SUSTAINABLE AGRICULTURE TRANSFORMATION IN NORTH AND CENTRAL ASIA

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific

Summary

The paper examines the impact of sectoral transformation in agriculture on sustainable development in North and Central Asia. It discusses trends and developments of agriculture and structural transformation, as well as its effects on sustainable development in the subregion. Since the breakdown of Soviet-Union, the subregion underwent economic and political transformation and recorded positive growth after eight years. In the course of transition, all countries in the subregion experienced constantly declining shares of agriculture in gross domestic product. However, the agriculture sector still employs a large share of the population, especially in rural areas. Potential gains from intrasectoral transformation in agriculture should not be underestimated. Increasing sectoral productivity, and hence profitability, bears the prospective to lift millions of people out of poverty while optimizing resource efficiency.

Analysing the linkages between agriculture transformation and the selected indicators of the Sustainable Development Goals empirically by a two stage fixed effects – instrumental variable estimation, it shows that product diversification and agriculture openness positively impact sectoral productivity. While technological growth exhibits a negative impact due to diminishing marginal returns, it is important to note that technology is a key driver for economic transformation. Water productivity remains insignificant because it stayed stagnant and unproductive throughout the transition period. Agriculture transformation consequently exhibits varying degrees of impact on the three pillars of sustainable development, with especially strong significance in reducing greenhouse gasses emissions. It also contributes to reduced prevalence of undernourishment and indirectly affects youth unemployment rates.

Sustainable agriculture transformation needs to be mainstreamed across the subregion. This can be facilitated by customization of national sustainable agriculture transformation plans, reassessment of current agriculture subsidies structure to target more efficient production inputs, leveraging private sector investment for agriculture modernisation, promote agricultural water use efficiency to combat water stress and strengthen regional cooperation to ensure supply chain resilience. These efforts to support the agriculture sector will in turn contribute to achievement of the 2030 Agenda for Sustainable Development.

Keywords: Economic transformation, Agricultural economics, Sustainable development

▪▪

Authors: Patricia Wong, Dinara Assaubayeva and Athina Anastasiadou with inputs from Cheng Jiayue
Editor: Mary Ann Perkins

▪▪

Contents

1. Introduction

The development trajectory of countries in North and Central Asia[1] has always been influenced by geopolitical developments which in turn shape the economic structure. After the collapse of the Soviet Union, the subregion recorded a positive gross domestic product (GDP) growth rate only after eight years, in 1999. The stable growth onwards was mainly driven by the expansion of extractive industries in resource rich countries, whereas other economies relied on existing production systems and alternative means of growth such as remittance inflow and re-export of goods. Reliance on natural resources exports and remittance inflow made the subregion vulnerable to external shocks such as fluctuations in oil prices, financial crises and the more recent COVID-19 pandemic. As productivity levels and economic growth start to wane, there is a need to reevaluate the current development model in the subregion and look into different measures that could further stimulate growth and development.

The agriculture sector can play a crucial role in the economic transformation process of North and Central Asian economies. However, the development and economic transformation trajectories in the past decades have downplayed and largely ignored the potential of intrasectoral transformation in the agriculture sector. Conforming with economic development trends, the share of agriculture in GDP in the subregion has been declining throughout the years across all North and Central Asian countries as employment shifted to the service and manufacturing sectors. Throughout this transition period, employment in the agriculture sector has tended to be marginalized while labour force and capital move to the more profit-promising and fast-growing sectors of resource mining or services. These developments increase the risk of rural poverty, food insecurity and unemployment.

As North and Central Asian countries seek to transition into the higher value services sector, the potential gains from intrasectoral upgrading in the agriculture sector should not be overlooked. In other developing countries in Asia, the agriculture sector played a key role in facilitating structural transformation through increased productivity gains (ADB, 2013). Agriculture transformation not only increases productivity in the primary sectors of farming, but also contributes to industrialization and processing of agriculture products which facilitates value chain integration. Since the agriculture sector still employs a large share of the total workforce while exhibiting low levels of productivity, increasing sectoral productivity bears the potential to lift millions of smallholders and rural population out of poverty. It also contributes to sustainable development through increasing efficiency of natural resources used in the agricultural production process which in turn reduces negative externalities.

This paper examines trends in agricultural productivity and sectoral transformation in North and Central Asia in the light of economic transformation in the subregion. It proposes agriculture transformation as a potential area to enhance and accelerate efforts in achieving the 2030 Agenda for Sustainable Development. The following analysis follows the objective to establish this relationship empirically by examining the linkages between sustainable agriculture transformation and selected indicators of the Sustainable Development Goals (SDGs). Based on the findings, this paper provides recommendations tailored to the North and Central Asia subregion to facilitate intrasectoral transformation in the agriculture sector which enhances the implementation of the 2030 Agenda.

---

[1] The countries in North and Central Asia are Armenia, Azerbaijan, Georgia, the Russian Federation, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

The rest of this paper is organized as follows: section 2 provides a summary of structural transformation in North and Central Asia and elaborates on the current trajectory of agriculture transformation in the subregion; section 3 proposes a conceptual framework and provides an analysis the relationship between agriculture transformation and the 2030 Agenda; section 4 outlines policy considerations for sustainable agriculture transformation in North and Central Asia; and section 5 concludes the paper. It is noted that the recommendations are formulated based on the analysis of the subregion as a whole, while tailored policies for each country will require further country specific analysis which is beyond the scope of this working paper.

2.   Context of transformation in North and Central Asia

Structural transformation refers to the process of reallocating factors of production to higher value activities which helps enhance productivity and is fundamental to sustain long-term growth (ESCAP, 2019b). It has long been discussed as one of the priorities for countries in North and Central Asia, a majority of which are landlocked developing countries, to achieve sustainable development. The discussion on structural transformation for landlocked developing countries received global interest through the adoption of the Almaty Programme of Action in 2003, which was then succeeded by the Vienna Programme of Action in 2014. Structural transformation was explicitly included as a priority action area of the Vienna Programme of Action, yet the midterm review in 2019 revealed North and Central Asian countries had made limited progress towards this priority.

2.1 Structural transformation in North and Central Asia

Structural transformation in North and Central Asian countries has progressed at different rates. Between 1991 and 2019, though there have been observations of structural transformation through a general shift in employment from agriculture to industry and services in the subregion, the data indicated two contrasting trends. The period from 1991 to 2001, immediately after the disintegration of the Soviet Union, marked an abrupt transition from a centralized economy to a market economy which saw significant declines in productivity and per capita income alongside high inflation rates. This period of recession left many North and Central Asian countries scrambling to get their economies back on track through transition strategies such as privatization policies, liberalizing trade activities and export diversification. From 2001 to 2019, countries in the subregion began to reverse the negative trends in labour productivity and income growth, compounded by within sector improvements and, to a lesser extent, by structural change. The institutional reforms of the past decade to promote a market-driven economy began to bear fruit. However, the economic growth of resource rich countries in the subregion is highly dependent on resource mining, which has high productivity levels but comes with constraints, such as limited employment opportunities, unsustainable environmental impacts and exposure to global resource price fluctuations. Diversification and integration of the economies into larger regional and global value chains have been limited.

The dissolution of the Soviet Union and the loss of this large primary market triggered deindustrialization and the collapse of welfare systems, while drops in sectoral output and productivity, accompanied by the shutdown of State-owned enterprises resulted in a significant surge in unemployment. Deindustrialization also forced a shift in economic activities from manufacturing to agriculture and services. Although there is a decrease in the share of employment in agriculture across all North and Central Asian countries since 1991, it remained higher than the share of employment in manufacturing in most of the countries, as illustrated in figure 1. In 2018, the agriculture sector employed about 30 per cent of the labour force in North and Central Asian countries, higher than the average of the Asia and the Pacific region at approximately 24 per cent. With regards to employment in the services sector, despite its increasing share in the region, productivity levels remain low (ESCAP, 2019b). This could be attributed to the nature and structure of the services sector which consist of low value-added activities which are supportive in nature and informal services which are largely not captured by official statistics. Many labourers were forced into the informal sector following the period of Soviet dissolution, especially in the resale of goods which does not contribute to significant value added. Though the services sector in North and Central Asia has developed considerably since then, especially in the Russian Federation, Kazakhstan and Kyrgyzstan

where the sector employs more than 50 per cent of the labour force, transformation in the services sector needs to be better facilitated by information and communications technology connectivity as well as enabling business policies and conditions which fosters positive investor sentiment to further productivity growth.

Figure 1. Employment share by sector, 1991 and 2019
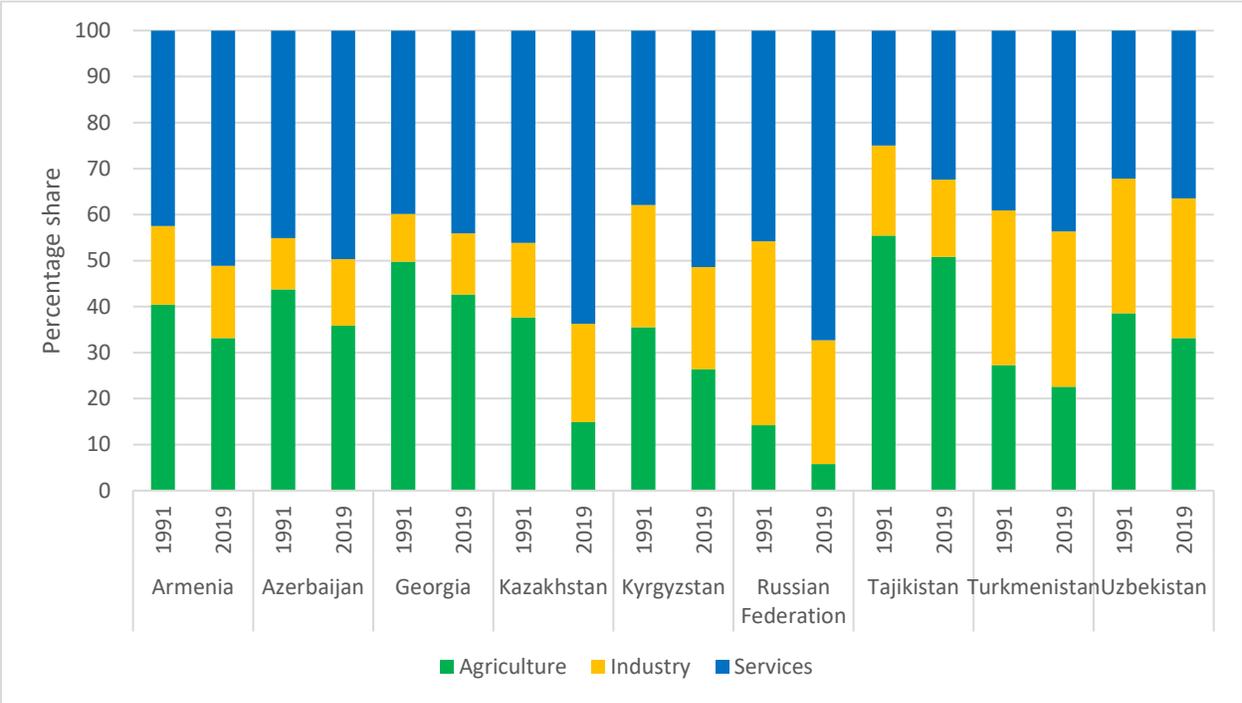
Source: World Development Indicators, World Bank.

2.2 Agriculture transformation in North and Central Asia

Agriculture has always played a significant part in the development of North and Central Asian countries. Although agriculture's share of GDP and total employment decreased over the years, agriculture value added continues to grow, as shown in figure 2. Despite the general increasing trend of agriculture value added, Kazakhstan, the Russian Federation and Georgia recorded limited growth rates over the years. The relationship between GDP per capita and the share of agriculture value added in North and Central Asian countries generally fits into the regular pattern of other developing countries, where the share of agriculture value added decreases as income level increases. However, irregularities could be observed in Tajikistan and Uzbekistan. Tajikistan experienced an increase in agriculture value added at GDP per capita levels of approximately $790 onwards, whereas Uzbekistan experienced a sharp increase in agriculture value added at GDP per capita levels of approximately $1,700. Tajikistan still has a highly agrarian economy and has the highest employment share in agriculture among North and Central Asian countries. This heavy reliance on the agriculture sector coupled with development assistance which was focused on agriculture can explain the increase in agriculture value added. Changes in agriculture value added in Uzbekistan reflect its move away from being a one-crop economy with supporting government policies to diversify the agriculture sector and move into higher value-added agriculture products and value chains.

4

Figure 2. Agriculture value added in North and Central Asia, 1991–2018 (Constant 2010 United States dollars)
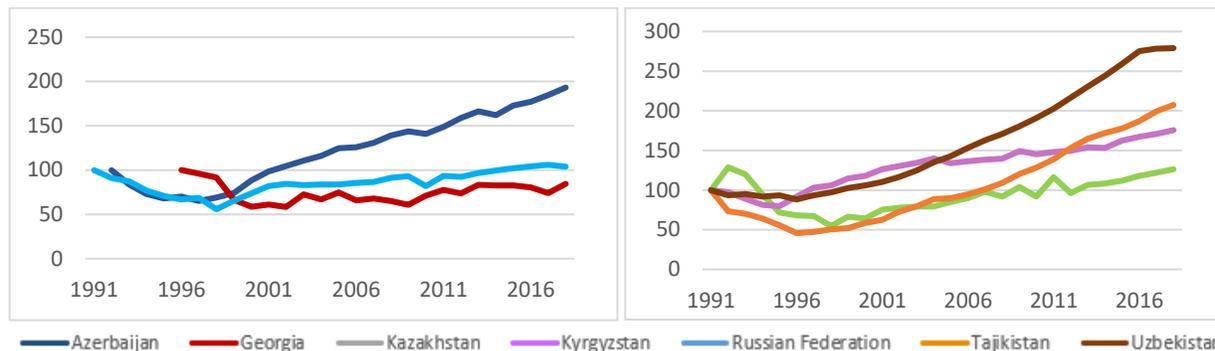
Source: World Development Indicators, World Bank, National Statistics Offices.

Note: Armenia and Turkmenistan omitted from graph due to lack of data.

The agriculture sector has largely been ignored in the conversation on structural transformation due to its small output share and slow growth (ADB, 2013). As the population continues to grow in the subregion, engaging agriculture to reach higher phases of transformation should be aimed to maximize gains in the agriculture industry and enable resources such as capital and labour to be allocated in a more effective manner that integrates and circulates in the economy, while keeping in mind the long-term objective of sustainable development. For North and Central Asian countries, the lack of competitiveness of the agriculture sector is mainly due to low productivity levels rather than slow growth in agriculture output (Gharlegi and Popov, 2018). Agricultural labour productivity gains in the subregion varied between 1991 and 2018. Although significant gains were recorded for Kazakhstan, they were still almost three time less than that of Russia, reflecting the inherent disadvantages of the agriculture sector and the potential for further intrasectoral transformation. Georgia observed an increase in agricultural labour productivity while also maintaining its relatively high level of employment in the agriculture sector (more than 40 per cent of labour force). The labour productivity trends across the subregion reflects the overall structural transformation where a steep decline in the 1990s was followed by a rebound in the 2000s (figure 3).

Figure 3. Percentage change in employment share and labour productivity in agriculture, 1991 vs 2018

Source: World Development Indicators, World Bank.

A key transformation point for the agriculture sector in North and Central Asian countries followed after their independence in the early 1990s, when countries commenced reform programmes aiming to transition from central planning to market economies. Several distinguished reforms contributed to the development process towards smallholder farming in North and Central Asia. Two substantial reforms in this regard were additional land allocations for household plots and a turn to a new organizational form of farms, such as peasant farms, which were independent entities outside the collectivist framework. They were larger than household plots and had a strong commercial orientation that led to a decrease in land worked by large corporations (Lerman and Sedik, 2017).

In the early 1990s, the agriculture landscape was mainly characterized by large corporate farms (Kolkhozy and Sovkhozy) which produced more than 70 per cent of gross agriculture output and controlled over 90 per cent of arable land. Small household plots run by the rural population existed but mostly in the form of subsistence farming, while the Kolkhozy and Sovkhozy produced most of the commercially traded output. The reformation of land and restructuration of farms accompanied by price and trade policy reforms entailed a striking fragmentation into a system of predominantly small farms, usually in the hands of individuals or families. For example, in Kyrgyzstan, the production of smallholder accounted for 31 per cent of gross value added in GDP as of 2018.[2] In contrast to the rise of smallholding in Central Asia's agriculture sector, the development in the Russian Federation followed differing trends. While smallholder production increased significantly in the post-Soviet era, amounting to 57 per cent of food production in 1997, it has been declining since 2004 to a share of 35 per cent of total food production in 2016. Factors that contributed to this contrasting development are that Russian smallholders' production is usually self-consumed and manual practices are widespread resulting in low surplus to be sold. Furthermore, household farms lack connections to food processors or markets and although smallholders appear to be the majority in agricultural production, the land worked by them is overall comparably small (Wegren, 2018).

In countries with low or no revenues from natural resources, the economic recovery process can be clearly linked to land privatization reforms. Starting in 1993, when Armenia and Georgia introduced reforms to dismantle collective agriculture and distributed land to individual farms, a recovery in gross agriculture output growth for these countries can be observed. Azerbaijan followed the reform path of its neighbours in 1996 and experienced a recovery of agricultural activities since then.

2.2.1 Agricultural production composition

In North and Central Asia, government objectives for the agriculture sector are mainly to achieve food security by stimulating domestic production, achieving diverse and balanced diets among the population, encourage product diversification through shifting away from traditional production methods, explore export orientation strategies and promote rural sustainable development, which are aligned with the Sustainable Development Goals. The objectives are mainly achieved by providing subsidies to farmers in the main sectors, access to finance on preferential rates, necessary infrastructure for electricity, water supply in remote areas and export support. In recent decades, several developments have influenced the composition of agricultural production in North and Central Asia, including population trends, more

---

[2] Smallholders include individual entrepreneurs and peasant farms as obtained from data provided by the statistics agency of Kyrgyzstan.

integrated markets and commodity prices. Population trends and income growth stimulated demand for healthier and balanced diets and in turn increased the consumption of meat, fruits and vegetables. Traditionally, the Russian Federation has been the main market for North and Central Asian countries, but recent trends show that there is a growing demand from China and Europe for oilseeds led by the processing sector as vegetables oil, protein meals and meal (cake) production (OECD and FAO, 2018).

Wheat has always been one of the most important crops in the subregion and is included as an integral component to ensure food security. The average share of wheat in cereals output accounts for more than 60 per cent. The Russian Federation and Kazakhstan are in the world's top 10 wheat exporting countries. Kazakhstan is also a main exporter of cereals to other Central Asian countries, despite the decrease in its cereal output due to the shift to the production of other crops as oilseeds. Since independence, the Russian Federation and Kazakhstan increased oilseeds production by 4.8 times, supported by demand growth in China and European countries, whereas other North and Central Asian economies increased production of roots, tubers, fruits and vegetables due to suitable climate conditions, except for Georgia. Georgia experienced a slower pace of agriculture development as a result of the *laissez faire* approach of the Government. However, there is a steady increase in milk production in Georgia, driven by individualization of the farming sector and the rapid growth of the importance of family farms as highlighted in section 2.1. A similar situation exists in Kyrgyzstan, Armenia and Azerbaijan (FAO, 2011a), and in Kazakhstan smallholder farmers dominate dairy production, with 80 per cent of milk in the country originating from family farms with fewer than five cows (EBRD, 2017).

Cotton was one of the key agriculture outputs for the subregion in the past decades. However, the development of the cotton industry has high environmental and social costs. In North and Central Asia, cotton as a monoculture without crop rotation has resulted in soil degradation with large shares of land exposed to various degrees of desertification. Poor water management systems and the massive expansion of irrigation without proper planning, coupled with excessive use of chemicals in cotton production, has been associated with the desertification of the Aral Sea, one of the worst environmental disasters observed. Recognizing the need to better manage and facilitate the development of the industry, Governments introduced various policy measures, resulting in a decline in cotton output by more than 50 per cent, since the collapse of the Soviet Union. The Government of Uzbekistan intentionally planned to reduce cotton production in highly salinized areas and mountainous regions and facilitate the production of other crops instead, including fruits, vegetables, potatoes and grains. In Tajikistan, despite the decrease in the share of cotton in the total agriculture output, cotton remains one of the main export products which provides a stable source of income and foreign exchange gains.

Agriculture diversification has many economic and ecological benefits, such as reducing water consumption, improving soil quality and spreading income risks, and it is recognized as one of the essential components of economic growth and development. It is a vital factor for rural transformation which enables the economy to shift agricultural production to meet the demand for food security, improved nutrition and increased rural employment. Data on the changes in agriculture output between 1992 and 2018 indicate limited agriculture diversification occurred in North and Central Asian countries (figure 4). Strategic agriculture diversification policies need to be carefully considered in order to reduce the economy's vulnerability and to encourage sustainable growth. Diversification strategies will also need to integrate environmental and social concerns to ensure that the transformation of the agriculture sector makes it more inclusive, sustainable and resilient.

Figure 4. Share in agriculture output by country (percentage), 1992 and 2018
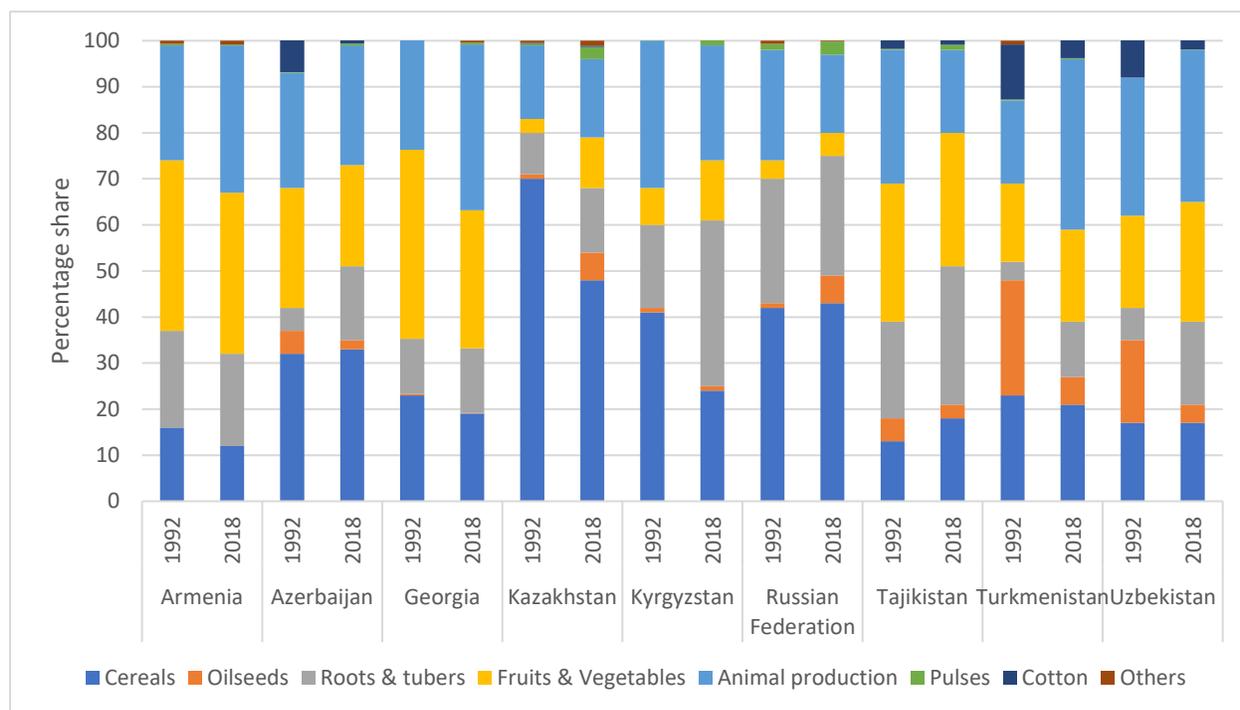
Source: FAOstat.

Currently, the share of agricultural raw products in North and Central Asian countries is relatively higher than that of the agriculture processing sector, indicating potential to conduct higher value-added activities in the agriculture sector and to continue to sieze opportunities for diversification. According to data from the Atlas of Economic Complexity and International Trade Center, Tajikistan exports not only cotton as raw material, but also cotton processed products such as yarns and ready-to-wear cotton clothes. In 2017, the share of agriculture-related processed products such as beverages and tobacco accounted for 7 per cent of GDP in Tajikistan, whereas textile and clothing manufactures accounted for only 3.9 per cent of GDP.[3] Armenia, Azerbaijan and Tajikistan were among the countries with a higher share of agriculture processing in GDP in 2018, at more than 6.5 per cent. The processed products which were exported included sunflower seed oil, spirits and wine, as well as cigars and cigarettes.

Since 2002, countries in North and Central Asia have diversified their agriculture exports in line with the objective to orient the agriculture sector towards exports. This economic orientation drives processing sector development, aims to eliminate barriers in doing business, supports small and medium-sized enterprise development and includes financial and non-financial measures such as loans on preferential rates, removal of tariff and non-tariff barriers, development of export insurance services and marketing support. As seen in table 2, of the new products added between 2002 and 2017, a substantial share are agriculture-related. Countries which diversified into a significant number of agriculture-related products include Armenia, Azerbaijan, Kazakhstan and the Russian Federation. New agriculture products introduced in the subregion during this period include oilseeds and fish fillets. The diversification into new export products contributed to a total value of approximately $7.5 billion in North and Central Asia, with

---

[3] Figures based on those provided by the Agency of Statistics of Tajikistan.

agriculture-related products consisting of 42 per cent of the total. However, although countries in the subregion diversified into a significant number of new products, the production volume is still too small to contribute to substantial income growth.

Table 1. Diversification into new export products, 2002–2017

Country	Number of new products	Total value of new products	Value of agriculture-related products	Agriculture-related products share in total value
		Millions of United States dollars		Percentage
Armenia	16	91.5	90.5	98.9
Azerbaijan	5	86.4	50.3	58.16
Georgia	36	479	97.5	20.35
Kazakhstan	14	707	425.4	60.17
Kyrgyzstan	22	110	11.5	10.43
Russia	18	5,090	2,400	47.18
Tajikistan	10	226	37.4	16.55
Turkmenistan	2	17.6	-	0
Uzbekistan	28	687	32.6	4.75

Source: Atlas of Economic Complexity.

2.2.2 Agricultural trade and openness

Market linkages are becoming increasingly important with globalization and the emergence of new consumption patterns, production systems and distribution channels. In the past five years, agriculture-related exports increased 1.5 times on average for most of the countries in North and Central Asia, except for Tajikistan, Turkmenistan and Uzbekistan. However, in the past couple of years, the biggest share of agriculture-related exports was recorded in Uzbekistan at 42 per cent of total exports. Resource rich countries such as Kazakhstan, the Russian Federation and Turkmenistan have the least share of agriculture-related exports at only 4 per cent out of total exports.

Relating agriculture trade to agriculture output in the subregion, the main exports consist of cotton, where Kyrgyzstan, Turkmenistan and Uzbekistan are major exporters, and wheat, where major exporters are Kazakhstan and the Russian Federation. Nevertheless, export composition is changing gradually due to sector diversification, with Turkmenistan being the exception. Aside from cereals export, Kazakhstan and the Russian Federation are experiencing an increase in oilseeds and fish products export, whereas vegetables export exceeded cotton export in recent years for Kyrgyzstan and Uzbekistan. Despite the decline in the output of fruits and vegetables in Azerbaijan since 1992, the country's top exports after petroleum remain fresh tomatoes and strawberries.

Generally, the countries in North and Central Asia trade within the subregion, with the Russian Federation being an important market, followed by China and the European Union. The dominance of trade within the subregion is explained not only by geographic proximity, but also free trade and intergovernmental agreements. However, intraregional trade among North and Central Asian countries remains relatively low compared to other subregions of Asia and the Pacific, such as South-East Asia, East and North-East Asia, and South and South-West Asia. According to the Asia Pacific Trade and Investment Report of the

Economic and Social Commission for Asia and the Pacific (ESCAP), the trade costs of North and Central Asia, in terms of time and money, are three times higher compared to East and North-East Asia.

Although significant trade cost reductions have been achieved in the past decade through the elimination of tariffs, non-tariff trade costs remain relatively high in the subregion. According to the World Bank ranking of trading across borders of 189 countries, Central Asian countries ranked relatively poorly compared to South Caucasus countries – Kyrgyzstan-89, Kazakhstan-105, Tajikistan-141 and Uzbekistan-152, whereas Armenia and Georgia ranked 43 and 45 respectively. The ranking measures the time and cost (excluding tariffs) associated with three sets of procedures – documentary compliance, border compliance and domestic transport – within the overall process of exporting and importing a shipment of goods.

Major initiatives that contributed to trade facilitation within the subregion include the establishment of the Eurasian Economic Union, bilateral trade and transport agreements and interregional initiatives such as the Central Asia Regional Economic Cooperation and the Transport Corridor Europe-Caucasus-Asia.

Figure 5. Volume of agriculture-related trade in selected countries, 2001 and 2018 (Millions of United States dollars)
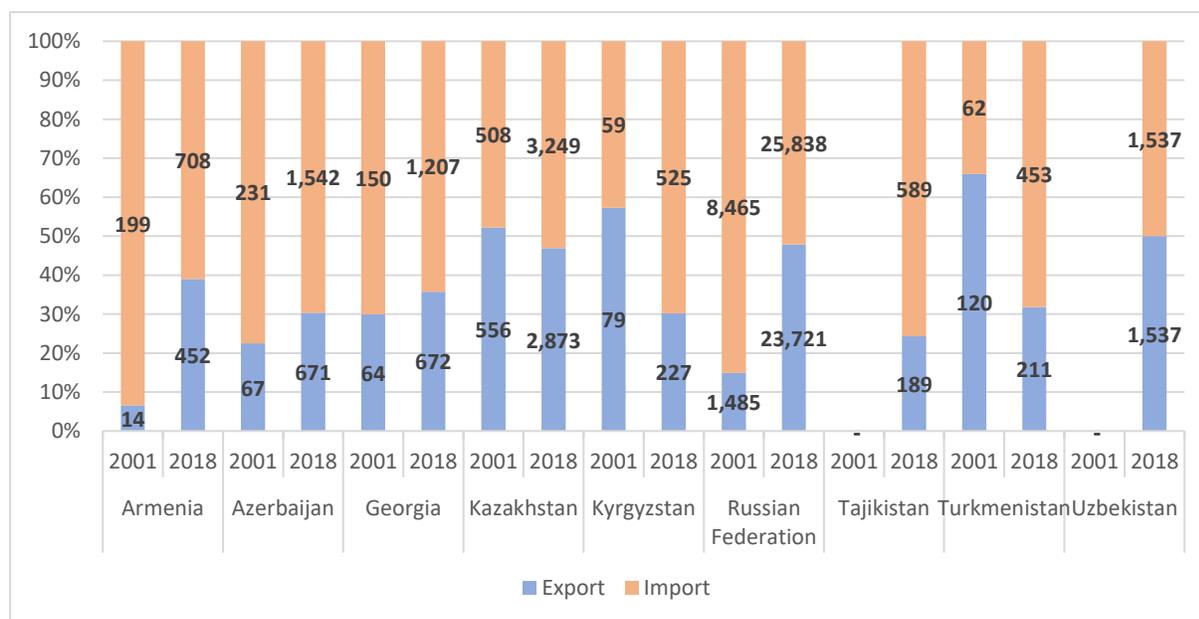
Source: International Trade Centre.

Note: 2001 data were unavailable for Tajikistan and Uzbekistan.

Over the past two decades, the structure of agriculture-related trade in North and Central Asia shows trends of import substitution, with significantly less reliance on the import of agriculture products in countries such as Armenia and the Russian Federation (figure 5). However, there are also reverse trends observed in Kyrgyzstan and Turkmenistan. Since the early 1990s, Uzbekistan approached economic liberalization very cautiously, therefore trade did not play a crucial role for its economy until more recently. In the past few years, Uzbekistan began to pursue a more liberalized trading regime, which was previously characterized by a high level of protection for import-competing industries and restrictions on exports of food among other products (World Bank, 2018). Meanwhile, Tajikistan chose a different

approach towards economic liberalization. Its economy was devastated by a civil war until the late 1990s. Due to severe droughts and the economic consequences of the civil war, agriculture output dropped significantly while agriculture imports also remained at lower levels compared to the subregion, resulting in a severe food crisis that lasted until the early 2000s (FAO, 2000).

Although it has been noted that countries with more open trading regime experience economic transformation relatively quicker, successes in value chain integration are not only due to linkages with global, regional, or domestic markets. The vertical integrated structure of value chains within a country's economy is of importance too. To thrive, value chain promotion and integration strategies need to be coupled with an enabling policy and marketing environment. Of particular importance for North and Central Asia is the integration of smallholders into the system. Although research showed that agricultural productivity increased when the large agriculture corporations in North and Central Asian countries were dissolved and broken down in the 1990s, there are limitations in sustaining these productivity gains as smallholders in the agriculture sector are unable to realize the benefits of economies of scale. Strategies to facilitate agriculture transformation could leverage existing networks of agriculture smallholders to integrate them into value chains, which could address structural imbalances as well as maximize income and productivity.

Sustainable connectivity and infrastructure development remain as key obstacles for many North and Central Asian countries due to their landlocked situation, which requires trade goods to transit through a neighbouring country. Logistics bottlenecks remain a major impediment to increasing connectivity due to geographical constraints, low efficiency of current infrastructure and poor service quality (OECD, 2019). Historically, the development of infrastructure connectivity in North and Central Asia was largely concentrated northwards due to the significant market in the Russian Federation. In recent years, more focus has been placed towards the development of east-west connectivity, largely driven by China through the Belt and Road Initiative and Europe through the Transport Corridor Europe-Caucasus-Asia. Southwards connectivity to integrate with South Asian markets as well as domestic connectivity within countries need to be further developed to facilitate the movement of goods.

2.2.3 Agricultural water productivity
Water is a transboundary matter in the North and Central Asia subregion and is a key input for agricultural activities. Efficient water management is essential, especially in the agriculture sector, considering that most of the fertile agriculture lands in the subregion are located in arid and semi-arid territories. Water resources in the subregion mainly comprise renewable surface water and groundwater with high interdependence among the upstream and downstream countries. Among the countries which are highly dependent on external water sources are Turkmenistan, Uzbekistan and Azerbaijan, with more than 70 per cent of their total renewable water resources originating outside their borders. The high level of water stress and concerns for water security in the subregion also highlight the need for better management of water resources to ensure sustainable withdrawals and supply of fresh water. All countries in the subregion, aside from Georgia, Kazakhstan and the Russian Federation, recorded water stress levels at above 50 per cent indicating serious water stress levels which may lead to more people suffering from water scarcity. It is especially worrisome for Turkmenistan and Uzbekistan where water stress is above 100 per cent.

Although the industrial sectors of mining and energy require a significant amount of water resources in North and Central Asia, the majority of water withdrawals are still directed to the agriculture sector. The

agriculture sector is estimated to consume approximately 70 per cent of water withdrawals in the subregion, and it accounts for more than 90 per cent of water withdrawals in countries such as Kyrgyzstan, Turkmenistan and Uzbekistan. Countries in the subregion that are major agriculture producers have large shares of water withdrawals in the agriculture sector, especially for the production of water-intensive crops such as cotton and for animal husbandry. The exception to this is the Russian Federation, where industrial water withdrawals consist of a larger share.

Despite the importance of water in the agriculture sector, agricultural water productivity has largely remained stagnant across the subregion as shown in figure 7. This is in contrast with water productivity trends in countries which have successfully transformed their economies, such as China, where water needs for food production has decreased on account of the investments in water infrastructure, agricultural research which increased crop yields as well as promoting technology uptake and development. The Russian Federation has been omitted from the figure as it considerably skews the data with water productivity levels which are at least three times higher than the rest of North and Central Asia. Although agricultural water productivity in the Russian Federation is considerably higher than the rest of the subregion, there is not much change between the productivity levels in 2001 (3.37) and 2016 (3.43). Agricultural water use efficiency is also low across the subregion, with water leakages and losses recorded along the water life cycle due to outdated and poor maintenance of water infrastructure. Irrigated agriculture in North and Central Asia is a legacy handed down from the Soviet Union where extensive water storage and distribution systems were necessary at that time for planned production to achieve food security. However, following the fragmentation of the agriculture sector into smaller farms, water storage and irrigation infrastructure upgrades were neglected, resulting in irrigated agriculture being one of the major sectors contributing to water waste. Considerable efforts need to be put into increasing the productivity and efficiency of agricultural water use in the subregion to facilitate transformation of the agriculture sector. This will further free up the limited water resources for other purposes and mitigate potential impacts of climate change and water scarcity.

Figure 7. Agricultural water productivity, 2001–2016
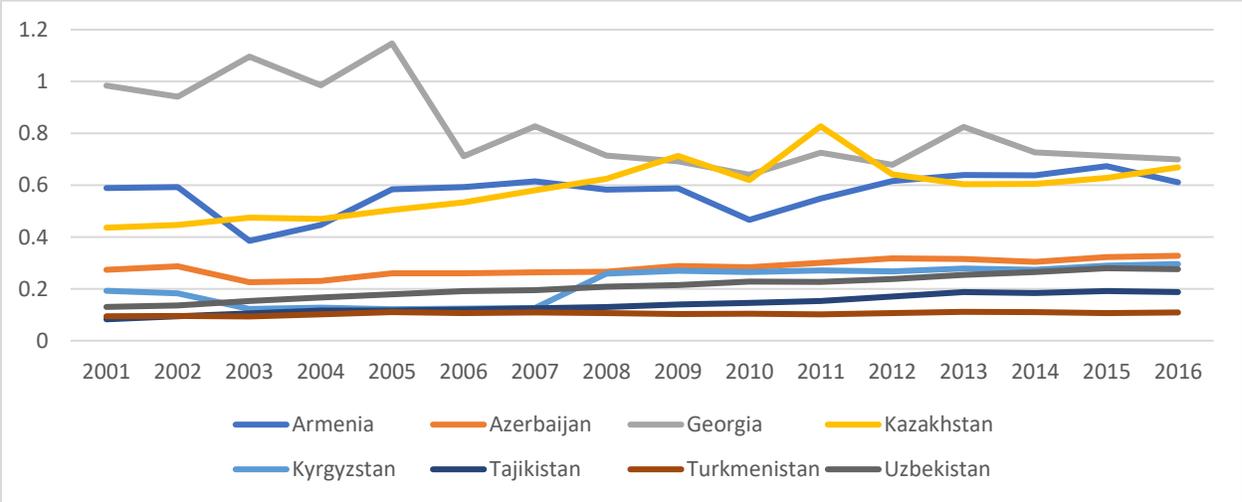
Source: ESCAP calculations based on data from AQUASTAT and the United States Department of Agriculture.

Note: Agricultural water productivity = gross agriculture output (United States dollars)/ water withdrawals in agriculture (cubic meter).

3. Agriculture transformation and the 2030 Agenda for Sustainable Development

The integral role of agriculture and its contribution to sustainable development needs to be at the forefront of economic transformation strategies in North and Central Asia. Agriculture transformation is an essential part of rural development which can contribute to more inclusive and sustainable progress.

In North and Central Asia, almost half of the population still lives in rural areas, with the highest share of rural population recorded in Kyrgyzstan and Tajikistan, accompanied by high shares of employment in the agriculture sector compared to total employment (figure 8). Rural areas thus present opportunities and are crucial engines to promote economic, social and environmental development in the subregion. Promoting agriculture-related activities and sustainable agriculture transformation strategies in rural areas can serve as the foundation to develop other complementary economic activities, through the development of new production models and agricultural reforms.

Figure 8. Share of rural and urban population in North and Central Asia, 2018
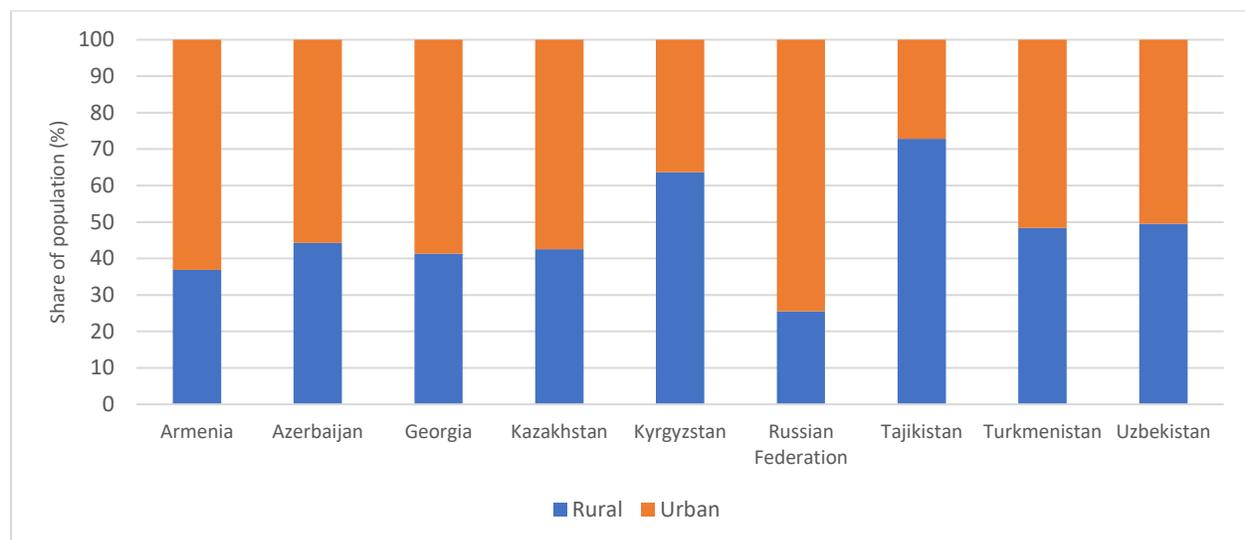
Source: World Development Indicators, World Bank.

These measures can also address inclusivity aspects of rural development by improving livelihoods for rural women through providing access to productive resources. The share of females employed in the agriculture sector in North and Central Asia is approximately 29 per cent as of 2019. The scope and quality of formal statistics in the subregion is limiting, and the informality of farming may indicate that actual numbers are not reflected in formal statistics. Given that the agriculture sector has the highest levels of informality (ETF, 2017) and women tend to be employed informally, there may be even higher numbers of female workers on family farms who are not seeking employment and thus, are not counted as participants in the labour force. The Food and Agriculture Organization of the United Nations (FAO) (2011b) indicated that if these women had the same access to productive sources as men, agriculture output could be raised by 2.5–4 per cent, which in turn would contribute to improved food security and nutrition and enhances overall economic growth.

Inclusive and sustained economic growth is part of the 2030 Agenda (Goal 8). Economic growth in the subregion has not been all smooth, with the interruption of the economic recovery process following the breakdown of Soviet Union, the 2008–2009 financial crisis and the fall in oil prices in 2014. North and Central Asian countries chose different paths of transformation and are currently in different development stages according to income levels. The subregion exhibited an average GDP growth rate of 4.7 per cent in 2019, with Tajikistan at the front (7 per cent) while the GDP of the Russian Federation was growing slowest (1.3 per cent). The average growth rate of agriculture value added amounted to 1.3 per cent in the same year, with the highest growth rate recorded in Azerbaijan (7.3 per cent) and a negative growth rate in Armenia (-4 per cent). Figure 9 illustrates how agriculture value added growth follows the trends of GDP growth only temporarily, suggesting that the agriculture sector in North and Central Asia is not a key driver of economic growth. GDP growth is expected to decline for 2020 due to the impact of measures to contain the spread of COVID-19 on economic activities, and the agriculture sector is expected to absorb some of the labour laid off during this pandemic.

Figure 9. Annual GDP growth and agriculture value added growth for North and Central Asia, 1991–2019
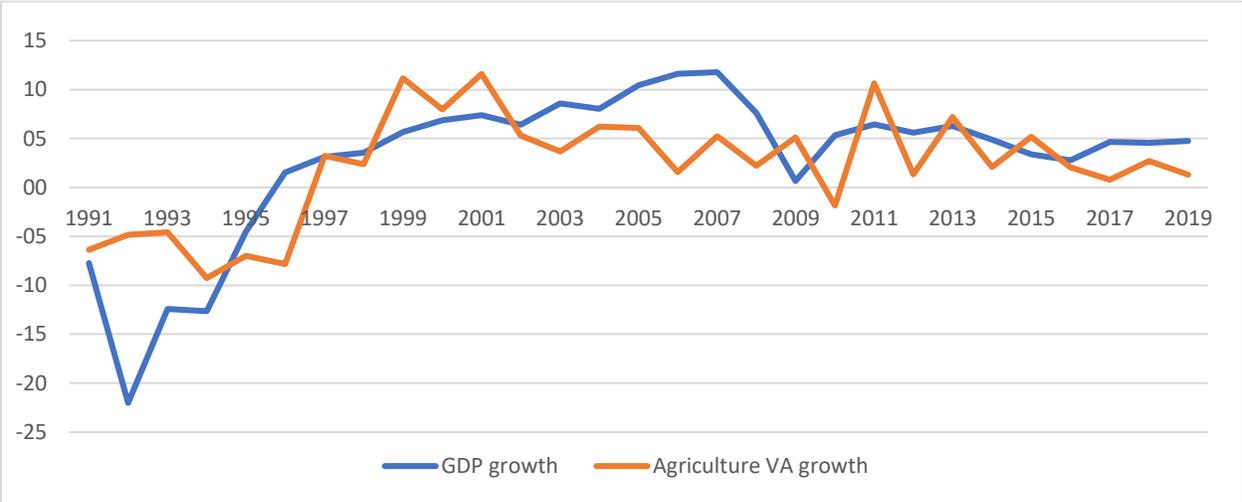
Source: ESCAP calculations based on World Development Indicators, World Bank.

The 2030 Agenda also aims at eradicating hunger, achieve food security and eliminate all forms of malnutrition (Goal 2). As income levels increase, poverty levels are expected to fall along with the prevalence of undernourishment. All North and Central Asian countries recorded negative trends in poverty and undernourishment since 1990 with the exception of Tajikistan. FAO (2016) found that countries in the subregion progressed from dealing mainly with undernourishment towards coping with the health hazards posed by low-nutrient dietary energy supply. The data show a shift in eating habits away from grains to sweeteners, fats and oils. Countries in the subregion moved towards the so-called "triple burden" of undernutrition, overnutrition and micronutrient deficiencies. This rising problem can be approached by controlling the healthfulness of foods, regulating prices through taxes, providing nutrition education and ensuring food security.

Countries in the subregion are also susceptible to the challenges of climate change that affect agricultural productivity. Research has shown that the rise in average temperature in Central Asia is higher than the global increase (Zhang and others, 2019). The same has been recorded for the average temperature change in Russia, which is 2.5 times higher than the global average (Tashilova, 2019). Droughts, floods and

extreme heat in the summer months lead to the expansion of deserts and melting of glaciers that undermine the conditions under which agriculture can take place. The consequences of these natural disasters and resulting water shortages are being felt strongly in the agriculture sector.

Greenhouse gases are a major factor contributing to climate change. Compared to the industry or transport sector, the agriculture sector accounts only for a small share of overall emissions in most North and Central Asian countries. Nevertheless, the share of agriculture emissions in total emissions varies between 3.7 per cent in the Russian Federation to 49.8 per cent in Tajikistan. Data for 2017 from FAO illustrates that in countries without strong primary industries, agriculture accounts for a larger share of overall emissions, while in Azerbaijan, Kazakhstan, the Russian Federation and Turkmenistan, agriculture contributes a relatively small share to overall greenhouse gas emissions. Within the agriculture sector, livestock farming generates the most carbon dioxide equivalent of greenhouse gas emissions, mainly from enteric fermentation gases produced by cattle, sheep, or goats, while poor manure management and inefficient cultivation practices can cause water pollution and soil erosion (see figure 10).

Climate change and its effects put the achievement of the SDGs at risk. The effects of climate change will mostly be felt by agriculture smallholders who have the least capacity to adapt to changing weather conditions. Climate-friendly agriculture practices need to be mainstreamed in the subregion to increase resilience and reduce long-term vulnerabilities in the sector. Measures to prevent climate change are also included in the 2030 Agenda (Goal 13).

Figure 10. Causes of emissions in agriculture, 2017 (Percentage of total emissions in agriculture)
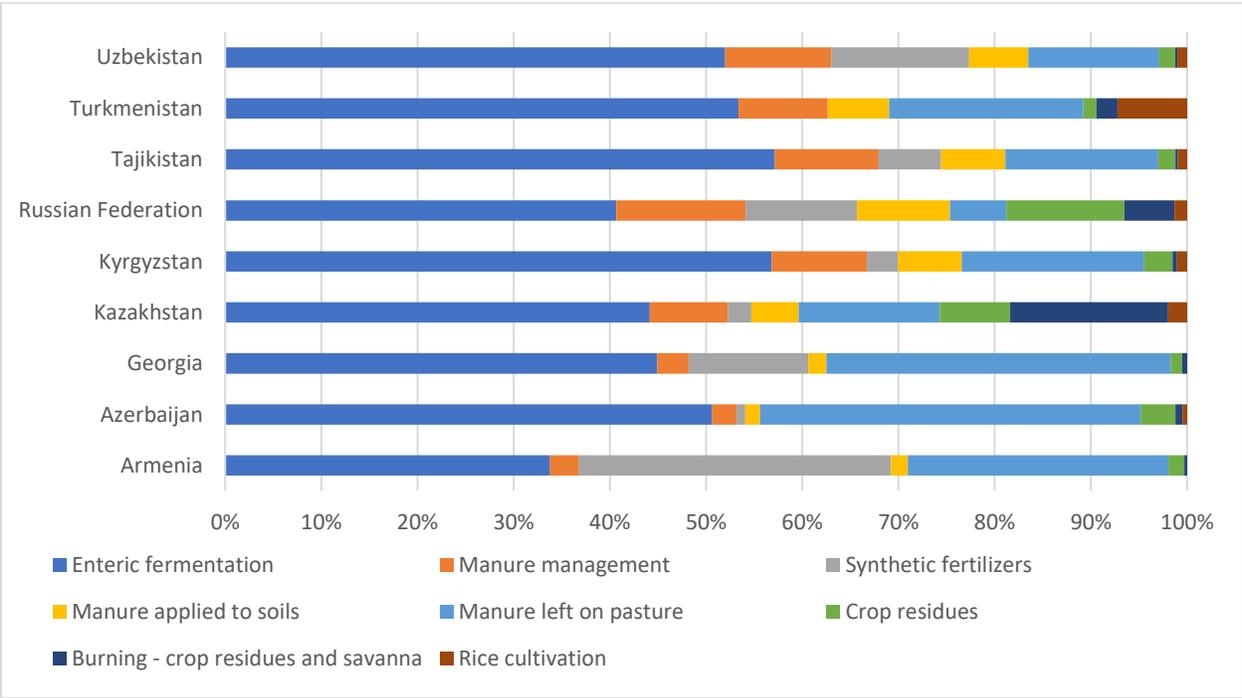
Source: FAOstat.

Literature and methodologies used to analyse the relationship between the agriculture system and sustainable development indicate that trends in the agriculture sector are incompatible with the achievement of the economic, social and environmental objectives of the 2030 Agenda (Godfray and

others, 2010). Researchers began looking into agriculture transformation pathways that could shift the agriculture sector towards a sustainable state. Examining the interlinkage between agriculture transformation and specific goals of the 2030 Agenda, Imai (2017) and Imai, Cheng and Gaiha (2016) show that agriculture transformation contributes to the reduction of poverty, child malnutrition and inequality while improving food security. Earlier works have also confirmed that agriculture development contributes to poverty reduction through the development of rural areas. This result is achieved through diversifying livelihoods and the emergence of higher value chains which increase productivity and income levels.

Adapting these analyses to the context of North and Central Asia, the contributions of agriculture transformation towards achieving the 2030 Agenda can be further explored. The analysis of priority areas and desired outcomes indicated in the national strategic documents of North and Central Asian countries shows structural transformation and rural development are among the priority areas for all of them.[4] Specific activities to develop the agriculture sector include improving the competitiveness of agriculture products in domestic and foreign markets for the Russian Federation, developing agriculture cooperatives to support the agro-industrial sector in Georgia and Kyrgyzstan, attracting foreign direct investments into agriculture processing development in Azerbaijan and Kazakhstan, and modernizing agricultural activities in Armenia, Azerbaijan, Georgia, Kazakhstan and Uzbekistan. These activities are expected to contribute to and are linked to the achievement of the SDGs, specifically: Goal 1 – No Poverty; Goal 2 – Zero Hunger; Goal 4 – Quality Education; Goal 8 – Decent Work and Economic Growth; Goal 9 – Industry, Innovation and Infrastructure; Goal 15 – Life on Land; Goal 16 – Peace, Justice and Strong Institutions; and Goal 17 – Partnership for the Goals.[5]

Given the strategic importance of the agriculture sector in North and Central Asian countries, it is essential that agriculture transformation in the subregion occurs in a manner that supports sustainable development and ensures prosperity for people and the planet.

3.1 Measuring agriculture transformation and sustainable development

Conceptual framework

Recognizing that there are various factors that influence agriculture transformation, as well as the data constraints in capturing all possible effects, the following conceptual framework is proposed to analyse agriculture transformation in North and Central Asia and its relationship with sustainable development. It consists of a two-step process. The first step is to analyse the significance of the variables identified which influence agriculture transformation, which are water productivity, agricultural production diversification and agriculture openness. For this part of the analysis, agricultural productivity is used as the dependent variable. The statistical significance and relationship is assessed through the equation $AT_{it} = x_0 + x_1 WP_{it-1} + x_2 AD_{it-1} + x_3 AO_{it-1} + x_4 T_{it-1} + \mu_{it} + \varepsilon_{it}$, where AT_{it} = agricultural productivity, WP_{it-1} = lag of water productivity, AD_{it-1} = lag of agriculture diversification, AO_{it-1} = lag of agriculture openness, T_{it-1} = technology μ_{it} = covariates, ε_{it} = error term. Further description of each variable is elaborated in below subsection. The

---

[4] The outcome mapping exercise of all North and Central Asian countries was conducted based on national strategic documents, United Nations Development Assistance Frameworks (UNDAFs) and United Nations Sustainable Development Cooperation Frameworks (UNSDCFs).
[5] Relationships between agriculture transformation of all North and Central Asian countries and listed SDGs are derived from the outcome mapping exercise.

relationship between these variables needs to be examined before proceeding to analyse the effects of agriculture transformation on sustainable development.

Figure 8. Conceptual framework to analyse the relationship between agriculture transformation and sustainable development
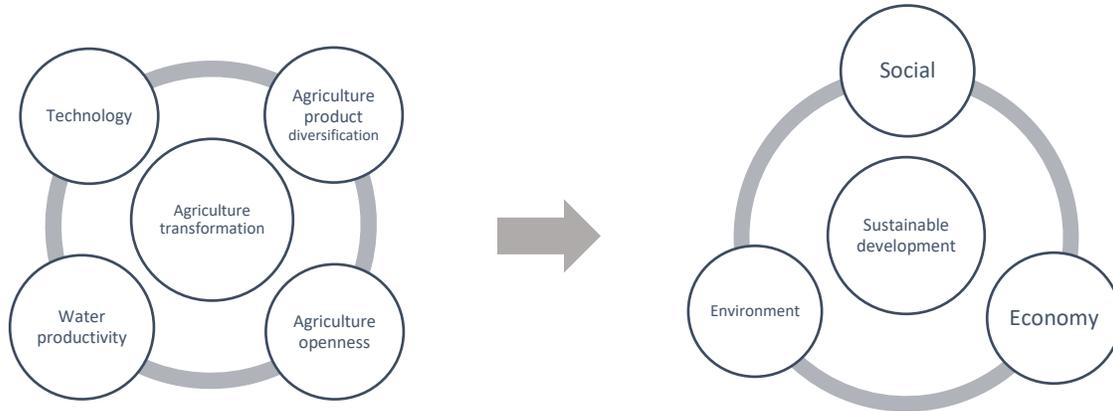
Once the relationship between agriculture transformation variables is established the second step is to analyse its effects on sustainable development. The empirical model proposed is $SDG_{it} = x_0 + x_1 AT_{it-1} + \mu_{it} + \varepsilon_{it}$.[6] The variables used for SDG_{it} are derived from the sustainable development indicators, namely prevalence of undernourishment, emissions per unit of GDP and economic growth, which represent the three pillars of sustainable development – economic, social and environmental. For the analysis, an unbalanced panel data set was used covering Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, the Russian Federation and Turkmenistan for the period 2001–2016. Due to many missing values, Tajikistan and Uzbekistan were excluded from the analysis.

Measurement for agriculture transformation

Based on the above proposed framework, change in agricultural productivity is used as a proxy for agriculture transformation and is influenced by water productivity, agriculture product diversification, agriculture openness and technology. The productivity gains are represented by the growth rate of total factor productivity (TFP) in the agriculture sector [$\Delta\ TFP\ \approx\ ln\ TFP_t - ln\ TFP_{t-1}$].[7] TFP is the ratio of value added in agriculture over the product of all factor inputs to the power of their respective factor shares in output. The necessary data allowing for this calculation were provided by the United States Department of Agriculture. Based on the same data set, a variable for the growth rate of labour productivity (LP) in agriculture [$\Delta\ LP\ \approx\ ln\ LP_t - ln\ LP_{t-1}$] is formulated. Labour productivity is defined as agriculture value added divided by employment in agriculture. Making use of the variables' natural logarithm allows us to determine percentage changes in the dependent variable and ensures comparability across countries.

Water productivity measures the monetary yield of the agriculture sector of one cubic metre of water. Sectoral water productivity can be calculated as the ratio of total agricultural production (in United States dollars) over water withdrawals for use in agriculture. The data were accessed in the AQUASTAT database

---

[6] SDG_{it} = sustainable development indicator, AT_{it-1} = agricultural productivity, μ_{it} = covariates, ε_{it} = error term.

[7] The results can be multiplied by 100 to yield the percentage change of agricultural productivity.

of FAO. The concept is based on the approach of FAO (2019b) to monitor sustainable use of water resources. If water is well embedded and efficiently used in the production process, the index for water productivity takes on a higher value. Low values indicate a lack of productivity of water in agriculture. A positive correlation between water use per capita and economic growth has been established in previous literature (FAO, 2019b); thus, a positive influence on TFP or LP growth can be assumed. In the agriculture sector, water is an essential resource for livestock and crop production. Enhancing the productivity of this key resource will contribute to agriculture transformation.

The measure for agriculture product diversification is based on the formula proposed by Imai (2017), which can be defined as the sum of all products from multiplying the monetary value of the production share of each agriculture product produced and its natural log value [$x = -\sum_{i=1}^{N}(p_i \ln p_i)$]. Based on the equation, *N* is the number of agriculture products produced in an economy; p_i is the production share in monetary terms of each agriculture product, which could be calculated from multiplying the production quantity of a product with its producer price and dividing it by the total value added in agriculture. The calculation is based on data obtained from FAOstat.[8] If an economy produces a larger variety of agriculture products and the monetary value of products is more evenly divided among different agriculture produce, the product diversification value x would take on a larger value and vice versa. Product diversification is especially important for analysing agriculture transformation and sustainable development in North and Central Asia as the subregion traditionally produced low value-added agriculture products.

Agriculture openness is derived from the measurement for trade openness and shows the degree to which the economy's agriculture sector is exposed to international trade. It is measured by calculating the sum of agriculture exports and imports divided by the agriculture value added of an economy. Data for export and import flows were obtained from the International Trade Centre database for trade statistics. A larger ratio of exports and imports to agriculture value added indicates that the economy's agriculture sector is more exposed to international trade. Agriculture openness is proposed as a factor that can influence agriculture transformation as it reflects the integration of an economy's agricultural production with the rest of the world economy. Since agriculture openness simply reflects the share of exports and imports on total production with values ranging between 0 and 1, if imports and exports constitute a large share of total agricultural production, this indicates a high level of agriculture openness.

The use of technology and technological change play a crucial role in the transformation of the agriculture sector. Since land is a production factor that cannot expand but is supplied to a fixed level, the only way to improve productivity is by the way in which the land is worked, mainly by machine support and by knowhow. A proxy for technology is farm machinery in use, given by the number of 40-CV tractor-equivalents including tractors, harvester-threshers, milking machines, water pumps. The data are provided by the United States Department of Agriculture.

As agriculture in North and Central Asia relies heavily on livestock farming, a variable is introduced that captures this dependence. It is inspired by a similar variable proposed by Imai (2017). The variable is obtained by the ratio of the sum of all animal products over the total output in agriculture for every country and each year. A high ratio reflects a high dependence on livestock farming and vice versa. The inclusion of this variable in the analysis can inform sector-tailored policy recommendations taking into account peculiarities in its production. Although this variable is introduced given the substantial share of

---

[8] Only products where values for price and quantity where available have been included in the calculations.

livestock production as a whole in the subregion and its effects on agriculture transformation, it is noted that specific effects of the diversity in livestock produced in the subregion is not captured.

Besides the main explanatory variables, covariates in the regression will include measures as follows: arable land in square kilometres; average yearly temperature changes; the previous year's productivity changes; the share of freshwater withdrawals in agriculture as a share of total water withdrawals; the growth of the rural population; official flows to the agriculture sector; the percentage share of natural resource rents in GDP, including oil rents, natural gas rents, forest rents, mineral rents and coal rents; and governance indicators, including the estimated value of government effectiveness, political stability and absence of violence, regulatory quality, rule of law, voice and accountability and control of corruption.

Measurement for sustainable development

Moving into the final decade towards the achievement of the 2030 Agenda, countries reaffirmed their commitment through the ministerial declaration on "Accelerated action and transformative pathways: realizing the decade of action and delivery for sustainable development". The measurements for sustainable development that are included in this analysis are derived from the global indicator framework for the Goals. To encompass the three pillars of sustainable development – economic, social and environmental – the various data are used for analysis as further elaborated below. Data on these indicators were sourced from the World Development Indicators database of the World Bank and the Asia Pacific SDG Gateway maintained by ESCAP.

To analyse the effects of agriculture transformation on social development, the indicators on undernourishment, poverty, infant and maternal mortality, and primary school enrolment of girls are included. Efforts to achieve social improvements are under threat of being reversed by the consequences of COVID-19, which are likely to push many people back or deeper into poverty and food insecurity. In rural areas, the poverty rate and prevalence of undernourishment is estimated to be higher than in urban areas. The prevalence of undernourishment is especially relevant and the impact of transformation in the agriculture sector will be evident in the data for this indicator. Goal 2 is most directly related to the analysis of sustainable agriculture transformation as the majority of targets under this goal directly concern agriculture and food production.

Goal 8 (decent work and economic growth) aims at achieving sustainable and inclusive growth patterns which can drive the creation of decent jobs and raise people's living standards. Countries in North and Central Asia have experienced a slowdown in economic growth in the past decade, with many countries seeking to move away from dependence on the mining and oil and gas sectors. Although growth prospects are dire in the light of the current pandemic, the goal to make economic growth inclusive and reach the whole population must not be set back. The indicators used to analyse economic development in each country are the annual growth rate of the economy, annual growth rate of GDP per capita, annual growth rate of GDP per person employed and total unemployment and youth unemployment as shares of the total work force.

The analysis on environmental development used the variables of carbon dioxide emissions per GDP, greenhouse gas emissions from agriculture, important sites for freshwater biodiversity and the carbon stock in living biomass. These are indicators of the following SDGs, which affect and hold significant relationships with each other: Goal 9 – Industry, innovation and infrastructure; Goal 12 – Responsible consumption and production; Goal 13 – Climate action; and Goal 15 – Life on land. In the past decade, it

has been observed that domestic material consumption has accelerated considerably in North and Central Asia, along with levels of carbon dioxide emissions, consistent with the trend in the rest of Asia and the Pacific. This is cause for concern that the greenhouse effect that triggers climate change will worsen.

3.2 Analysing agriculture transformation and sustainable development

As elaborated above, agriculture transformation is unobserved and assumed to translate into agricultural productivity, which is affected by agriculture openness, product diversification, water productivity and technology. Establishing a relationship between those variables will demonstrate a direct effect of (unobserved) agriculture transformation on (observed) productivity changes. Given the respective peculiarities of each country in the panel, it can be assumed that productivity in the agriculture sector varies across countries and is also influenced by uncaptured variables. All series in the panel have been checked for stationarity and in case of non-stationarity have been transformed accordingly.

While trying different variable constellations for the model, the two main explanatory variables – agriculture openness and the product diversification index – exhibited joint dynamics due to multicollinearity. Therefore, both variables have been separated into different model specifications. Changes in productivity growth are influenced by their respective changes in the previous year. The past changes were not included for explanatory reasons, but to remove autocorrelation in the residuals and serve as covariates. In general, (non-linear) multicollinearity cannot be fully eliminated from the model since the variables introduced by the underlying conceptual framework overlap occasionally in varying degrees. This does not bias the least squares estimator (neither in the pooled ordinary least squares (OLS) model nor in the fixed or random effects model) but it can lead to inefficiency of the estimator. The output tables for the different models indicate that different constellations of covariates have been included but only the results of significant covariates have been displayed.

In order to account for the variation across countries and heteroskedasticity, a pooled OLS model using Newey-West robust standard errors was first considered. This type of model can determine average effects for the explanatory variables on productivity changes across countries. Unfortunately, this model has the drawback that it cannot account for omitted variables. Due to this downside of pooled OLS, within estimation or fixed effects estimation was also conducted. This method assumes that heterogenous unobserved country specific effects exist and eliminates them by subtracting the mean of each variable from the respective variable's value (demeaning). Fixed effects estimation has the advantage of accounting for unmeasured confounders or omitted variables. To find out if fixed effects estimation is the right approach or if random effects estimation might be more efficient, between estimation for similar model specifications was conducted.[9] In contrast to fixed effects, random effects estimation assumes that individual time-invariant effects are random. One shortcoming of this method is the underlying assumption that the unobserved heterogeneity is not correlated with the independent variable. This is a relatively strong assumption which might be violated by this panel data variation. Table 2 shows the results obtained. Fitted values from highlighted models are used in further analysis.

---

[9] Including the exact same amount of variables is not possible because for random effects estimation the number of coefficients must not exceed the number of countries included in the panel.

Table 2. Results of analysing the variables for agriculture transformation

	Pooled OLS				Fixed effects				Random effects	
	ΔTFP	ΔLP	ΔTFP	ΔLP	ΔTFP	ΔLP	ΔTFP	ΔLP	ΔTFP	ΔLP
ΔTFP_{t-1}	-0.441*** (0.085)		-0.480*** (0.103)		-0.471*** (0.092)		-0.528*** (0.096)		-0.459*** (0.096)	
ΔLP_{t-1}		-0.404*** (0.085)		-0.411*** (0.104)		-0.423*** (0.089)		-0.458*** (0.094)		-0.340*** (0.092)
$Ln\ AO_{t-1}$			2.463 (3.762)	5.008 (4.642)			6.901* (3.611)	10.284** (4.361)	-0.424 (1.192)	
ΔWP_{t-1}	0.148 (1.357)	-2.371 (1.653)	-0.661 (1.598)	-3.385* (1.976)	-5.252 (4.989)	-10.269* (6.053)	-6.84 (5.144)	-12.051* (6.261)	-0.090 (1.304)	-0.647 (1.470)
AD_{t-1}	4.337** (1.642)	6.359*** (2.009)			5.618** (2.446)	8.137*** (2.952)				0.500 (1.384)
ΔMachines	-20.741** (9.586)	-4.299 (11.601)	-21.959* (11.364)	-4.675 (13.966)	-21.879** (9.428)	-5.337 (11.342)	-23.708** (9.904)	-6.554 (11.966)	-23.553** (10.770)	1.583 (12.464)
Ln Land	0.203 (0.715)	2.390*** (0.876)	0.590 (0.836)	2.862*** (1.040)	25.518** (11.395)	33.235** (13.865)	42.899*** (12.455)	57.320*** (15.059)	0.138 (0.631)	1.022 (0.728)
Animal share	-23.937*** (6.367)	-30.656*** (7.791)	-15.620* (8.995)	-21.277* (11.108)	-27.451*** (8.456)	-35.765*** (10.226)	-24.494*** (8.499)	-32.017*** (10.290)		
Oil rents	-0.084 (0.093)	-0.330*** (0.113)	-0.039 (0.118)	-0.289** (0.144)	0.518* (0.264)	0.398 (0.315)	0.639** (0.257)	0.498 (0.311)		
Gov. eff.	0.649 (2.391)	1.601 (2.909)	-0.942 (5.352)	-2.283 (6.598)	13.295* (6.787)	16.719** (8.142)	21.187*** (6.660)	25.503*** (8.062)		
Constant	2.838 (5.576)	-7.964 (6.796)	7.934 (8.675)	2.488 (10.792)					0.140 (4.416)	-3.556 (6.438)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.355	0.352	0.294	0.278	0.421	0.407	0.498	0.486	0.214	0.169
Adj. R^2	0.283	0.280	0.218	0.200	0.308	0.292	0.394	0.381	0.171	0.116
Number of observations	81	81	83	83	81	81	83	83	98	84

Notes: ***(**)(*) indicates statistical significant at the 1%(5%)(10%) level. Standard errors are given in parenthesis.

Agriculture openness (AO) has a positive and significant effect on the changes of both productivity measures. That is in line with theory, as we can expect that a stronger exposure to international trade will translate positively into productivity changes. The observed differences in the coefficient estimates might be due to the measurement of TFP which takes into account all production inputs and their respective factor shares, while labour productivity per capita only takes into account labour input.

Water productivity (WP) exhibits consistently negative coefficient estimates which are either insignificant or shows weak significance. Its coefficient estimates only turn significant if the variable for the share of water withdrawals in agriculture on total water withdrawals is included. Since this result is not consistent, this model specification is excluded from further analysis. This insignificant result is at odds with the underlying theory that increasing water productivity will contribute positively to the overall productivity of the agriculture sector. Through the lens of agriculture transformation, water productivity can be theoretically identified as a driving component towards more sustainable and resource-efficient production methods. This also bears potential for increased efficiency in water use in livestock farming, which requires an intensive water supply. Crop yields can also be expected to be positively impacted due to more productive use of this resource. As mentioned in section 2, the history of efficient water use in North and Central Asia has been poor. Little to no improvements in this regard can be observed and the formerly centralized water supply systems suffer from leakages and other inefficiencies. This might serve as an explanation for the poor performance of the water productivity variable.

Another important component of agriculture transformation and a main explanatory variable is the diversity in products of the agriculture sector (AD). The coefficient estimates suggest a positive and significant relationship between product diversification and changes in agricultural productivity. If the value of the product diversification index rises, implying a greater variety of products and a more evenly distributed monetary value across shares, this will cause positive changes in sectoral productivity. This validates the hypothesis that diversification is an important driver of agriculture transformation in North and Central Asia.

Another component constituted in the conceptual framework is technology, observed by agricultural machinery in use. The coefficient estimates for the growth rate of machines in use for agriculture is consistently negative and significant for models with TFP growth as the dependent variable. Technological change is a key component of economic transformation and agriculture transformation. The negative sign of the coefficient is an indicator for diminishing marginal returns if factor inputs are increasing, with other things being equal, in a production function. However, the negative sign of this coefficient may also be biased by the proxy variable for technology since machinery in use can only reflect the quantity rather than the quality of technology. Besides, technology contains a wide range of factors, including the use of pesticides, disease resistant hybrids and many others. Agricultural machinery is used here as a proxy variable for technology as it has the most complete data available. Many scholars have underlined that the application of innovative technology in the agriculture sector can substantially improve agricultural productivity and sustainability.

A variable worth mentioning, which is not incorporated in the underlying theoretical model, is the share of livestock production in total agricultural production. As stated earlier, livestock production and animal products are a major component of the total agriculture output in North and Central Asia. The negative significant impact it has on changes in productivity might be owed to the fact that livestock farming requires resource intense production, usually in an unsustainable manner. Due to its significance for the

region, sustainable transformation in livestock production is essential for the transformation of the agriculture sector.

For other covariates, the consistently positive and significant relationship of land with agricultural productivity is valid given that land is a key input for agricultural production. For the percentage of resource rents, it has been included given that many countries in North and Central Asia are resource dependent. However, it is also important to note the heterogeneity in the North and Central Asia subregion, which consists of both resource rich and less resource rich countries. The coefficients for government effectiveness as measured by the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of government commitment to such policies are positive and significant for the fixed effects models, indicating that better governance stimulates agricultural productivity. Monchi Lio and Meng-Chun Liu (2008) validated the hypothesis that better governance fosters agricultural productivity based on their empirical results, pointing out that better governance drives agriculture capital accumulation, which further increases agriculture output given the same amount of agriculture input and the same climate conditions. Moreover, better governance that emphasizes the protection of property rights and the enforcement of contracts helps create a competitive agricultural ecosystem, which encourages innovation, stimulates the adoption of new technologies and boosts agriculture investment.

It is worth mentioning that causality analysis was also performed since causality is a multilayered issue in econometric analyses, and it requires further explanation. For this purpose, the Pedroni cointegration test, which controls for long-term interdependencies of time series was performed. The first problem with the unbalanced panel is that the matrices for the test statistic need to be of the same dimension. However, an important feature of cointegration methods is that they allow the cointegrating vector, dynamics and fixed effects to differ across countries. Running the test for AD, AO and both productivity measures allows us to reject the null hypothesis that no cointegration between the two series exists. Thus, we can assume that for a significant number of the countries in the panel the series are cointegrated, meaning that a long-term relationship can be assumed between the time series tested. Pedroni (2004) mentions that a caveat worth noting is that not all cross-sectional dependencies are simple common time effects. Other cross-sectional dependencies could exist in forms of persistent dynamic feedback effects that vary across countries, which will not be detected by the test (Pedroni, 2004).

A Granger-causality test was performed, having in mind the limitations of its results, which indicates that lagged values of one series explain the variation in another time series, although this is not exact causality as the relationship can be random. The pendant of this test for panel data sets is the Dumitrescu-Hurlin test. It detects if a variable Granger-causes another variable for at least one country in the panel. With this test procedure, only the first lags can be included due to the different number of observations for every variable and country in our panel. Running this test for the series AD, AO and both productivity growth measures yields unsatisfactory results – the null hypothesis that no Granger-causality is detected cannot be rejected for any constellation. It can be concluded that the time series are not temporally related, though a main drawback of this test is that it produces misleading results if the true relationship involves more than two variables.

The second step of the analysis is conducted to determine the effects of agriculture transformation indicators on the selected sustainable development indicators. This allows an analysis of the relationship

between agriculture transformation and sustainable development. The methodology used by Imai (2017) proposes the two-step analysis based on the assumption that the agricultural productivity measure might be endogenous to the transformation indicators. Therefore, the first stage regresses the lagged values of agriculture transformation indicators on agricultural productivity, which serves as a proxy for agriculture transformation. Since endogeneity is expected in the relationship between the indicators of transformation, the fitted values for both measures of productivity and their respective residuals to the model will be included in the second step for analysing the effect of agriculture transformation on selected sustainable development indicators. This fixed effects – instrumental variables approach accounts for endogeneity of two kinds: heterogeneity endogeneity – the case where an explanatory variable is correlated with time-invariant heterogeneity; and idiosyncratic endogeneity – when the explanatory variable is correlated with a time-variant unobservable. In the previous step endogeneity was accounted for by using solely the lags of the main explanatory variables. For the second stage, agricultural productivity might be correlated to the error terms in the regression with many of those indicators and thus be endogenous. An instrument is valid if it is uncorrelated with the error term in the second-step estimation equation as well as correlated with the dependent variable. Due to the scope of the analysis, the model suffers omitted variable bias and thus leads to correlations between error terms and agricultural productivity. One response to this problem is to use fitted values of agricultural productivity as an instrument. Moreover, the instrument is supposed to be highly correlated with the endogenous variable it serves as instrument for. In this case, it can be assumed that the fitted values of agriculture transformation are highly correlated with the actual values of agricultural productivity, which ensures the relevance of the chosen instrument.

Given the limitations in the random effects model and upon conducting Hausman tests to gain information about the preferred model type, results of the four fixed effect models as highlighted in table 2 are brought over for the second step of the analysis. Tables 3, 4 and 5 only show results of the AO fixed effect model with TFP as the dependent variable and the AD fixed effect model with LP as the dependent variable as the results obtained are consistent with the two other models excluded from the table.

Table 3 shows the significant effects of agriculture transformation on social development. The slightly significant negative coefficient for the undernourishment variable underlines the initial expectation that agriculture transformation leads to increased productivity levels and has the potential to lessen the prevalence of undernourishment, hunger and food insecurity. Other social indicators such as poverty, maternal mortality and infant mortality were also included in the analysis. No significant influences were observed on those indicators by the explanatory variables. One explanation for this surprising result might be that productivity gains unfold both direct and indirect effects. Undernourishment has a more direct connection with productivity gains, while poverty and mortality rates, which are connected to improvements in social services and health care systems, can only be affected indirectly by productivity gains.

The covariates of rural population growth and official flows into agriculture are supposed to capture some variation in the social indicators which can arise from pressure through the growing number of people who are dependent on agriculture as an income and nutrition source as well as improvements through subsidies. Growth in the rural population is expected to have a negative effect on undernourishment and poverty, while official flows into agriculture are expected to have a positive impact. This is supported by the results. However, with the dependent variables of maternal mortality and infant mortality, the coefficients of rural population growth turned positive while official flows into agriculture turned

negative. This can be attributed to the gap in socioeconomic development between urban and rural areas, which leads to differences in health care accessibility. The development of the rural/urban nexus needs to be reevaluated and rural development needs to be emphasized in the subregion to bridge the growing rural/urban divide.

Table 3. Results of analysing agriculture transformation and social development

	ΔUndernourishment		ΔPoverty $3.20		Maternal mortality		Infant mortality	
$\Delta\widehat{TFP}^{FE}_{t-1}$	-0.028* (0.015)		0.044 (0.084)		-0.001 (0.121)		0.051 (0.075)	
$residuals^{FE}$	0.026 (0.021)		-0.148 (0.124)		0.082 (0.179)		-0.074 (0.107)	
$\Delta\widehat{LP}^{FE}_{t-1}$		-0.005 (0.016)		0.037 (0.088)		0.020 (0.132)		0.040 (0.080)
$residuals^{FE}$		-0.022 (0.022)		-0.170 (0.122)		-0.179 (0.185)		-0.129 (0.109)
ΔRural population	-484.31*** (129.104)	-471.32*** (130.666)	-1,785.48** (855.975)	-1,689.28* (851.792)	5,190.73*** (1,308.900)	5,171.29*** (1,295.210)	4,882.89*** (651.279)	4,995.97*** (653.144)
Flows to AG	0.028*** (0.007)	0.023*** (0.008)	0.078* (0.042)	0.061 (0.044)	-0.109* (0.062)	-0.150** (0.066)	-0.107*** (0.038)	-0.120*** (0.039)
R^2	0.305	0.309	0.130	0.154	0.235	0.255	0.474	0.482
Adj. R^2	0.208	0.221	-0.0004	0.025	0.119	0.151	0.401	0.416
Number of observations	83	81	70	69	77	75	83	81

Notes: ***(**)(*) indicates statistical significant at the 1%(5%)(10%) level. Standard errors are given in parenthesis.

The next pillar for sustainable development of interest in the second stage analysis is sustainable and inclusive economic growth. Indicators used are annual GDP growth, annual GDP growth per capita, annual GDP growth per employed person and youth unemployment. The results in table 4 indicate some connection between agricultural productivity and youth unemployment. The slightly significant negative coefficient for the residuals indicated that there is an indirect negative relationship between agricultural productivity growth and youth unemployment. No significant relationship is observed between agricultural productivity growth and economic growth. This can be interpreted to mean that agricultural productivity is partly disconnected from the overall growth of the economy in North and Central Asia and has not been a key driver of economic growth in the subregion despite constituting a large share of GDP in certain countries. The results may also be skewed by larger economies in the subregion, such as Kazakhstan and the Russian Federation, where economic growth is mainly driven by non-agriculture sectors, such as the extraction of natural resources and heavy industry. Furthermore, theory suggests that economic expansion is typically accompanied by economic transformation from agriculture into other sectors, such as service or manufacturing. The agriculture sector grows more slowly than the other sectors

as the economy transforms, thus the agriculture sector accounts for less employment, output and consumer expenses (Norton and others, 2015). However, this should not be an excuse to underinvest in the agriculture sector. Increasing agricultural productivity to significantly contribute to economic growth can steer the economy of the subregion towards a more sustainable and inclusive pathway which includes the rural population as well, given its great significance to the economies of North and Central Asia.

Table 4. Results of analysing agriculture transformation and economic development

	ΔGDP per capita		ΔGDP		ΔGDP per employed		Youth unemployment	
$\widehat{\Delta TFP}^{FE}_{t-1}$	0.022 (0.100)		0.025 (0.100)		0.029 (0.088)		0.068 (0.094)	
$residuals^{FE}$	0.097 (0.142)		0.095 (0.142)		0.074 (0.125)		-0.245* (0.134)	
$\widehat{\Delta LP}^{FE}_{t-1}$		-0.031 (0.107)		-0.030 (0.107)		-0.024 (0.094)		0.034 (0.097)
$residuals^{FE}$		0.173 (0.145)		0.180 (0.144)		0.158 (0.127)		-0.291* (0.131)
ΔRural population	3,627.23*** (863.444)	3,442.23*** (869.613)	3,345.80*** (863.211)	3,155.24*** (868.110)	2,376.71*** (758.365)	2,210.64*** (762.092)	-1,091.02 (809.984)	-722.95 (786.754)
Flows to AG	-0.115** (0.050)	-0.094* (0.052)	-0.112** (0.050)	-0.090* (0.052)	-0.115** (0.044)	-0.095** (0.046)	0.090* (0.047)	0.055 (0.047)
R^2	0.258	0.265	0.235	0.245	0.208	0.219	0.129	0.185
Adj. R^2	0.155	0.172	0.129	0.150	0.098	0.120	0.009	0.082
Number of observations	83	81	83	81	83	81	83	81

Notes: ***(**)(*) indicates statistical significant at the 1%(5%)(10%) level. Standard errors are given in parenthesis.

To analyse the effects of agriculture transformation on environmental development, the indicators of interest included in the analysis are the level of carbon dioxide and other greenhouse gas emissions per gross agriculture output, important sites for freshwater biodiversity and the carbon stock in living biomass. There is slightly significant negative relationship between agricultural productivity changes and freshwater biodiversity. This might be owed to the fact that enhancement of agricultural productivity in the subregion relies heavily on freshwater withdrawals and unsustainable methods that pollutes water sources which negatively impact the natural biodiversity in these water bodies. More sustainable agricultural production methods need to be introduced through technological upgrades that can minimize the negative impact on natural resources.

There exists a strong correlation between the fitted values of all four models and the change in emissions from agriculture. In line with theory, the coefficients for the fitted values have a negative sign. This negative relationship between agricultural productivity growth and greenhouse gas emissions in agriculture is encouraging as it implies that increases in productivity contribute to environmental

sustainability through increased efficiency and better allocation of natural resources in the production process. Furthermore, the agriculture sector is cleaner compared to heavy industries. Increasing its contribution to economic growth by productivity enhancement in a sustainable manner can reduce emission levels.

Table 5. Results of analysing agriculture transformation and environmental development

	ΔEmissions from agriculture		Water biodiversity		Carbon stock in living biomass	
$\widehat{\Delta TFP}^{FE}_{t-1}$	-0.015*** (0.004)		-0.028 (0.113)		1.377 (1.417)	
$residuals^{FE}$	0.008 (0.006)		0.100 (0.162)		-3.132 (2.089)	
$\widehat{\Delta LP}^{FE}_{t-1}$		-0.020*** (0.004)		-0.195* (0.114)		1.672 (1.581)
$residuals^{FE}$		0.012** (0.005)		0.424*** (0.154)		-2.272 (2.210)
ΔRural population	13.951 (33.759)	7.364 (31.443)	-336.593 (841.290)	-1,214.675 (981.500)	-62,373.67*** (15,303.530)	-59,761.88*** (15,454.940)
Flows to AG	0.002 (0.002)	0.002 (0.002)	0.115** (0.057)	0.148** (0.057)	-0.330 (0.730)	-0.345 (0.787)
R^2	0.209	0.332	0.059	0.148	0.212	0.200
Adj. R^2	0.099	0.247	0.010	0.039	0.093	0.089
Number of observations	83	81	82	80	77	75

Notes: ***(**)(*) indicates statistical significant at the 1%(5%)(10%) level. Standard errors are given in parenthesis.

By establishing the effects of agriculture transformation on agricultural productivity changes, the results also reveal the indirect impact that agriculture transformation has on selected sustainable development indicators. Agriculture openness and product diversification exhibit positive and significant effects on subsequent sectoral productivity growth. While changes in technology have a negative and significant effect on TFP growth, this may be due to diminishing marginal returns, and it is important to keep in mind that technology is a key driver for economic transformation. Additionally, an increase in agricultural productivity is shown to lessen greenhouse gas emissions from agriculture, and a negative and significant relationship between agriculture transformation and undernourishment can be deduced. Agriculture transformation also indirectly affects youth unemployment. Given the large significance of the rural population in North and Central Asia, its strong ties to the agriculture sector and the economy as whole, it is important that development strategies and plans take into account inclusive rural development. Therefore, sustainable agriculture transformation can bring the countries of North and Central Asia closer to the goal of implementing the 2030 Agenda and forge new paths for sustainable and inclusive development.

4. Recommendations moving forward: sustainable agriculture transformation

A more dynamic agriculture sector will be required to support sustainable economic growth and development in North and Central Asia. Sustainable agriculture transformation can help the region achieve food security, better nutrition and improvement of livelihoods. Sound democratic institutions and governance at all levels serve as a cornerstone to mainstream sustainable agricultural production systems through the just distribution of assets, develop inclusion policies – especially for marginalized groups and smallholders in rural areas – to improve economic development process, and prioritize environmental challenges to ensure resilience. Governments play a central role in these efforts for a more sustainable agriculture transformation process through regulation, providing financial incentives and promoting research and development. However, a multistakeholder approach is needed to ensure buy-in from the private sector, research institutions and society to fully realize the 2030 Agenda. The transformation process can also benefit from domestic, regional and international partnerships which promote the transfer of knowledge, technology and resources.

Agriculture connects people and the planet. As arid and semi-arid territories, North and Central Asian countries are especially susceptible to changes in climate and weather, which majorly affect the agriculture sector. The increase in temperature due to changing climate patterns is expected to be higher than the global mean in Central Asian countries, whereas South Caucasus countries are expected to record a decrease in 20 per cent of mean annual precipitation if the global temperature increases by 4°C (SDC, 2019). Agriculture is not only a victim but also a perpetrator of climate change. Its impact on land use accounts for approximately 23 per cent of greenhouse gas emissions worldwide (ECLAC, FAO and IICA, 2019). As seen in the analysis of the determinants of agriculture transformation in section 3, livestock production, which is a key source of methane emissions, has a significant impact on agriculture transformation in North and Central Asia as animal-based food products are usually more resource intensive than plant-based products. These realities emphasize that agriculture development strategies in the region require targeted interventions in specific agriculture subsectors that serve both development and environmental objectives.

Agriculture transformation can also promote inclusive development and employment opportunities in rural areas of North and Central Asia. Growth in productivity levels, especially among smallholders in the agriculture sector who are mainly based in rural areas, accelerates favourable impacts on poverty levels. Among the rural population, it is essential that access to resources and opportunities are available to women and youth as inequality continues to worsen, not just along the urban-rural divide but within rural areas as well. Creating gender equality in the agriculture sector is essential as women play a crucial role in the rural transformation process as farmers, wage earners and entrepreneurs on top of their traditional role as care takers of the family. Although official statistics showed that the share of women employed in the agriculture sector in North and Central Asia is approximately 30 per cent, unofficial numbers may be higher as many rural women are involved in the informal sector. They aslo engage in unpaid work which is essential for the family life Empowerment strategies to involve women in rural development processes need to take into account these realities. Young people aged between 15–34 years old consist of approximately 30 per cent of the population in North and Central Asia[10] and are a pool of labour force

---

[10] Statistics based on data from World Development Indicators as of 2018.

that can significantly contribute to socioeconomic development in the region. The majority of youths currently engaged in agricultural activities are mainly contributing as home-based or low-skilled workers. The stereotype of unattractive job prospects, low profitability and backbreaking work associated with the agriculture sector needs to be broken to reengage youth in agriculture.

Additionally, agriculture systems can be adapted to the concept of green economy. The significant amount of agriculture smallholders, low level of fertilizer and pesticide use and the availability of agricultural labour presents opportunities for North and Central Asia in sustainable and organic agriculture. Sustainable agriculture products allow for a premium in the form of higher prices and could benefit from clever branding. Agriculture brand value is elevated when associated with sustainability, with examples ranging from organic products to fair trade practices and social enterprises. The adaption of agriculture systems into green economy strategies has been initiated in Kazakhstan, where the development of sustainable and high productivity agriculture is one of the priority areas in the Action Plan of the Concept for the Transition to Green Economy 2013–2020. The actions taken include subsidies to develop modern irrigation systems, investment passports to acquire advanced greenhouse technologies and integrated solutions, and the establishment of knowledge dissemination centres to promote green agriculture principles and practices.[11]

Box 1. COVID-19 impact on agriculture sector in North and Central Asia

COVID-19 has brought major economic and social disruptions to the world. The effects of measures taken to contain the pandemic along with fall in natural resource prices majorly impacted economic development and social life in North and Central Asia. GDP growth for the region is estimated to record negative trends for 2020, at -3.6 per cent.[a]

During the implementation of quarantine and lockdown measures, the agriculture industry was labeled as critical and essential services which allow agriculture-related businesses to continue to operate, albeit with more stringent hygiene measures. The effects of COVID-19 on the agriculture industry span across the supply chain, from smallholder farmers to the agriculture processing industry and trade of agriculture and food products. In North and Central Asia, there were concerns that quarantine measures would affect harvest in 2020, with seasonal workers being unable to travel for spring sowing and harvest seasons. Although forecasted harvest levels were optimistic due to the increased crop area planted in 2019,[b] these might not be realized due to the impact of measures related to COVID-19. Farmers in the region experienced difficulties with getting mineral fertilizers, veterinary supplies and machinery spare parts due to logistical bottlenecks. It was essential to avoid any distortions in raw materials and machinery spare parts supply chain during harvest and while planting spring crops in May and June, in order to ensure food security in the second half of the year. Moving down the value chain, agriculture processing and trading experienced challenges in dealing with both supply and demand shocks, where production activities were affected due to quarantine measures and where consumer demand was low, especially due to limited operations of the HoReCa[c] sector. Trade restrictions on socially important agriculture and food products started to come into effect in North and Central Asian countries since the spread of COVID-19 to mitigate shortages at the national level, but this created a beggar-thy-neighbour scenario.

Measures taken by North and Central Asian Governments to support the agriculture sector during these times are mainly related to fiscal and monetary assistance such as tax exemptions or reductions, prolonging debt payment and providing concessional lending to farmers through financial organizations

---

[11] As reported by the Minister for Ecology, Geology and Natural Resources.

for spring sowing campaigns and other substantive activities. Apart from fiscal and monetary measures, local government authorities also created green lanes at block posts between the regions for raw materials and machinery spare parts delivery, monitored sufficient water supply during sowing periods and established discussion platforms for quick responses to support the agriculture industry.

<u>Four key lessons learned</u>

a. The pandemic highlighted the importance of **sanitary and regulatory compliance** in agrifood processes. Adequate control systems need to be in place to ensure food safety and quality. Compliance with international standards also facilitate trade.

b. **Information sharing and transparency** is crucial to monitor agricultural production and movement of agricultural products. Up to date statistics and data allow authorities to respond accordingly to ensure food security whereas current information on restrictions inform agriculture producers to appropriately plan their activities.

c. It is essential to **include smallholder agriculture producers in value chains.** They are usually the first to be impacted by such a crisis and have little means and financial cushion to continue operations and effectively market their products. Wastage will occur along the value chain as products fail to be moved from producers to consumers.

d. **Regional cooperation is needed to facilitate supply chain resilience**. As border closure measures and trade restrictions were put in place to minimize the spread of the pandemic, a regional agreement to maintain freight operations to facilitate the movement of goods and essential products is crucial. Regional connectivity needs to be enhanced and complemented by digital solutions.

Notes:
[a] ESCAP calculations based on data and information available up to 27 April 2020.
[b] Figures taken from FAO quarterly global report, Crop Prospects and Food Situation, March 2020.
[c] HoReCa stands for hotel, restaurants and cafes, and it is a subset of the hospitality industry.

Considering past transformation histories, possible future transformation pathways for countries in the subregion are heterogenous depending on local, national and regional contexts. Although the focus for agricultural development differ among countries in the subregion, there are common principles and strategies that can be incorporated to facilitate the attainment of the 2030 Agenda. The specific recommendations for the subregion listed below are based on the analysis of agriculture transformation and its relationship with sustainable development.

Customize national sustainable agriculture transformation plans

Almost all countries in North and Central Asia have agriculture development programmes which correspond to the sustainable development principles in varying degrees. The common objective in all these agriculture development programmes is to achieve food security by attaining self-sufficiency in food production and increasing agriculture export. Nevertheless, not all agriculture development plans take a balanced approach to integrate economic, social and environmental aspects. A few characteristics that need to be emphasized and are applicable to countries in the subregion to mainstream sustainable agriculture transformation are: (i) the inclusion of smallholders in value chains; (ii) emphasis on environmental sustainability in agricultural production; and (iii) digitalization of agriculture processes. The sustainable agriculture transformation plan will form a key component for rural development in the subregion.

Starting the Decade of Action to accelerate sustainable solutions for the delivery of the SDGs, this is a good opportunity for countries to develop and customize the strategic directions of the agriculture sector in the coming decade. This will be especially relevant for countries which have agriculture development strategies and plans that end in 2020 such as the "State program on the development of viticulture in Azerbaijan 2012–2020", the Strategy for agricultural development in Georgia 2015–2020 and the programme for the development of the agro-industrial complex of Kazakhstan for 2013–2020. Good practices from countries which have developed national strategies and specific action plans moving forward can be considered to encourage a balanced integration of sustainable development objectives in agriculture development. The Strategy of the main directions ensuring development in agriculture sector of the Republic of Armenia 2020–2030 emphasizes the 10-year vision to aggregate smallholdings and fragmented value chains, promote climate smart agriculture practices and technology focused modernization, among others. The Russian Federation State programme for the development of agriculture 2018–2025 also emphasizes digital agriculture and environmentally friendly agriculture practices, with the first national law on organic agriculture taking effect on 1 January 2020. It is also important to ensure complementarities between different state programmes and strategies. For example, the agriculture sector is a key area for development in the ambitious Kazakhstan Green Economy 2050 plan and can be a beneficiary of the Digital Kazakhstan State programme 2018–2022. Development of the agriculture transformation strategy in Kazakhstan will need to take complementary state programmes into account and align with them.

Reassess the agriculture subsidy structure to meet sustainable development objectives

Complementing the development of sustainable agriculture transformation plans, the current agriculture subsidy structure needs to be reassessed to align with longer-term sustainable development objectives. Since independence, many agriculture policies concerning incentives and subsidies have been introduced in North and Central Asian countries, with many of the subsidies aimed at increasing productivity and decreasing cost of production for agriculture producers. With the onslaught of COVID-19, many Governments in the subregion have stepped in to subsidize agriculture loans to keep the sector afloat and running, recognizing its contribution to ensure food security. The pandemic also provided an opportunity to reassess and prioritize strategic areas for further agriculture development.

It is important that subsidies allocated to the agriculture sector are oriented toward sustainable development and do not encourage further deterioration of natural resource management and rural development. Currently, agriculture subsidies in North and Central Asia are targeted to the production of priority crops, fertilizers, pesticides, water and machinery. In order to meet sustainable development objectives, conservation-related subsidies can be introduced by reallocating resources from other subsidy streams to incentivize and reward agriculture producers who implement sustainable agriculture practices. As organic agriculture starts to gain traction in the subregion and among many of its agriculture trading partners, the subsidy structure on synthetic pesticides and fertilizers needs to be reassessed. The results show the significant and large share of livestock production in the subregion, and its contribution to greenhouse gas emissions indicates opportunities to incentivize sustainable livestock farming with an aim to reduce greenhouse emissions in the sector. The agriculture sector needs to respond to changes in consumer demands and also promote more balanced nutritional options considering the shift in dietary patterns. Additionally, the modality of how subsidies are being implemented needs to be transparent to avoid the misallocation of resources.

Leverage private sector investment for agriculture modernization to facilitate resource use efficiency

When incentives and subsidies are provided by Governments, agriculture producers need to take initiative to upgrade the machinery and technology in use for agricultural production to ensure more efficient use of production inputs. The private sector plays a key role alongside government actors to modernize the agriculture sector and increase its competitiveness. Policymakers need to identify opportunities to leverage private sector capital and expertise to jointly work towards achieving sustainable agricultural objectives. Investments from the private sector to upgrade agriculture technology and modernize agricultural production systems can fill in the gaps to further develop the agricultural ecosystem, especially in ensuring the provision of infrastructure. Connectivity infrastructure for transport, trade and digital services is crucial to drive agriculture modernization.

Results of the analysis indicate that technological change in the subregion is observing diminishing returns on productivity levels. According to FAO, approximately 80 per cent of agricultural machinery in use in Kyrgyzstan is outdated. Given that technological advancements in agricultural machinery have developed considerably in recent years, the introduction of new digital technologies in agriculture processes can further facilitate the adaptation of sustainable agriculture practices. These digital technologies include satellite sensors that assist in monitoring crop status, weeding and harvesting robots which minimize the use of agrochemicals and soil compaction, and blockchain technology that decentralizes storage of information and promotes better coordination for agriculture data. The integration of these technologies in the agricultural production cycle can facilitate the transition towards agroecological systems, fulfilling the dual objective of increasing agricultural productivity and value added while protecting and prioritizing the use of natural resources. Specifically, innovations in artificial intelligences can reduce the use of agrochemicals by up to 60 per cent in the production of crops and generate up to 50 per cent savings in the use of water for agriculture (ECLAC, FAO and IICA, 2019).

Promote agricultural water use efficiency to combat water stress

Water is a key input to the agriculture sector. However, water productivity levels have not improved much over the years in North and Central Asia and bear a negative insignificant relationship with the performance of the agriculture sector over the past decades. Water use efficiency is also low with leakages occurring throughout the agricultural production cycle. Initiatives to increase water productivity levels are needed, given the history of water tensions in the subregion and the looming threat of climate change. In Central Asian countries, flood and drought are among the seasonal disasters that affect agricultural production.

Integrated water and soil management approaches and ecosystem approaches can be introduced to increase the resilience and productivity of the agriculture sector. Projects initiated in the subregion to improve water productivity, enhance nutrient-use efficiency and soil fertility have demonstrated that an integrated management approach can enhance agricultural productivity and provide higher incomes while conserving soil and water quality.[12] These integrated approaches can help overcome persistent problems in many areas of North and Central Asia where arable land has gradually deteriorated due to overgrazing, drought and unbalanced crop rotation patterns.

---

[12] For example, ADB funded projects such as "On-farm soil and water management" and "Improving rural livelihoods through efficient water and soil fertility management in Central Asia".

Modernization of irrigation systems and mechanization of agriculture processes are two significant determinants that positively contribute to increasing agricultural productivity while potentially minimizing environmental externalities. The insignificant relationship between water productivity and growth in agricultural productivity can potentially be changed through modernizing irrigation systems to prevent waste and leakages in the agricultural production cycle. Results of the analysis also revealed the positive impact of water stress on undernutrition. Easing the stress on water resources and increasing efficient water resources management can reduce the prevalence of undernutrition in the region.

Strengthen regional cooperation to facilitate supply chain resilience

As the analysis revealed, agriculture trade and openness are key drivers for agriculture transformation and subsequently advancing sustainable development. However, countries need to ensure that these gains will not be reversed by the impact of COVID-19. The landlocked status of most North and Central Asian countries implies the interdependence of their economies. These countries can take advantage of increasing interest on the subregion as a corridor linking the East and the West, along with growing demand for diverse agrifood products from within and outside the region.

Multiple forms of cooperation and partnerships can be considered to better integrate the economies of North and Central Asian countries both nationally and abroad. Strategic economic corridors can be developed through coordination at both the national and the regional level to stimulate agricultural activities with targeted investments and development plans. These economic corridors can specifically target routes connecting China and Europe to facilitate the movement of agriculture goods. These measures coupled with investments in infrastructure and the adaptation of new technologies can allow agriculture producers to discover new markets outside the region, and they are beneficial for smallholders who produce products that meet international standards.

Of particular interest in the strategy to facilitate agricultural value chain resilience in North and Central Asia is the integration of smallholders as they contribute to a significant amount of agriculture outputs in the region and are the most vulnerable to external shocks, as evident from the lessons learned from COVID-19. Experiences from other regions demonstrated that a multisectoral integrated and networked approach to support agriculture smallholders could deliver on inclusive growth. Strengthening regional cooperation to leverage on value chains and trade markets can also help North and Central Asian countries to address the objective of food security by complementing domestic agricultural production with external trade.

5.   Conclusion

For North and Central Asia, despite achieving success in structural transformation, the gains are mainly limited to certain aspects such as mining and dependence on remittances, with lack of diversification. Limited productivity gains had been realized through intrasectoral upgrading in the agriculture sector, which has potential to drive the achievement of sustainable development in North and Central Asia. It needs to be reemphasized that it will be difficult for countries in the region to achieve sustainable and inclusive growth without taking into account agriculture transformation. Sustainable agriculture transformation can drive the rural development process by increasing and diversifying agricultural production while being a catalyst for non-agricultural activities to flourish as well. Rural development in turn will lead to a decrease in poverty rates and increase employment opportunities. However, successful transformation does not happen overnight.

Results of the analysis show positive significance of agriculture openness and product diversification on agriculture transformation. Other variables which showed strong significance include arable land, share of livestock production and government effectiveness. Although the historical relationship between growth in agricultural machinery and productivity is negative, it is important to note that technology is a key driver to facilitate sectorial transformation. Although there are limitations in terms of data quality and availability to perform the analysis, results generally reflect the trends of agriculture development in the subregion. Agriculture transformation in turn shows varying degrees of impact on the three pillars of sustainable development, exhibiting both direct and indirect effects. In particular, it showed strong significance in decreasing emissions from the agriculture sector and in decreasing the prevalence of undernourishment in North and Central Asia. Although agriculture transformation may have a long pathway to impact certain aspects of sustainable development, and some effects may be delayed due to changes in external factors, these are no excuse for countries to underinvest in the agriculture sector. Future agriculture transformation strategies need to look beyond economic factors that have already proven to be significant – such as agriculture openness and product diversification – and explore ways to better integrate new and innovative technologies into agricultural production systems, as well as improve the productivity and efficiency of resource use such as water. These efforts can be supported by encouraging agricultural research, building human capital and new capacities, and strengthening regional cooperation.

To realize the 2030 Agenda, countries in North and Central Asia need to foster capacities and generate momentum for sustainable economic transformation and embed sustainable agriculture transformation in the process of economic transformation. Better understanding of the agriculture transformation process in the region is essential to develop evidence-based policies that prioritizes the 5Ps of sustainable development – people, planet, peace, partnership and prosperity.

References

Antonakis, J., S. Bendahan, P. Jacquart, and R. Lalive (2014). *Causality and endogeneity: Problems and solutions.* In D.V. Day, ed., The Oxford Handbook of Leadership and Organizations (pp. 93–117). New York: Oxford University Press.

Arvis, J.F., and C. Rastogi (2014). *The Eurasian connection: Supply-chain efficiency along the modern silk route through Central Asia.* Available at http://documents.worldbank.org/curated/en/730031468030581540/The-Eurasian-connection-supply-chain-efficiency-along-the-modern-silk-route-through-Central-Asia.

Asian Development Bank (ADB) (2019). *Agriculture development in the Central Asia Regional Economic Cooperation Program member countries: Review of trends, challenges and opportunities.* Available at www.adb.org/publications/trends-agricultural-development-carec-countries.

Briones, R., and J. Felipe (2013). *Agriculture and structural transformation in developing Asia: Review and outlook*. Available at http://hdl.handle.net/11540/2305.

Central Asia Regional Economic Cooperation (CAREC) (2018). *CAREC corridor performance measurement and monitoring.* Available at www.carecprogram.org/uploads/CAREC-Corridor-Performance-Measurement-Monitoring-Annual-Report-2018.pdf.

Dawe, D. (2015). Agricultural transformation of middle-income Asian economies: Diversification, farm size and mechanization. Available at www.fao.org/publications/card/en/c/26f0548f-e90c-4650-9e17-9c378f6484dd.

Economic and Social Commission for Asia and the Pacific (ESCAP) (2017). *North and Central Asia as a transit hub: Potential, challenges and the way forward.* Available at www.unescap.org/sites/default/files/North%20and%20Central%20Asia%20as%20a%20Transit%20Hub%20_final.pdf.

— (2019a). *Digital and sustainable trade facilitation in North and Central Asia.* Available at www.unescap.org/resources/digital-and-sustainable-trade-facilitation-report-nca-2019.

— (2019b). *Structural transformation and its role in reducing poverty: Asia-Pacific countries with special needs development report.* Available at www.unescap.org/sites/default/files/publications/CSN%20Report_01-5-2019.pdf.

— (2019c). *Asia's Landlocked Developing Countries: Structural Transformation, Poverty Reduction and Financing for Development.* Available at www.unescap.org/resources/asia-lldcs-report-2019.

Economic Commission for Latin America and the Caribbean (ECLAC), Food and Agriculture Organization of the United Nations (FAO), and Inter-American Institute for Cooperation on Agriculture (IICA) (2019). *The outlook for agriculture and rural development in the Americas: A perspective on Latin American and the Caribbean 2019–2020*.

European Bank for Reconstruction and Development (EBRD) (2017). *Modern technology improves traditional livelihoods in Kazakhstan.* Available at www.ebrd.com/news/2017/modern-technology-improves-traditional-livelihoods-in-kazakhstan.html.

European Training Foundation (ETF) (2017). Torino Process 2016–17: Central Asia. Available at www.etf.europa.eu/en/publications-and-resources/publications/torino-process-2016-17-central-asia.

Food and Agriculture Organization of the United Nations (FAO) (2000). *Special Alert: FAO/WFP crop and food supply assessment mission to Tajikistan.* Available at www.fao.org/3/x7844e/x7844e00.htm.

— (2011a). *The Kyrgyz Republic: Opportunities and challenges to agricultural growth.* Available at www.fao.org/3/a-i2711e.pdf.

— (2011b). *The state of food and agriculture. Women in agriculture: Closing the gender gap for development*. Available at www.fao.org/3/i2050e/i2050e.pdf.

— (2016). *Regional Overview of Food Insecurity: The Food Insecurity Transition.* Available at www.fao.org/news/story/en/item/522759/icode/.

— (2018). *Transforming food and agriculture to achieve the SDGs*. Available at www.fao.org/3/I9900EN/i9900en.pdf.

— (2019a). *Gender, agriculture and rural development in Uzbekistan: Country gender assessment series.* Available at www.fao.org/3/ca4628en/ca4628en.pdf.

— (2019b). Change in water-use efficiency over time (SDG indicator 6.4.1).

Gharlegi, B., and V. Popov (2018). *Farewell to agriculture? Productivity trends and the competitiveness of agriculture in Central Asia*. Available at https://mpra.ub.uni-muenchen.de/89520/.

Godfray, C., J. Beddington, I. Crute, L. Haddad, D. Lawrence, J. Muir, J. Pretty, S. Robinson, S. Thomas, and C. Toulmin (2010). *Food security: The challenges of feeding 9 billion people*. Available at https://science.sciencemag.org/content/327/5967/812/tab-pdf.

Huh, H.S., and C.Y. Park (2017). *Asia-Pacific regional integration index: Construction, interpretation and comparison*. Available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2982755.

Imai, K.S. (2017). *Roles of agricultural transformation in achieving sustainable development goals on poverty, hunger, productivity and inequality*. Available at https://ideas.repec.org/p/kob/dpaper/dp2017-26.html.

Imai, K.S., W. Cheng, and R. Gaiha (2016). *Does Agricultural Growth Reduce Poverty and Inequality in Developing Countries?* Available at www.rieb.kobe-u.ac.jp/academic/ra/dp/English/DP2015-23.pdf.

International Labour Organization (ILO) (2019). *Empowering women in the rural economy.* Available at www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_601071.pdf.

Lerman, Z., and D. Sedik (2017). *Transition to smallholder agriculture in Central Asia.* Available at www.researchgate.net/publication/320857983_Transition_to_Smallholder_Agriculture_in_Central_Asia.

Lio, M., and M.C. Liu (2008). *Governance and agricultural productivity: a cross-national analysis*. Food Policy, vol. 33, No. 6, pp. 504–512.

Norton, G.W., J. Alwang, and W.A. Masters (2015). *Economics of Agricultural Development.* New York: Routledge.

Organisation for Economic Co-operation and Development (OECD) (2019). *Sustainable infrastructure for low-carbon development in Central Asia and the Caucasus: Hotspot analysis and needs assessment, green finance and investment*. Available at https://doi.org/10.1787/d1aa6ae9-en.

Organisation for Economic Co-operation and Development (OECD), and Food and Agriculture Organization of the Untied Nations (FAO) (2018). *OECD-FAO agricultural outlook 2018–2027.* Available at https://doi.org/10.1787/agr_outlook-2018-en.

Pedroni, P (2004). *Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis.* Available at www.jstor.org/stable/3533533?casa_token=VOHfPRT8PnUAAAAA%3AcjoSXbtr4ynSp_iGxOI6aBl cHLomMSJLC84O6G1Ws6EMlrimjo6pgcmD62mBco8YPq_RcmOCrs6UGWH-Ekzmm0vZCGcOUKF3o3jqapRHfXszwb1DyJQu&seq=1#metadata_info_tab_contents.

Petrick, M., D. Oshakbayev, R. Taitukova, and N. Djanibekov (2017). *The return of the regulator: Kazakhstan's cotton sector reforms since independence.* Available at https://doi.org/10.1080/02634937.2017.1392928.

Russell, M. (2019). *Connectivity in Central Asia: Reconnecting the Silk Road.* Available at www.europarl.europa.eu/RegData/etudes/BRIE/2019/637891/EPRS_BRI(2019)637891_EN.pdf.

School of Oriental and African Studies (SOAS) (2007). *The cotton sector in Central Asia: Economic policy and development challenges*. D. Kandiyoti, ed. Proceedings of a conference held at SOAS, University of London, 3–4 November 2005. Available at www.soas.ac.uk/cccac/events/cotton-sector-in-central-asia-2005/file41585.pdf.

Schwoob, M.H., P. Timmer, M. Andersson, and S. Treyer (2018). *Agricultural transformation pathways toward the SDGs.* Available at www.researchgate.net/publication/328983237.

Swiss Agency for Development and Co-operation (SDC) (2019). *Managing disaster risks and water under climate change in Central Asia and Caucasus*. Available at https://reliefweb.int/sites/reliefweb.int/files/resources/managing_disaster_risks_and_water_u nder_climate_change_in_ca_and_caucasus-compilation.pdf.

Tashilova, A., B. Ashabokov, L. Kesheva, and N. Teunova (2019). Analysis of Climate Change in the Caucasus Region: End of the 20th – Beginning of the 21st century. Available at www.mdpi.com/2225-1154/7/1/11/htm.

Wegren, S.K. (2018). The "left behind": Smallholders in contemporary Russian agriculture. Available at https://onlinelibrary.wiley.com/doi/abs/10.1111/joac.12279.

World Bank Group (2018). *Uzbekistan: Agricultural trade policy report.* Available at http://documents.worldbank.org/curated/en/745361544159774580/Uzbekistan-Agricultural-Trade-Policy-Report.

— (2019). *Farm restructuring in Uzbekistan: How did it go and what is next?* Available at http://documents1.worldbank.org/curated/en/686761549308557243/pdf/134322-WP-P162303-PUBLIC-Report-Farm-Restructuring-in-Uzbekistan-eng.pdf.

Zhang, M., Y. Chen, Y. Shen, and B. Li (2019). *Tracking climate change in Central Asia through temperature and precipitation extremes.* Journal of Geographical Science, vol. 29, No. 1.