March 2025

Integrated Policy Strategies and Regional Policy Coordination for Resilient, Green and Transformative Development: Supporting Selected Asian BRI Partner Countries to Achieve 2030 Sustainable Development Agenda

Project Paper No. 4

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Role of Agriculture in Green Industrialization in Pakistan

Abstract

As a critical sector of the Pakistani economy, accounting for about 23% percent of the GDP and providing employment to around 37% of the population. In addition to providing food, fodder, livelihood, and raw materials to industry, this sector is a major employer of rural labour in Pakistan. However, in addition to low productivity, resource inefficiency, and limited adoption of modern technologies; Pakistan's agriculture sector is generally unsustainable in terms of the use of natural resources such as water and soil. These problems are further compounded by climate change as Pakistan is a highly vulnerable country and the agriculture sector has a high exposure to climate change. Furthermore, there is unequal distribution of land, inadequate infrastructure, poor agricultural extension, lack of innovation, and supply chain issues. The antidote to this problem is the structural green transformation of Pakistani agriculture, which entails adopting sustainable agricultural practices, improved resource efficiency and productivity, agricultural mechanisation, backward and forward linkages between agriculture and industry, and resilience to climate change. This study conducts a detailed investigation of the problems mentioned above and suggests several concrete and practical policy recommendations for the transformation of the agricultural sector in Pakistan.

Contents

KEYWORDS: Greening, Sustainable, Food, Resilience, Productivity, Policy

Acknowledgements

This paper has been prepared under the UNCTAD project “Integrated Policy Strategies and Regional Policy Coordination for Resilient, Green and Transformative Development: Supporting Selected Asian BRI Partner Countries to Achieve 2030 Sustainable Development Agenda”, funded by the 2030 Agenda for Sustainable Development Sub-Fund of UN Peace and Development Trust Fund of DESA. The author would like to thank UNCTAD staff for comments on earlier drafts. This paper represents the personal views of the author only. The author accepts sole responsibility for any errors.

1. Overview of the agriculture sector in Pakistan

1.1 State of agriculture in Pakistan

1.1.1 Importance of the sector in the rural economy

The agriculture sector plays a critical role in Pakistan's economy, accounting for about 23% percent of the GDP and providing employment to around 37% of the population (GoP. 2023). This sector remained by far the biggest employer in addition to providing food, fodder, livelihood, and raw materials to the industrial sector. However, food production in Pakistan has not kept up with the increased population and thereby the food demand. The Pakistani agriculture sector maintained a growth rate of 5% from 1960 to 1989 and 6% from 2004 to 2006, whereas recently the agriculture sector growth rate in Pakistan was noted as low as 2%, which is even lower than the population growth rate (Husain, 2023). This is in addition to the agriculture sectors' vulnerability to climate change-driven natural disasters and subsequent food shortages, domestic inflation, and price hikes in the global market (CIAT, 2017). Ukraine war and the impact of the COVID-19 pandemic also contributed to the problem of food shortage in recent times. Thus, an increase in the domestic production of grains is critical in improving the food supply and hence the affordability and accessibility for the masses.

Pakistan has to spend its scarce foreign exchange to feed its population which underscores that Pakistani agriculture has serious problems. The per capita food remained greater than the population growth rate due to cereal crop output growth. However, in recent times the domestic production of food was unable to keep pace with the rising consumption of the growing population which resulted in food and other agricultural imports. The slow progress of the agriculture sector has serious implications for the economy as it negatively affects inflation, poverty, employment, income distribution, current account, and food security.

Since low-income population spends as much as 40% of their income on food, a boost to domestic production of key crops such as cereals, sugar, vegetables, and pulses could potentially lower the prices and thus pacify the impact of inflation on poor households. This would help address the problems of poverty, food security, and unemployment. As indicated above, the agriculture sector in Pakistan was growing rapidly till the mid-2000s and it had a profound impact on the country's rural economy. Employment in rural areas surged during this period, largely driven by the expansion and modernisation of agriculture. The robust growth of the agricultural sector not only boosted employment on farms but also had ripple effects across ancillary activities, including the supply chain, transportation, processing, and marketing. These sectors played a vital role in contributing to rural employment and income generation. There is a strong correlation between agricultural growth and rural employment. The improvements in the production of key crops and livestock could significantly enhance the income of impoverished farm households.

This has the potential to facilitate non-farm employment and income opportunities, thereby creating a virtuous cycle of poverty reduction. A buoyant agricultural sector not only ensures food security but also contributes to rural economic development, which, in turn, plays a pivotal role in alleviating poverty. This interconnectedness between agricultural growth and rural employment underscores the importance of sustained efforts to enhance agricultural productivity, modernize the sector, and create an enabling environment for value addition. These actions can play a pivotal role in lifting

impoverished households out of poverty and promoting overall economic development, including generating supporting domestic industry.

The agricultural growth in the 2000s improved output as well as ancillary activities and supply chain, including transportation, processing, and marketing which contributed to rural employment. This means improvement in the production of key crops and livestock could also enhance the income of poor farm households and facilitate non-farm employment and income opportunities, resulting in lifting some of them out of poverty. Historically, growth in agricultural output resulted in improvement in income distribution and poverty eradication. Thus, a robust agriculture sector has the potential to guide Pakistan's development path while helping address challenges such as population growth, rapid urbanization, climate change, and natural disasters.

Nevertheless, it is important to highlight that there is a change in food demand trends as with the increase in incomes, urbanization, and the liberalization of markets; there is a growing demand for dairy products, meat, fresh fruit and vegetables, and processed foods, and less unprocessed grain staples. This allows many large foreign and local companies to benefit from Pakistan's changing food demands (Horst and Watkins, 2022).

1.1.2 Structural green transformation of the agrarian sector in Pakistan, what does it mean?

Unfortunately, Pakistani agricultural policies are not designed using robust scientific evidence and indigenous research. For example, empirical evidence (Aftab et al, 2021) shows that effective agricultural extension alone could increase farmers' climate adaptation uptake by 23%, however, agricultural extension in Pakistan lacks the capacity and resources to enable farmers to use agricultural land efficiently and pave the way for backward and forward linkages in the agriculture sector. Similarly, infrastructure for water management and irrigation systems, efficient procurement of crops' yield, availability of cold storage, and supply chain and price issues are not addressed, resulting in unstable input and output markets.

Table 1: Irrigated area (%age) by different sources

Types/Year	Total	Canals		Tube well	Well	Canal tube well	Canal wells	Tanks	Others
-	-	Govt.	Private	-	-	-	-	-	-
2010-11	100	32.19	2.09	21.00	1.71	40.71	1.34		0.96
2011-12	100	30.12	1.99	21.61	1.72	42.35	1.02	0.11	1.08
2012-13	100	29.49	2.40	20.96	1.73	43.26	1.11		1.06
2013-14	100	29.75	2.26	19.96	2.04	43.63	1.40	0.00	0.97
2014-15	100	29.85	2.30	19.65	2.51	43.03	1.55	0.00	1.12
2015-16	100	29.89	2.15	19.35	1.88	43.82	1.51	0.00	1.40
2016-17	100	30.35	1.98	19.87	2.20	43.08	1.59	0.00	0.93
2017-18	100	30.17	2.04	19.32	2.36	43.75	1.45	0.00	0.91
2018-19	100	29.08	1.75	20.51	1.58	44.68	1.47	0.11	0.82
2019-20	100	29.47	1.71	20.99	1.40	43.80	1.24	0.10	1.29

Source: Pakistan Bureau of Statistics

Notwithstanding Pakistan is an agricultural country, due to general neglect of the rural economy and agriculture sector, rural-urban migration, and climate change; Pakistan suffers from the problems of food insecurity and rampant poverty in rural areas. In the 1990s, the poverty rate in rural areas of Pakistan was around 40%. Despite some improvements in subsequent years, poverty rates remained relatively high. By the early 2000s, the poverty rate had decreased to around 34% in rural areas. However, this still indicated a significant proportion of the rural population living below the poverty line. In the 2010s, the poverty rate in rural areas stood at approximately 30%. While there was a slight reduction, it remained a substantial challenge (GoP, 2021; World Bank, 2021). As of 2021, the poverty rate in rural areas of Pakistan stands at approximately 25% which indicates a notable reduction in rural poverty compared to the figures from the 1990s, however, it still signifies a significant challenge for the country (GoP, 2021; World Bank, 2021).

Table 2: Agriculture growth rate

Years	Kharif	Rabi	Total
Average	67.1	36.4	103.5
2015-16	65.5	32.9	98.4
2016-17	71.4	29.7	101.1
2017-18	70	24.2	94.2
2018-19	59.6	24.8	84.4
2019-20	65.2	29.2	94.4
2020-21	65.1	31.2	96.3
2021-22	65.1	27.4	92.5
2022-23	43.3	29.4	72.7

Source: Pakistan Economic Survey

Furthermore, the Pakistani agriculture sector also needs a transformation by prioritizing high-value production and focusing on improving the business environment, equity, financial inclusion, and competitiveness (Horst and Watkins, 2022). Structural green transformation is impossible without the efficient use of resources. However, efficient and judicious use of resources remained a problem which resulted in resource scarcity. For example, freshwater shortage and pollution are serious issues in Pakistan (Natasha et al., 2023). The agriculture sector also contributes to the pollution of water as agricultural toxins can degrade the quality of surface as well as groundwater using fertilizer and pesticide residue runoff and infiltration into local water bodies.

Despite water scarcity issues, old irrigation techniques, e.g., flood and furrow irrigation, are being used in Pakistani agriculture. However, there is a need for the adoption of drip irrigation to improve the efficiency of water use and reduce the use of energy in water pumping and subsequent carbon emissions. Due to the inefficient use of water, water withdrawal has increased over time (Table 1). For example, the Water Management Directorate data shows roughly a 7% increase in the withdrawal of canal water from the year 2010 to 2020.

1.1.3 Major crops, farming practices, and productivity issues

The major crops cultivated in Pakistan include wheat, maize, rice, sugarcane, and cotton (Table 3). The productivity of major crops remained low due to expensive inputs, lack of mechanization, infrastructure problems, poor market linkage, and bad agricultural policies, including pricing mechanisms, research and development support, and risk management hindered the sector's growth and the adoption of sustainable and modern

farming practices, perpetuating the problem of low crop productivity and stifling the rural economy's potential for growth and poverty alleviation. Nevertheless, Pakistan is an agricultural country with massive potential to produce food, it has to import agricultural products such as cotton, wheat, sugar, edible oil, milk powder, and pulses which amount to about $10 billion. Pakistan had a deficit in the food trade of almost $3.6 billion in the year 2022.

Table 3: Areas and production* of key crops

Crops/Year	Wheat		Maize		Rice	
	Area	Production	Area	Production	Area	Production
2011-12	8649.8	23473.4	1087.3	4338.3	2571.2	6160.4
2012-13	8660.2	24211.4	1059.5	4220.1	2308.8	5535.9
2013-14	9199.3	25979.4	1168.5	4944.2	2789.2	6798.1
2014-15	9203.9	25086.1	1142.5	4936.8	2890.6	7002.8
2015-16	9223.7	25633.1	1191.2	5270.9	2739.5	6801.3
2016-17	8972.5	26673.6	1348.4	6134.2	2724.0	6849.3
2017-18	8797.2	25076.1	1250.8	5901.6	2900.6	7449.8
2018-19	8677.7	24349.0	1373.9	6826.4	2810.0	7202.0
2019-20	8804.7	25247.5	1404.2	7883.0	3034.0	7413.7
2020-21	9168.2	27464.1	1417.8	8939.8	3335.1	8419.7
	Sugarcane		Cotton**			
	Area	Production	Area	Production	-	-
2011-12	1057.5	58397.0	2834.5	13595.0	-	-
2012-13	1128.8	63749.9	2878.8	13030.7	-	-
2013-14	1172.5	67460.1	2805.7	12768.9	-	-
2014-15	1140.5	62826.4	2961.3	13959.6	-	-
2015-16	1131.6	65482.4	2901.9	9917.4	-	-
2016-17	1217.6	75482.2	2488.9	10670.6	-	-
2017-18	1341.8	83332.8	2700.3	11945.6	-	-
2018-19	1101.9	67174.0	2373.0	9860.8	-	-
2019-20	1039.8	66379.6	2517.3	9148.0	-	-
2020-21	1165.0	81009.3	2078.9	7063.9	-	-

(Area '000' hectares, and Production '000' tonnes)

*Cotton production is in thousand bales of 375 lbs. each.

Source: Pakistan Bureau of Statistics

The Pakistani agriculture sector employs intensive farming techniques, resulting in the concentrated use of synthetic fertilizers, pesticides, and herbicides to promote rapid plant growth and protect crops from pests and diseases (Tables 4 and 5). While these inputs enhance productivity, they have implications for human health and the natural environment. Hence, careful management of agrochemicals is needed to mitigate environmental risks.

Table 4: Overall fertiliser consumption (Thousand nutrient tonnes)

Year	Fertiliser types			
-	Nitrogen	Phosphate	Potash	Total
2010-11	3132.1	767.1	32.4	3931.6
2011-12	3206.5	633.1	21.3	3860.9
2012-13	2853.6	747.0	20.9	3621.5
2013-14	3184.5	880.9	23.7	4089.1
2014-15	3308.7	975.0	32.9	4316.6
2015-16	2671.9	1007.3	20.0	3699.2
2016-17	3730.0	1268.7	41.2	5039.9
2017-18	3434.3	1278.4	49.8	4762.5
2018-19	3407	1153.2	53.4	4613.6
2019-20	3414.5	1083.6	50.2	4548.3

Source: Pakistan Bureau of Statistics

Productivity is often attributed to the total share of agriculture in overall GDP; however, a true and realistic measure of agricultural output and performance should be output per unit area, i.e., per acre of the farmland, output per unit of on-farm labour, and output per unit of irrigation water which are abysmally low in Pakistani agriculture. It is estimated that the Pakistani agriculture sector uses around 90% of the freshwater which is highly inefficient, especially considering the performance of the agriculture sector.

Table 5: Crop-wise fertiliser consumption (Thousand nutrient tonnes)

Crops	Wheat	Rice	Maize	Cotton	Sugarcane	Others	Total
Fertilisers share	50%	6%	1.5%	25%	8%	9.5%	
2010-11	1965.80	235.90	58.97	982.90	314.53	373.50	3931.60
2011-12	1930.45	231.65	57.91	965.23	308.87	366.79	3860.90
2012-13	1810.75	217.29	54.32	905.38	289.72	344.04	3621.50
2013-14	2044.55	245.35	61.34	1022.28	327.13	388.46	4089.10
2014-15	2158.30	259.00	64.75	1079.15	345.33	410.08	4316.60
2015-16	1849.60	221.95	55.49	924.80	295.94	351.42	3699.20
2016-17	2519.95	302.39	75.60	1259.98	403.19	478.79	5039.90
2017-18	2381.25	285.75	71.44	1190.63	381.00	452.44	4762.50
2018-19	2306.95	276.83	69.21	1153.48	369.11	438.32	4613.90
2019-20	2274.15	272.9	68.22	1137.08	363.86	432.09	4548.3

Source: National Fertilizer Development Centre, Islamabad.

In terms of regional comparison, Pakistan's cereal yield in 2020 was around 2,852 kilograms per hectare (kg/ha), according to the Food and Agriculture Organization (FAO). However, countries like India achieved a cereal yield of 3,628 kg/ha, China achieved 5,935 kg/ha, and the United States achieved 9,437 kg/ha. According to the World Bank's World Development Indicators, Pakistan's cereal yield (in kilograms per hectare) in 2019 was 4,057.5, which is lower than the global average of 5,663.8. This indicates that there is room for improvement in terms of maximizing output from the available agricultural land in Pakistan.

The productivity of on-farm labour in Pakistani agriculture is also relatively low. According to the International Labor Organization (ILO), Pakistan had a labour productivity index of 28.5 in agriculture in 2020. In comparison, India's index stood at 33.1, China's at 53.8, and the United States at 104.7. The International Labor Organization (ILO) reported that Pakistan had a labour productivity index of 21.3 in agriculture in 2019. This index is significantly lower than countries like India (35.1), China (45.2), and the United States (109.9). These figures suggest that there is a need to improve the efficiency and output generated from the labour employed in Pakistan's agriculture sector.

Efficient utilization of irrigation water is crucial for sustainable agricultural productivity. In Pakistan, the water productivity in agriculture is relatively low. According to the International Water Management Institute (IWMI), Pakistan's water productivity in agriculture was estimated at 0.79 kg/m³ in 2019. In comparison, India achieved a water productivity of 1.21 kg/m³, China achieved 1.26 kg/m³, and the United States achieved 2.10 kg/m³. In Pakistan, the efficiency of irrigation water usage has been a concern. The International Water Management Institute (IWMI) reported that Pakistan's water productivity in agriculture was 0.84 kg/m³ in 2019, which is relatively low compared to other countries like India (1.35 kg/m³), China (1.38 kg/m³), and the United States (2.34 kg/m³). Nonetheless, agriculture in Pakistan is highly fragmented having a small average farm size as roughly 89 percent of farms are less than 5 hectares which makes it difficult to establish good market linkages (Horst and Watkins, 2022).

1.1.4 Structural issues, including land inequality, infrastructure, agricultural extension programmes, challenges in upscaling innovation, and supply chain issues

Pakistan is endowed with roughly 43 million acres of adjoining irrigated areas however it has not been able to fully exploit this due to technical and technological constraints. For example, despite large irrigated farmlands, there is an inefficient use of irrigation water as the irrigation methods are very old, i.e. most of the farming in Pakistan is done using flood irrigation method which results in waste of irrigation water as a precious resource in addition to causing salinity, weed, increased energy use for pumping, leaching of nitrogen and other micronutrients, among others. It is estimated that if the Pakistani irrigation system is properly managed and utilised, the country can fetch output worth $200 billion which currently stands at around $70 billion[1].

Table 6: Support/procurement prices/40KG for selected crops

Types/Year	Crops			
-	Wheat	Sugarcane		
-	Overall	Punjab	Sindh	KP
2011-12	1050	150	154	150
2012-13	1200	170	172	170
2013-14	1200	170	172	170
2014-15	1300	180	182	180
2015-16	1300	180	172	180
2016-17	1300	180	182	180
2017-18	1300	180	182	180
2018-19	1300	180	182	180
2019-20	1400	190	192	180
2020-21	1800	200	202	200

Source: Pakistan Bureau of Statistics

[1] https://cdpr.org.pk/wp-content/uploads/2023/05/Reviving-Agriculture-Growth-Part-1.pdf

In terms of structural issues, land ownership distribution in rural areas of Pakistan is highly skewed, for example, one percent of the population owns about 22% of the total farmland while almost 90% majority have 45% of the total farmland. This means that the majority of farmers in Pakistan are small which deters their chances of upscaling and leveraging from the economies of scale. On the other hand, there are inefficiencies in large farms and the ratio of unused land is often very large, resulting in low per-hectare yield of large farms compared to small ones. Furthermore, over-deployment of resources and disguised labour are also the problems of large farms.

Table 7: Agriculture growth rate

Sector	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Agriculture	3.88	0.94	3.91	3.52	4.27	1.55
Crops	4.61	-4.38	6.32	5.83	8.19	-2.49
Livestock	3.59	3.65	2.8	2.38	2.25	3.78
Forestry	2.24	7.22	3.36	3.35	4.07	3.93
Fishing	1.57	0.78	0.63	0.73	0.35	1.44

Source: Pakistan Bureau of Statistics

If Pakistan could maintain the growth rate of 5 to 6% in grains the same as in the 1965-95 period, it would have stabilized consumer prices, leading to food security, improved livelihood and reduction in rural poverty in addition to earning foreign exchange by selling surplus produce at international prices. This could have also supported the domestic industry by enabling the import of raw materials. In Pakistan, farm productivity varies based on the size of farms and the type of crops cultivated. Nevertheless, the average growth rate of Pakistani agriculture is around 3% which is almost half of what it used to be before the 2000s (Table 7).

1.2.5 Environment and climate change – vulnerability and sustainability

The agriculture sector in Pakistan is highly vulnerable to climate change. The country often experiences prolonged droughts and devastating monsoon floods. Frequent natural disasters such as flooding severely affect the performance of the agriculture sector. For example, the 2022 flood damaged about 4.4 million acres of crops and around 1 million animals lost (GoP. 2023). Pakistani agriculture however still lacks adaptation to climate change and requires changes in cropping patterns, including crop mix and sowing and harvesting timing. It is important to note that Pakistan is among the most climate-vulnerable countries in the world, it also suffers from poor socioeconomic conditions such as poverty, unemployment, and inequality.

While the country has a comprehensive network of irrigation infrastructure which includes canals and dams, water resources for agriculture are declining and there are no concrete measures for future water shortage in this sector (Table 1 and 2). Similarly, there is an urgent need for critical investments in key areas such as procurement of improved seeds, development and adoption of crucial farming technology and techniques, and improved water use efficiency in the face of climate change, and subsequent declining water availability (CIAT, 2017). Nevertheless, Pakistan's greater dependence on agriculture and water resources makes it more susceptible to climate change. Furthermore, there is low adaptive capacity and insufficient preparation in addition to a lack of mainstreaming climate adaptation in agriculture. There is an urgent need for investments to develop climate resilience to mitigate climate change impacts, especially in the agriculture sector (World Bank Group, 2022). Small-scale subsistence farmers lack access to agricultural

insurance and microcredit mainly due to a lack of collateral, and an inability to service loans (Hussain and Thapa, 2012; Nouman et al., 2013).

In terms of sustainability, Pakistani agriculture, as currently practiced, is generally unsustainable due to the degradation of agricultural resources (Zulfiqar and Thapa, 2017). The existing agriculture approach is based on intensive farming practices which involve the concentrated use of agricultural inputs such as irrigation water and agrochemicals. While intensive farming practices are used to increase crop yields, they are harmful to human health and the natural environment as they pollute water, air, and soil in addition to health hazards. For example, there is strong evidence of the presence of agrochemical residue in Pakistani water (Tariq et al., 2007; Azizullah et al., 2011; Waseem et al., 2014). In this respect, Shahid et al. (2016) claim that over 500,000 Pakistanis were annually exposed, and about 10,000 of these died due to agrochemical poisoning. This requires the adoption of healthy and environmentally friendly sustainable agricultural practices to mitigate the harmful effects of intensive farming and make farming cleaner and greener.

2. Transforming the agricultural sector for green industrialization

2.1 Strategies for low productivity

2.1.1 A brief overview of the literature to explain low productivity in Pakistan

Agricultural production in Pakistan is stagnant due to several impediments such as fixed cropping patterns, few major crops, a narrow genetic pool, poor seed quality, high cost of production, and climate change (Khan and Khan, 2018), among others. Malik et al. (2016) argue that declining farm size and fragmentation, limited access to markets, poor infrastructure, limited access and uptake of technology, weak credit markets, high transportation costs, poor agricultural extension, and lower profit margins are some of the key constraints for Pakistani agriculture. Similarly, Horst and Watkins, (2022) state that small average farm size impedes establishing good market linkages as roughly 89 percent of farms are less than 5 hectares. The majority of landowners in Pakistan are small as there is an inherent problem of land inequality in Pakistani agriculture due to the obstruction of land reforms by influential landlords in Pakistan, which deters crops' productivity and efficiency, undermining the overall performance of the agriculture sector in Pakistan.

Rehman et al. (2019) found that fertilizer consumption, improved seed distribution, and credit access are key factors of agricultural output. Poorly functioning agricultural markets, greater government interventions, inefficient public spending, and poorly targeted subsidies in addition to inefficient use of agricultural inputs and low-value agriculture hinder agricultural progress in Pakistan (World Bank, 2022). This is mainly because of ineffective legal and intuitional frameworks that restrict farmers from marketing and sale of their produce, resulting in supporting rent-seeking by mediators who manipulate the market, undermining farmers' interests as well as agricultural enterprise (Rana, 2018). Furthermore, the Pakistani agriculture sector needs to go beyond productivity improvements towards its transformation into a high-value production system with greater competitiveness, sustainability, equity and inclusion, and modernised marketing to cater to the growing demand in the domestic market (Horst and Watkins, 2022). These impediments make Pakistani agricultural produce less competitive in export, and this is despite that agriculture is a primary industry in Pakistan.

Aslam (2016) claims that the average yield of Pakistan's major crops such as wheat, cotton, rice, maize, and sugarcane is lower than international averages by 70, 53, 61, 82, and 60 percent, respectively, and stresses the use of modern technology and improved inputs such as seed, irrigation, agricultural credit, farmers' capacity, and support price. Similarly, Ahmed and Heng (2012) show that farmer education and timely access to fertilizer and agricultural credit are crucial to enhancing agricultural productivity. As for credit, Horst and Watkins, (2022) claim that limited access to affordable finance, need for collateral, and lack of suitability of financial products are major problems for small farmers to take advantage of markets.

2.1.2 Existing strategies to increase land productivity

As mentioned above, unfortunately, Pakistani agricultural policies are not designed using robust scientific evidence and indigenous research. For example, empirical evidence (Aftab et al, 2021) shows that effective agricultural extension alone could increase farmers' climate adaptation uptake by 23%, however, agricultural extension in Pakistan

lacks the capacity and resources to enable farmers to use agricultural land efficiently and pave the way for backward and forward linkages in the agriculture sector. Similarly, infrastructure for water management and irrigation systems, efficient procurement of crops' yield, availability of cold storage, and supply chain and price issues are not addressed, resulting in unstable input and output markets.

Productivity of the agriculture sector in Pakistan remained low in the recent past which resulted in problems related to food security, rural employment, poverty, and livelihood in addition to scarce foreign exchange on food imports. Hence, it is highly crucial to improve agricultural productivity. Notwithstanding that Pakistan is presently self-sufficient in major staples, the National Nutritional Survey 2018[2] reveals that only 63.1% of the surveyed households are food-secure, indicating a gap between food security and food self-sufficiency, while it is challenging for Pakistan to sustain the current level of food-sufficiency (SBP, 2019).

One way to improve the productivity of the agriculture sector is to ensure the judicious and efficient use of agricultural inputs such as seeds, agrochemicals, irrigation water, and labour. Similarly, the adoption of new technologies and agricultural mechanization would not only improve productivity but will also liberate surplus labour, resolving the problem of disguised employment in Pakistani agriculture. Thus, productivity improvement would allow surplus labour to be released from agriculture and used in other sectors of the economy. This will also result in job creation in industry and services sectors in urban areas, paving the way for backward and forward linkages between agriculture and industry which will accelerate the growth momentum in the economy.

2.1.3 Gaps and shortcomings in the implementation

There is a lack of efficiency in Pakistani agriculture, especially small-scale farming, resulting in the underutilization of resources, low productivity, poor competitiveness, and wasteful use of natural resources (Horst and Watkins, 2022). Small farmers are often poor and unable to invest in mechanisation which results in inefficiencies (Aslam, 2016) which could be attained from optimal scale (Salam and Hameed, 2022). Another reason for the low productivity and efficiency of the small farms is their limited access to credit due to several factors, including the lack of collateral (Kashif et al., 2016; Chandio et al., 2018). Battese et al. (2017) also found that small-scale farmers tend to be less technically efficient.

Similarly, the traditional marketing system is highly inefficient and costly for smallholders as the supply involves multiple intermediaries, resulting long supply chain and low farm gate price of the produce. Furthermore, due to a lack of quality standards in place; farmers' lack of awareness, transparent trading practices, and limited bargaining power; commission agents and traders' collusion; and poor access to the market; farmers do not get good returns on their produce. This results in apathy and reluctance for further investment to improve farming efficiency. It is also true that Pakistani farmers lack the information and capacity to be able to meet the standards required by big food businesses, including supermarkets, processors, and exporters, resulting in their lack of access to high-end businesses and significant profit margins. This capacity gap needs to be filled by farmers' education and awareness through improving agricultural extension and facilitating agricultural mechanization.

While farmers play a crucial role in the agricultural supply chain, various other factors, including infrastructure, market issues, and government support, are equally important in addressing the challenges faced by the agricultural sector. For example, inadequate

[2] https://www.unicef.org/pakistan/media/1951/file/Final%20Key%20Findings%20Report%202019.pdf

infrastructure, such as roads, transportation, storage facilities, and market linkages, can significantly hinder the ability of farmers to access higher-value markets. Without proper infrastructure, it becomes difficult for farmers to transport their produce to markets or processing centers in a timely and cost-effective manner. This can lead to post-harvest losses and reduced profitability.

Agricultural markets in many developing countries, including Pakistan, face challenges such as fragmentation, lack of transparency, and the dominance of intermediaries. These issues can result in farmers receiving a lower share of the final market price for their produce. Reforms in market structures and the introduction of transparent and efficient market systems can help address these challenges. Government policies and support are crucial for fostering a conducive environment for agriculture. This includes providing infrastructure investments, access to credit, research and extension services, and market information. Government interventions can help farmers adopt modern and sustainable farming practices, access high-value markets, and receive fair prices for their produce.

Enhancing the capacity of farmers through training and extension services is essential. Farmers need support and knowledge to meet quality and safety standards demanded by high-end businesses. Capacity building can cover areas like sustainable farming practices, post-harvest handling, and compliance with international quality standards. Encouraging value addition at the local level can help increase the profitability of farmers. This includes processing and packaging agricultural products to meet market demands. Government policies and private sector investments in value addition can empower farmers and rural communities. Farmers often require access to credit and financial services to make investments in their farms and adopt new technologies. Access to affordable and appropriate financing can significantly impact their productivity and profitability.

It's important to recognize that the challenges in the agricultural sector are multifaceted, and addressing them requires a comprehensive approach that considers the entire supply chain, from farm to market. While farmers' capacity and knowledge are crucial, they alone cannot overcome systemic challenges without supportive policies, infrastructure, and market reforms. A holistic and coordinated effort involving multiple stakeholders, including the government, private sector, and development organizations, is necessary to create an enabling environment for agricultural growth and to ensure that farmers can access high-end businesses and profit margins.

2.1.4 Key interventions to address the gaps

There is a need to improve the efficiency of small-scale farming as well as farm-to-market linkages, making it more competitive and export-oriented (Horst and Watkins, 2022). There is a dire need to improve the capacity of agricultural extension so that it helps farming communities to transform Pakistani agriculture into a modern, efficient, and competitive industry which meets the needs of the present. There is a need to increase the productivity of livestock and fish farming as there will be an increase in the demand for fish, dairy, and meat products soon.

There is also a need for support for smallholder commercialization which would result in strengthening local businesses and value chains where investment remained insufficient. This also includes arrangements such as collection centers for agricultural produce to facilitate aggregation for growers and thereby the sale of fresh produce in bigger quantities. In addition to ease of transportation, this will help in sorting and grading agricultural commodities concerning quality to attract buyers who want larger volumes.

This will a pivotal role in mitigating opportunistic buy and sell and encouraging more consistent sales relationships between registered producers and farmers to sell to known trading partners.

2.1.5 Regional/ provincial differences

While agricultural activity is all over Pakistan, 80% of the total agricultural output is scoured by the Indus River basin of Punjab and Sindh. There are a few other places where crop yield is comparable to the Indus River basin, but the performance of the agriculture sector is mostly sub-optimal when compared with similar farming systems elsewhere. Similarly, most of the Pakistani food and beverage processing industry is located in Punjab (60 percent) and Sindh (30 percent), and it is important to mention that this is the second largest industry in Pakistan after textiles, which makes up 27 percent of the value-added production in addition to 16 percent of employment in the manufacturing sector (Horst and Watkins, 2022).

2.2 GHG emissions and decarbonisation of the agriculture sector

2.2.1 GHG emission contribution

After energy, agriculture is the biggest contributor to GHG emissions in Pakistan with 198.59 MT CO2 eq. as per 2018 estimates. The main reasons for a greater share of agriculture in GHG emission in Pakistan include the burning of agriculture residue (for example, rice and sugarcane stubble), solid waste, and other hazardous materials. Furthermore, inefficient irrigation methods such as flood irrigation and intensive use of synthetic fertilisers also contribute to agricultural emissions. Since irrigation methods in Pakistani agriculture are old and water efficiency and productivity are low, additional water is pumped out and it uses a lot of energy which results in GHG emissions. Similarly, Pakistani agriculture lacks multifunctionality in terms of on-farm biodiversity. This is achieved through implementing agri-environmental schemes to integrate biodiversity into farming practices, for example, agroforestry. The integration of biodiversity with mainstream crops creates a carbon sink in addition to regulating essential ecosystem services.

However, there is a need to adopt novel approaches for sustainable and climate-smart agriculture which are successful in many developing countries. The main source of agricultural emissions are energy use and manure management. Energy use is mainly in agricultural inputs which could be reduced by reducing intensive farming and adopting sustainable agricultural practices. For example, concentrated use of agrochemicals and water pumping for irrigation, and rigorous tillage cause a lot of GHG emissions, not to mention the degradation of soil and water resources.

2.2.2 Key contributing factors

One appropriate solution for intensive farming and concentrated use of agricultural inputs is precision agriculture which entails the regulated use of inputs and sustainable farming practices. Similarly, solar energy for pumping and the adoption of drip irrigation instead of flood irrigation could reduce a lot of energy-related GHG emissions in the agriculture sector. Moreover, reduced tillage, judicious use of inputs, and the adoption of agroforestry are some of the approaches to make agriculture greener and cleaner. The adoption of agroforestry using climate finance has been investigated in the Pakistani context and there is enough empirical evidence to create a carbon sink and adapt agriculture to climate change using this novel approach.

As for manure management in agriculture, crop residues should be returned to the soil instead of burning it. This will not only reduce agricultural emissions but it will also

improve soil fertility. One of the key hurdles and a gap that has been identified and reported in previous research is the lack of farmer awareness and training to make agriculture sustainable and climate-friendly. This requires a bottom-up approach to educate farmers about the policies formulated in a centralised fashion. This could be achieved by improving the capacity of agricultural extension which is seriously under-resourced and ill-trained.

The food certification schemes could be very helpful in GHG emission reduction. The certification regime is very common in food and agriculture as organic, cleaner, and sustainable produce is inspected and labelled to distinguish it from traditional produce. While this is sustainable from the environment and climate point of view, there is a premium on cleaner produce which is an incentive for farmers and producers to adopt sustainable practices. There is empirical evidence available in the Pakistani context as consumers are willing to pay additional prices (premium) to buy relatively cleaner food. In addition to efficient use of resources and low emissions, this paves the way for producing export quality agricultural goods and making this competitive in the international market.

One of the hurdles in emission is the measurement and quantification of GHG emissions from different agricultural activities which could serve to gauge the GHG potential by reducing it in different areas. In this respect, the use of technology on small scale could be very helpful.

2.2.3 Mitigation strategies

As for decarbonisation in the agriculture sector of Pakistan, several policies stress GHG mitigation in the agriculture sector. For example, the Climate Change Policy of Pakistan and the National Sustainable Development Strategy underscore the need for agricultural emissions. However, there is a lack of implantation plans and strategies to implement the goals of these policies. A penalty for burning crop residue using the polluter-pay principle could help reduce agricultural emissions.

Imposing penalties on farmers for burning crop residue, while a potential measure to discourage harmful agricultural practices, should be part of a broader strategy that provides farmers with alternatives and support to manage crop residue in an environmentally friendly way. Punitive measures alone may not be effective and could create unintended consequences, including farmer resentment and non-compliance. Hence, the state should actively promote and support alternative practices for managing crop residue. These may include no-tillage farming, conservation tillage, mulching, and the use of crop residues as livestock feed or for bioenergy production. These practices can help farmers maintain soil health and reduce the need for burning.

Furthermore, it's essential to educate farmers about the environmental and health impacts of crop residue burning and the benefits of adopting alternative practices. Extension services and training programs can play a crucial role in building awareness and capacity among farmers. Government support in the form of subsidies, grants, or low-interest loans can help farmers invest in equipment and technologies that facilitate residue management, such as mulchers, shredders, or no-till planters. State-funded research and development can lead to the adaptation of crop varieties that produce less residue or are more suitable for no-tillage farming. Research can also identify the best practices for residue management in local contexts. The government can help create markets for crop residues as feedstock for bioenergy production or as raw material for industries. This can provide economic incentives for farmers to manage residue in an eco-friendly way. In addition to penalties, the state should develop and enforce policies

and regulations that encourage sustainable agricultural practices. These may include standards for residue management, emissions reduction targets, and incentives for compliance.

Similarly, promoting the use of green manure could help in better manure management and reduce the use of synthetic fertilisers which also causes emissions. Furthermore, the adoption of efficient irrigation methods and efficient motors and pumps could improve energy efficiency in irrigation. It is very crucial to start metered water supply on a cost-recovery basis for agricultural purposes. This will conserve water, the energy required for pumping the water, and subsequent emissions in addition to creating an incentive for the adoption of drip irrigation technology. Development and use of new technologies such as genetically modified crops that are more carbon responsive could also help reduce agricultural emissions and adaptation to climate change.

3. Key policy issues of the agriculture sector in Pakistan

3.1 Global policy environment and initiatives

3.1.1 EU Carbon Border Adjustment Mechanism (CBAM)

Under the European Green Deal, the EU's Carbon Border Adjustment Mechanism (CBAM) is essentially the world's first carbon tariff regulation. It is a landmark tool of the European Green Deal to put a fair price on carbon emitted in the production of carbon-intensive goods that are entering the EU. The CBAM legislation is being introduced in pursuit of making Europe the world's first climate-neutral continent by 2050. In other words, it is an attempt to decarbonise the EU economy to contribute to the global fight against climate change which is a threat to the global community and the natural environment itself. The CBAM package of legislation envisages imposing a penalty on the imports of certain products which involve energy-intensive production processes.
This policy measure aims to encourage cleaner industrial production in non-EU countries and curb GH emissions. Nonetheless, CBAM will have serious implications for developing countries such as Pakistan where decarbonisation is still nascent and hindered by a lack of technology, finances, required policy framework, and political will. While CBAM covers a few selected carbon-intensive goods such as aluminum, cement, electricity, and, iron and steel at the moment, the list could be expanded soon, further penalizing the carbon emission.

3.1.2 CBAM's potential impacts on Pakistan's agricultural exports

CBAM impacts on the trade of different countries are different as they are at different stages of development and specialize in different commodities (Ren et al., 2023). Nevertheless, these impacts are unclear and unexpected with implications for inequality and inequity (Zhong and Pei, 2022). Furthermore, research indicates that the legislation adopted by the EU is expected to exacerbate the fragilities of emerging and developing economies (Magacho et al., 2023) as they will not be able to meet the stringent requirements in terms of emission and adoption of technology, resulting in undermining their capacity to trade. Furthermore, even the European Agricultural Machinery Association (CEMA) is critical of the CBAM for the legislation's implications for EU farmers. For example, the controlled import of fertilisers and agricultural machinery could affect EU farmers. However, this legislation could potentially have significant implications for agriculture-related exports of developing countries to the EU.

Presently, Pakistan only exports cement to the EU from the products listed in the CBAM. Still, this legislation could have a significant impact on Pakistan's competitiveness. There are however discussions to broaden the sectoral coverage of CBAM in the future which might include agricultural exports to the EU, resulting in further difficulty for the Pakistani agriculture sector which is already plagued with low productivity, emission-intensiveness, a lack of mechanization, and thus unsustainable farming. It is important to note that the EU is one of the important trading partners of Pakistan, and any regulations related to EU imports would affect the country. As CEMA raised concerns about the availability of fertilisers, this can also have implications for fertiliser production and import in Pakistan.

As a key destination for Pakistani exports to the EU which are almost 28%[3] of the total exports, it might present a challenge for Pakistan. For example, data shows that a major part (almost 75%) of total Pakistani exports to the EU are textiles-related. Regulations such as CBAM can potentially reduce this proportion. This could have serious negative implications for cotton farmers in Pakistan. Similarly, rice farmers could be affected by having CBAM-type legislation packages. Hence, there is an urgent need to transform Pakistani agriculture into a cleaner and greener industry. This will not only ensure the production of healthy and environmentally friendly sustainable food production, but it will also generate scarce foreign reserves.

3.1.3 Regional cooperation in decarbonizing the agriculture sector

Collaborative efforts between neighbouring countries can always facilitate the sharing of knowledge, technologies, and best practices for climate-smart and green agricultural practices. Successful strategies to reduce carbon emissions in the agriculture sector from one country or region can be imitated and implemented in others. In this respect, joint research initiatives could be instrumental in designing region-specific solutions for the mitigation of emissions in the agriculture sector. For example, developing drought-resistant crops, promoting precision agriculture techniques, and improving waste management practices can significantly reduce agricultural emissions.

Decarbonisation efforts at the regional level are not possible without having coordinated policy frameworks across regional partners to create a conducive environment for a climate-friendly and cleaner farming system. Such a framework could help in setting emissions reduction targets, promoting renewable energy adoption, and incentivizing climate-smart farming techniques. Furthermore, capacity building and resource sharing at the regional level can help adopt climate-resilient and low-carbon practices.

3.1.4 Sustainability certification and labelling regimes

Sustainability certification and labelling are effective tools to promote health and environmentally friendly and socially responsible practices in the food and agriculture industries all over the world. Sustainability certification and labelling ensure that consumer makes more informed choices about the products they consume while producers adopt sustainable production methods. For example, certain labels inform consumers about the environmental, social, and economic impacts associated with the production and distribution processes of different products. This includes information about the use of agrochemicals, GHG emission, and labour rights in agricultural practices.

A variety of sustainability labels exist, each focusing on different aspects of sustainability. These labels may indicate organic production, fair trade practices, reduced carbon

[3] https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/pakistan_en#:~:text=Pakistani%20exports%20to%20the%20EU,(22.2%25%20in%202020).

emissions, responsible water use, animal welfare, and more. In other words, these labels denote the product credence attribute and assist consumers to differentiate products based on their adherence to specific sustainability standards, helping consumers make informed choices and rewarding producers who prioritize sustainability. The labels are assigned after rigorous assessments conducted by third-party organizations which evaluate products on various criteria such as resource use, pollution levels, social equity, and animal welfare.

Nevertheless, labels are useful for consumers as well as producers. For example, sustainability labels empower consumers to align their purchasing choices with their values, encouraging sustainable and ethical consumption. Labels provide clear information about the products' environmental and social impact, enabling consumers to support practices that contribute positively to the planet and society. On the other hand, certification and labelling regimes incentivize producers to adopt sustainable practices which access niche markets that prioritize sustainability and offer greater margins.

3.2 Greening the agriculture sector in Pakistan

3.2.1 Key challenges and opportunities

There are several challenges with regard to the greening of the agriculture sector in Pakistan. For example, Pakistan faces serious water scarcity worsened by inefficient irrigation practices and a changing climate. Addressing water management and adopting efficient irrigation technologies are critical challenges to improve agricultural sustainability. There is a need for soil conservation practices and sustainable land management as soil degradation is a serious problem in Pakistani agriculture. Excessive use of pesticides and synthetic fertilizers contributes to environmental pollution and health risks.

The absence of income and employment opportunities in non-farm sectors, such as industry and services, push a significant portion of the population to rely on agriculture for their livelihoods. This can lead to over-reliance on the agricultural sector, as rural communities have limited alternative sources of income. Consequently, farmers may resort to practices like excessive pesticide and fertilizer use to maximize yields on limited land, exacerbating environmental and health issues. Structural issues in the economy, such as limited industrial development and underinvestment in non-agricultural sectors, contribute to the concentration of economic activity in agriculture. Encouraging structural transformation that promotes the growth of non-agricultural sectors can reduce the pressure on the agrarian sector to generate income and employment, leading to more sustainable and balanced economic development.

Facilitating the diversification of rural livelihoods is crucial. Policies and initiatives that promote off-farm income opportunities, such as agribusinesses, small and medium-sized enterprises, and service-oriented businesses in rural areas, can reduce the dependency on agriculture and the associated environmental pressures. Limited access to credit and financial services can constrain the ability of rural communities to invest in non-agricultural businesses. Improving access to financial resources can help rural entrepreneurs establish and expand businesses outside of agriculture. Investing in education and skill development in rural areas can empower individuals to pursue a wider range of employment opportunities. This can include vocational training programs that prepare the workforce for non-agricultural roles.

Encouraging sustainable agricultural practices such as organic farming and integrated pest management can reduce the reliance on excessive pesticide and fertilizer use. This

requires educational programs and incentives for farmers to adopt more environmentally friendly approaches. Ensuring that rural products have access to markets, including urban and international markets, can create opportunities for value addition and diversification. Infrastructure development and market linkages are critical in this regard. Promoting integrated pest management and organic farming practices can reduce these negative impacts while improving the agriculture sector's performance and hence the livelihood of the rural population. Crop residue burning also causes carbon emissions, hence there is a need for strict regulation for this.

As for opportunities, water-efficient irrigation technologies like drip and sprinkler systems can improve water-use efficiency and reduce water wastage. Similarly, solar energy for pumping and drip irrigation can reduce energy-related GHG emissions in the agriculture sector. The use of climate finance for the adoption of agroforestry in marginal and climate-vulnerable small farms could help diversify the crops and hence farmer livelihood. Farmer awareness and training to make agriculture sustainable and climate-friendly could be very effective in making the agriculture sector green. This could be achieved by improving the capacity of agricultural extension which is seriously under-resourced and ill-trained. Food certification schemes are a big opportunity to mitigate GHG emissions and make food production sustainable while earning additional revenue from sustainable agricultural produce. Developing efficient supply chains and improving market access for smallholder farmers can enhance their income and incentivize sustainable practices.

3.2.2 Green industrialization- backward forward linkages, how can agriculture be the engine of green industrialization?

The Pakistani agriculture sector needs a transformation by prioritizing high-value production and focusing on improving the business environment, equity, financial inclusion, and competitiveness to facilitate green industrialization and optimize backward-forward linkages (Horst and Watkins, 2022). There is an interrelationship between agriculture and industry, and agriculture maintains a balance between this sector and other sectors of the economy. There is a structuralist approach, initially proposed Lewis (1954), in agriculture development, whereby the agriculture sector provides resources to industry which results in prosperity. As Johnston and Mellor (1961) indicated, the share of agriculture in GDP is relatively high and there is more labour involved in the agriculture sector in developing countries. Furthermore, despite greater use of resources such as labour in the agriculture sector in developing countries, their productivity is low.

In this respect, the Lewisian dualistic model, proposed by Sir Arthur Lewis in 1954, envisions an economy with two sectors: a traditional agricultural sector and a modern industrial sector. In a country like Pakistan, where there is a surplus of labour in the agricultural sector, this theory becomes highly relevant. The surplus labour in agriculture can potentially be absorbed by the industrial sector. In countries with large and growing populations, there is a constant influx of labour into the job market, particularly in rural areas. This "unlimited" or surplus labour pool is a key feature of many developing economies. In Pakistan, the agricultural sector traditionally absorbs a significant portion of this labour force.

Agriculture as a Reservoir: The agricultural sector in these economies is seen as a reservoir of surplus labor. As the population grows and more labour enters the workforce, the agricultural sector alone cannot provide sufficient employment opportunities or increased incomes. This situation triggers the need for economic transformation and industrialization. The Lewis model suggests that industrialization is the key driver of

economic growth and development. The surplus labour from agriculture can be absorbed by the growing industrial sector, leading to increased employment, higher wages, and improved living standards. This structural shift contributes to prosperity by diversifying the economy and reducing dependency on agriculture.

To facilitate this transition, government policies and investments are crucial. These may include investments in infrastructure, education, and healthcare, which improve the quality and productivity of the labour force, making it more attractive to the industrial sector. While the Lewisian model offers a compelling framework for development, it's important to note that the transition is not without challenges. Managing the shift from agriculture to industry, ensuring equitable growth, and addressing issues related to rural-urban migration are complex tasks that require careful planning and policy implementation. In Pakistan's context, the Lewisian model highlights the need for a deliberate strategy for industrialization to absorb surplus labour from agriculture. Policies should aim to create an enabling environment for industrial growth, improve infrastructure, and enhance the employability of the labour force through education and skill development. Additionally, addressing rural-urban disparities and ensuring that the benefits of industrialization reach all segments of the population are crucial considerations in the country's journey toward prosperity and economic development.

In the presence of disguised employment in rural farming in Pakistan, there should have been the reallocation of surplus agricultural workers with a low contribution to output to industry to become a productive workforce and earn higher wages. This forms the basis of what is usually referred as backward and forward linkages between agriculture. Lewis (1954) thesis of backward and forward linkages between agriculture and industry was further developed by Rannis and Fei (1961) and Johnston and Mellor (1961). Rannis and Fei (1961) call it the transition process and claim that through this process an underdeveloped economy could move from stagnation to sustainable growth. Rannis and Fei (1961) use the framework in which they assume that the proportion of the rural population reduces, savings rates are doubled, and this results in the continuous industry due to the availability of surplus labour.

Malik et al. (2016) claim that the share of the Pakistani agriculture sector in the GDP remained high due to poor performance of the agriculture sector and increasing poverty. Authors believe that this is due to some of the fundamental problems of the Pakistani agriculture sector such as low yield, lack of crop diversification, inefficient use of water, inadequate technology, decayed extensions, poor input markets, and declining investment. Furthermore, land inequality is a critical issue in Pakistan, with a small percentage of landowners controlling a significant portion of agricultural land. This inequality can lead to inefficiencies in land use, hinder equitable access to resources, and limit opportunities for landless and small-scale farmers. Addressing land reform and promoting more equitable land distribution is vital for sustainable agricultural development.

Notwithstanding the agriculture sector’s critical role in rural livelihood, food security, and industry in Pakistan, there has been neglect of the rural economy and agriculture sector. For example, the agriculture sector in Pakistan lacks technical, financial, and policy support and hence plays a very limited role in effective demand for industrial output. This resulted in rural-urban migration, low productivity of the sector, food insecurity, unemployment, and rampant poverty in rural areas of Pakistan.

3.2.3 Current sources of financing

Agricultural finance empowers farmers to increase their production efficiency and improve value chains by providing market-based financial services and funding long-term green investments to support sustainable agriculture. Notwithstanding government efforts, financing for the agricultural sector remained inadequate in Pakistan due to financial constraints of the government, the negligible share of private sector financing for the agricultural sector, risk aversion of the financial institutions, a lack of conducive policies to encourage agricultural finance, and poor financial literacy of farming communities, among others. Some of the existing initiatives regarding agricultural finance include the State Bank of Pakistan's allocation of the indicative agricultural credit disbursement target of Rs 1,819 billion for the fiscal year 2023. This amount is 28.2% higher than last year's disbursement of Rs 1,419 billion (GoP, 2023). However, information about the minimum amount of credit, purpose and use of credit, and the farmers who get this is not available. This facility is likely to be used by relatively large farmers.

In addition, there are several private financial institutions which give agricultural credit. This includes commercial banks and a few specialized banks such as the Zarai Taraqiati Bank Limited and Punjab Provincial Cooperative Bank. However, the coverage and outreach of existing sources of agricultural finance are limited, not to mention the difficulties farmers face in eligibility, etc. As for potential sources of financing for reducing carbon emissions in the future, agricultural finance through NGOs and local organizations could help in improving efficiency and productivity in addition to the uptake of new technologies to reduce GHG emissions and achieve commercialization of the rural economy which is necessary for the backward and forward linkages of agriculture and industry in Pakistan.

3.2.4 Challenges of financing for the agricultural sector

Agriculture finance has been an integral part of the process of commercialization of the agriculture sector and the rural economy in most developing countries. Agriculture finance empowers farmers in many ways and facilitates the development of food value chains, however, the access to agricultural credit in Pakistan remained very low, resulting in less innovation, upgradation, and uptake of new technologies in farming. Improved access to agricultural credit could have improved the performance of the agriculture sector in Pakistan. The financial systems in Pakistan remained ill-prepared to finance the agriculture sector to enable it to shift to sustainable agriculture, resulting in the sector's competitiveness and modernisation.

Due to small-scale farming, lack of mechanisation, poor irrigation facilities, and low uptake of modern agricultural technology, Pakistani agriculture has a low output, and hence it does not generate enough income. The major challenges for financing for the agriculture sector in Pakistan include insufficient institutional credit, high rates of interest, lack of collateral with farmers, farmers' literacy, and the difficult procedures to access and qualify for the credit. These constraints create a gap which paves the way for informal sources of agricultural credit such as middlemen, shopkeepers, and money lenders who often exploit the poor farmers and they end up indebted and selling their assets to pay back the debt. Hence, the current system of agricultural credit has created inefficiencies and has failed to fulfill the credit needs of farmers.

Land inequality in Pakistan is a well-documented issue. A small number of landholders own a significant portion of the agricultural land, while a large segment of the population has limited access to land. This inequality can result in inefficient land use, as large

landowners may not fully utilize their land, while small-scale farmers often lack access to adequate land for productive farming. This situation can limit overall agricultural output and income distribution. The level of government support and investment in agriculture can significantly impact its productivity. Inadequate public investment in agriculture, including research and extension services, can hinder the adoption of modern farming practices, technologies, and techniques that can boost output. Limited access to credit and insurance for farmers can also hinder their ability to invest in their farms.

Insufficient infrastructure, including rural roads, transportation, and storage facilities, can lead to post-harvest losses and inefficiencies in the supply chain. These shortcomings make it challenging to get agricultural products to markets in a timely and cost-effective manner, reducing the income that farmers can earn from their produce. The lack of strong linkages between the agricultural and manufacturing or industrial sectors can limit the value addition to agricultural products. For example, agro-processing industries can add value to agricultural produce and create employment opportunities. Weak linkages mean that the full economic potential of the agricultural sector may remain unrealized.

In addition, farmers' ability to access markets, both domestic and international, is crucial for their income generation. Inadequate market access can result in lower prices for agricultural products and missed export opportunities. This, in turn, affects the income of farmers. Addressing these challenges requires a multifaceted approach, including land reform, increased government support, infrastructure development, strengthening linkages between agriculture and industry, and improving market access for farmers. While these issues have been recognized, progress in addressing them often requires coordinated efforts by various stakeholders, including the government, civil society, and international organizations, and may evolve with time.

3.2.5 Potential sources of financing for reducing carbon emissions in the future.

Greening the agriculture sector in the context of Pakistan would mean changes in the existing agricultural practices to make farming clean, green, and sustainable. The adoption of clean, green, and sustainable agricultural practices would entail healthy and environmentally-friendly cleaner food production which ensures the cleanliness of food as well as the conservation and efficient use of environmental and other resources, including irrigation water, soil, biodiversity, and fertilisers. Furthermore, this also means reducing the GHG emissions from farming practices and making the agriculture sector resilient to unfavorable climate changes and natural disasters such as floods and droughts. To decarbonize the existing agricultural activities, the use of efficient irrigation, and new technologies, e.g. solar water pumps, improved crop mix, organic manure, minimum tillage, and adoption of agroforestry could be used.

This also includes green structural transformation which would mean changes in the allocation of resources from low-productivity high-carbon-emission activities such as agriculture to low-carbon-emission and high-productivity activities such as green industries. Nevertheless, the main challenges which impede green industrialization, include a lack of technical and institutional capacity, financial support, and appropriate incentives. For example, the improved capacity of the agricultural extension could help farmers adopt sustainable agricultural practices, resulting in generating enough input for cleaner production in the industry. Similarly, reducing GHG emissions at source would also help the industry in curbing the carbon footprint of final products as the inputs would be sourced from sustainable farms which will be certified, and agricultural products will be labelled as cleaner. This will also pave the way for Pakistani agricultural exports to become competitive as labelling is used as a credence attribute in agricultural exports in the EU and other developed parts of the world.

3.3 Policy recommendations for green structural transformation in agriculture

3.3.1 Decarbonisation

For decarbonisation of the agriculture sector, the following are the policy recommendations. First, the use of solar energy for pumping and the adoption of drip irrigation instead of flood irrigation could reduce a lot of energy-related GHG emissions in the agriculture sector. Second, reduced tillage, judicious use of inputs, and the adoption of agroforestry are some of the approaches to make agriculture greener and cleaner. Third, the adoption of agroforestry using climate finance has been investigated in the Pakistani context and there is enough empirical evidence to create a carbon sink and adapt agriculture to climate change using this novel approach.

Fourth, crop residues should be returned to the soil instead of burning it. This will not only reduce agricultural emissions but it will also improve soil fertility. Fifth, one of the key hurdles and gaps is the lack of farmer awareness and training to make agriculture sustainable and climate-friendly. This requires a bottom-up approach to educate farmers about the policies formulated in a centralised fashion. This could be achieved by improving the capacity of agricultural extension which is seriously under-resourced and ill-trained.

Last, the food certification schemes could be very helpful in GHG emission reduction. The certification regime is very common in food and agriculture as organic, cleaner, and sustainable produce is inspected and labelled to distinguish it from traditional produce. While this is sustainable from the environmental and climate point of view, there is a premium on cleaner produce which is an incentive for farmers and producers to adopt sustainable practices.

3.3.2 Finance

There is a need to improve agricultural financing in Pakistan and this requires a coordinated effort among government agencies, financial institutions, development organizations, and the private sector. This can create a more inclusive and robust financial ecosystem that supports the growth and sustainability of the agricultural sector in Pakistan. There are a number of things which could be done in this respect. For example, improving microfinance services targeted at small farmers with easy terms could help improve farmer access to credit. Similarly, simplification of loan application processes and collateral requirements would make it easier for farmers to access credit. Agriculture credit should be more comprehensive, covering the entire agricultural value chain, from input suppliers to producers, processors, and distributors. The creation of partnerships between financial institutions, agribusinesses, and cooperatives to provide integrated financial services to farmers could be more effective. The optimal use of digital technology and mobile banking to reach farmers in remote areas is extremely important for lending agencies as well as farmers. Providing training to farmers as well as financial institution staff in managing and implementing agricultural credit can be very helpful. Lastly, the collection and use of data on agricultural and financial aspects and subsidies by the government may support the whole process.

3.3.3 Backward-forward linkages

As for backward and forward linkages between agriculture and manufacturing/industry, there is high food inflation, resulting in demand for high wages of labour. Government must support farmers by ensuring effective agricultural extension services, efficient

irrigation systems, and access to inputs such as seed and agrochemicals in addition to providing good connection to market and price support. This will enable the increase in production and improved crop yields and hence the exports. This will improve foreign exchange accumulation and subsequent import of raw materials for the industry. Presently, Pakistani agriculture is one of the least productive and inefficient in the region. The outcome is that despite a severe economic crisis including a liquidity crunch, Pakistan imports food.

Effective demand and generation of agricultural surplus and its realisation into purchasing power for industrial goods is possible under conditions of sufficiently high agricultural growth. Current agricultural policies and the performance of the agriculture sector are not conducive to generating effective demand. Since more than one-third of the labour force is employed in the Pakistani agriculture sector, there is disguised unemployment or underemployment.

This is fundamentally due to a lack of use of modern technology and equipment and thereby limited agricultural mechanisation as many tasks are still performed manually by semi-skilled and illiterate farmers. This also undermines the performance of the agriculture sector in terms of efficiency and productivity. However, agricultural mechanisation is critical to the movement of surplus labour from agriculture to industry and thus the structural transformation. This reallocation of surplus labour from farming to nonfarm sectors in aligned industries such as agro-processing, marketing, input supply, mechanics, and operators, to urban areas and elsewhere will boost agricultural performance as well as employment and income opportunities in aligned industries, for example.

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