultry feed milling industry is located, KP does not much feed milling of maize. So, KP's farmers are typically not growing maize with poultry feed millers in mind—hence the choice of traditional varieties.

Figure 18: Introduction of hybrid maize seed in 2001 has led to a maize revolution in Pakistan




*Source: Economic Survey of Pakistan (various editions)*

The use of hybrid maize seed, most of which is imported, has been the main catalyst for the increase in maize production and rise in maize yields in Punjab. Multinational seed companies Bayer and Corteva dominate the maize seed market and import their seed. Some local seed companies also sell imported hybrid seed.

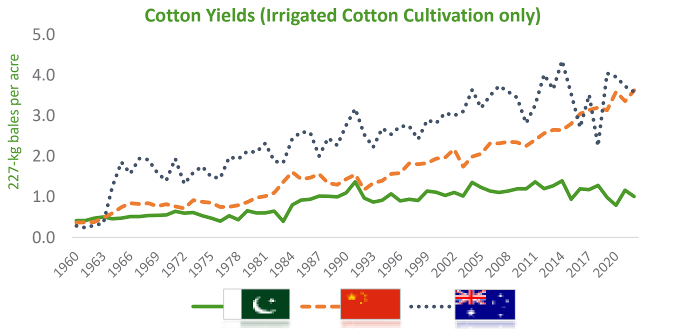
According to industry experts, over 70 percent of the maize produced in Pakistan is utilized by feed mills, while approximately 10 percent is used in wet-milling (mostly for producing industrial starches) and production of silage. The improved value chain of maize has had a far-reaching impact on various sectors, particularly the poultry industry, which has greatly benefited from the increase in feed mills that process a significant portion of the maize produced in Pakistan. Moreover, the growing maize production has opened up new market opportunities, particularly in the form of maize exports.

## Sad state of cotton seed in Pakistan

**Pakistan's cotton production suffers from stagnant yields and falling production.** According to the Pakistan Economic Survey 2021-22, Pakistan is still the fifth largest producer of cotton and exports of cotton and textile products were around 60 percent of country's exports. In FY20, Pakistan still had a 6 percent share in global cotton production and was also the third largest consumer of cotton, second largest yarn exporter, and third largest cloth exporter in the world. However, Pakistan's cotton production has declined over the years, with an average of 10 to 12 million bales per annum produced in the last two decades but falling precipitously in the last few years. This is in stark contrast to the exponential increase in area and yield of maize in Pakistan since the turn of the century.

**By contrast, cotton production and average yields have continued to increase in other countries.** China and Australia are major cotton producing countries that cultivate irrigated cotton like Pakistan. As figure 19 shows, their average productivity per acre has continued to rise over the years (barring years of drought) while Pakistan's yields have remained constant at around 1 bale per acre with a fall in recent years. Yield gains in China and Australia were mainly led by the adoption of improved seeds following by improved farming techniques, seedling transplantation, better crop management strategies to combat disease, more suitable irrigation, stronger fertilizer application, and the adoption of Genetically Modified (GM) technology traits in seeds for pest and weed control.

Figure 19: Pakistan's cotton yield: From stagnant to falling

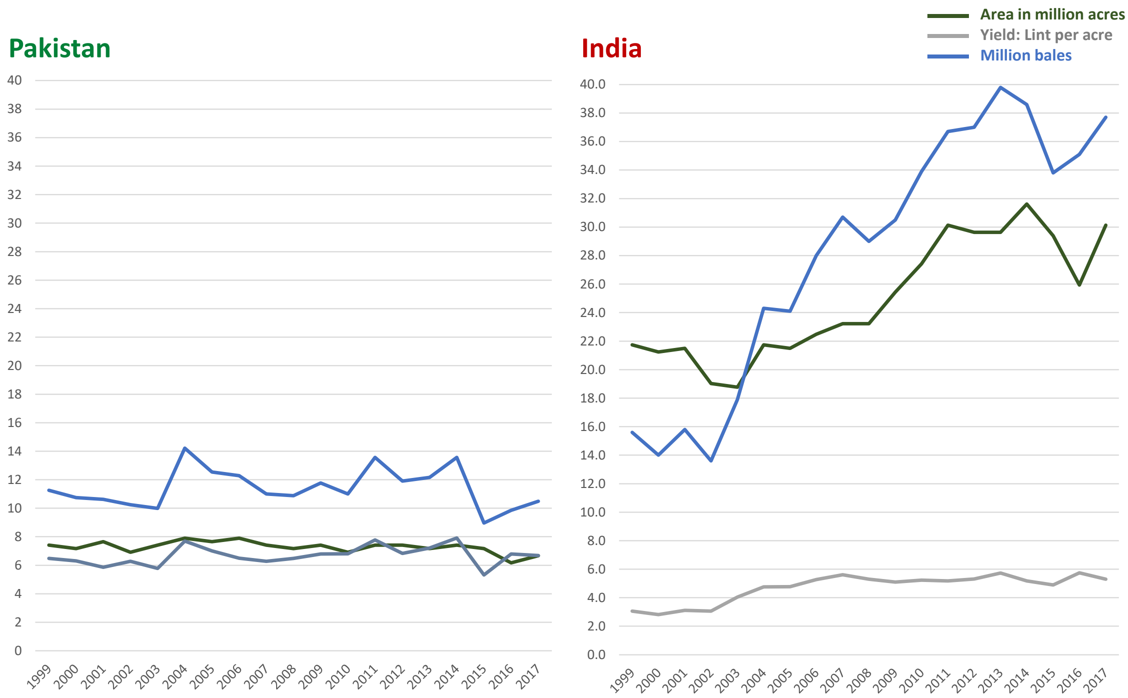



**The rise of cotton in India:** In the last twenty years, India's cotton production has more than doubled (figure 20). In the first few years of the 21st century, India's cotton production hovered between 14 and 16 million bales while Pakistan's cotton production ranged between 11 and 14 million bales. This was the period in which Bt cotton had been introduced in Pakistan—but without a robust seed industry. Yields rose sharply. In the subsequent decade, Pakistan's cotton production continued to stagnate within this range, India's cotton production skyrocketed to almost 40 million bales as early as 2013.

The rise in cotton production is primarily attributed to good quality hybrid cotton seed previously existing in the Indian market. This was a robust seed industry with adherence to quality standards which allowed international genetic technology providers like Monsanto to enter the Indian market with GMO technology (see Annex C for detail). This was Bt cotton under the brand name of Bollgard. This transgenic trait provided the cotton plant significant protection against bollworms ('*sundi*') which helped reduce the cost of pesticide sprays and increased yields. This raised farmers' profitability. As a result, average Indian cotton yields increased from an average of 3.1 maunds per acre in 1999 to 5.6 maunds per acre in 2007 which has plateaued since then. As more and more farmers switched to the profitable cotton crop, area under cotton also increased from 21.7 million acres in 1999 to 30.1 million acres in 2017. India's average cotton yield per acre is lower than Pakistan's, as shown in the two graphs below, because India grows rain-fed cotton while Pakistan's cotton is canal-fed.

**Introduction of GMO technology in Indian cotton seed was made possible due to a robust and dynamic seed industry.** Some of these seed companies were competing at the international level. This allowed a technology provider like Monsanto (now Bayer) to enter into a joint venture with a local company like Mahyco to establish Mahyco Monsanto Biotech (MMB). MMB became the master licensee of the relevant bio-technology and has sub-licensed Bollgard and Bollgard II technologies to over 45 Indian seed companies which have introduced this technology into their own seed varieties. The stewardship provided by MMB for post-release management of GMO technology was crucial to ensure trait performance, management of the pest's development of resistance to the technology, high quality of seeds, and stronger intellectual property management.

Figure 20: Tale of two cotton producers

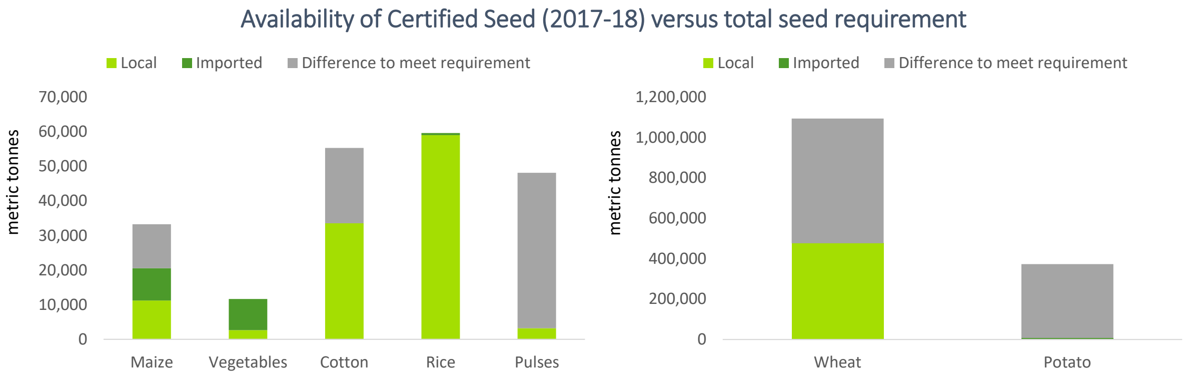



*Source: Cotton Advisory Board of India, Index Mundi*

**Another reason that an international GMO technology provider could enter the Indian market more readily was the prevalence of hybrid cotton in India.** By comparison, cotton produced in Pakistan is from open pollinated or OP seeds (the difference between hybrid and OP seeds is explained in Annex C). The production of cotton hybrids (unlike maize hybrids) requires substantial manual labor and a large number of people are already trained in India to develop hybrid cotton. Moreover, hybrid cotton seed in India also allowed easier implementation of intellectual property rights as farmers usually do not save hybrid seeds and purchase new seed each season which allows trait providers to earn from the sale of seed. Therefore, GMO technology providers enter markets with hybrid seed much more readily. If transgenic traits are introduced in OP seeds in a market with a weak Intellectual Property Rights (IPR) regime and poor regulations and enforcement, pilferage of technology is more common.

**The major reason for stagnant yields and falling area under cotton is the lack of good quality seed.** Poor quality seed means low germination levels leading to higher seed cost per acre and more labour cost. It means low yields which lead to low earnings. It also means a higher susceptibility of the crop to climatic effects, and disease and pest attacks, inability to compete against weeds, and poor uptake of nutrients. Moreover, Bt cotton was brought to Pakistan through irregular channels without any formal stewardship, which is why, although most of Pakistan's cotton has transgenic technology, its effectiveness remains questionable. All these factors culminate in sub-par cotton yields. The small farmer is the biggest sufferer from poor quality seed. The fundamental challenge of seed in Pakistan emerges from the structure of Pakistan's seed sector and the legal/regulatory regime governing the development, certification and distribution of seed.

Figure 21: Pakistan's farmers have a large unmet demand for quality seed




*Source: Changing the Seedscape in Pakistan, Dr. Ahsan Rana*  *Source: FSC&RD*

## Pakistan's seed system is not organized to provide quality seed to all farmers

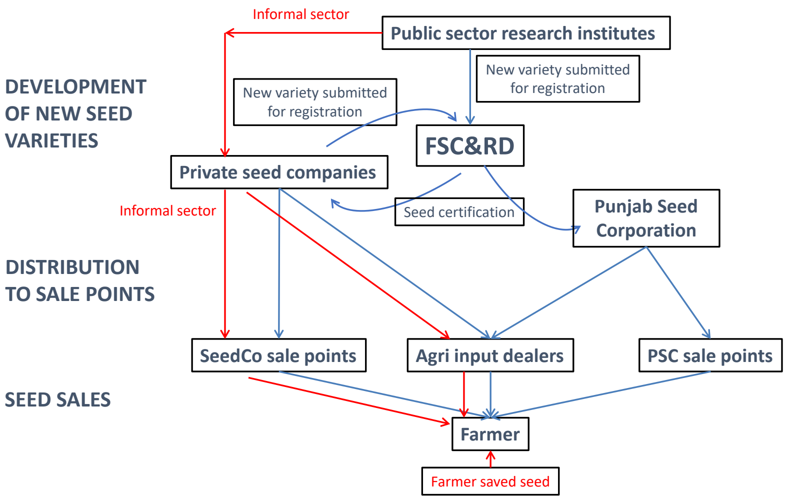
From the development of a seed variety to its delivery to farmers, the seed provision system can be divided into three main phases: development of new seed varieties, distribution of seed to sale points, and seed sales. This section draws on the work of Dr. Ahsan Rana.

**1. Development of new seed varieties:** new seed varieties are developed either by private sector seed companies (local or multinational) or public sector research institutes like Central Cotton Research Institute (CCRI) Multan, Ayub Agriculture Research Institute (AARI), Nuclear Institute for Agriculture and Biology (NIAB), National Institute of Biotechnology and Genetic Engineering (NIBGE), and others. New seed varieties are submitted for registration to the Federal Seed Certification and Registration Department (FSC&RD) which conducts various trials for two years to record the performance of the variety before registering it. This is typically a 2-year trial period of a new variety to check for yield performance as well as distinctness, uniformity, and stability (DUS) of the variety. If the variety passes these tests, it is registered after two years. But this is a step private seed companies generally fear. This step is often the source of pilferage of varieties where seed multipliers procure the pilfered seed, multiply it, and start marketing it before the actual developer/producer of seed has a chance to sell their registered product in the market. The registration certificate is valid for 10 years and can be renewed later. The registered varieties become eligible for quality control and certification through the Federal Seed Certification Department.

New seed varieties are also often imported by private seed companies, however, imported seed does not have to be certified by FSC&RD. Instead, the importing entity must ensure that the seed is accompanied by a certificate that confirms it has been thoroughly examined and approved in the country of origin.

**2. Distribution to sale points:** Once the seed is certified, the public sector research organizations and private seed companies multiply their seed to deliver it to their distribution points. Among public sector organizations, the Punjab Seed Corporation is the only active one and has its own seed farms, processing plants, and marketing network of input dealers (in Punjab and other provinces) and own sale points. Private seed companies also either have their own sale points (e.g. Naya Savera franchise network holds only Syngenta product) or they market their product through agri-input dealers.

Figure 22: Pakistan's seed provision system

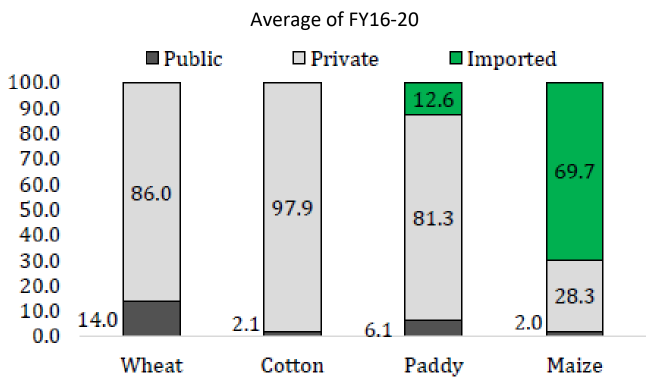



*Source: Changing the Seedscape in Pakistan, Dr. Ahsan Rana*

**3. Seed sales:** Farmers purchase the seed from either these public or private dedicated seed sale points or from agri-input dealers. Parallel to this formal seed provision sector, there is a vast informal seed provision sector which relies on a lot of the formal infrastructure. In 2018, 60 percent of the total seed requirement was fulfilled by uncertified seed. Informal seed sector consists of either farmer-saved seed for the next season or unregistered seed.

The informal sector bypasses the certification process and directly markets uncertified seed. The seed certification process is so tedious and open to pilferage that a number of unregistered seed varieties are popular in the market at any given time. For example, figure 21 shows that 55 percent of wheat seed and 40 percent of cotton seed requirement was met by uncertified seed in 2018. Uncertified does not necessarily equate to poor quality seed as seed companies often sell unregistered but pure seed in the market to avoid the laborious certification process for fear of pilferage and inefficiency of the process. Seed companies only sometimes sell uncertified seed under a brand name due to weak enforcement of seed laws, however, uncertified seed is usually sold as generic seed (seed sold in 'brown bags').

Figure 23: The private sector is the main supplier of seed




Source: FSC&RD

A weak intellectual property regime also helps the informal market flourish as seeds are often pirated (especially open pollinated varieties as they are easier to copy) by other seed companies and sold in the informal market. In 2019, around 850 local seed companies were registered with FSC&RD and more than a 100 of them were in the cotton seed business. Most of these seed companies are weak, 'fly-by-night' operators and act as seed multipliers with little or no seed breeding operations. They either procure uncertified seed developed by public sector organizations or they procure private-sector seed leaked at some stage with under-the-table deals. In comparison, the typical process followed by multinational companies for developing a seed includes:

- Getting market feedback to see what characteristics are being demanded by farmers and industry (in terms of crop color, yield, heat tolerance, etc.),
- Getting a couple of hundred seed lines to test against the desired characteristics,
- The better ones are short listed for planting again the next year and the process is repeated for a few more iterations,
- In the fourth year, a few varieties that meet the breeding objectives are then placed for commercialization.

Therefore, international seed companies prefer to market hybrid seeds in places with weak enforcement of the intellectual property regime. Today, both Bayer and Corteva import hybrid maize seed produced in other countries which are then marketed in Pakistan. These companies had at one time started producing hybrid maize seed locally to be more competitive and bring down the price of hybrid maize seed, however, the parents of these hybrids were also pirated and local hybrids entered the market. However, multinational companies recaptured the hybrid seed market over time when they stopped producing hybrids locally and resumed sale of imported new varieties. The farmers' verdict is clear. These two multinational companies dominate the maize seed market (figure 22). Wherever good quality seed is available, farmers respond by spending significantly larger sums on them.

## Policy priorities to the address legal and regulatory constraints to growth

**The Seed Act of 1976** was aimed at regulating and controlling the quality of seeds in Pakistan. It established three institutions to perform various regulatory and advisory functions: the National Seed Council, provincial seed councils, and the Federal Seed Certification & Registration Department (FSC&RD). The Act authorizes the federal government to prescribe seed quality standards and information to be printed on labels. It prohibits the sale of seed of an approved variety that does not meet quality standards and bear the required label. FSC&RD is responsible for registering new varieties and certifying seeds. And it has the power to control seed quality through inspections. The Act only focuses on the public sector development and delivery of seed and assigns no role to private seed companies except for seed multiplication, for which FSC&RD must register seed growers. There are restrictions on the sale of notified seed varieties, but none on the production or storage of non-notified varieties. The Act does not regulate farmers' seed saving or non-commercial exchange of seed.

Following the Seed Act of 1976, three sets of rules have been framed: the Seed (Registration) Rules of 1987, the Seed (Truth-in-labeling) Rules of 1991, and the Pakistan Fruit Plants Certification Rules of 1998. The Seed (Registration) Rules of 1987 established a committee to evaluate new seed varieties and prohibited the production of unregistered varieties which was at odds with the Seed Act. Somehow, the Seed Act was silent on the production of unregistered varieties and kept the registration and certification process of the seed optional which means that an unregistered variety could be marketed by the breeder at their own risk.

**The truth-in-labeling rules of 1991** dealt with labeling of seeds packaging with information on purity levels, germination rates, production month, expiration date, etc. The objective of a 'truth-in-labelling' regime is to allow a seed company to go into business with new varieties after a simple process. Farmers can themselves decide which seed meets their cultivation objectives more effectively. At any time, the authorities can pick up that company's seed and test it for the quality levels listed on the seed bag label. The authorities can easily proceed against the seed company if they conclude that it has not provided the truth in its labelling. This approach to seed regulation is successfully being followed in the United States, India, and many other countries. The key to its success is that it checks the seed at the point of sale (not during the production cycle) and this benefits farmers more.

**Unfortunately, the Seed Act of 1976, its accompanying rules, and the 2015 amendment to the Seed Act emphasize a minimal role for the private sector in seed** and impose lengthy and bureaucratic procedures for variety approval which exposes any seed breeders to piracy risk. Weak enforcement of seed laws has led to a large informal sector, and as a result, many companies and breeders market their new varieties without registering them. The regulation extends to all crops, including those that are not as commercially important, leading to an overly regulated system that discourages private sector involvement. Recent legislative changes add administrative burden without much benefit and require significant infrastructure for effective enforcement. Another important regulatory aspect is that quality control occurs during production, not at the point-of-sale.

**The Seed Act is in dire need of an overhaul to establish an enabling environment for seed regulation that encourages reputable private seed companies to invest with confidence in seed development** and which should only extend to crops of commercial importance. The role of FSC&RD needs to be reimagined at a higher level to specify standards for new varieties and hybrids, and operational standards for seed businesses. Only seed companies that meet these mandatory standards should be allowed to do business. A proactive and rigorous monitoring of seed businesses should be performed to ensure compliance with such standards. The role of FSC&RD needs to be re-envisioned with a reduced administrative burden while allowing a greater role of provincial governments in regulating the seed sector.

**A dual regime for commercial release of new OP and hybrid seeds needs to be adopted.** Under this, one tier would be registered seed companies and the public sector which will continue to release new varieties after the usual 2-year mandatory pre-release evaluation. Another tier would be seed businesses that meet higher standards of excellence and should be able to send their new varieties to FSC&RD for 'enlistment,' which does not require pre-release evaluation. FSC&RD should ideally evaluate enlisted varieties for the purity, germination, and agronomic performance of these varieties after they are released. This will shift the focus of regulation from the production stage to the point-of-sale. Under this system, seed certification will be a voluntary and paid-for service. A seed company 'enlisting' sub-standard varieties stands to lose its customers and status of meeting higher standards. The term of license for dealership can be extended to five years, with no need to register seed processing plants. The renewal of a seed company's registration and license should come automatically upon application, unless there is suspicion of a violation of conditions, which will be recorded in writing.

**Practical implementation of Plant Breeders' Rights is awaited.** Any individual or commercial entity that breeds a new seed variety has a right to the intellectual property associated with it. And this right needs to be protected if a commercial eco-system is to be developed for investment in seed development for agricultural growth. To address the intellectual property rights issues, a bill for the Plant Breeders' Rights Act was initiated by the Government of Pakistan in 1999. Subsequently, several draft bills were submitted and the draft of 2007 made it the farthest when it was presented to Cabinet in 2007. The final approval to the last draft was only granted in December, 2016, and the rules were subsequently framed and finalized in 2018. Under the law, a Plant Breeders' Registry was created to register new varieties and for cataloguing relevant information about the variety which will, upon approval, confer rights to develop, import, export, sell, and market that variety for 20 years (25 years for trees and vines). Concerns persist regarding the placement of the PBR registry within FSC&RD as it is severely under-resourced. Submission of a variety's information including DNA fingerprints for IPR protection under the Plant Breeders' Rights Act is a voluntary exercise. However, as no cases have arisen so far since the framing of PBR rules, it remains to be seen how a case involving PBR violation will be adjudicated.

## Conclusions

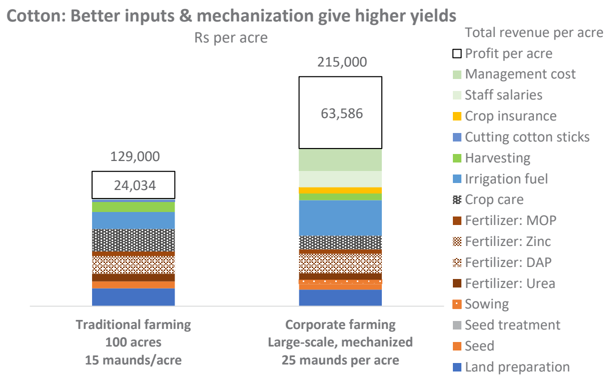
The farmers' verdict on seed quality is clear: good quality seed which performs is adopted by all types of farmers. The example of hybrid maize seed adopted across Punjab province makes it clear that even small farmers adopt more expensive seed if it gives them higher returns. In this context, it can be said that the biggest sufferer from poor quality seed is the small farmer. Pakistan's seed sector is the achilles heel of Pakistan's agriculture. It is time for the government-first approach of the Seed Act to give way to a seed act which encourages reputable seed companies from within and outside Pakistan to invest in seed development. It is time for seed regulation to shift from an approach of controlling the seed sector to an approach of maximizing benefit to the farmer.

# FINANCING GROWTH IN AGRICULTURE

# IV. Financing growth in agriculture

**Pakistan's agriculture sector needs capital to progress!** It remains stagnant in a low productivity, low returns cycle with limited access to capital. A jump to a higher level of productivity and returns is not possible through debt alone. Therefore, growth in agriculture requires not only working capital financing (especially formal credit) and risk transfer tools (such as crop insurance) but also funding for transformative investments through equity, grant funding, risk mitigation tools, etc. **This chapter outlines these constraints and presents specific solutions that have been developed by Pakistan's corporate and financial sector players.**

Figure 24: The jump to precision agriculture




Irrigation fuel included in corporate farming to control timing of water supply

**What it takes to raise agri-productivity**: Figure 24 illustrates the jump from traditional farming to precision agriculture practice at scale through corporate farming. It compares the basic profit & loss statement for traditional cotton cultivation taking place in Pakistan with the profit & loss for corporate farming with mechanization. Better seed sown by machines increases not only the germination level of the seeds (how many of the seeds sown will actually sprout into plants) but also the population of plants sown per acre. This means that a higher yield can be achieved. This potential yield is protected through a better fertilizer mix. This contributes to better plant health. Modern farming involves less crop care cost per acre not only because of more efficient mechanized spraying but also because of pest scouting which gives an indication of whether a segment of the crop requires spraying or not. The example shows higher use of fuel for irrigation to control the timing of water supply. Since corporate farming is agriculture with much higher predictability than traditional agriculture, crop insurance becomes an essential expense. Finally, the staff salaries and management cost are significantly higher than in corporate farming similar to an industrial activity requiring technical expertise and management muscle.

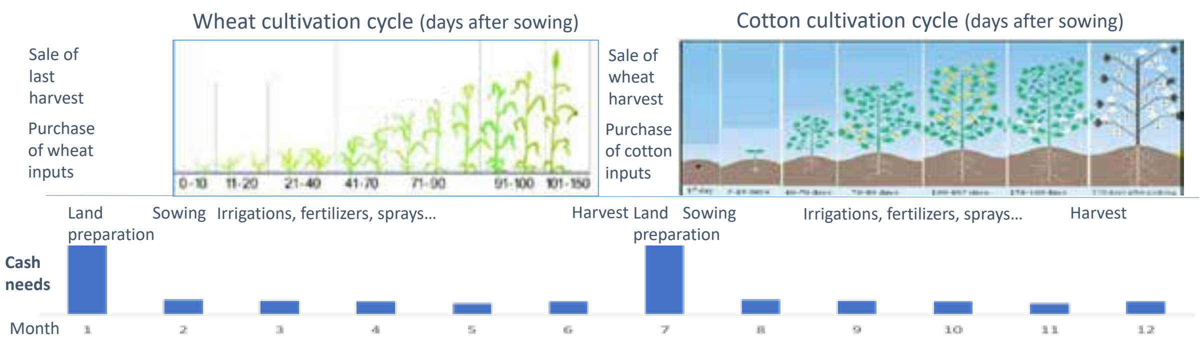
The jump from traditional farming to corporate farming requires a significant capital investment which has to come mostly from equity. Mechanized farming brings reduction in cost and increase in yield: in rice cultivation, mechanization can bring the farmer's breakeven point down from Rs. 900 per acre to the range of Rs. 700 per acre which can make Pakistan's rice more competitive in export markets. But mechanized agriculture requires scale! For example, the modern 6-row cotton picker requires at least 10,000 acres for it to be a financially viable investment. Figure 24 shows only the depreciation and opex related to modern farm machinery. But the machines first have to be financed somehow.

For modern cotton cultivation, sufficient scale is preferable to include a ginning operation inside the farming operation. This allows elimination of the loss of quantity and quality of cotton between farm and gin. A modern gin becomes a viable investment if the cotton cultivation operation associated with it is at the scale of 50,000 acres. The investment required for such projects is in the range of $1,200 per acre. Pakistan must start investment in such projects not least since even Uzbekistan has begun to mount such projects with cultivation at 50,000 or 100,000 acres including ginning operations to feed spinners directly.

In summary, the main reasons for the low productivity and low returns in Pakistan's agriculture are both systemic and farm-level. At the systemic level, quality seed is only available to a small minority of farmers and for a limited number of crops; water availability is irregular and unsuited to the scheduling needs of the crops being sown in each area. On the farm level, traditional farming methods are being practiced even on larger farms with little mechanization. **The shift to higher productivity and higher returns through precision agriculture requires not only debt but all the pillars of finance: debt, equity, insurance, and government support.**

**Agriculture is a highly time-sensitive business.** On most of Pakistan's cultivable land, every day of delay in wheat sowing from its ideal window of October 15 to November 15 means a lower wheat yield at harvest time. For field crops, the change-over from one crop to the next is typically the time when farmers have the highest working capital needs. Over 80 percent of Pakistan's farms cultivate wheat over the winter. As figure 25 shows, a farmer cultivating the wheat-cotton rotation, the sale of the wheat harvest typically produces revenues that can be used to secure the inputs for the cotton crop. Over half the expenditure on each crop is made in its first month. This need is best addressed through credit.

Figure 25: Understanding financial needs in the agriculture sector



## Credit

Commodity trade players estimate that only a quarter of Pakistan's farmers have been able to extricate themselves from the clutches of the middleman (*arhti)*. And these are mostly large farmers. The middleman has many names and avatars along the value chain, all of them much maligned. But **the most important play of the middleman is to connect the sale of the last crop's harvest with the purchase decision for the next crop's inputs.** This gives the middleman control of commodity in his role as aggregator. As a result of this combined transaction, the majority of Pakistan's farmer are not paying cash for the next crop's inputs. And this 'delayed payment' for crop inputs is booked by the middleman at a higher price: typically, 13-15 percent higher than the price to be paid if payment is made in cash. Since the crop cycle for major crops is typically 130-150 days, the annual percentage rate is extrapolated to be north of 35%. Money from speculators typically follows this route into agriculture as informal funding.

**How far are banks falling short on agri-credit?** According to the last Agriculture Census, 88% of Pakistan's 8.26 million farms have less than 12.5 acres (5 hectares, considered a minimum for sustainable farming). Further, two-thirds of Pakistan's farms are below 5 acres. On the other end of the spectrum only 90,000 farms have 50 acres or more.

The traditional collateral for farm loans required by banks is a two-step arrangement: the first security is the crop itself while the second security is the land owned by the farmer. A section below outlines how the insurance associated with the crop is sub-optimal in Pakistan. This reduces the value of the crop as collateral. So, the land comes into greater focus as collateral against direct loans to farmers which brings many constraints. The first is the low loan-to-value ratio: the loan is typically in the range of 1-2% of land value which farmers do not appreciate. On the other hand, banks do not prefer land either since it is considered illiquid collateral. Finally, the requirement of land as collateral means the exclusion of tenant farmers from formal credit—these are often the best farmers. Loan processing and disbursement time is usually in weeks which also makes formal lending unattractive for farmers. And, typically, small farmers also report shabby treatment by bank staff.

In this light, there is little surprise that for 8.2 million farms, there are only 1.4 million direct farm sector loans from banks in FY20 with PKR 638 billion disbursed directly for all crops. Of these loans, only about 3,000 large farms (above 50 acres) received some 60 percent of the financing. So, while an estimated 18% of Pakistan's farms had loans directly from banks, 1.34 million smallholder farmers received only 28% of -the financing. The lack of access to direct bank lending to small farmers is one of the key constraints to Pakistan's agriculture sector.

When farmers are asked why they are not direct borrowers from the banking sector, their most common responses (two-thirds) are either that the documentation requirements are complex or that they do not know how to get a bank loan (Karandaaz, 2023). The result is that two-thirds of farmers report that they borrow informally from family/friends and money lenders/loan sharks. Some 14% report that they borrow from ZTBL (which has the largest portfolio of smallholder farmers), 12% report they borrow from microfinance banks and 4% report borrowing from commercial banks which cater mainly to larger farmers, hence the smaller proportion (Karandaaz, 2023). The theme that large farmers dominate direct borrowing from banks is supported by the fact that the average loan size reported for loans from commercial banks is PKR 600,000 compared to about PKR 100,000 or less from all other sources mentioned.

A simple estimate of credit demand among Pakistan's farms can be made by multiplying the loan limit (ceiling for lending per acre) for each crop advised by the State Bank of Pakistan with the actual acreage under each crop. This calculation was done for FY20 and the result for only the five major field crops was PKR 2.6 trillion compared to actual disbursement of PKR 638 billion for all crops! The breakdown of the credit demand estimate by farm size reveals a demand of PKR 338 billion for farms above 50 acres (which is comparable to the PKR 384 billion actually disbursed to farms above 50 acres in FY20), PKR 843 billion for farms of 12.5-50 acres (compared to PKR 73 billion actually disbursed to this category), and PKR 1,450 billion for farms below 12.5 acres (which is 8 times the PKR 181 billion actually disbursed to such smallholder farmers). So, the smallholder farmers are the ones beholden to the middlemen!

**These estimates indicate that some 80% of Pakistan's farms lack direct access to bank credit and at least 75% of the credit demand for crops is not being met through bank credit.** It is clear that the coverage and flow of bank credit to Pakistan's farmers, especially small farmers, needs to be expanded manifold.

**More bridges are needed between farmers and banks.** The bridges between the banking sector and farmers remain thin. Figure 26 outlines these links in the maize value chain. Generally, there are four routes for bank financing (and also speculator money) to reach farmers:

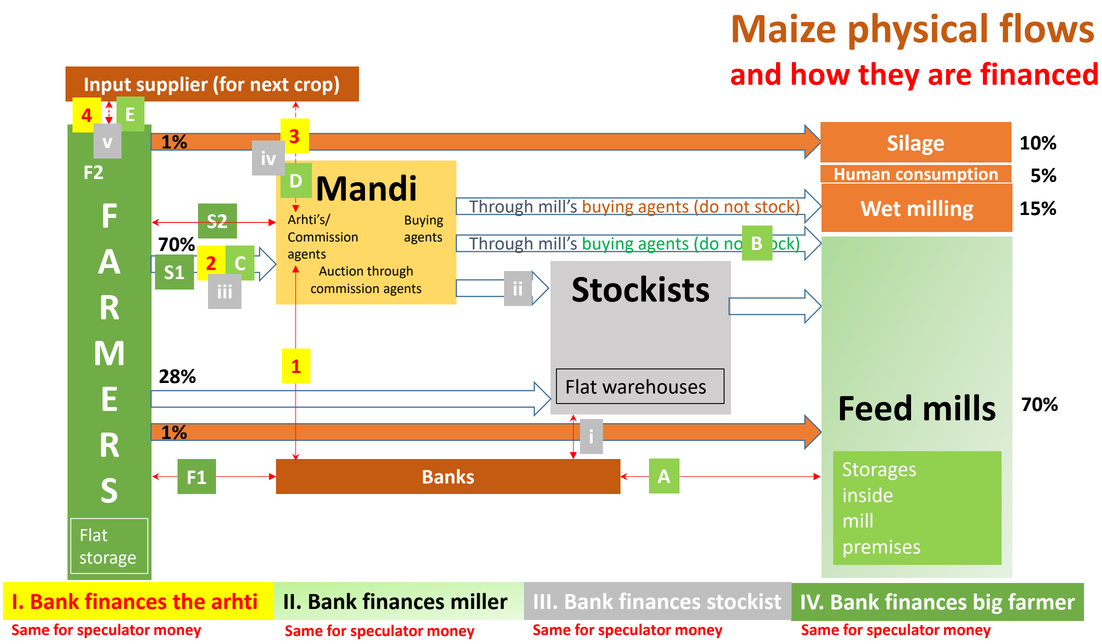
I. When the bank finances the middleman (*arhti*), the middleman uses these funds to make a partial payment to the farmer against the farmer's harvest of the last crop and to make a payment to input suppliers on behalf of the farmer;

II. The more common route is for the bank to lend to a processor of the farmer's crop. This processor basically on-lends these funds through its buying agents to the middleman in the wholesale market (*mandi*). And the funds find their way to middlemen/aggregators and follow the steps outlined in route I above;

III. A small portion of bank credit goes to stockists who purchase commodity at harvest, stock them for 2-3 months and mostly on-sell to processors. When a bank finances a stockist, the funds also find their way to middlemen/aggregators and follow the steps outlined in I above;

IV. A small portion of bank credit goes directly to (mostly large) farmers who have the capacity to store the last crop's harvest on their farms and use the bank funding to purchase inputs for the next crop.

Figure 26: Four different routes for bank credit (and speculator money) to reach farmers



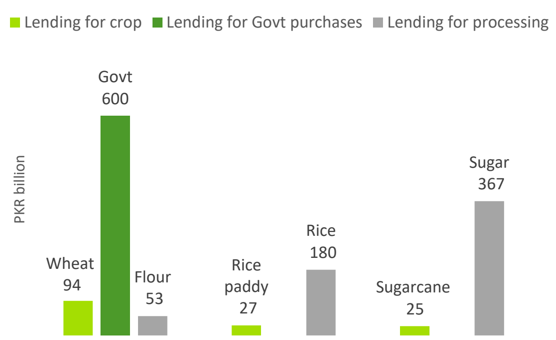

*Source: IFC*

Of these, the route that carries the largest amount of credit is the one that passes through processors. As figure 26 shows, bank lending to sugar millers was more than half the value of sugar produced in FY22. This is a strong conduit for bank financing to reach sugarcane farmers but at the terms dictated by millers and middlemen. The numbers for wheat are telling: bank lending to wheat farmers is higher than bank lending to flour millers. The key reasons are that an estimated 40 percent of the wheat crop is retained by farmers for their own families' consumption over the rest of the year so it is not milled. Also, wheat is the only crop purchased by the government (heavily financed by banks) for sale to millers later on.

Banks lend to agriculture through processors mainly because through this route: (i) they understand their exposure better, and (ii) they can work with one counterpart rather than thousands of farmers. This can be a springboard for growth in agriculture.

**Excellence in Pakistan's agriculture is often seen where processors have done backward integration with farmers.** It is true that Pakistan's progressive farmers are conducting high performance agriculture. But there are some processors which have bolstered their supply chain by helping large numbers of small- and medium-sized farmers upgrade not only farm performance but also profitability. The most-cited examples of processors who have conducted highly successful backward

Figure 27: Lending: crop vs. end-product (FY22)




Source: State Bank of Pakistan, IFC

integration with large numbers of farmers are Rafhan in maize, JDW in sugarcane, Nestle in milk, British American Tobbaco in tobacco, and PepsiCo Lays in potato, etc.

For example, contract farming relationships developed by PepsiCo Lays over the past decade have resulted in globally competitive potato yields achieved by farmers in the Okara area. A contract price is set before each season for off-take by the processor with a promise of payment within 3 days of harvest being delivered by the farmer (down from the traditional 45 days or more). In addition, farmers are given high quality potato seed by the processor on unsecured credit. The processor's off-take guarantee becomes a backstop for financial institutions to lend to participating farmers. In case of a default, the processor aims to recoup the loss from future payments to the farmer. In recent years, PepsiCo Lays started offering a premium to farmers using drip irrigation to promote sustainability goals.

This arrangement brings supply security and predictable prices to the processor and a reliable off-taker with a known price for each participating farmer. This allows the elimination of exploitation by middlemen. In the 2014-15 season, excessive frost caused destruction of about 50 percent of the crop. But farmers provided PepsiCo Lays with the agreed supply from the surviving portion of the crop. This shows that a mutually beneficial relationship garners a farmer loyalty that is not seen commonly.

**Expanding agri-credit through securitization of agri-commodities:** As mentioned earlier, the exploitation of the farmer by middlemen is through the bundling of two transactions sorely needed by the farmer: the sale of the last crop's harvest and the purchase of the next crop's inputs. An eco-system that separates these two transactions for the farmer has been introduced in Pakistan. This is the Electronic Warehouse Receipts (EWR) eco-system intended mainly for non-perishable items.

What are EWRs? Under a warehouse receipts-based financing regime, any owner of an eligible commodity can get their commodity tested for entry into an accredited warehouse/silo and secure bank financing against their warehouse receipt as collateral. Commodities eligible for EWR-based financing are usually non-perishable and have a highly liquid market. In Pakistan, these commodities are: wheat, maize, rice paddy, rice, sugar, oilseeds, etc. Banks as well as holders of commodity are looking for an alternative to land as collateral for agri-financing. The prospect of receiving bank financing creates a strong incentive for all stakeholders to preserve its quality so it can pass the testing requirements for proper storage. This will reduce Pakistan's high post-harvest losses.

Within 18 months of its launch, this regime has issued electronic warehouse receipts over Rs. 2 billion worth of commodity in mainly in maize and rice. Participating banks have disbursed loans against 90% of these EWRs within 24 hours to holders of electronic warehouse receipts (due diligence and KYC is completed before the season starts). This feature and the fact that no property documents other than the electronic warehouse receipt is required for a loan are being appreciated by traders, farmers, and 'farmer-cum-traders'. The critical addition required is the expansion of modern warehousing companies which can garner the confidence of banks as well as holders of electronic warehouse receipts.

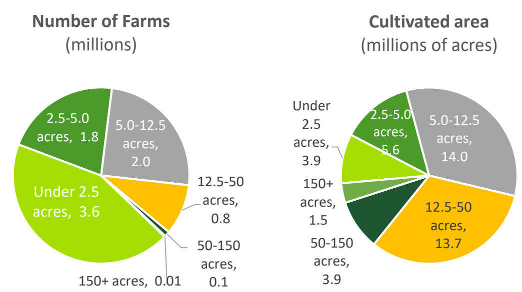
The securitization of agri-commodities in the form of electronic warehouse receipts holds great prospects for upgrading Pakistan's grain supply chains. This eco-system has the potential to become the backbone of a national commodity market for Pakistan with trading of electronic warehouse receipts which represent tested, standardized agri-commodities that buyers can trust within Pakistan and abroad.

## Equity

A critical financial pillar required to catapult the agriculture sector towards high growth is equity whether it is in the form of capital invested in farm machinery, modern warehousing and cool chains, human resources, etc., or in the form of land. In the absence of detailed financial information about farms today, land can be taken as a proxy for equity in the agriculture sector. The distribution of the 42.6 million acres (17.3 million hectares) of cultivated land among Pakistan's 8.2 million farms is such that 45% of the cultivated area is with farms which have less than 12.5 acres while 55% of the cultivated area is with farms which have more than 12.5 acres. On the other end of the spectrum, only about 13,500 farms are of more than 150 acres holding about 1.5 million acres. Therefore, the vast majority of farms are highly unlikely to own machinery, storage, cash reserves, etc., given that they have hardly any ability to invest. A plain measure of the value of this land can be taken by multiplying the 42.6 million acres of cultivated land with an average price of PKR 2.5 million per acre of agricultural land. The total is PKR 106.5 trillion.

The question is: is this enormous asset of Pakistan being utilized to high productivity. Unfortunately, a vast proportion of *large farms* are also being run with traditional practices due to absentee landlords. These larger farms are typically located in upper Sindh and southern Punjab. Corporate farming remains restricted to a few, small islands of excellence but truly large-scale farming is yet to emerge in Pakistan. This must change if Pakistan is transition to the next level of agricultural productivity.

Figure 28: Cultivated area dominated by larger farms




*Source: Agriculture Census of Pakistan (2010)*

In recent years, investments from venture capital funds—both global and local—were made in new agri-tech start-ups: digital financial services, last-mile delivery solutions, services supporting precision agriculture, etc. The impact of these new operations has not yet reached scale and their impact is awaited.

## Insurance

**Rising need for insurance:** Pakistan's banks remain wary of lending to farmers without strong collateral. The key risk is the farmer's ability to repay the loan when the farmer's main source of revenue—the crop—is unsecured from climate and biological risks. The data presented earlier indicates a preference for banks to lend to large farmers. This is mainly because large farmers have non-crop collateral (mainly property) that banks are more comfortable with. The small farmer, on the other hand, only has the cropped land and the crop itself as collateral. The need for effective crop insurance to address these risks has been understood for some time. But more recently, the rising impact of climate risks has begun to bring crop insurance into greater focus.

Traditional indemnity insurance is suited to situations where the types of damage are easily verifiable. Unlike insurance for cars (where accident, theft, etc., can be verified easily), crops are impacted by perils (typically not controllable by humans) whereby the extent of damage caused by them is not easy to agree upon. Therefore, indemnity insurance is not well-suited to serving farming operations. An alternate is weather-index insurance which simply offers a payout if, for example, the temperature rises above 45 centigrade during a certain portion of the crop cycle. This can be useful to protect the wheat crop from heat waves close to the harvesting period (as experienced in 2022). But some crops are impacted heavily by non-weather perils such as the pest attacks for the cotton crop. For such applications, area yield index-based insurance provides a more comprehensive cover. As explained in Annex D, under this type of insurance, the yield achieved in an entire area is taken as a proxy for the extent of damage by identified perils that impact the crop. This also benefits farmers by giving them a graduated payout scale (the greater the yield loss, the greater the payout) rather than a fixed payout only if a specific temperature is crossed.

**Existing crop insurance schemes: There is broad consensus in banking and insurance circles that Pakistan's existing crop insurance offerings require upgrade.** *The Crop Loan Insurance Scheme (CLIS)* was introduced in 2008 as a federal government scheme administered by State Bank of Pakistan, the central bank. CLIS made crop loan insurance mandatory for all crop loans by regulated banks which means up to 1.4 million farmers benefit from this insurance and, of these, CLIS subsidies premium for 300,000 to 500,000 small farmers per season. CLIS subsidizes crop insurance premium for farmers with less than 25 acres. Farmers above 25 acres pay in the range of 1.4% of sum insured as premium for their crop loan insurance. This scheme puts an artificial ceiling of 2% on the insurance premium.

This scheme covers the main perils typically covered by crop insurance schemes globally but has two major constraints: (i) the trigger for insurance pay-out in an area is a declaration of calamity by the government (which is a subjective decision not linked to an accepted scientific method), and (ii) the maximum insurance payout is limited for each bank at three times the insurance premium paid by the bank (this is often a miniscule amount compared to the losses incurred by farmers as well as banks). These constraints also help explain the limited extent of crop loans by regulated banks to Pakistan's farmers.

Apart from this crop *loan* insurance scheme, Pakistan's Punjab province has a government-run program called the *Punjab Fasal Bema* scheme. This program was initiated in 2018 with World Bank advice and is based on area yield index insurance with crop data collection by the Government of Punjab's Crop Reporting Service. The Punjab Fasal Bema scheme subsidizes the premium for small farmers without bundling the insurance with loans or any other commodity. This program involves participating insurers directly marketing crop insurance to farmers and has reached around 300,000 farmers to date.

## Government support

Governments typically support farmers through fiscal incentives, subsidized credit, direct transfers of cash or inputs, and grants for specific purchases (mainly for technology upgrades). **Policy packages for farmers** offered by the government are typically a mix of measures to address farmers' working capital requirements and their investment needs. Typically, the government policy packages are tilted in favor of working capital requirements with a primary dependence on loans. The Kissan Package announced in late 2022 is a case in point. It offered Rs. 1,800 billion in agri loans, Rs. 50 billion in subsidized loans for agri projects of rural youth, no import duties on used tractors, reduced duty on tractor parts, and interest-free loans to shift 300,000 tube wells to solar power. The Kissan Package 2022 also offered a reduction in fertilizer cost (DAP price reduction and Rs. 30 billion urea subsidy), cheaper gas to fertilizer producers to reduce the price of urea, a subsidized electricity tariff for farmers to run tube wells, and for flood victims: 1.2 million bags of wheat seed and Rs. 5 billion in interest-free loans to landless farmers.

**Grant support** Government support can introduce new technology into private hands in agriculture. An excellent example from Pakistan's own experience is the introduction of laser land levelers across Punjab.

Laser land levelling of farms ensures that plants are neither suffocated with excess water in a trough on the farm surface nor kept thirsty on a crest. It has been shown to bring on-farm water saving of 30-40% and yield increase of 15-20%. Traditionally, provincial governments would purchase a few laser land levelers for each district and allow these to be used by farmers. Invariably, these were captured by local big wigs with nominal machine utilization during each sowing season. In 2003-04, the Government of Punjab offered 50% grant with World Bank support for the purchase of laser land levelers by farmers. This led to a mushrooming of small service providers all over Punjab who shot the utilization of their equipment to nearly 100% during the sowing season. Today, Punjab has some 17,000 land levelers and Sindh is following the same path with strong uptake in lower Sindh. Uptake is slow in upper Sindh because the large farms there require a one-time land levelling by earth-moving equipment after which laser land levelers can do their work.

From the average farmer's point of view, laser land levelers are a reasonable capital expenditure at Rs. 500,000-600,000 each. With fifty percent grant, many small and medium sized farmers can become service providers. But this is not the case for regular rice transplanters (Rs. 2.7 million each) or rice harvesters (Rs. 4 million each) at FY22 prices. These machines are also more complex and require expert training plus a parts inventory to make sure the farmer's sowing time is not lost to machine breakdowns. This is why Pakistan's agriculture sector requires a fledgling crop of farm machinery service providers. This need has begun to be addressed by a number of enterprising rural entrepreneurs in the informal sector. But they have little access to capital and import scrap machinery from China, Thailand, Vietnam, etc.

## Conclusions and policy priorities

**Not through debt alone!** The jump from traditional, small-scale agriculture to large-scale precision agriculture with machines and quality inputs does not come without risk. In particular, large-scale corporate agriculture would at least be on thousands of acres for which modern farm machinery is typically intended. For new players to enter corporate agriculture, even in partnership with leading local farmers, there is a steep learning curve regarding the cultivation of each crop in a specific agro-climatic zone and on a specific soil with a new management team that needs to be grown. The uncertainties to be tackled mean that this jump is not ideally taken with debt alone—equity capital is required. At this stage of minimal corporate farming in Pakistan, government land in rural areas can be offered under public-private partnerships on long-term lease to kick-start this activity, as done in many countries. The demonstration effect of a few large-scale operations can shift the direction of Pakistan's agriculture. But they will also require crop insurance.

**Crop insurance** offered to be availed by farmers voluntarily has not scaled up anywhere in the world. For the vast majority of Pakistan's small farmers to be protected from climate and biological perils, the global good practice of aggregating insurance for large numbers of farmers is required. Banks are a natural aggregator through their lending portfolios. But over 80 percent of Pakistan's farmers do not borrow directly from banks and cannot afford the insurance premium anyway. Here, the global good practice is that governments consider crop insurance a public good and subsidize its cost for smallholder farmers. Out of 104 countries with crop insurance schemes, 85% involve insurance premium subsidies from governments (including in developed countries) and these subsidies covered 68 percent of average premium value[5]. Subsidization of insurance premium for small farmers has also been prevalent in Pakistan for over 15 years.

5 The World Bank (2010). G*overnment Support to Agricultural Insurance: Challenge and Options for Developing Countries,* Oliver Mahul and Charles Stutley

Therefore, the main recommendation is for each provincial government to become the insurance policy holder on behalf of its smallholder farmers. To increase efficiency and transparency in distribution of insurance pay-outs, the pay-outs should be made directly from insurers to the farmers insured, rather than to the government, even when the government is the policyholder. Finally, Pakistan's farmers can be provided crop insurance on a much larger scale if global reinsurers participate by underwriting the majority of the risk alongside local reinsurers. The participation of specialized insuretech firms brings comfort to global reinsurers to take a proposed level of risk. Corporate agriculture can absorb its cost of insurance.

**Commodity markets** Governments, donors, and others have attempted for decades without success to upgrade—even dislodge—Pakistan's traditional wholesale market system (mandi's) and its powerful middlemen. At the very least, the legal and regulatory space for new market mechanisms to appear beside the traditional mandi system has been created. This offers the opportunity for investment in parallel trading mechanisms and agri-storages which are a win-win for all stakeholders. This is where the electronic warehouse receipts eco-system can become the foundation of a modern nation-wide agri-commodity market. The proof of concept has been done with farmers getting loan disbursements within 24 hours of collateralizing their commodity. The critical need is for reputable players to be attracted to invest in modern warehousing under this regime. For this, some government measures are required to mitigate risks associated with land title in rural areas, regulations associated with commodities considered essential food items, fear of food department raids related to wheat, etc.

**Building service providers:** Given so many small farmers and a general lack of capacity among large farmers for a shift to modern farming, the role of service providers becomes very important. One-time grant funding from government towards purchase of reliable new technology must be provided to service providers. The key is to make it feasible for reputable formal sector players to operate in this space without unfair competition from those who are running informal, cash-only operations. For this, tax incentives have already been provided by the Government of Punjab in 2020 such as reduction in the sales tax on farm machinery services from 16% to 1%. Now a focused effort to get this industry goes is required. Finally, international expertise is an essential ingredient for rapidly building up domestic human resources.

# MITIGATING ANIMAL DISEASE TO SUPPORT GROWTH

# V. Mitigating animal disease to support growth

**Pakistan's prospects for export of meat and other livestock products depend on effective animal disease management.** Livestock contributes more than half of agriculture GDP and one-eighth of national GDP. It is also the leading driver of growth in the agriculture sector. Therefore, at the domestic level, outbreaks of animal disease have consequences for the supply of meat, milk, and other livestock products, price levels of these products, and the need to expend foreign reserves to import vaccines. But the major prospect of livestock-based exports is heavily constrained by the current disease management regime in Pakistan. This chapter first illustrates the state of disease management through a case study of the recent lumpy skin disease outbreak and then presents how a path to livestock exports can be achieved through better surveillance, disease-free zones, vaccines, farmer awareness, and greater involvement of the private sector.

## Case study of disease management: outbreak of lumpy skin disease in Pakistan

The most common animal diseases in Pakistan are: foot and mouth disease in cows and buffaloes, PDPR in goats and sheep, and avian influenza in poultry (Annex E). But Pakistan's recent experience with the lumpy skin disease in 2021-22 has important lessons for how a slow government response and lack of awareness caused a national emergency and culminated in significant economic loss.

The lumpy skin disease outbreak was first detected in Sindh province in November, 2021. Pakistan's response to the disease was slow leading to higher mortality and morbidity rates. The disease spread more rapidly in Sindh and some parts of Punjab. Outbreaks had been observed in India, Bangladesh, and China in 2019. In 2020, outbreaks were witnessed in other Asian countries including Bhutan, Myanmar, Nepal, Taiwan, Vietnam and Sri Lanka. It was just a matter of time before the disease would have appeared in Pakistan. But Pakistan seemed to have been caught off-guard. Cattle holders had little knowledge on the SOPs to be followed in case the signs of lumpy skin disease are spotted. The disease was only notified by the government on March 4, 2022.

In March 2022, the Ministry of National Food Security and Research set up a task force to develop a framework for controlling the outbreak in March 2022. A ban on the livestock markets was imposed to prevent its spread. Special teams were sent to dairy farms to vaccinate cattle against the viral disease. Awareness was raised about the disease and about prevention methods by the government. Sindh government also aims to develop its own vaccine (GAVI, 2022).

Table 1 highlights the extent of damage caused by the lumpy skin disease outbreak of 2021-22 in Pakistan. Like Covid-19, a sizable portion of the disease's impact may have gone undetected due to lack of reporting, reporting errors, and lack of signs appearing on cattle due to strong animal immunity. Moreover, table 1 does not reflect the effect lumpy skin disease had on consumer choices and on the price of meat. The demand of livestock meat including cows, goats, and sheep declined resulting in increased prices of broiler chicken causing additional burden on the masses. The political fall-out was also palpable. At one point, the Meat Merchant Welfare Association protested at Karachi Press Club to demand the local government to lift the ban on cattle markets.

Table 1: Lumpy skin disease in Pakistan

| Impact of outbreak in 2021-22 |
|---|
| 190,000 cattle infected |
| 7,500 cow deaths |
| 33% morbidity rate |
| 3.9% mortality rate |
| 4+ mn of vaccine import |
| 5 million dairy farmers & meat sellers suffered |

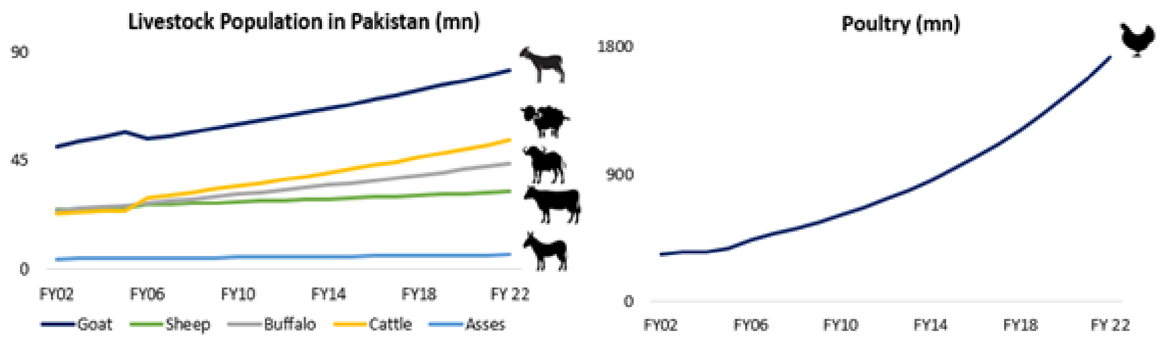
*Source: Global Alliance on Vaccines and Immunization (GAVI)*

There are some obvious lessons from this case study. If the government had sprung to action earlier and taken the measures that it took later, more animals could have been protected and economic loss could have been curtailed. Livestock disease management requires a national approach in coordination with provincial systems to control outbreaks efficiently. Livestock disease management requires awareness on animal disease management at the lowest level to avoid future outbreaks!

## The contradiction in regulation: over-regulate the formal few, ignore the rest

The Government of Pakistan estimates a consistent rise in livestock populations over the past two decades. The growth in poultry overshadows the number and leads the growth rate compared to all other types of animals. The numbers for the poultry population can be considered more reliable given that 95 percent of Pakistan's poultry grows in commercial operations most of which are likely to be registered with the government. But the rest of the animal population is mostly in the informal sector with only a sliver of the population growing in formal sector farms.

Figure 29: Livestock has been rising with poultry dominating by number




*Source: Economic Survey of Pakistan (various editions)*

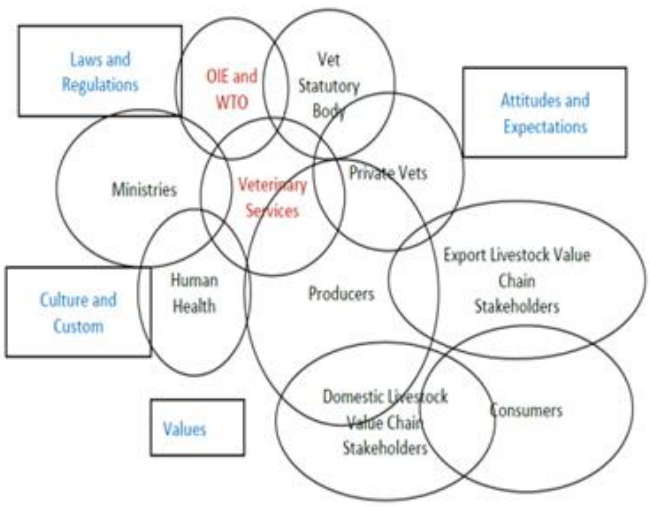
Milk is a critical livestock product with great prospects for growth—it is sometimes labelled 'white gold' in Pakistan. The major challenge for Pakistan's livestock sector is that the ownership of livestock is dominated by rural families and small farmers. (Rehman et al., 2017; Tahir et al., 2019). It is estimated that about 80 percent of milk-producing animals are owned by 'backyard farmers' of 1-10 animals of which the highest proportion is families with 2-5 animals. These animals are cared for by a family member typically with little or no education plus only traditional methods of animal care. On the other end of the spectrum, there are over 50 large 'corporate' dairy farms in Pakistan with large herds of imported animals. But they contribute only a few percent of the milk produced in the country. It is believed in trade circles that, in between these extremes, there are a few thousand dairy farms with herd sizes of 50-200 domestic animals.

This sector structure gives root to a contradiction in the way the livestock sector is regulated. Those who choose to operate in the formal sector are subjected to severe over-regulation akin to developed countries. By contrast, the vast majority of the sector's players who operate in the informal sector are under-regulated. This pattern is reflected in the implementation of the disease management regime as well whereby the highest standards are expected of the formal sector dairy farms while the vast majority of animals are in the care of unregulated dairy farmers.

## Mapping the stakeholders

Figure 30 presents the web of stakeholders that should typically be incorporated into animal disease management efforts for it to function efficiently. At the center are the growers/producers but their composition varies. The growers in the poultry sector are predominantly commercial players while the growers in the dairy sector are predominantly rural families.

Figure 30: Disease management: Stakeholders, key factors




*Source: World Organization for Animal Health*

The government's policy role is executed by the federal Ministry for National Food Security and Research (with linkages to the World Trade Organization and the World Organization for Animal Health, formerly OIE) as well as each province's relevant department titled 'livestock and dairy development' in Punjab, 'livestock and fisheries' in Sindh, etc. The government's regulatory role is typically also executed by the same departments. Since agriculture is a subject devolved to the provinces, these provincial departments provide the veterinary services to growers—although their footprint is extremely limited given the scale of the sector and the resources available to these departments. Private vets exist but their footprint is also limited relative to the need.

The domestic livestock value chain includes aggregators of livestock products, processors, suppliers of livestock inputs to growers, wholesale market players, and retail level sellers. There is a small export community dealing in livestock exports.

The work of all these stakeholders is influenced by attitudes and expectations prevailing in the sector, many of which can be from another era of livestock development when government took the lead in all activities. The values, culture and customs also impact outcomes on disease management. In this context, when a national level response is required during a disease outbreak, coordination among this panoply of stakeholders is required.

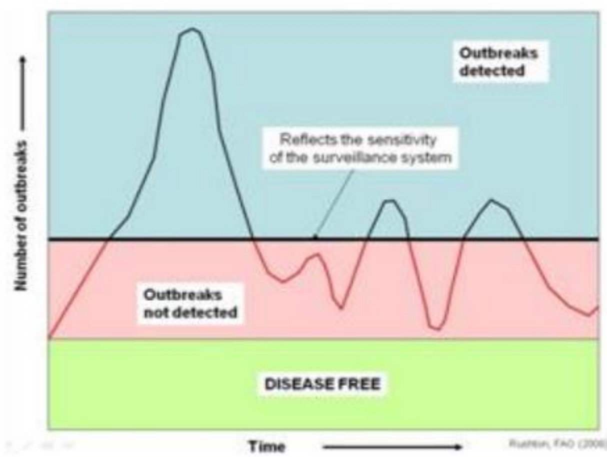
## Surveillance

Surveillance systems are the key pillar of disease management. Figure 31 illustrates that the sensitivity of the surveillance system determines the time a disease outbreak spends undetected. Outside of disease-free zones, a reasonably sensitive surveillance system typically detects a large number of diseases soon after an outbreak takes place (tallest peak). But other diseases may only be detected much later (smaller peaks).

Surveillance systems hinge on the concept of notifiable diseases—those which the public is legally obliged to report to the authorities. But growers cannot themselves control viral diseases. So, it is not sufficient for the authorities to simply be informed on outbreaks of notifiable diseases. The effective measures to be taken are to remove the infected animals and give compensation to the growers for this removal as well as the clean-up and disinfection.

In Pakistan, the formal surveillance system for animal disease outbreaks is inside the public sector. Currently, the role of private sector in animal disease management is negligible. Among public sector surveillance systems, the Government of Punjab's surveillance system merits mention. Each District Animal Disease Investigation Officer (ADIO) is required to submit a Monthly Notifiable Disease Report by post or email. Data is then manually entered in Lahore. But not all districts provide regular, monthly reports because of reasons that generally ought to be easy to address. District Officers may fear reprisal for not having effectively prevented the disease in the first place. Or the travel allowance for surveillance across the district may be too low with no additional provision for fuel.

Figure 31: Tracking outbreaks




*Source: Animal disease management, Livestock and Dairy Development Department, Government of Punjab (2012)*

The inevitable result of under-reporting from the field is that central level epidemiologists receive an incomplete picture of the disease situation because the sensitivity of reporting is sub-optimal. The private sector's role is mostly limited to private livestock holdings only. However, there is room for private sector engagement for better animal disease management.

Broadly, the SOPs exist and range from detection, investigation, process management and control. Even though the SOPs are comprehensive and cover every aspect of the disease response, there is a lot of room for improvement in implementation. Greater engagement with the private sector, simplification of processes through automation, and better engagement of large numbers of growers through technology is required.

Animal disease management faces greater difficulty because the livestock sector is even more skewed towards the rural areas than human population is. Therefore, frequent reporting from remote areas remains a big gap in the overall surveillance process. The general SOPs to stop outbreaks and check transmission are: controlled introduction of animals into existing herds, regular cleaning and disinfection of livestock areas, monitoring and reporting of illness, and use of effective vaccination strategies.

## Disease-free zones

**Lack of exports of livestock and livestock products is attributed to the absence of disease-free zones** in the country, especially, foot-and-mouth disease free zones. Creating disease-free zones and compartmentalization of disease outbreaks are procedures implemented for the purpose of disease control and/or protecting international trade. A zone is a clearly defined part of a country, with (a) a distinct animal sub-population, (b) animals having a distinct health status with respect to a specific disease, and (c) surveillance, control and biosecurity measures that are required for the purpose of international trade. A compartment has the same characteristics but only comprises one or more premises in which animals are kept.

Zoning and compartmentalization can enable a staged approach to disease control, with resources concentrated where they have most effect. The strategy can enable export once the agreed target of disease control or eradication has been reached. But practically, the compliance requirements set by the World Organization for Animal Health are demanding. A disease-free zone has high maintenance costs for retaining the disease-free status. It requires maintenance of a continuous surveillance system preventing the introduction of the pathogen through revised imports and border controls. It also involves appointing additional personnel and controlling the movements of animals and animal products.

The Government of Punjab's Livestock and Dairy Development Department prescribes how disease-free zones can be developed. The process starts with the identification and announcement of proposed area. The notification of the area is done in communication the World Organization for Animal Health. Both the holders of livestock and the animals have to be identified and registered.

Awareness activities are conducted for the farmers of the area on the advantages of disease-free zones/ compartments. Broadly, models are established for animal fattening and production through breeding. Quarantine camps and laboratories are set up at entry and exit points. Vaccinations against notifiable diseases, e.g., foot-and-mouth disease, are ensured. Finally, intensified disease surveillance and reporting are commenced.

The development of disease-free zones should ideally be coordinated with private sector investment in export-oriented slaughterhouses and meat processing plants. This necessitates the regular provision of best treatment and diagnostic facilities in the area and the enforcement of a legal framework for control of animal movement on entry and exit points. Regular surveillance and reporting of disease as well as data sharing with the relevant national and international agencies becomes critical.

## Pakistan needs to expand vaccination with a path to domestic production of vaccines

Controlling animal diseases with vaccination presents great potential for a stronger linkage of Pakistan's livestock sector to the international export market. Without disease-free certification, this potential cannot be reached. Improvement in the production, efficacy, and utilization of animal vaccines is an important complement to the development of disease-free zones. But there is a great of distance to cover on these important goals.

Pakistan's livestock herd requires the production of over 200 million good quality vaccine doses per annum to achieve an 85 percent vaccination rate—the target rate for herd immunity (FAO 2014). Current production is lacking in quantity and is perceived to be of lower quality. Some 95 percent of locally produced animal vaccines in Pakistan are developed in six public sector research institutions, while the role of private industry is minimal (Khattak 2019). The quality and quantity of vaccines produced in these research institutions is not sufficient for the annual vaccination requirements of livestock, requiring vaccines to be imported. An estimated US$ 45.5 million was spent in 2019 on importing animal vaccines (World Integrated Trade Solution). Increasing local vaccine production is imperative given the global scenario and constant rupee devaluation to keep animal care affordable.

Foot and Mouth Disease is a reoccurring issue in Pakistan with biannual outbreaks occurring all over the country but most commonly in the Landhi Dairy Colony in Sindh. In the Landhi Dairy Colony, 88 percent of all farmers are using vaccines on their animals, but only when the animal first enters the herd or when the animal is already symptomatic. The good practice to prevent constant outbreak is that farmers should be vaccinating all their animals twice a year: before the beginning of rainy seasons in June and September (Klein et al. 2008). The FAO has introduced cost sharing in their foot and mouth disease vaccination program for new enrollees as dairy farmers near to Karachi had seen the efficacy of the program vaccine (FAO 2014). This has expanded vaccination coverage.

Animal vaccine production is crucial to support the growth of livestock products and ensures the economic sustainability of this important sector. Production and distribution of quality vaccines requires effective disease surveillance, independent vaccine quality control, and appropriate cool chains to maintain vaccine quality during transport and application. Pakistan needs vaccine accessibility and friendly policies to incentivize local manufacturers to produce it. China has signed MoUs with local industry for producing Chinese vaccines in Pakistan (Daily Times, 2022). Supporting local industry production of these vaccines through partnerships is an untapped avenue to improve the quality of local vaccination.

## Conclusions and policy priorities

**For Pakistan to gain access to high-end export markets, upgrading animal disease management is critical.** Livestock is the main driver of growth in Pakistan's agriculture sector. Much greater growth can be achieved by accessing export markets for livestock and livestock products. But a significant jump in these exports will remain elusive until Pakistan addresses animal disease management. Animal disease management is a priority for domestic consumption of livestock products as well. This paper has highlighted better surveillance, management of disease outbreaks, farmer awareness, vaccine accessibility and production, setting up disease free zones, and private sector involvement in disease management for realizing the potential.

**Surveillance and reporting must be strengthened and coordinated nationally and internationally.** Modern disease surveillance involves provision of global positioning systems (GPS) based devices to Animal Disease Investigation Officers so they can identify and report coordinates of disease outbreak sites. Farmers must be encouraged to report specific diseases of concern by integrating surveillance with extension, informing farmers what to report and to whom/how. Sampling surveys must be designed according to the requirements demonstrating disease freedom in the planned disease-free zones and vaccination coverage.

Disease reporting officers must be incentivized to report diseases for early detection and rapid response rather than living in fear of reprimand upon finding disease. Early disease notifications are quintessential in decreasing the mortality and morbidity rates. Reporting outbreaks of animal diseases serves the greater good of the global animal health community. Government functionaries at the local level should not have to worry about the negative publicity associated with such outbreaks. The incentives at all levels should be associated with such reporting. Regular disease reporting from abattoirs must be established with veterinary meat inspectors, and field laboratories should be made more functional and laboratory test results better integrated with disease reports from the field.

**Coordinated oversight of outbreaks:** Government's response to lumpy skin disease seemed slow and weak initially until it developed a national level task force to deal with it. Oversight at the federal level with active participation from all provinces would have been a better way to respond to the outbreak from the onset. Building upon the experience from lumpy skin disease and Covid-19, a national control and command center should automatically become active in case of an animal disease outbreak with participation of all relevant stakeholders in it. All provinces should know their roles and responsibilities and should adhere to the regulations set out at the national level.

**Disease free zones:** The compliance can be a bit costly but so are the returns. Disease free zones can open up avenues to export livestock and livestock products to high end markets across the globe. Pakistan should start with small disease-free zones linked to investment in export-oriented projects. This must be used as a springboard for consistently expanding disease-free areas across Pakistan in a phased manner.

**Building awareness.** It is critical to invest in disease awareness among small cattle holders who are at the frontline of animal disease outbreak. Farmers should be trained to identify and report on specific diseases of concern. Government should start developing a repository of cattle owners with their contact numbers and constantly inform them on various disease outbreaks in the world and the signs that they should watch for in their livestock through recorded phone calls. The calls should also guide them on not vaccinating their livestock without consulting a qualified veterinarian. The call should also guide them on how to report signs of disease in their livestock.

**Involvement of the private sector:** The traditional approach to disease management has been that it is only government and its functionaries which can operate this regime. Given the scale of the challenge, government resources can be supplemented with the involvement of the private sector in three main areas. The first area is private service providers to farmers funded by the government. In fact, the government can pilot a private curative service delivery system in one or more districts. The second area is the involvement of processors of livestock products who are connected with livestock farmers. Many programs along this theme already exist. For example, Friesland Campina Engro has a program in Sindh under which women are trained to provide veterinary services in their own local areas to livestock farmers. This provides a stream of income to women while providing a great benefit to farmers and processors alike. Some of these women have turned a dedicated room in their houses into a warehouse to become a supplier of associated inputs. The third area where the private sector can become involved is community-based animal health care. A large number of livestock owners are unable to access private services due to the long distances and cost of getting their livestock checked by private practitioners. For this purpose, community-based animal health care can be established in areas where professional veterinarians are unwilling to work due to low remuneration.

# BETTER FEED FOR HIGHER LIVESTOCK GROWTH

# VI. Better feed for higher livestock growth

According to government data, Pakistan's population of dairy animals (buffaloes, cows, goats, and sheep) was 211.5 million in FY22[6]. This is just shy of Pakistan's human population but mostly growing faster at three to four percent per annum for buffaloes and cows and 2.7 percent for goats over the past fifteen years. With ninety-seven million buffaloes and cows in the country in FY22, beef dominated meat production at 2.5 million tons; with eighty-two million goats (much smaller animals), the mutton production was 0.8 million tons. The total milk output available for human consumption was 53 million tons—among the highest in the world. These milk- and meat-producing animals are challenged by Pakistan's poultry population both in number (1.7 billion birds), output (two million tons of chicken meat and 22.5 billion eggs) and growth rate (a blistering 9.5 percent per annum rise in the flock over the past fifteen years). Even though many industry stakeholders question government data regarding animals in Pakistan, these numbers definitely indicate the momentous challenge of providing sufficient food to Pakistan's human population and sufficient feed to Pakistan's animal population.

Pakistan's poultry sector has shifted to a mostly commercial industry over the past couple of decades. Over ninety-five percent of Pakistan's poultry is grown on commercial farms with modern genetic material and modern feed systems. The remaining poultry is under the husbandry of rural families. By contrast, about eighty percent of Pakistan's dairy animals are with small farm families. A livestock census has not been held since 2006. And multiple floods and other natural calamities having hit Pakistan since then. So, industry experts express concerns that the animal population may be less than the government data cited above. In this situation, a useful outcome from the 2006 census is the herd distribution. Nearly eighty percent of the cows and buffaloes at that time were in herds of up to fifteen animals. These animals are mostly of local breeds held by an estimated 8 million farm families. The vast majority of these families holds three to six animals averaging four to seven liters daily milk yield mainly to fulfil their own family needs while a portion of these farm families sell some of their milk to the market. Among a good part of the subsistence-level dairy farming families, there is scarce inclination towards the potential of modern livestock[7]. This is why the concept of 'idle dairy capacity' is often mentioned about them.

A second category is of mid-sized dairy farms typically with a herd of twenty-five to a hundred animals each, including in peri-urban areas. Again, the traditional breeds dominate these farms with some imported animals cast off from Pakistan's handful of 'corporate' dairy farms. Using the average daily milk yield of the animals as a proxy for performance, these mid-sized farms are estimated to yield fifteen to twenty liters per day per animal which may hit twenty-five liters at peak lactation in some cases. Lastly, there are less than twenty 'corporate' dairy farms in Pakistan which typically carry 2,000 to 8,000 genetically proven imported breeds. These farms attain twenty-five to thirty-five liters daily milk yield

6 Government of Pakistan (2022). Pakistan Economic Survey 2022-23, Tables 2.14, 2.15, and 2.24

7 This is section is based on Shahzad, A. (2022). The need for national livestock surveillance in Pakistan, Muhammad Aamir Shahzad, Journal of Dairy Research, Volume 89, Issue 1, February 2022, pp. 13 – 18 (published online by Cambridge University Press: 2022).

per animal. They employ modern livestock management practices and technologies with precision feeding delivered using appropriate feed machinery, feeds, and practices.

Pakistan's feed challenge is to deliver an adequate and reasonably priced supply of quality feed inputs for these poultry and dairy animals (targeted in this note) while motivating family farms to move in the direction of improved feeds for higher animal productivity and better animal health.

## Feed 101

Feed for animals is like food for humans. The animals can be fed 'whatever is available' but, for specific commercial outcomes—such as greater meat output and higher milk productivity—the composition of feed must be based on the science underpinning the conversion of feed into energy. This typically involves giving the animal a feed mix delivering carbohydrates, protein, fats, vitamins, and minerals, etc. (and, of course, water), in optimal measure. As in food for humans, sources of carbohydrates (typically, wheat and rice—*roti chawal) are cheaper than sources of protein. Fats have a higher energy content than both* carbohydrates and proteins and so are the most expensive used sparingly in feed[8].

*Dairy feed* Pakistan's feed for dairy animals is mostly in the 'whatever is available' camp. The dominant sources of feed are conventional: crop residues and forage.

*Crop residues:* The crop residues available for animal feed are primarily the stems and leaves (or straw) that remain after the grain is removed from field crops such as wheat, rice, maize, etc. When the proverbial wheat is separated from the chaff, the chaff is typically found to weigh the same or more than the grain depending on the crop. So, a small farmer's wheat crop yield of thirty maunds of wheat grain per acre (1.2 tons per acre) also yields 1.5 times this weight in wheat straw.

In a modern farming operation, this organic matter is chopped and ploughed back into the soil to increase the proportion of nutrients for the next crop. But this is not commonly practiced by small farmers in Pakistan. The straw is either kept for the small farmer's own animals or sold for additional revenue to the market that serves animal feed, the pulp and paper industry, and other products. In this way wheat, Pakistan's dominant crop and staple food, produces food for humans plus feed for animals.

Figure 32: Dairy feed in Pakistan

Conventional feed sources

- Crop residues
  Straw fromwheat, rice, maize, etc.
- Forage
  Grasses, fodders (Lucerne/ alfalfa, berseem), sorghum, millet (bajra), hay, etc.
- Concentrates
  Bran (choker), rice polishing, oil seed cakes, oil seedmeal, etc.
- Other
  Fooditems unfit for human consumption

Modern commercial feeds

- Silage/Hay
- Wanda *(Concentrate)*
- Total M ixed Rations
- Other

8 This section is based on Abbas, R. et al. A Study on Feed Stuffs Role in Enhancing the Productivity of Milch Animals in Pakistan- Existing Scenario and Future Prospect, Global Veterinaria 14(1): 23-33, 2015

Crop residues are considered low quality feed mainly because they are low in protein and minerals though high in fiber. But they are less digestible. Wheat straw is by far the largest component of crop residue for feed followed by maize and rice straw as well as rice husk (shell in which grains grow—removed before processing).

*Forage* includes various types of grasses and fodders as well as sugarcane tops, tree leaves, etc. Generally speaking, grass is just grass. But among specialized grasses, Rhodes grass has been cultivated in Pakistan for local consumption by animals as well as export. The common fodders cultivated even by Pakistan's small farmers for their own animals' feed are Barseem and lucerne (alfalfa) which typically grow in the winter. Forage is easily digestible but high in moisture (the dry matter is what counts for feed, not the moisture). Hay is dried fodder and, since medieval times, small farmers have typically made hay only while the sun shines. Sorghum (*Jowar) is* also grown locally in summer often with imported seed.

*Concentrates* are often low in fiber but high in protein and highly digestible by animals. They are often the expensive part of feed used in small quantities and are mixes of multiple ingredients. These ingredients are typically by-products of other commercial activities and generally have informal markets which serve farmers and other users of these items. These ingredients can be of plant origin or animal origin:

- The common plant-origin ingredients in Pakistan are by-products of grains—rice polishings, maize bran, wheat or rice bran (choker), molasses (sheera), etc.—and by-products of the extraction of oil from oilseeds. The feed by-products from mechanical extraction of oil from various types of seeds are called oilseed cakes and the by-products from solvent-based extraction of oil are called oil meals (low in protein but high in residual fat). Oilseed cakes (khal) from cotton seed (banola) are quite common. Oilseeds imported for production of edible oil (e.g., soybean seed, canola seed, etc.) are sources of soybean seed cakes, canola seed cakes, soybean meal (figure 33), etc.
- Animal-origin ingredients (blood meal, fish meal, bone meal, meat meal and feather meal) are good sources of protein but are used less now given the prospect of disease transfer through them. Plant-origin concentrates are more widely available in rural areas than animal-origin concentrates and are also cheaper.

*Other* Feed affordability and supply constraints mean that animals are also fed pieces of dried bread (pieces of *naan or roti) and,* mainly at urban/peri-urban farms, confectionary waste as well. Damaged wheat that is discarded from the food industry as unfit for human consumption is also fed to animals. These sources of feed can have higher levels of aflatoxins (a family of carcinogenic fungus) and the levels are also high in seed cakes especially Cotton Seed Cake.

Figure 33: Soybean meal, oil and soybeans

*Source: Feedpedia*

*Supply dynamics of conventional feed*

As with food for humans, no single animal feed source is sufficient to meet all the nutritional needs of animals. Most commonly on Pakistan's small farms, animals are fed a mixture of crop residues, green fodder, and concentrates. The exact mix/requirement depends on multiple factors: the prevailing temperatures and environment, the phase that the animal is in (dry phase, lactation phase, weaning, etc.). The most commonly used additives for animal feed which are also sources of protein for animals on smallholder farms are cottonseed cake (*banola khal) and* wheat or rice bran (*choker).*

Figure 34: Traditional storage of wheat straw

*Source: Daily Dawn (Sahiwal, Pakistan).*

*Fodder* is grown on small patches even by small farmers to serve their animals and to sell in local markets. Pakistan's growers have faced a fodder shortage for decades particularly off-season: June-July and December-January. Therefore, animal feed in these periods is mostly in the form of crop residues. Farmers usually store crop residues to feed their animals because of easier storability, especially for periods of fodder shortage. As figure 34, these roughages are stored in piles (*dhar) in an open field layered on top* with a paste of mud and chaff to protect it from rain and other environmental factors. Dry crop residues are also stored as bundles and are available for purchase locally.

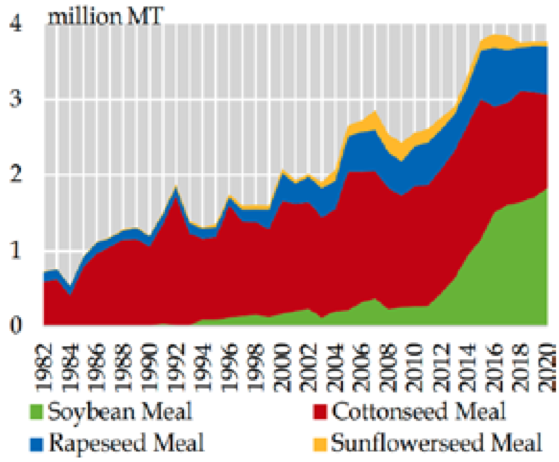
The dominant conventional sources of feed have a high moisture content while the actual feed available to the animal is measured in terms of Dry Matter Intake (DMI). With periodic shortages, the difficulty in storing and transporting these traditional sources of feed in large quantities while maintaining quality is a reason why modern commercial feeds are becoming more popular among growers who can afford them.

*Modern commercial feeds* to protect animal health and boost animal productivity, balanced feed typically includes the requisite proportions of carbohydrates, protein, fats, vitamins, and minerals. The average dry matter intake requirement of an animal is in the range of three percent of its body weight[9].

9 Abbas, R. et al (2015)

*Silage* is primarily based on maize (corn) in Pakistan. In simple terms, silage is the entire maize plant (including the corn and the cob) harvested, chopped up, packed into bales or dumped in silage bunkers, and allowed to ferment without oxygen. In this form, the maize can be stored for long periods which improves the availability of green fodder during times of fodder shortage. If suitable anaerobic conditions are not provided, then proper acidic conditions will not develop which is crucial for the fermentation process to preserve the quality of fodder and to avoid spoilage. Silage is yet to gain popularity among smallholder farmers and its use is still limited to medium- to large-scale farms.

Figure 35: Rising use of oil seed meal in Pakistan




*Source: State Bank of Pakistan*

*Wanda* or compound feed is another increasingly common source of protein and other nutrient supplements for a balanced diet. A typical compound feed consists of cereal grains (like maize), choker/bran, soybean meal, canola meal, sunflower meal, rapeseed meal, rice polishing, minerals, vitamins, molasses, and bypass fats.

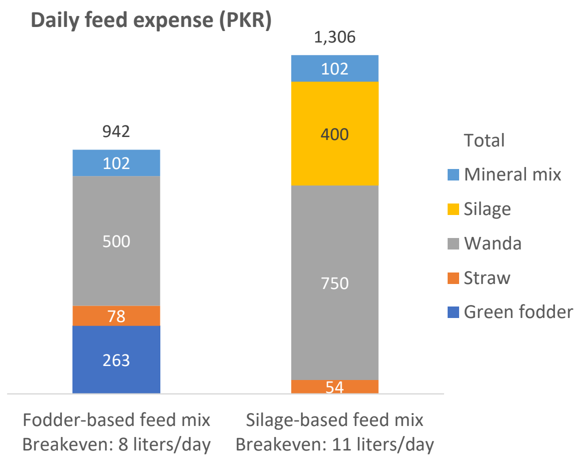
*Total mixed rations* (TMR) refer to dairy feeding systems that are a combination of roughages (like wheat straw), fodder, maize, bran, soybean meal, canola meal, sunflower meal, rapeseed/mustard meal, rice polishing, minerals, vitamins, molasses, and bypass fats. Figure 35 shows the rising use of oilseed meal in Pakistan. The combination of TMR also depends on environmental factors and the phase that the dairy animal is in. TMRs are mostly used in what are called 'Corporate/Mega Dairy Farms' in Pakistan. These farms have the dairy farm design and equipment (e.g., TMR mixers) that allows for the provision of a balanced feed. A corporate dairy farm also makes the provision of TMRs relatively less expensive with economies of scale.

*Poultry feed is* typically a combination of maize, soybean meal, canola meal, and other ingredients. Maize is the dominant component accounting for some forty-five percent of poultry feed. Soybean meal is next at about a quarter of feed as a source of protein. The rest are canola meal, rapeseed meal, and animal protein feed, rice polishing (the finely ground material obtained in polishing the rice kernels after the husk and the bran have been removed), etc. So, fluctuations in maize and soybean prices impact the price of feed.

## How the economics of feed impacts the farmer's choice of feed

For larger dairy farms, animal feed costs account for roughly seventy percent of the total cost of producing milk. These dairy farms incur the capital expenditure of building proper housing for animals, milking machines, TMR mixers, etc., while salaries, electricity, feed, and animal disease are the major operational costs. But, at the smallholder level, animal feed is considered to be the only expense as members of the household normally handle the animals and extra help is not hired for the animal's upkeep. Moreover, the animals are kept in or near the household and no major expenditures are incurred for their shelter or general maintenance. Occasional veterinary services can incur some expense. Therefore, it is important to understand how the economics of feed impacts the farmer's choice of feed.

Figure 36: Better feed requires better genes




Calculations based on dry matter intake.

The general rule of thumb in the dairy sector is that the average animal's dry matter Intake is in the range of three percent of the animal's own weight. This means that a five-hundred-kilogram dairy animal should be fed about fifteen kilograms of dry matter daily. This dry matter content differs from one feed type to another. For example, green fodder usually has between eighty and ninety percent moisture content which means it has sparse amounts of dry matter. By contrast, the moisture levels in silage are a little lower (between sixty and seventy percent) while straw and other crop residues have between twelve and twenty percent moisture levels. Therefore, the gross weight of feed required daily is much higher than the range of fifteen kilograms mentioned above. Another rule of thumb is that the kilograms of concentrate mix required in dairy feed are generally half of the average milk produced per day. For example, a dairy animal producing ten liters per day will be fed a total of three to five kilograms of concentrate throughout the day[10].

A five-hundred-kilogram animal will be fed a combination of green fodder, crop residue, and concentrate to fulfill the animal's dietary requirements. At prices prevailing at the time of writing, this feed mix is estimated to cost close to 950 rupees per day. Therefore, at a farm-gate milk price of Rs. 120 per liter, the breakeven production is at around eight liters per day. The average milk yield of buffaloes owned by 'part- commercial' growers is around ten liters per day which means the farmer's profits are only two liters per day. However, many smallholder dairy farmers do not sell all of the milk produced and keep a portion of the milk for household consumption. So, a smallholder dairy farmer would barely be breakeven with this feed mix. The result is that a number of smallholder farmers reduce their feed expenditure by supplementing the feed requirements through other cheaper sources of feed like grazing where possible

10 Dairy hub training booklet, Balanced Ration.

and adding kitchen scraps like fruit and vegetable peels and residues, dried *roti, bakery leftovers, etc.*[11] Providing a balanced feed is only economical for farmers if they obtain a higher yield. Of course, this stylized calculation does not account for the dry periods in the milking cycle of the dairy animal so the breakeven production is effectively much higher than eight liters.

The animal needs to have the genetic potential for higher milk productivity, otherwise the expenditure for improving animal feed will not be compensated. Figure 35 shows the farmer's economics for replacing green fodder with silage which is more expensive (but with less moisture than fresh fodder) for a higher yielding dairy animal. The increased spending on quality feed is mainly justified by a higher milk productivity genetic potential.

Typically, the sources of better genetic potential in Pakistan's dairy sector are the dairy animals imported by the 'Corporate/Mega' dairy farms and some mid-sized commercial farms. Some of these animals find their way to other growers as well. The practice of artificial insemination can improve the genetic potential of domestic breeds. In simple terms, this is the process of introducing the semen of better breeds into female dairy animals of local breeds. The result is off-spring (next generation) with characteristics of better breeds. Artificial insemination is already in use in Pakistan but requires significant expansion to improve the genetic composition of the national dairy herd.

## State of Pakistan's feed industry

*Poultry* Pakistan's poultry feed industry produced 6.4 million tons of feed worth Rs. 448 billion in FY21[12]. This feed is produced from the key inputs of maize, soybean meal, canola meal, and other agricultural products/by-products. Covid-19 hit poultry consumption hard causing a significant reduction in poultry consumption. This impacted the feed industry as well forcing it to operate at 45 percent of its capacity of 13.3 million tons in FY21. That year, the feed industry's production was about a third lower than its peak production of 9.8 million tons in FY17. The poultry feed industry is fragmented with about 350 feed mills scattered mostly in Punjab's maize belt (broadly, the districts between Lahore and Multan).

*Dairy* Pakistan's dairy feed industry is pre-dominantly in the informal sector and specific information about each component is not easily available. The different types of fodder are typically grown on an estimated 6 million acres producing about 55 million tons of fodder in FY19[13]. A number of small dairy farmers grow their own fodder on a patch of their land and rely on stored hay, straw and other crop residues to feed during periods of fresh fodder shortage. Excess fodder and crop residues are also sold and the market for these products is mostly in the informal sector. Concentrates of varying quality and compositions are manufactured in compound feed processing mills and are available for purchase in the local market. The ingredients depend on the exact composition, although a large amount of grains,

11 Handbook of Dairy Nutrition Pakistan, published by American Soybean Association, 2009

12 This section is based on PACRA (2022). Poultry Feed Sector Study, January 2022.

13 Government of Punjab (2019). Ayub Agricultural Research Institute, Faisalabad, website: https://aari.punjab.gov.pk/fodder_cropvarities

residues from grain processing (such as bran and polishing), oilseed cake and meal are used to manufacture concentrates. Credible reports that describe the concentrate industry are difficult to finds.

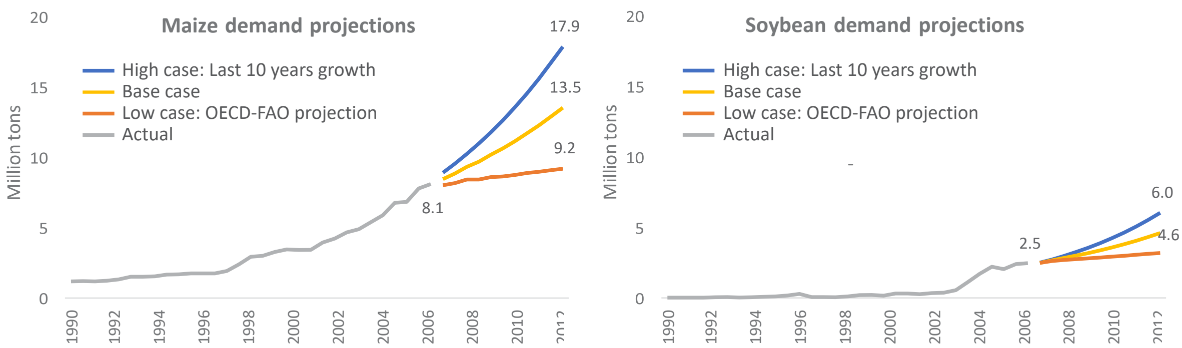
## Can Pakistan produce the feed required in the coming decade?

The demand for livestock products, particularly poultry, has continued to rise over the past decade or so despite the fluctuations in Pakistan's economic growth from year to year. Growth is expected in the rest of this decade as well. The OECD expects that India and Pakistan, important milk producers, will contribute more than half of the growth in world milk production over the next ten years and will account for more than 30% of world production in 2030[14].

The number of poultry birds in Pakistan has risen at 9.1 percent per annum in the decade ending in FY21. The poultry feed produced for these birds was 6.4 million tons. This feed output was made possible by a 9.2 percent annual growth in Pakistan's maize output in the same decade. Poultry feed demand for maize accounted for seventy percent of total maize production according to poultry industry experts. These experts see maize demand from the poultry feed industry continuing to grow similarly over the next decade. Along with this poultry feed demand for maize, industry experts estimate that the proportion of the maize output going to dairy feed products (silage, wanda, etc.) is about ten percent. This maize demand for dairy feed can be assumed to grow at the rate at which the number of cows and buffaloes has been rising over the past decade—about 3.5 percent per annum. Figure 36 shows a high case for maize demand projection using the projected growth in two components of maize demand while keeping other components constant (maize for production of industrial starches and for human consumption).

By contrast, the OECD-FAO Agricultural Outlook 2022 does not project this breakneck growth in maize consumption in the decade ending FY31. The OECD-FAO projections show Pakistan's maize demand rising at 2.2 percent per annum between FY21 and FY31. This can be considered a low case for maize demand. Figure 37 shows the high case, the low case, and the average of these two projections as a base case.

Figure 37: Maize demand projections




*Source: Author calculations (Economic Survey of Pakistan, OECD-FAO)*

14 OECD/FAO (2021). OECD-FAO Agricultural Outlook OECD Agricultural Statistics, http://dx.doi.org/10.1787/agr-outl-data-en

*Maize* Pakistan has had a remarkable maize production journey since 2001 when the government introduced a framework for the import of hybrid seeds. Maize yields have tripled since that time while the acreage under maize has risen by fifty percent. The result is a 444 percent increase in maize production to about nine million tons in FY21 and rising. Looking back at the past two decades, the main reason why the increase in maize production was possible was the rising adoption of hybrid maize seeds (primarily across the Punjab where nearly all of the hybrid maize is grown). Even if we assume non-feed demand for maize to remain constant between FY21 and FY31, these basic calculations project the maize demand to nearly double from 8.9 million tons in FY21 to 17.9 million tons in FY31. How can this increase be achieved?

*Soybean meal* Pakistan imported 2.5 million tons of soybean worth US$ 1.4 billion in FY21 which was a notable component of national imports—three percent of the total import bill for the year[15]. About two million tons of soybean meal was produced as a by-product of the extraction of oil from this imported soybean by the edible oil industry. Soybean has been imported into Pakistan since the 1980s. Figure 37 shows that soybean meal consumption has risen sharply over the past decade as a high case, the OECD-FAO 2022 projection as a low case, and their average as a base case. This is driven primarily by the poultry feed industry's demand for soybean meal. Pakistan's local soybean output is a few thousand tons a year.

These numbers allow an estimate of the foreign exchange impact of maize and soybean imports in the coming decade. Using the projected base case and the last three years' average maize price (US$260 per ton), these projections indicate that Pakistan's import bill for maize would be US$ 1.2 billion in FY31. Similarly, using the base case projection of volume of soybean and the last three years' average soybean price (US$500 per ton), the import bill for soybean—only driven by poultry feed demand—would rise to an estimated US$ 2.3 billion in FY31. The local cultivation of these crops can take place with imported hybrid seed costing a fraction of the large bills for importing the crops themselves.

## How can domestic production of feed rise to meet demand?

The main prospect for increasing maize output further from the same acreage is the adoption of genetically modified hybrid maize. Industry experts expect GMO hybrid maize to increase output by twenty to thirty percent from the same acreage. And this could take the domestic maize output halfway to the base case maize demand projected for FY31. But Pakistan is yet to make up its mind about GMO products. This is an issue that has caused significant difficulty for Pakistan's feed industry. In October 2022, the federal government's Department of Plant Protection (DPP) started requiring that soybean importers present an import license from the Ministry of Climate Change (MOCC) as a condition for releasing soybean shipments (even those on the high seas enroute to Pakistan). The MOCC had no system for receiving and/or processing import licenses for soybeans destined for food, feed, or

15 Special Section: Pakistan's Rising Palm & Soybean Imports: Understanding the Drivers and Challenges to Domestic Oilseed Production, SBP quarterly report for 1st quarter FY22.

processing[16]. In the seven prior years, DPP had approved and cleared nearly 14 million tons of GMO soybean imports, none of which included an MOCC license. By the time this was resolved, poultry prices had risen and importers had suffered. The GMO seed issue must be addressed to expand Pakistan's maize and soybean output.

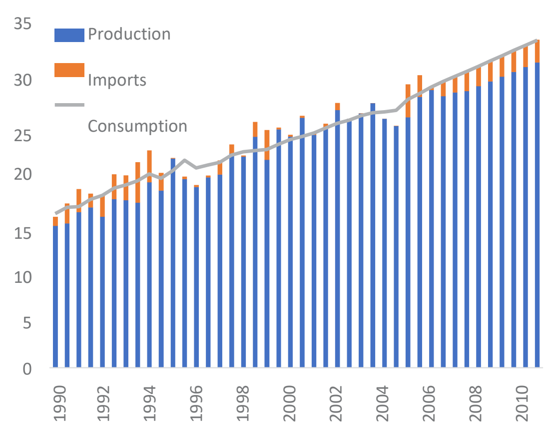
The remaining increase in maize and soybean output would have to come from increase in the area under maize and import substitution of soybean. This can only happen at the expense of other crops. Maize has two crops each year in Punjab: its summer *(Kharif)* planting is bigger than its winter *(Rabi)* planting. Soybean and other oil seeds are all sown in the winter. The summer maize crop has already taken away acreage from other kharif crops, including cotton. So, further increase in acreage during the summer would be difficult. By contrast, the winter maize crop and oilseeds compete mainly with wheat. The prospect of maize replacing more acreage under wheat can only be realized if wheat yields rise.

*Wheat* is an important crop from the animal feed point of view as well in Pakistan. An estimated eighty percent of Pakistan's farms grow wheat during the winter and keep a third of it (plus the corresponding straw) for the use of their families and animals during the rest of the year. The remaining wheat output is either purchased by provincial governments or by flour millers both aiming to deliver flour to the urban population. The most likely path towards convincing more smallholder farmers holding three acres to grow maize or soybean in the winter is by providing them with higher quality wheat seed than they currently have access to. The current average wheat yield of thirty maunds (1.2 tons) per acre means this farmer's total wheat output is 3.6 tons. But Pakistan's progressive farmers easily take forty-five maunds (1.8 tons) from each acre of wheat. If a smallholder can get the same yield of wheat from each acre, i.e. 3.6 tons from just two acres, then it is possible for the farmer to grow maize or soybean on one of the three acres. But this is not the only reason for increasing wheat yields.

The OECD-FAO Agriculture Outlook 2022 projects growth in wheat consumption in FY21-31 which is generally congruent with the wheat consumption growth witnessed in the past couple of decades (figure 38). So, these projections can be used as a base case. The projection assumes business-as-usual for the wheat crop with the same seed and other inputs being used in the coming decade as well. This shows Pakistan's wheat demand reaching thirty-three million tons in FY31 while production only reaches 30.8 million tons—an import of over two million tons!

Pakistan's annual wheat import is projected at two million tons in this decade—a consistent burden on Pakistan's foreign exchange reserves. Using the international wheat price for the last ten years (US$ 250 per ton), Pakistan's average wheat import bill can

Figure 38: Wheat projections for Pakistan




Source: OECD-FAO

16 USDA (2023). *Oilseed and Products Update – Pakistan,* Report PK2023-004, page 2

be estimated at half-a-billion dollars each year. But taking the elevated international wheat price average of the last three years (US$ 337 per ton), this bill rises to US$ 700 million per year. And the imports come without straw to feed dairy animals. Overall, Pakistan *must increase its wheat yields as soon as* possible—not just for food but also for feed.

## Feed quality

A major concern in milk quality is the occurrence of aflatoxins (carcinogenic toxins). A 2020 study conducted in Punjab on over 240 samples (of milk and animal feed each) revealed that over 53% of raw milk samples from dairy farms exceeded the maximum residue limit for aflatoxin M1 set by the US Food and Drug Administration (FDA)[17]. Moreover, 95% of feed samples surpassed the FDA limit for aflatoxin B1. The results indicate the prevalence of feed of poor quality and its impact on the quality of milk. The study also found that higher-priced feed correlated with lower levels of M1 and B1 aflatoxin contamination. Farmers sometimes offer bread pieces and other kitchen and bakery waste to animals, which can contain high levels of aflatoxin contamination. Another study indicated that animals fed with bread pieces produced milk with higher aflatoxin levels. Meat quality is less impacted by feed quality but meet yield is reduced by low quality feed. Unfortunately, thermal processing methods like pasteurization and UHT treatments are ineffective in reducing aflatoxin effects due to their stability at high temperatures. Oil Seed cakes are also prone to fungal growth, underscoring the importance of using high-quality concentrates and feed to maintain animal health and ensure the quality of dairy products. Therefore, improving the quality of feed is critical for quality livestock outputs from a food safety perspective.

## Conclusions and policy priorities

Pakistan's livestock endowment is critical to national food security. This paper shows that Pakistan is looking at **not only a rising food insecurity in the coming decade but also a rising feed insecurity.** Since feed typically accounts for about seventy percent of the cost of producing livestock products, the rise in feed insecurity means a lower quality and quantity of livestock products which means **higher prices of livestock products.** Further dependence on imported ingredients of feed is also a source of insecurity.

**The primary policy goal for feed must be: adequate and reliable feed supply at affordable prices.** But the outstanding rise in maize production over the past two decades (driven by the adoption of hybrid maize seed) is reaching its limits. The import of soybean is at three percent of Pakistan's import bill and rising. Wheat imports are projected to rise. Foreign exchange is already scarce.

Some eighty percent of Pakistan's dairy animals are with small farm families. So, what is the way forward? It is well known that higher animal yields require better feed. But this paper has tried to demonstrate

17 Akbar, Naveed, et al. Assessment of Aflatoxin in Milk and Feed Samples and Impact of Seasonal Variations in the Punjab, Pakistan. Food Science & Nutrition, 14 Apr. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7300088/

that, in a developing country like Pakistan where smallholder farmers have extremely limited resources, the opposite is true as well. For better dairy feed to be financially feasible for smallholder farmers, higher dairy yields are required and for that improved genetic potential is important.

The good news is that Pakistan's poultry industry has already cracked this chicken-and-egg problem through the consistent introduction of higher and higher genetic material in Pakistan's poultry flock. Yields have consistently risen which means that the price at which the poultry farm breaks even has fallen. The result is a decrease in the price of poultry products *in real terms.* But this jump was possible because over ninety-five percent of Pakistan's poultry is raised on commercial farms—not on family farms. This experience shows that the poor-feed-low-productivity nexus can be addressed through the introduction of better genetic material in Pakistan's dairy herd. But for this, a major shift is required on the demand side of the dairy feed sector. In addition to the 'Corporate Dairy Farms, Pakistan needs to encourage the expansion and increase in sophistication of commercial dairy farming particularly medium-sized dairy farms by facilitating financing as well as the adoption of new technologies through tax incentives.

There is also a way forward for smallholder farms. The **expansion of artificial insemination** is a route to achieving higher genetic composition in Pakistan's dairy herd. Smallholder farm families need to be provided with the financial resources, know-how, and technical services to allow such improvement of their breeds. This will create demand for higher quality feed and lead to higher dairy productivity. This shift should gradually help reduce the proportion of feed of low quality that is fed to dairy animals.

On the feed supply side, **the future of wheat, maize, and soybean must be guided in tandem.** The projections for these key components of feed indicate that shortages of maize, soybean, and wheat can be added to Pakistan's fodder shortage. The estimates show that, if business as usual prevails, Pakistan could be looking at an incremental $4.2 billion of imports related to feed in FY31. To avoid further imports of maize especially soybean, Pakistan must quickly **remove the broader challenges to seed improvement and resolve the debate on genetically modified crops.** Pakistan's institutional framework for seed must instill sufficient confidence in international seed players to **invest in local production of hybrid seed**—which will remove the need for seed imports as well. With that, the way to substitute soybean imports is to displace wheat since both are sown in the winter. Similarly, the ways to increase Pakistan's maize production are the introduction of genetically modified hybrid maize and expanding the area under maize. The latter is most feasible in the winter crop which, once again, requires displacement of area under wheat. Therefore, **to increase maize and soybean output, wheat yields have to rise** to give farmers the same income from less acreage. These measures can put Pakistan's feed sector on a sustainable footing to serve the coming growth in demand for food and feed.

# POLICY PRIORITIES FOR GROWTH IN AGRICULTURE

# VII. Policy priorities for growth in agriculture

**Within this decade, Pakistan must shift from being a victim of high global agri-commodity prices to a beneficiary.** Pakistan's economic growth targets must include 4 percent real GDP growth in agriculture. This requires a rise in crop yields to take Pakistan from being a food importer to a food exporter—net of the food security stocks required in-country. Today's balance of payments crisis has created the need for significant import substitution and increase in exports.

**Better seed is at the core of the long-term growth prospects in Pakistan's agriculture.** The outstanding success in maize (a tripling of yields in the past two decades) and the sad story of cotton (stagnation followed by a fall in yields) is directly attributable to seed. The stagnant yields in wheat, the country's largest crop, require better quality seed. Seed is 'agriculture's great equalizer' since it gives the small farmer a chance to achieve the results available to large farmers. And farmers' verdict on seed quality is clear: they have purchased even more expensive seed if it performs reliably and gives higher returns. The main hurdles to seed development are the legal and regulatory regime that discourages the private sector to invest. The Seed Act must be amended to encourage reputable private seed companies to invest and the approach to seed regulation must shift from an approach of controlling the seed sector to an approach of maximizing benefit to the farmer. As demonstrated by maize and poultry, the import of modern genetic material for crops as well as livestock is critical for growth across the agriculture sector. Similarly, the genetic potential of livestock must be improved by facilitating the import of high-quality genes with support to farmers for artificial insemination and better feed. For food security and feed security, Pakistan needs to guide its wheat, maize, and soybean crops in tandem to reach not only self-sufficiency but also an exportable surplus. Local production of hybrid seed must also become a common activity in Pakistan.

**Fruits and vegetables must expand from 5 percent of cultivated land to 15 percent to save water and to achieve more growth in agriculture.** If global players in this trade can be attracted to Pakistan for off-take of fruits and vegetables for export, serious investment into cool chain infrastructure can be justified. Farmers are ready to respond to an assurance that their fruit and vegetable will be guaranteed off-take and the certainty that this produce will not die on the way end-consumers. But since land does not grow on trees, this shift is only possible with a rise in the yields of Pakistan's five major field crops which dominate agriculture's resources: land, water, inputs, etc. Another major roadblock to this transition is the government's intense involvement in the wheat value chain with little benefit to the farmer and little improvement in yields to show for it. This system must be shifted away from patronage and towards strength for competing in global markets through higher value wheat-based products.

**The global buyers' demand for traceability and sustainability is not difficult to meet. It just requires stronger linkages between processors and growers.** Pakistan's own examples of excellence in agriculture are found where processors have done backward integration with farmers. Processing of agri-commodities into higher value products is what drives agriculture to the next level. Investment in agro-processing right in the production areas is a priority for Pakistan to multiply its agriculture GDP.

**Growth in agriculture requires a leap to modern agri-technology. And this is best achieved with equity capital.** This leap requires capital for modern farm machinery, silo storages, cool chains for fruits and vegetables, controlled sheds for poultry, high efficiency irrigation systems, etc. And such an upgrade is difficult to achieve through debt alone. Equity needs to be invested. And it needs to be invested at scale since Pakistan's agriculture sector is yet to mechanize. The institutional vehicles best suited for bringing this technology upgrade are corporate farming operations which invest in machinery for their own use and service providers who invest in machinery to serve growers. Growth in agriculture requires investment not just farmers by all types of reputable players, particularly, the corporate sector.

**An increase in agriculture exports is dependent upon a serious upgrade of Pakistan's irrigation system.** Precision agriculture is not possible without precision water delivery. Seedlings from a rice nursery must be transplanted to the field typically in the range of 16 to 24 days after sowing. If a seedling is made to wait for the arrival of water for transplantation till it is 35 days old, it has grown too much to be sown by machine. Thus, the unpredictability of water from Pakistan's irrigation system harms not only the transition to mechanization, it encourages flood irrigation causing enormous on-farm wastage of water.

**The massive loss of water in the irrigation system and the uncertainty associated with water delivery are the reasons why farmers are drawing on groundwater so aggressively.** Of the 95 million acre-feet (MAF) diverted from the Indus River System to the canals, only 50 MAF is available at the farmgate. The Indus River System is fed by an annual cycle of snow melt (and more recently glacier melt) but the Indus Aquifer has a slower source of re-charge: mainly seepage from the rivers and canal system. And that aquifer now constitutes *half* of the water available to Pakistan's farmers. It must be preserved. This requires Pakistan's irrigation system to be fixed to deliver water when farmers want and in the volumes they want. The first step is better water accounting at each level but that also requires better water governance—both are politically charged activities but also essential for building trust. But growth in agricultural exports also requires a focus on the quality of water. If drainage and water treatment are ignored, 'bad water' from farms and harmful chemicals from industries will impact farms.

**The tools to protect farmers from the impacts of climate change and biological perils are now available.** The devastating heatwave and biblical floods of 2022 have highlighted the need for strong, globally accepted institutional mechanisms to address these risks. Instead of irregular pay-outs by the government to compensate farmers for such impacts every year, risk transfer mechanisms are now available at a predictable cost to shift this burden to local and global insurers using 21st century tools.

**Livestock has driven growth in Pakistan's agriculture sector but it has plenty of further potential for growth.** As the growth trajectory of the poultry sector has shown, modern feed is necessary for animals with modern genetics. The smallholder farmers with small parcels of land are also the ones with a couple of animals per family. Better surveillance and management of disease outbreaks with the involvement of key stakeholders can protect their animals' health and economic value. Disease-free zones with a complementing vaccination regime can be pillars of livestock-based exports.

**As crop yields and animal yields rise, the price at which each grower breaks even falls.** This bears the great promise of agricultural growth regarding lower inflation, higher profitability for growers, and better competitiveness for exporters. Many elements have to come together to realize this promise of higher yields: better seed and genetic material, reliable water supply, appropriate machinery, timely capital, insurance, suitable feed, etc. Coordinated action by the business community, the financial sector, governments, donors, and growers is required to achieve this. Finally, Pakistan must resolve its debate on genetically modified crops and remove the uncertainty associated with them.

**Wealth generation from growth in agriculture is the main route to prosperity in rural Pakistan** where most of Pakistan's poverty resides. Just shy of 40 percent of Pakistan's labour force earns from agricultural activities. But the vast majority of these workers are earning from jobs that machines have been doing for decades in developed countries but even in advanced developing countries. These low-productivity, low-pay jobs are at the core of rural poverty. The introduction of technology can create better-paying jobs in the rural landscape. But those whose jobs get displaced will also need to be accommodated into industry. Every country of the world that has modernized its agriculture has seen the mass of agricultural labour shift to industry. This is a shift Pakistan must navigate with care and compassion.

# ANNEXURES

# Annex A. Understanding poultry technology

**Grandparents, parent breeders, and broilers/meat chicken:** Grandparent stock is like seed for the poultry sector. New genetic lines are imported as grandparent stock by breeder farms which raise this stock and crossbreed them to produce the next generation of birds called the parent stock. This parent generation is further crossed and their fertile eggs then produce the final generation of broiler chicken. This broiler chicken is the one that is raised for poultry meat. At each breeding stage, different lines are crossed that produce crossbred male and female lines for the next breeding generation. The number of chickens multiplied at each stage as the offspring reach maturity at about 20 weeks of age and each breeder hen can produce about 130 offspring in a single year. Typically, 725 Grandparent chickens (Rs. 3.6 million) are converted into 25,000 Parent stock (Rs. 8.75 million) which produce 3 million broilers (Rs. 513 million). Three million broilers mean 3.75 million kg of meat worth Rs. 1.23 billion.

The genetic technology of the poultry sector has improved significantly over the past few decades. Broiler chickens are now able to gain much more weight than conventional lines in a shorter span of time. In 1978, where a chicken would weigh only 623 grams at 26 days of hatching, it weighed almost 1400 grams in 2005 in the same 26 days since hatching.

**Controlled sheds:** A major technological change that has led to significant improvement in the poultry sector is the introduction of environmentally controlled sheds on poultry farms. The basic environment that poultry birds require include feed, lighting, air (temperature, humidity, pathogen concentration, ammonia, etc.), water, and litter quality. The environment has an impact on the flock's performance which in turn affects the poultry farm's profitability. For example, the rate of poultry feed conversion to meat deteriorates if temperatures are outside the recommended comfort zone—this increases cost. Environmentally controlled sheds provide the optimum environment to allow poultry farmers to obtain better feed conversion ratio, allow uniform air movement, and provide automatic feeding systems so that the same amount of feed is available at all locations along the feeder (as the birds are normally fed 7 to 8 times a day). This improves uniformity in the flock which is preferred by the market for poultry. Controlled sheds also lower incidence of disease which decreases medication cost and also lowers mortality.

The 'conventional open-sided houses' on poultry farms are open from the sides which makes the birds more susceptible to natural elements. Controlled sheds bring the ambient temperature for birds down by 10 to 15°C more than open-sided houses. Poultry production in open-sided houses often has to be stopped in summer due to severe heat stress which reduces animal productivity. They also have higher disease incidence which increased the vaccination and medication costs. Mortality rates in controlled sheds are 2-3 percent compared to 8-10 percent in open-sided houses. Automated systems in controlled sheds also reduce labor requirement. Equal distribution of feed in controlled sheds increases uniformity (up to 95 percent in controlled sheds versus 75 percent uniformity in open-sided). The flock is also ready for market earlier in controlled sheds (35 days versus 42 days) with a better feed conversion ratio (1.8 in controlled shed versus 2.0 in conventional open-sided houses).

# Annex B. Pakistan's freshwater resources

The Indus Basin spans four nations: Pakistan (47 percent), India (39 percent), China (8 percent), and Afghanistan (6 percent) (FAO Indus River Basin, 2011). Within Pakistan, the Indus River System comprises 21,000 sq km of riverine area and 88,000 sq km of underground aquifer area, making up more than 10 percent of the total area of the country (Hussain & Abbas, 2019). Freshwater inputs to the river system include melting snow and glaciers in the northern headwaters, groundwater from the aquifer (natural outflow and pumped water), and rainfall. Freshwater is defined as water fit for living organisms (technically: with less than 1500micro Siemens/cm, which is a measure of water salinity). The Indus River System is the primary contributor to Pakistan's freshwater resources, contributing approximately 95 percent of all nationally utilized water (FAO Indus River Basin, 2011). The rest comes from smaller basins such as small rainwater-fed farms or the groundwater-fed Karez system of Northern Balochistan.

The Indus River System begins in the northern glacial areas of the Hindu Kush, Karakorum, and Himalayan Mountain ranges. The headwaters then organize into major tributaries to the Indus with one comprising the Kabul River coming from the west. The other comprises of 6 major rivers: the Sutlej, Beas, and Ravi Rivers, known as the eastern rivers under the Indus Water Treaty of 1960, and the Chenab and Jhelum, known as the western rivers plus the Indus River. Within the Indus Water Treaty, all surface waters of the eastern rivers are available to India for unrestricted use, while the western rivers and any water from the eastern rivers that have crossed the border are designated to Pakistan for unrestricted use.

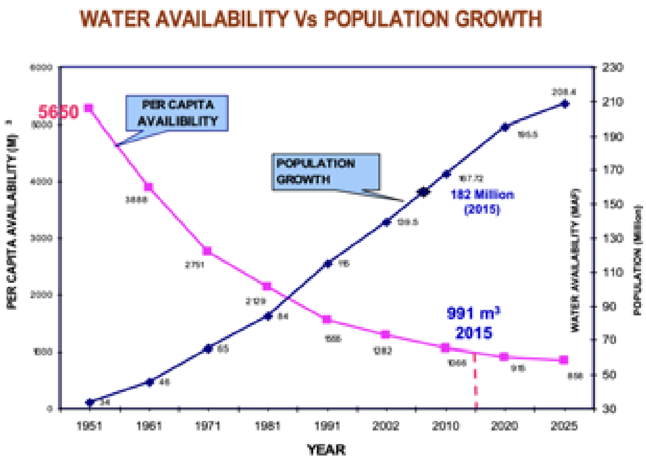
**The Transboundary Indus Basin**


Historically, the average annual flow from the Indus River System available within Pakistan is 145 million acre-feet (MAF), around 70 percent of which is from rain during the monsoon season (IRSA, 2013). From this, up to 105 MAF of surface water is diverted through dams and barrages along the rivers which feed the Indus Basin Irrigation System. The Indus Basin Irrigation System is the largest contiguous irrigation system in the world extending over 60,800 km and serving 43 million acres of irrigated land within

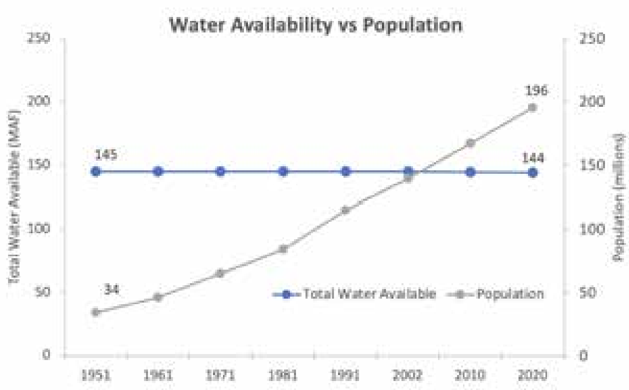
Khyber Pakhtunkhwa (KPK), Punjab, Sindh, and Balochistan. The diversion system includes three reservoirs (Tarbela, Mangla, and Chashma), 23 barrages, 12 inter-link river channels, and 45 primary canals. Detailed in Pakistan's Water Accord of 1991, water is apportioned between the four provinces with Punjab receiving 49 percent, Sindh 43 percent, KPK 5 percent, and Balochistan 3 percent.

Groundwater in the Indus River System accounts for approximately 55 MAF of renewable freshwater, which is anthropogenically fed from the seepage of unlined canals (FAO AQUASTAT, 2019). Groundwater from the Indus aquifer is an important resource for Pakistani farmers due to year-round availability at a distance from the riverine area. The groundwater in Punjab is relatively shallow and has low salinity (<1000 ppm), whereas much of Sindh has deep groundwater with higher salt concentrations (>3000 ppm). Some 77 percent of Punjab's irrigated area has groundwater suitable for irrigation (Qureshi 2020).

**Per capita availability seems to be falling…**




**…but water availability has been constant…**




Source: IRSA

Each crop has a different water requirement. And the water requirement of each crop varies by geographic region as well. For example, the crop water requirement for wheat is low, from 290mm per year in northern Punjab to 520mm per year in lower Sindh, making it a good crop for the dry Kharif season (Amir & Habib 2015). In the wet Rabi season, the cash crops such as rice, cotton, sugarcane and maize are grown. Maize also has relatively low requirements of 244mm and 450mm per year in northern Punjab and lower Sindh, respectively. The other crops have much higher crop water requirements: rice (587 and 1000mm per year), cotton (540 and 1156mm per year), and sugarcane (1000 and 1900 mm per year) in northern Punjab and lower Sindh, respectively.

A common misconception is that water availability is falling in Pakistan. According to data from the Indus River System Authority (IRSA), the average quantity of fresh surface water available in the Indus River System has hovered around 145 MAF annually for the past many decades (Figure X1). The misconception comes from the per capita availability of freshwater which is often used to demonstrate water scarcity. But it can tell a misleading story that the country is losing water. Water is a finite natural resource with natural annual variation. It is population that is rising which gives the impression that Pakistan is running out of water. As population rises, per capita availability is bound to fall.

# Annex C. Basics of seed technology

**What are varieties?** For the mango lover, each of the commonly known types of mango, e.g., sindhri, langra, chaunsa, etc., is a distinct variety of mango. Each has its own cultivation cycle, unique agronomy, crop care needs, etc. Each crop has multiple varieties in this way.

**Pollination** Nature has its way of connecting male and female seeds to facilitate reproduction. It's called pollination. In recent decades, hybrid plant varieties have been developed as well. Hybrids are also found in animals and common examples include mules and hinnies.

**Open Pollinated Varieties** Seeds produced from natural, random, open pollination by wind, birds, or insects is referred to as open pollinated seed. Any typical plant growing in nature is usually open pollinated and the resulting seeds also produce plants roughly identical to the parents. A key feature of open pollinated (OP) seeds offspring is that they can be saved by farmers to be used next year which, if stored under the right conditions, give roughly the same yield as the previous generation.

**Hybrid Varieties** are developed through a specific, controlled cross of two distinctly different parental types where the offspring get a combination of characteristics from the parents. These hybrids are usually created by means of controlled pollination, sometimes by hand pollination (as done in India for cotton) which is difficult to perform at a mass scale. A key feature of hybrids is that unlike OPVs, the next generation of hybrids can give significantly lower yields. The offspring of hybrids can follow different traits of either of the two distinct parents. Therefore, farmers prefer to buy new hybrid seeds each season to get higher yields. Maize and rice hybrids are commonly cultivated in Pakistan.

**Genetically modified seed technology** Genetic modification (GM) technology allows transfer of genes between two different species to introduce desired characteristics using a range of laboratory techniques for splicing DNA segments together. For example, Bt cotton (GMO) has the Cry1ac gene introgressed into the (OP or hybrid) cotton seed which helps the cotton plant fight against pests, thus reducing the sprays required for cotton.

## GMO: Biosafety in Pakistan

Genetically modified seed can help achieve significant gains in agriculture. As seen in India's cotton example, the introduction of Bt cotton led to doubling of yields which raise farmers' profitability and more than doubled India's cotton production. It also reduced input costs as well as impact on the environment as less sprays were required. In Australia, there has been a 97 percent decrease in insecticide use since the introduction of Bt cotton[i]. Another trait that can be introduced in crops is drought tolerance which, given Pakistan's high susceptibility to climate change, can be important for Pakistan and can help cultivate areas with less water, especially at canal tails.

From October, 2022, soybean shipments were held up at Karachi port for several months (which resulted in extra expenditure in demurrages for importers) before the soybean was finally released. The delay in the release of soybean led to a shortage of soybean meal which is a critical ingredient for the poultry feed industry. The absence of good quality feed eventually led to the shutdown of several poultry farms which resulted in an increase in the price of day-old chicks, broilers, and poultry meat. Confusion regarding regulations allowed this as the importers did not have a certification from MoCC to import genetically modified soybean. Despite the lack of such a certificate from MoCC, GM soybean was being regularly imported under a temporary arrangement until the certificates could be issued.

The import, export, manufacture, trial, and sale of genetically modified organisms (GMOs) is under the Pakistan Biosafety Rules and National Biosafety Guidelines of 2005 framed under the Pakistan Environment Protection Act of 1997. These Rules prohibit the trade, manufacture, and trial of GMOs without a license. The National Biosafety Committee (NBC) housed under the Ministry of Climate Change (MoCC) is the highest forum for biosafety regulations which has, so far, only approved the MON-531 event (Cry1Ac gene or Cry1Ab gene) contained in biotech cotton seed varieties. According to the biosafety rules and guidelines, an event is approved based on agronomic, safety, bio-efficacy, and gene expression studies to check for any harmful effects of the event. After the approval of an event, biotech seed commercialization requires a three-tier review. The first review is conducted by an Institutional Biosafety Committee (IBC) at all public and private institutes undertaking development of GM seeds, followed by a review by the Technical Advisory Committee housed under the Environmental Protection Agency of the MoCC. The Technical Advisory Committee then makes recommendations to the National Biosafety Committee for approval of biotech seed commercialization.

Between April, 2006, and February 2021, the TAC had held 30 meetings while the NBC has met 22 times and during these meetings, NBC has approved mostly cotton varieties[ii]. Trials for all GM crops have been put on hold since 2019 except for cotton as NBC is currently developing regulations regarding the import of GM crops intended for food, feed, and processing.

A robust regulatory regime that allows the commercialization of GM crops is critical for the country to fulfill its growing need for not only being self-reliant, but producing enough surplus to be able to export and earn precious foreign exchange. A good technology provider will also enter the market only if the regulatory environment is clearly defined and if a stable IPR regime is in place.

# Annex D. Area Yield Index Insurance (AYII)

**A type of crop insurance well-suited for small farmers is Area Yield Index-based Insurance (AYII)** which was developed in the early 1950's in Sweden, adopted in India in 1979 and in the United States since 1993 specifically to address the prohibitively high cost of individual insurance policies for smallholder farmers. In AYII, instead of insurance surveyors' visits to individual small farms, if the average yield in a specified area goes a certain level below the area's historical average yield, then farmers in the area receive a payout—provided the average yield fell due to the perils covered by insurance. Typically, these perils are: flood, drought, excessive or untimely rain, heat wave, windstorm, hail, frost, pest/insect attacks, viral/bacterial attacks, and locust attacks. By using statistical methods, satellite data, and crop cuts on a random selection of the area's farms to determine the average yield, AYII reduces the administrative cost of going to individual small farms which would be prohibitively expensive. AYII is a leading mode of insurance for smallholder farmers in dozens of countries in Asia, Africa, and Latin America because of its cost-efficient use of technology, faster implementation than traditional insurance infrastructure, independent source of index-based data (no conflict of interest), and minimized moral hazard/adverse selection. India's PMFBY program, one of the world's largest insurance crop insurance schemes in the world, is based on Area Yield Index-based Insurance. Pakistan Agricultural Coalition's insuretech partner, Pula Advisors of Switzerland, alone supports AYII programs serving 5.5 million smallholder farmers in 22 countries.

AYII is also the recommended type of crop insurance by a Government of Pakistan crop insurance task force. Under the Government of Pakistan's National Financial Inclusion Strategy, a key goal is to launch a National Crop Insurance Scheme for all farmers. A government-notified task force led by SECP (the insurance regulator) with participation of multiple federal and provincial government stakeholders recommended the same basic model (based on AYII) in December 2020 which was successfully piloted in 2021-22 by Pakistan Agricultural Coalition and its partners: HBL, Bank of Punjab, TPL Insurance, insure-tech firm Pula Advisors of Switzerland, and global re-insurer SCOR of France.

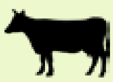
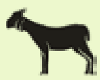
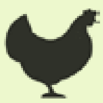
**Transaction structure for crop loan insurance**

Wheat pilot in Sheikhupura, Hafizabad, Gujranwala, and Pakpattan


The role of the insurtech firm is to design the index based on historical weather and yield data and conduct crop cuts to calculate loss for the season, which affords a <u>more objective, timely, accurate basis of pay-outs determination</u> in the occurrence of climatic events causing yield loss to farmers. Globally, the Area Yield Index-Based Insurance model is a well-established mechanism for delivering reliable crop insurance to smallholder farmers. The results of the wheat pilot conducted in 2021-22 in four districts of Punjab have demonstrated its effectiveness in the Pakistani environment as well. Now it is time to move to scale-up.

# Annex E. Common livestock diseases in Pakistan

Pakistan is home to various type of bacteria and viruses that cause different types of diseases in livestock. The most commonly prevailing livestock diseases in Pakistan include:

| | Contagious disease | Non-contagious disease | Vector born disease | Metabolic disorders |
|---|---|---|---|---|
|  | MOST COMMON IN PAKISTAN: Foot and Mouth Disease | Round worm | Babesiosis | Ketosis |
| | Hemorrhagic Septicemia | Liver fluke | Thaleriosis | Milk fever |
| & | Black Quarter | Tape worm | Anaplasmosis | Hemoglobinuria |
|  | Anthrax | Mange | Trypanosomiasis | Bloat / Tympani |
| | Brucellosis | Lice | | Rheumatism |
| | Mastitis | Fleas | | Diarrhea / indigestion |
| | Scabies | Johne's Disease | | |
| | Rabies | Coccidiosis | | |
| | Hemorrhagic Septicemia | Tetanus | | |
|  | MOST COMMON IN PAKISTAN: Peste Des Petitis Ruminants | Gastritis | | Hemoglobinuria |
| | Contagious Caprine Pleuro Pneumonia | Pneumonia | | Ketosis |
| & | Enterotoxemia | Star gazing | | Bloat / Tympani |
|  | Sheep Pox | Paraplegia | | Rheumatism |
| | Goat Pox | Metritis | | Diarrhea / indigestion |
| | | Tetanus | | |
| | | Bronchitis | | |
|  | MOST COMMON IN PAKISTAN: Avian Influenza | Salmonellosis | | |
| | Fowl Pox | Coccidiosis | | |
| | Newcastle Disease | | | |
| | Infectious Bronchitis* | | | |
| | Pullorum | | | |

*Source: Sindh Livestock and Fisheries Department*

The Pakistan Business Council

FOSTERING ECONOMIC GROWTH

8th Floor, Dawood Centre, M.T. Khan Road,
Karachi, Pakistan

T -+92 21 3563 0528 - 29
F -+92 21 3563 0530

Ground Floor, Unit No. 7, Block 3001, Rehmat
Plaza, Blue Area, Islamabad, Pakistan

T: 051-8444008
F: 051-8444009

www.pbc.org.pk