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# *Agricultural Transformation and Rural Welfare in Emerging Economies: Institutional and Productive Pathways Linking Resilience, Food Security, and Poverty Reduction*

Neo Molefe <sup>1</sup> and Kabelo Masire <sup>2</sup>

<sup>1</sup> University of Botswana - Botswana

<sup>2</sup> University of Botswana - Botswana

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## Abstract

Food security, rural poverty, and agricultural development remain closely related dimensions of economic transformation in emerging economies. This paper examines how agricultural productivity, climate resilience, market integration, productive assets, institutional arrangements, livelihood strategies, digital technologies, and nutrition-sensitive policies shape rural welfare. The literature shows that agricultural development can contribute substantially to poverty reduction and food security when productivity improvements are accompanied by functioning markets, access to productive resources, effective institutions, and mechanisms that reduce exposure to climatic and economic risks. Technological adoption can increase yields and income, but its effects vary according to profitability, liquidity constraints, market access, extension services, and farmers' capacity to manage uncertainty. Climate change adds further pressure by reducing agricultural productivity and increasing production instability, while commercialization creates opportunities for income growth but also exposes households to market conditions and food-price fluctuations. Rural poverty reduction also depends on structural transformation, women's access to productive resources, livelihood diversification, migration, and social protection. Digital extension, mobile finance, and insurance can strengthen farmers' productive capacities when supported by infrastructure and institutional arrangements. Finally, agricultural production and income gains do not automatically improve nutrition. Sustainable rural transformation therefore requires coordinated policies linking productivity, resilience, markets, inclusion, institutions, and household welfare.

**Keywords:** Food security; Rural poverty; Agricultural development; Agricultural productivity; Emerging economies

**JEL classification:** Q12; Q18; O13; I32; O18

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## Introduction

Food security and rural poverty remain major development concerns in emerging economies where agriculture continues to provide employment, income, food, and economic opportunities for large shares of the population. Agricultural development can improve household welfare



through several channels, including increased food production, higher farm income, lower production risk, stronger market participation, and greater demand for labor and rural services. However, agricultural growth does not necessarily translate directly into better living conditions. Differences in access to land, productive assets, technology, finance, information, infrastructure, and markets influence the capacity of households to participate in agricultural transformation. Farmers also face considerable heterogeneity in expected technological returns and exposure to production risks, making uniform agricultural interventions inappropriate in many contexts. Climate change further modifies the conditions under which agricultural development takes place by reducing productivity growth, increasing temperature-related yield losses, and intensifying exposure to drought and other extreme events. Commercialization and value-chain participation can increase income and improve access to food, but they may also expose households to price volatility and changing market requirements. Food security must therefore be understood as the outcome of interactions between production, income, market access, resilience, and the wider institutional environment in which rural households make economic decisions.

The paper examines these relationships through three interconnected dimensions. The first concerns food security and considers agricultural productivity, technology adoption, climate shocks, commercialization, food prices, and agricultural value chains. The second focuses on rural poverty by examining agriculture-led growth, structural transformation, gender inequalities, land and productive assets, livelihood diversification, migration, social protection, and mechanisms for managing rural risks. The third addresses agricultural development through public policy, extension systems, input-support programs, digital agriculture, mobile finance, insurance, and nutrition-sensitive interventions. These dimensions are closely related because improvements in one area often depend on conditions established in another. Technological adoption may raise agricultural output while producing limited welfare gains when farmers cannot participate effectively in markets. Commercialization may increase household income without eliminating vulnerability to changes in food prices. Social transfers may protect consumption while simultaneously relaxing liquidity constraints that restrict productive investment. Similarly, digital technologies can improve access to information and financial services but remain dependent on infrastructure, skills, institutions, and market conditions. The paper therefore adopts an integrated interpretation in which agricultural productivity, resilience, structural transformation, inclusion, institutional quality, and nutrition jointly determine whether agricultural development contributes to sustainable reductions in rural poverty and improvements in food security.

## **1. Food Security: Agricultural Production, Shocks and Markets**

### **1.1. Agricultural productivity, technology adoption and sustainable intensification**

Emerick et al. (2016) show that the value of agricultural innovation extends beyond its direct effect on yields because technologies that reduce downside risk can also modify farmers' production decisions. By protecting rice production against flooding, risk-reducing innovation can encourage greater investment and the adoption of more productive cultivation practices. This implication connects closely with Kassie et al. (2015), who show in Malawi that agricultural technologies differ not only in their productivity effects but also in their capacity to reduce production risk and improve household food security. The two contributions therefore suggest that technological adoption should be assessed through both expected returns and the stability of those returns under adverse conditions. Manda et al. (2016) complement this perspective by showing that improved maize technologies and sustainable agricultural practices can raise



productivity and household income, particularly when they are adopted in combinations adapted to farmers' production systems. Kassie et al. (2018) extend these implications beyond the farm by demonstrating that welfare improvements from improved maize technologies also depend on market participation and the institutional conditions governing input acquisition and output sales. Taken together, these contributions imply that agricultural technologies support food security most effectively when productivity gains, risk reduction, household welfare, and market integration reinforce one another.

Suri and Udry (2022) provide a broader interpretation of agricultural technology adoption in Africa by emphasizing that persistent productivity gaps cannot be attributed simply to the absence of profitable innovations. Differences in returns, exposure to risk, market access, input quality, credit constraints, and institutional conditions create substantial heterogeneity in farmers' incentives and capacities to adopt. This perspective is consistent with Kathage et al. (2016), who show that nonadoption of hybrid maize in Tanzania does not necessarily indicate market failure, since some farmers may face relatively limited economic returns from the technology. Their findings imply that adoption policies should distinguish between constraints preventing the use of profitable technologies and situations in which technologies are not sufficiently attractive under local conditions. Krah et al. (2019) reinforce this distinction by showing that farmers may value soil-fertility-management practices while remaining constrained by liquidity, fertilizer availability, technical assistance, and implementation costs. Khonje et al. (2018) add that welfare gains can become larger when several complementary agricultural technologies are adopted jointly, although households differ in their capacity to access these packages. Together, these studies imply that food-security policies require differentiated interventions combining technological suitability, financing, technical support, input availability, and complementary investments rather than assuming that information or subsidies alone can produce sustained adoption.

Khonje et al. (2018) demonstrate that the welfare effects of agricultural innovation can depend substantially on whether farmers adopt technologies individually or as complementary packages. Their evidence from eastern Zambia indicates that joint adoption can generate greater income improvements and stronger poverty reductions, suggesting that the effectiveness of innovation depends partly on interactions among technologies and on households' capacity to combine them. This implication closely parallels Kassie et al. (2015), who show across eastern and southern Africa that adoption decisions are interdependent because some sustainable intensification practices complement one another while others compete for limited household resources. Agricultural policy should therefore consider the portfolio of technologies available to farmers rather than treating each adoption decision independently. Krah et al. (2019) strengthen this interpretation by identifying liquidity, fertilizer availability, technical assistance, and implementation characteristics as factors that determine whether farmers can translate interest in soil-fertility practices into actual adoption. Kathage et al. (2016), however, introduce an important qualification by showing that low adoption may also reflect heterogeneous or modest economic returns rather than binding constraints alone. Taken together, these contributions imply that integrated technological packages should not be promoted uniformly. Their effectiveness depends on complementarities among practices, local profitability, household resources, technical support, and the opportunity costs farmers face when allocating scarce financial and productive resources.

Manda et al. (2016) indicate that productivity-enhancing agricultural technologies can contribute to poverty reduction when improved varieties are combined with sustainable resource-management practices. The implication is that technological performance cannot be separated from the production system in which innovations are introduced, because complementarities



among practices affect the magnitude of productivity and income gains. Kassie et al. (2018) reinforce this argument by showing that improved maize technologies in Ethiopia generate welfare effects whose magnitude depends not only on farm-level productivity but also on diffusion, market participation, and the institutional conditions surrounding input and output transactions. Emerick et al. (2016) add another dimension by demonstrating that technologies capable of reducing downside risk can alter farmers' incentives to invest more intensively in productive activities. Their findings imply that agricultural innovation can influence both realized output and farmers' willingness to undertake production decisions that would otherwise appear too risky. Suri and Udry (2022) place these mechanisms within the broader African context, emphasizing that technology outcomes vary because farmers differ in expected returns, access to markets, credit constraints, risk exposure, and input quality. These contributions collectively imply that successful agricultural modernization requires more than introducing technically superior innovations. It depends on combinations of productivity, risk management, market functioning, institutional support, and locally appropriate economic returns that enable technological improvements to produce durable food-security and welfare effects.

Kassie et al. (2015) show that sustainable intensification practices are adopted through interdependent decisions shaped by household assets, information, market conditions, and agroecological characteristics. This implies that policies centered on the diffusion of a single technology may overlook the way farmers combine practices according to resource constraints and production objectives. Khonje et al. (2018) provide complementary evidence by showing that joint adoption of agricultural technologies can yield larger welfare improvements than isolated adoption, although access to such combinations remains uneven across households. The policy implication is that complementarity among innovations must be supported by complementary access to finance, knowledge, inputs, and markets. Kassie et al. (2015), using evidence from Malawi, further show that the composition of technology packages matters because different combinations generate different productivity, risk, and food-security outcomes. This shifts attention from the simple number of technologies adopted toward the specific functions performed by each combination, particularly its capacity to limit downside production losses. Krah et al. (2019) deepen this perspective by showing that adoption of soil-fertility-management practices can remain limited when immediate liquidity requirements, fertilizer availability, or technical difficulties are substantial. Together, these findings imply that technology portfolios should be designed around both agronomic complementarity and farmers' economic constraints, since technically compatible practices may still remain inaccessible when households cannot finance or implement them effectively.

Kathage et al. (2016) question the assumption that increasing agricultural technology adoption necessarily requires correcting information, credit, or market failures. Their findings from Tanzania imply that observed nonadoption can also represent a rational response when expected returns are heterogeneous or insufficient under particular farm conditions. Suri and Udry (2022) generalize this reasoning by emphasizing that productivity gaps across African agriculture coexist with substantial differences in technological returns, risk, input quality, market access, and institutional environments. The implication is that uniform technology-promotion programs can produce uneven results because the same innovation does not generate identical incentives across farmers and locations. Emerick et al. (2016) nevertheless show that the attractiveness of a technology can change when it reduces exposure to severe production losses, since lower downside risk encourages farmers to intensify investment and adopt more productive practices. Kassie et al. (2018) further indicate that even when improved technologies raise yields, welfare gains depend on whether farmers can participate effectively in input and output markets. These contributions therefore suggest that adoption policy should distinguish between profitability, risk, and market transmission mechanisms. A technology may be technically



effective but economically unattractive, profitable but excessively risky, or productive without generating proportional welfare gains when market and institutional conditions prevent households from converting higher output into higher income.

## **1.2. Climate shocks, agricultural resilience and food security**

Ortiz-Bobea et al. (2021) show that climate change has already slowed global agricultural productivity growth, which implies that climatic pressures should be treated as an ongoing constraint on agricultural development rather than only as a future risk. This cumulative effect on productivity connects with Ray et al. (2019), who demonstrate that climate change has already altered the production of several major crops across different regions. Their findings imply that agricultural planning must incorporate observed climatic trends into decisions concerning irrigation, research, extension, and rural infrastructure. Zhao et al. (2017) reinforce this perspective by showing that rising temperatures systematically reduce yields of major staple crops in the absence of effective adaptation. Their contribution suggests that gradual warming can undermine baseline agricultural productivity even without the occurrence of extreme disasters. Lesk et al. (2016) complement these longer-term effects by demonstrating that droughts and extreme heat can also cause substantial immediate cereal-production losses. Together, these contributions imply that climate-related food-security risks operate through both gradual productivity deterioration and acute production shocks. Agricultural policy in emerging economies therefore needs to combine long-term adaptation to rising temperatures with mechanisms capable of protecting production when extreme climatic events occur, particularly where domestic food supply and rural incomes remain strongly dependent on agriculture.

Clay and King (2019) show that agricultural intensification does not automatically improve climate resilience because the capacity to adapt remains unevenly distributed among smallholders. Their findings imply that modernization policies can increase production while simultaneously weakening traditional coping mechanisms or creating new vulnerabilities for households with fewer resources. This distributional dimension is closely related to Niles and Salerno (2018), who show that the effect of climate shocks on household food insecurity varies according to assets, poverty, and access to coping mechanisms. Their contribution suggests that climatic vulnerability cannot be understood only through exposure to adverse weather, since households facing similar shocks may experience very different food-security consequences. Wossen et al. (2018) broaden this interpretation by demonstrating that climatic disturbances often interact with food-price volatility, producing combined pressures on household income and food consumption. Access to improved seeds, irrigation, credit, and productive assets can moderate these effects. Mulwa and Visser (2020) add that diversification across crop and livestock activities can help spread climatic risks, particularly when households have access to useful climate information. Taken together, these contributions imply that resilience depends on both productive strategies and household capacity. Effective adaptation policies should therefore combine technological support, financial access, information systems, diversification opportunities, and attention to inequalities in the ability of rural households to absorb environmental and market shocks.

Arslan et al. (2017) demonstrate that the effectiveness of sustainable land-management practices depends partly on climatic conditions, implying that agricultural technologies should not be evaluated solely according to their average productivity effects. A practice may be particularly relevant when it limits weather-related losses rather than when it produces the highest output under normal conditions. This interpretation complements Wossen et al. (2018), who show that rural households frequently face climatic variability and price instability simultaneously. Their findings imply that resilience policies need to address several interacting sources of risk instead of relying on a single instrument. Mulwa and Visser (2020) provide a related



mechanism by showing that diversification between crop and livestock activities can spread production risks when activities respond differently to climatic disturbances. Access to climate information further improves households' ability to make appropriate diversification decisions. Niles and Salerno (2018) place these responses within a wider socioeconomic context by demonstrating that the food-security effects of climate shocks differ according to household resources and coping capacity. The combined implication is that climate-smart agriculture cannot be reduced to the promotion of particular farming practices. Its effectiveness depends on whether technologies, diversification strategies, information, and household resources jointly strengthen the capacity to maintain food production and consumption when weather conditions deteriorate.

Ray et al. (2019) establish that climate change is already influencing crop production and that these effects vary geographically, which implies that adaptation measures should be tailored to local production conditions rather than applied uniformly across regions. Zhao et al. (2017) reinforce the need for such adaptation by showing that rising temperatures reduce yields of wheat, rice, maize, and soybean when effective responses are absent. Their findings point toward investment in breeding, irrigation, and improved crop management as components of long-term agricultural policy. Arslan et al. (2017) add that some sustainable land-management practices can protect productivity from weather-related losses, although their performance depends on climatic conditions. This implies that adaptation strategies should consider not only whether a practice raises average yields but also whether it stabilizes production under unfavorable weather. Ortiz-Bobea et al. (2021) extend these implications by showing that climate change has already reduced the rate of global agricultural productivity growth. This slower growth can accumulate over time, limiting food availability and agricultural incomes. Together, these contributions imply that adaptation should become an integral component of productivity policy. Research, infrastructure, farm-management practices, and technological innovation need to be designed around changing climatic conditions if emerging economies are to sustain agricultural growth while limiting the cumulative effects of warming on food production.

Lesk et al. (2016) show that droughts and extreme heat can sharply reduce cereal production, implying that climatic disasters can create immediate pressures on both food availability and agricultural income. These production losses may be particularly damaging in economies where households depend heavily on domestic agriculture and where mechanisms for insurance or food imports remain limited. Wossen et al. (2018) deepen this implication by showing that climatic shocks can become more damaging when they coincide with food-price volatility. Their findings suggest that agricultural households face interconnected production and market risks whose combined effects can exceed those associated with either shock separately. Clay and King (2019) introduce an important distributional qualification by showing that poorer farmers may be less able to adjust to climatic variability and to the requirements created by agricultural intensification policies. This means that policies intended to increase production can generate unequal resilience outcomes when access to assets is uneven. Mulwa and Visser (2020) identify diversification as one possible response, showing that combining crop and livestock activities can distribute risk across different sources of income and production. Collectively, these contributions imply that climate resilience requires more than emergency responses after disasters. It requires diversified livelihoods, productive assets, market stabilization mechanisms, and policy designs that account for differences in households' capacity to withstand climatic and economic disturbances.

Niles and Salerno (2018) demonstrate that climatic disturbances translate into food insecurity through household-specific vulnerabilities, implying that exposure alone does not determine the severity of food-security outcomes. Poverty, assets, and coping capacity influence whether households can absorb shocks without substantial reductions in food consumption. Clay and



King (2019) provide a compatible perspective by showing that intensification policies can affect farmers differently according to their resource endowments, with better-equipped households generally possessing greater capacity to respond to climate variability. Their findings imply that modernization strategies should consider whether existing coping mechanisms are preserved or effectively replaced. Ortiz-Bobea et al. (2021) shift the focus from household-level vulnerability to the cumulative macroeconomic consequences of climate change by showing that agricultural productivity growth has already been slowed. Ray et al. (2019) similarly demonstrate that climate-related production effects are already observable and geographically heterogeneous. Taken together, these contributions imply that climate adaptation must operate simultaneously at several levels. Household resilience requires resources and coping mechanisms, while agricultural systems require technological and infrastructural adjustments capable of responding to changing local production conditions. Food-security policy should therefore connect social protection and household adaptation with longer-term investment in agricultural productivity, ensuring that climate responses address both immediate vulnerability and the persistent transformation of the conditions under which food is produced.

### **1.3. Markets, food prices, commercialization and value chains**

Ogutu and Qaim (2019) show that stronger commercialization among small farms can reduce multidimensional poverty by influencing agricultural income, employment, consumption, and broader dimensions of household welfare. This implication supports the view that food security does not necessarily require maintaining subsistence-oriented production when farmers can participate profitably in markets. Muriithi and Matz (2015) reach a related conclusion in their study of vegetable commercialization in Kenya, where market participation is associated with improved household welfare, although opportunities remain unevenly distributed according to assets, productive capacity, and the institutional environment. Radchenko and Corral (2018) add an important qualification by showing that commercialization can improve food security in rural Malawi, but its effects depend on household characteristics and the imperfections affecting credit, labor, and food markets. Reardon et al. (2019) broaden this relationship by demonstrating that agricultural commercialization increasingly occurs within transforming food systems shaped by processing, logistics, wholesale, retail, and changing consumer demand. Taken together, these contributions imply that commercialization can support food security when households possess the capacity to connect with profitable markets and changing value chains. Its benefits therefore depend not only on producing for sale but also on infrastructure, institutions, information, productive assets, and market structures that allow smallholders to convert commercial participation into sustained improvements in household welfare.

Headey and Martin (2016) demonstrate that the welfare consequences of food-price changes differ substantially between net food sellers and net food buyers, implying that agricultural price policies cannot be judged solely according to their effect on producer revenues. Higher prices may support farmers with marketable surpluses while simultaneously reducing the purchasing power of landless workers, urban households, and farmers who buy more food than they sell. Bellemare (2015) strengthens the consumer-side implications of this argument by showing that higher food prices can contribute to social unrest, particularly where households devote a large proportion of expenditure to food. Aragie et al. (2018), however, show that attempts to stabilize domestic food prices through export restrictions can weaken producer incentives and influence investment, processing, and trade, creating longer-term costs for agricultural development. Reardon et al. (2019) extend the policy problem beyond farm-gate prices by emphasizing that modern food systems increasingly depend on the performance of processing, logistics, wholesale, retail, and other downstream activities. The combined implication is that food-price policy must reconcile consumer affordability with producer incentives and value-



chain development. Protecting consumers through restrictive market interventions may create adverse effects when such measures reduce incentives for production or investment, while unregulated price increases can impose significant burdens on vulnerable food-buying households.

Bellemare and Novak (2017) show that contract farming can improve household food security by shortening the hungry season among participating farmers in Madagascar, implying that contractual market integration can influence food access through income stabilization, improved market access, and reduced uncertainty. Meemken and Bellemare (2020) place these potential benefits within a broader body of evidence and conclude that contract farming frequently generates economic gains, while warning that participation is selective and that companies may favor farmers with particular assets, locations, or productive capacities. This qualification connects with Muriithi and Matz (2015), who show that profitable commercialization opportunities are also unevenly accessible because household resources and institutional connections determine participation. Ogutu and Qaim (2019) similarly demonstrate that commercialization can reduce multidimensional poverty, but households differ in their ability to benefit from stronger market orientation. Together, these findings imply that contractual and commercial integration should not be treated as universally accessible pathways out of poverty. Their welfare effects depend partly on which farmers can enter emerging value chains and sustain participation within them. Policies designed to promote commercialization should therefore complement market opportunities with infrastructure, productive assets, institutional support, and mechanisms capable of reducing exclusion so that the gains associated with market integration extend beyond relatively advantaged smallholders.

Aragie et al. (2018) show that export restrictions adopted to contain domestic food prices may provide short-term protection to consumers while simultaneously weakening agricultural incentives, trade, processing, and investment. This implies that food-security interventions based on market controls must be evaluated against their broader effects on productive capacity and structural transformation. Bellemare (2015) nevertheless demonstrates why governments face strong pressure to control food prices, since high prices can substantially reduce consumer welfare and contribute to social unrest. Headey and Martin (2016) clarify this tension by showing that food-price movements generate heterogeneous effects according to whether households are net sellers or net buyers and according to the responses of wages and agricultural supply. Radchenko and Corral (2018) add that rural households operate within imperfect markets, meaning that production and consumption decisions cannot always adjust smoothly to changing price signals. Taken together, these contributions imply that neither high nor low food prices can be considered universally desirable. Effective food-security policy requires mechanisms that maintain adequate incentives for agricultural production while protecting vulnerable consumers from severe losses of purchasing power. This favors interventions that improve market functioning, productive capacity, infrastructure, and risk management rather than repeated reliance on restrictive measures that may stabilize prices temporarily while weakening the conditions necessary for longer-term agricultural development.

Meemken and Bellemare (2020) emphasize that contract farming can improve income and market access but may not be intrinsically inclusive because participation often depends on location, assets, and production capacity. This implication is closely connected to Reardon et al. (2019), who show that food-system transformation is changing the conditions under which farmers access markets as processing, logistics, retailing, and quality requirements become increasingly important. Smallholders unable to satisfy these changing requirements may therefore face exclusion even when expanding value chains create new commercial opportunities. Bellemare and Novak (2017) demonstrate that participation in contract farming can neverthe-



less generate tangible food-security benefits by reducing the duration of seasonal hunger, suggesting that well-functioning contractual arrangements can improve household welfare beyond their immediate effects on agricultural sales. Radchenko and Corral (2018) reinforce the importance of surrounding institutions by showing that commercialization outcomes depend on imperfect rural markets and on constraints affecting households' ability to participate profitably. Together, these contributions imply that value-chain integration can strengthen food security when contractual arrangements, infrastructure, market institutions, and household capacities evolve together. Expanding commercialization without addressing barriers to participation may concentrate benefits among better-positioned producers, whereas inclusive market development requires policies that help smaller or more constrained farmers satisfy the financial, technical, and organizational requirements associated with increasingly coordinated agricultural markets.

Muriithi and Matz (2015) demonstrate that commercial horticulture can improve smallholder welfare when farmers have access to profitable markets, implying that market-oriented agriculture can strengthen purchasing power and reduce dependence on subsistence production as the sole mechanism of food security. Ogutu and Qaim (2019) reinforce this implication by showing that commercialization can reduce multidimensional poverty through channels extending beyond farm income to employment and household consumption. Headey and Martin (2016), however, indicate that greater market integration also exposes households to food-price movements whose welfare effects depend on whether they are net producers or consumers. This means that commercialization can improve incomes without eliminating vulnerability to price increases, particularly for households that continue purchasing substantial quantities of food. Bellemare (2015) further demonstrates that severe food-price pressures can have consequences extending beyond individual welfare to broader social instability. Taken together, these contributions imply that commercialization should be understood as part of a wider relationship between production, income generation, food markets, and household purchasing power. Market-oriented agricultural development can support poverty reduction and food access, but its benefits are more likely to persist when farmers obtain profitable market opportunities while consumers remain protected from destabilizing food-price movements. Agricultural policy should therefore connect commercialization strategies with efficient markets and mechanisms that preserve affordable access to staple foods.

## **2. Rural Poverty: Distribution, Assets and Livelihood Strategies**

### **2.1. Agriculture-led growth, structural transformation and poverty reduction**

Gollin et al. (2021) show that the diffusion of high-yielding crop varieties during the Green Revolution generated long-run increases in agricultural yields and income, with consequences extending to broader structural and demographic transformation. This implies that agricultural technological change can shape development trajectories well beyond the immediate expansion of food production. McArthur and McCord (2017) support this interpretation by demonstrating that fertilizer, modern seeds, and water are associated with higher cereal yields, subsequent increases in GDP per capita, and a declining agricultural employment share. Agricultural productivity can therefore contribute to structural change by releasing resources and supporting the expansion of nonagricultural activities rather than merely preceding labor movement away from farming. Diao and McMillan (2018), however, qualify this relationship by emphasizing that labor reallocation is development-enhancing only when workers move toward activities offering meaningful productivity advantages. Christiaensen and Martin (2018) similarly argue that successful structural transformation combines productivity improvements within agriculture with movement toward increasingly productive activities outside the sector. Together,



these contributions imply that the declining employment weight of agriculture should not itself be interpreted as evidence of successful transformation. Development outcomes depend on productivity improvements within farming, technological diffusion, and the capacity of expanding nonagricultural sectors to employ released labor in activities capable of generating higher incomes and sustained economic progress.

Ivanic and Martin (2018) show that agricultural productivity growth can produce stronger poverty-reduction effects than comparable productivity improvements in industry or services in poorer economies, although this relative advantage diminishes as countries become richer. The implication is that the sectoral origin of growth matters substantially for distributional outcomes where poverty remains concentrated in rural areas. Ligon and Sadoulet (2018) reinforce this argument by demonstrating that agricultural growth can generate disproportionately large expenditure gains among poorer households, especially in lower-income settings where livelihoods remain closely connected to farming and food markets. Dorosh and Thurlow (2018) broaden the mechanisms through which these benefits occur by showing that agricultural expansion affects poverty not only through direct farm income but also through demand for processing, trade, services, and other rural nonfarm activities. El Hamidi (2023) provides a complementary Moroccan perspective by emphasizing that aggregate economic growth should not automatically be interpreted as pro-poor growth because institutional and socioeconomic conditions determine whether benefits reach vulnerable populations. Taken together, these contributions imply that agricultural growth possesses substantial poverty-reducing potential, but this potential depends on distributional transmission mechanisms. Productivity gains become more inclusive when they increase farm earnings, stimulate surrounding economic activities, influence food prices favorably, and operate within institutional conditions that allow disadvantaged households to participate in and benefit from economic expansion.

Diao and McMillan (2018) emphasize that structural transformation cannot be evaluated simply through the movement of labor out of agriculture because workers may enter nontradable or informal activities offering only limited productivity gains. Their argument implies that the quality and productivity of destination sectors are as important as the decline of agricultural employment itself. Dorosh and Thurlow (2018) reinforce this interpretation by showing that agricultural and nonagricultural growth are connected through demand, employment, processing, trade, and rural services. Agricultural expansion can therefore stimulate nonfarm activities rather than merely lose workers to them. McArthur and McCord (2017) provide a productivity-based foundation for these intersectoral effects, showing that improved agricultural inputs can increase cereal yields and contribute to higher GDP per capita while supporting changes in employment structure. Christiaensen and Martin (2018) further indicate that agriculture retains an important developmental role throughout structural transformation, although the strength of its poverty-reduction effects depends on land distribution, labor mobility, and the stage of economic transformation. Together, these studies imply that agricultural development and diversification should be treated as mutually reinforcing processes. Productivity growth within agriculture can generate income and resources for wider transformation, while productive nonagricultural activities can create employment and demand for farm output, making stronger rural–urban and intersectoral linkages central to inclusive economic development. Makhrouf et al. (2024) emphasize that pro-poor growth in Morocco depends on complementary public policies involving education, employment, redistribution, social inclusion, and institutional quality. Their contribution implies that increases in agricultural production cannot be expected to reduce rural poverty automatically when the wider policy environment limits vulnerable households' access to opportunities. El Hamidi (2023) similarly demonstrates that aggregate economic expansion does not necessarily improve the position of poorer populations and stresses the importance of institutional and socioeconomic conditions in translating growth into



poverty reduction. This broader pro-poor framework is consistent with Ligon and Sadoulet (2018), who show that agricultural growth can disproportionately benefit poorer households, but that its distributional effect changes with the level of development and the structure of household income. Ivanic and Martin (2018) likewise demonstrate that agricultural productivity growth tends to have particularly strong poverty-reduction effects in poorer economies while becoming relatively less distinctive as economies develop. Taken together, these contributions imply that the poverty effects of agricultural expansion should be assessed within the broader distributional and institutional structure of the economy. Agricultural productivity can provide an important foundation for inclusive development, but its ability to reduce poverty depends on whether public institutions, employment opportunities, human-capital policies, and redistribution mechanisms allow low-income households to capture the benefits generated by productivity and income growth.

Christiaensen and Martin (2018) argue that agriculture remains central to poverty reduction even as economies diversify, implying that development strategies should not treat agricultural modernization and industrialization as competing alternatives. The poverty-reducing effect of agricultural growth depends on labor mobility, land distribution, the stage of transformation, and connections between farming and nonagricultural activities. Gollin et al. (2021) demonstrate how these relationships can unfold over long periods by showing that the diffusion of high-yielding varieties generated substantial increases in agricultural yields and income while contributing to broader structural transformation. McArthur and McCord (2017) identify a related mechanism through which improved access to fertilizer, modern seeds, and water raises cereal productivity and supports subsequent increases in GDP per capita. Ivanic and Martin (2018) add a distributional dimension by showing that productivity growth in agriculture can produce relatively strong poverty reductions in poorer economies through effects on producers, workers, and food consumers. Together, these contributions imply that agricultural investment can perform both transformational and redistributive functions. Improvements in agricultural technology and inputs can increase production and income while creating conditions for labor reallocation and wider economic activity. The resulting transformation is more likely to be inclusive when productivity improvements reach poorer agricultural households and when the sectors receiving workers released from agriculture offer sufficiently productive employment opportunities.

Dorosh and Thurlow (2018) demonstrate that poverty reduction emerges through interactions between agricultural and nonagricultural activities, implying that rural development strategies should strengthen economic connections among farms, towns, services, processing, and trade. Agricultural growth can increase rural purchasing power and stimulate demand outside farming, while expansion in nonagricultural sectors can create employment and increase demand for agricultural products. Makhrouf et al. (2024) complement this intersectoral perspective by showing, within the Moroccan context, that pro-poor growth depends on employment, education, redistribution, inclusion, and institutional quality. Their findings imply that agricultural expansion contributes more effectively to poverty reduction when complementary public policies enable disadvantaged populations to participate in broader economic opportunities. El Hamidi (2023) reinforces this conclusion by emphasizing that economic growth alone does not guarantee improvements for poorer groups and that institutional conditions influence the distribution of growth benefits. Gollin et al. (2021) provide a longer-term perspective by showing that agricultural technological change can generate lasting effects on income and structural transformation. Together, these contributions imply that agricultural productivity should be embedded within a wider development framework. Its contribution to inclusive transformation depends not only on raising farm output but also on creating intersectoral demand, productive



employment, institutional support, and complementary social policies capable of translating economy-wide growth into durable reductions in rural poverty.

## **2.2. Gender, land, productive assets and inclusive agricultural development**

Kassie et al. (2020) show that agricultural technology adoption produces stronger dietary-diversity gains when women possess greater agency, implying that technological change and empowerment should be considered complementary rather than separate dimensions of rural development. This relationship is consistent with Seymour (2017), who links women's participation in agricultural decision-making with technical efficiency and shows that intrahousehold agency can influence how productively farm resources are used. Aguilar et al. (2015) provide a related resource-based explanation by demonstrating that gender productivity differences in Ethiopia reflect unequal access to productive resources and unequal returns to those resources rather than gender itself. Slavchevska (2015) reaches a similar conclusion in Tanzania, where differences in land, labor, household conditions, and other productive factors shape observed productivity gaps. Together, these contributions imply that improving women's agricultural outcomes requires more than making technologies formally available to female farmers. Technologies may generate weaker nutritional or productivity effects when women remain constrained in their access to land, labor, inputs, or decision-making authority. Conversely, policies that strengthen women's control over resources and their participation in farm decisions can improve the conditions under which technological investments translate into higher efficiency, production, and household food consumption, thereby linking gender equality directly with agricultural and nutritional performance.

Melesse et al. (2018) demonstrate that joint land certification can strengthen several dimensions of women's empowerment by reinforcing tenure security and expanding participation beyond the household. This implies that formal recognition of land rights can influence both women's productive incentives and their broader capacity to participate in economic and social decisions. Muchomba (2017) extends this implication by showing that stronger land-tenure security for women is associated with changes in household expenditure on food, healthcare, and other forms of human capital. Land institutions therefore affect welfare not only through investment incentives but also through bargaining power and intrahousehold resource allocation. Quisumbing et al. (2015) provide a complementary warning from market-oriented agricultural interventions, showing that increases in household production, income, and assets do not necessarily reduce gender asset gaps when women and men benefit differently from commercialization. Doss et al. (2018) further emphasize that such gender relationships should be examined using context-specific evidence rather than generalized claims about women's agricultural roles. Taken together, these contributions imply that land reform and commercialization should be assessed through ownership, control, bargaining power, and expenditure outcomes rather than aggregate household indicators alone. Institutional reforms can contribute to inclusive agricultural development when they strengthen women's effective rights and their capacity to influence how economic gains are used.

Kilic et al. (2015) show that gender productivity disadvantages in Malawi vary across the productivity distribution, implying that average comparisons can conceal important differences in the constraints facing female-managed plots. Their concept of a productivity trap suggests that limited resources and structural disadvantages may reinforce one another, particularly among farmers already positioned at lower productivity levels. Aguilar et al. (2015) support this interpretation by showing in Ethiopia that gender gaps are associated with unequal productive resources and differences in the returns generated by those resources. Slavchevska



(2015) similarly demonstrates that women's productivity outcomes in Tanzania are conditioned by differences in land, labor, household characteristics, and access to productive factors rather than by gender itself. Doss et al. (2018) place these findings within a broader methodological perspective by cautioning against universal statements about women in agriculture and emphasizing substantial variation across countries and production systems. Together, these studies imply that gender-sensitive agricultural policy should not be designed around a single average productivity gap or a standardized representation of female farmers. Interventions need to identify which resource constraints are most restrictive in specific settings and at different productivity levels. Improving access to land quality, labor, inputs, and services can consequently address inequality while also releasing agricultural productivity that remains constrained by structural differences in resource access.

Quisumbing et al. (2015) show that market-oriented agricultural interventions involving high-value crops and livestock can raise household production and income without necessarily narrowing gender asset gaps. Their findings imply that commercialization may expand household welfare while leaving women's economic position relatively unchanged when initial asset inequalities and gender norms restrict their ability to control new resources. Seymour (2017) adds that women's decision-making agency has productive consequences because greater empowerment is associated with technical efficiency in agriculture. This means that control over resources is not only a distributional outcome but can also influence the effectiveness with which household assets are used. Kassie et al. (2020) extend this connection to nutrition by demonstrating that the dietary benefits associated with agricultural technology adoption are stronger where women possess greater empowerment. Muchomba (2017) provides another intrahousehold mechanism by showing that stronger women's land rights can influence expenditure patterns toward food, healthcare, and human capital. Taken together, these contributions imply that evaluating agricultural commercialization or technological change solely through household income may overlook important mechanisms determining how gains are distributed and converted into welfare. Market and technology policies can produce broader benefits when women possess secure productive rights and meaningful influence over decisions concerning farm resources, income, consumption, and household investment.

Doss et al. (2018) caution against constructing agricultural policy around widely repeated but insufficiently supported claims concerning women's poverty, land ownership, or contribution to food production. Their argument implies that gender-sensitive interventions require precise, context-specific indicators capable of identifying actual inequalities in resources and decision-making. Melesse et al. (2018) illustrate the importance of such institutional context by showing that joint land certification in Ethiopia improves aspects of women's empowerment, demonstrating that formal land documentation can modify agency and participation. Kilic et al. (2015) similarly reveal that gender productivity disadvantages are not uniform across farmers, since the magnitude and sources of the gap vary along the productivity distribution. Quisumbing et al. (2015) add that women's initial asset positions and prevailing gender norms influence how benefits from market-oriented agricultural projects are distributed within households. These contributions collectively imply that gender policy in agriculture should move beyond generalized categories toward interventions grounded in specific constraints, productive positions, and institutional arrangements. A program that increases aggregate production may still preserve unequal access to assets or benefits, while a reform that strengthens formal rights may generate broader changes in agency. Effective policy therefore requires measuring who controls productive resources, who participates in decisions, and how different groups benefit from agricultural interventions under particular local conditions.

Muchomba (2017) demonstrates that strengthening women's land-tenure security can alter household spending on food, healthcare, and other investments in human capital, implying that



agricultural institutions influence welfare through intrahousehold bargaining as well as through production. Melesse et al. (2018) reinforce this interpretation by showing that joint land certification can increase women's empowerment and participation, potentially strengthening their capacity to negotiate land use and engage more confidently in economic activities. Kassie et al. (2020) connect such agency directly with food-security outcomes by showing that women's empowerment strengthens the dietary-diversity gains associated with agricultural technology adoption. Seymour (2017) further demonstrates that empowerment can affect technical efficiency, indicating that greater decision-making capacity may influence both the allocation and the productivity of agricultural resources. Taken together, these contributions imply that women's rights and agency operate through several interconnected channels linking agricultural production, efficiency, nutrition, and household welfare. Secure land rights can strengthen bargaining positions, while greater decision-making authority can influence how technologies are used and how resulting income or production gains are allocated. Agricultural and food-security policies should therefore treat empowerment as part of the productive environment itself, since limiting women's control over land and household decisions can reduce both the efficiency of agricultural resources and the welfare gains generated by technological change.

### **2.3. Livelihood diversification, migration, social protection and rural risk management**

Van den Broeck and Maertens (2017) show that rural poverty reduction can occur through different pathways, including improved agricultural opportunities and movement toward nonagricultural employment. Their findings imply that rural households should not be expected to follow a single development trajectory because the relative benefits of agricultural commercialization, wage employment, and labor mobility depend on education, assets, location, and market access. Davis et al. (2017) reinforce this perspective by showing that rural African households commonly combine farming with wages, self-employment, and transfers rather than abandoning agriculture altogether. This suggests that diversification is better understood as the construction of livelihood portfolios than as a simple transition away from farming. Asfaw et al. (2019) add that the welfare effects of diversification vary according to the type of activity undertaken and the household's initial conditions, distinguishing income-enhancing diversification from responses driven mainly by distress. Dzanku (2019) further demonstrates that geography and gender shape access to remunerative off-farm employment and therefore influence the food-security effects of diversification. Together, these contributions imply that rural transformation depends on the quality and accessibility of both farm and nonfarm opportunities. Policies should therefore strengthen agricultural productivity while expanding productive employment outside agriculture, particularly for households facing spatial, gendered, or asset-related barriers to participation.

Abebaw et al. (2020) demonstrate that rural outmigration can improve calorie consumption and reduce the depth and severity of food poverty among households remaining in rural Ethiopia. This implies that migration can operate as an income- and risk-management strategy when remittances and changes in household resource allocation compensate for the labor that leaves agriculture. Dzanku (2019) introduces an important qualification by showing that access to beneficial nonfarm employment is strongly shaped by geography and gender, meaning that households do not face equal opportunities to diversify through labor mobility. Van den Broeck and Maertens (2017) similarly distinguish between moving up through better agricultural opportunities and moving out toward nonagricultural employment, suggesting that both routes can reduce poverty but are accessible to different groups. Davis et al. (2017) provide a broader livelihood perspective by showing that farming continues to coexist with wages, transfers, and self-employment across rural Africa. Taken together, these findings imply that migration and



nonfarm employment should not be interpreted as substitutes for agricultural development. Their contribution to food security depends on the quality of employment available to migrants, the continuity of transfers to origin households, and the ability of rural families to combine farm and nonfarm income sources. Rural policies should therefore support mobility without assuming that successful transformation requires complete disengagement from agriculture.

Handa et al. (2018) show that unconditional cash transfers can improve food security and living standards while also encouraging productive investments and economic activities. This implies that social protection can relax liquidity constraints that prevent poor rural households from exploiting potentially profitable opportunities. Daidone et al. (2017) strengthen this interpretation by demonstrating that cash transfers combined with agricultural inputs and support for homestead production can generate complementary effects on livelihoods and food security. Their findings suggest that consumption support and productive assistance address interconnected dimensions of rural poverty rather than separate policy problems. Cai (2016) adds a risk-management mechanism by showing that agricultural insurance can encourage households to allocate more resources to profitable but uncertain activities when protection against downside risk becomes available. Jensen and Barrett (2017), however, caution that index insurance can remain ineffective when basis risk, limited information, liquidity constraints, or weak trust reduce farmers' willingness or ability to rely on coverage. Together, these contributions imply that rural households require combined instruments addressing both resource constraints and exposure to risk. Social transfers can provide immediate consumption protection and investment capacity, while insurance and productive support can influence longer-term production decisions. Integrated programs may therefore generate stronger welfare effects than policies relying exclusively on transfers, insurance, or agricultural inputs in isolation.

Cai (2016) demonstrates that agricultural insurance can modify production and borrowing decisions by reducing the consequences of adverse outcomes, implying that some farmers remain in low-return activities because uninsured losses would threaten household welfare. The productive value of insurance therefore lies partly in changing farmers' willingness to assume economically beneficial risks. Jensen and Barrett (2017) qualify this potential by emphasizing that index insurance exposes farmers to basis risk when compensation does not correspond closely to individual losses. Their findings imply that insurance cannot provide complete protection unless product design, affordability, information, and trust are adequately addressed. Handa et al. (2018) identify a complementary constraint by showing that liquidity shortages can limit productive investment even when opportunities exist, while cash transfers can support both consumption and economic activity. Asfaw et al. (2019) further demonstrate that climatic and economic risks influence livelihood-diversification decisions, with welfare outcomes depending on whether households enter productive activities or diversify primarily as a defensive response. Taken together, these studies imply that risk and liquidity jointly shape rural investment choices. Insurance can reduce exposure to losses, but households may still lack the resources required to act on improved incentives. Combining effective risk protection with transfers, credit, savings, or other financial instruments can therefore provide stronger conditions for productive diversification and agricultural investment.

Daidone et al. (2017) show that integrating agricultural support with social protection can address both immediate food shortages and longer-term constraints to productive investment. This implies that policy boundaries between welfare assistance and agricultural development may be poorly suited to the realities of poor rural households, which simultaneously manage consumption needs, production risks, and limited access to productive assets. Handa et al. (2018) provide supporting evidence by showing that unconditional cash transfers can improve food security while stimulating certain investments and economic activities. Abebaw et al.



(2020) identify migration as another mechanism through which households diversify resources, since income generated by migrants can improve food consumption and reduce food poverty among those who remain in rural areas. Davis et al. (2017) place these mechanisms within broader livelihood portfolios in which farming, wages, self-employment, and transfers coexist. Together, these contributions imply that rural resilience is built through combinations of income sources and support mechanisms rather than through dependence on a single activity. Social transfers, migration income, agricultural production, and nonfarm earnings can perform complementary functions in stabilizing consumption and financing investment. Development policies should therefore recognize household portfolios explicitly and design interventions capable of strengthening both immediate welfare protection and the productive capacity needed for more durable reductions in rural poverty.

Asfaw et al. (2019) emphasize that livelihood diversification can improve welfare, particularly for poorer households, but that outcomes depend on whether diversification leads toward productive activities or reflects a response to economic and climatic distress. This distinction implies that the number of activities undertaken by a household is less important than their quality and income-generating capacity. Dzanku (2019) reinforces this point by showing that gender and geography influence access to remunerative off-farm employment, so the same diversification strategy may generate different food-security outcomes across households and locations. Jensen and Barrett (2017) add that risk-management instruments such as index insurance can support rural livelihoods but remain constrained by basis risk, liquidity, information, and trust. Daidone et al. (2017) demonstrate that combining social protection with agricultural interventions can respond more directly to the multiple constraints facing poor households. Taken together, these contributions imply that successful rural diversification requires more than encouraging households to engage in additional activities. It requires access to productive opportunities, credible mechanisms for managing risk, and sufficient resources to invest in both agricultural and nonagricultural livelihoods. Policies that combine employment creation, financial protection, agricultural support, and social transfers are consequently better positioned to distinguish productive diversification from coping strategies that merely redistribute poverty across several low-return activities.

### **3. Agricultural Development: Institutions, Digitalisation and Nutrition**

#### **3.1. Public policy, extension, input support and agricultural institutions**

Jayne et al. (2018) show that agricultural input subsidies can increase fertilizer use and crop production, but their productivity and welfare effects are often reduced by crowding out, targeting failures, low yield responses, and substantial fiscal costs. This implies that expanding subsidized input use should not automatically be interpreted as evidence of successful agricultural transformation. Ragasa and Mazunda (2018) reinforce this point by showing that the effectiveness of subsidized inputs depends partly on the quality, accessibility, and usefulness of agricultural extension. Their findings imply that farmers require appropriate information and technical support if subsidized technologies are to be used effectively under actual production conditions. Messina et al. (2017) add that yield responses to input subsidies vary according to soils, rainfall, farming systems, and farmer characteristics, meaning that nationally uniform programs can conceal important spatial heterogeneity. Arndt et al. (2016) broaden these implications by showing that subsidy programs also affect prices, public finances, and wider economic linkages. Together, these contributions imply that agricultural subsidies should be evaluated as part of a wider institutional and economic system. Their effectiveness depends on extension quality, local agronomic conditions, implementation, and opportunity costs, particularly where



governments must choose between recurrent input support and longer-term investments in research, infrastructure, soil management, and other productivity-enhancing public goods.

Wossen et al. (2017) demonstrate that the design of subsidy-delivery mechanisms can influence agricultural productivity and household welfare, with Nigeria's electronic-voucher system improving farmers' access to productive inputs while reducing some administrative problems associated with conventional distribution. This implies that institutional design matters even when the basic policy instrument remains an input subsidy. Ricker-Gilbert and Jayne (2017) introduce a dynamic dimension by showing that fertilizer subsidies can affect farmers' subsequent commercial fertilizer purchases and maize production, while also potentially displacing inputs that farmers would otherwise have bought on the market. Their findings imply that program success should be assessed according to additional input use rather than subsidized distribution alone. Jayne et al. (2018) reinforce this qualification by showing that crowding out and targeting problems frequently reduce the expected returns from subsidy programs. Ragasa and Mazunda (2018) further demonstrate that extension services can condition the productivity of subsidized inputs by influencing farmers' ability to use them appropriately. Taken together, these contributions imply that the performance of input-support programs depends on the interaction between delivery systems, farmer behavior, technical advice, and market responses. Improving administrative efficiency can increase access, but lasting productivity gains require complementary extension and careful assessment of whether public support expands rather than merely replaces privately financed input use.

Keil et al. (2016) show that access to agricultural technologies can depend more on institutional arrangements than on individual ownership, since custom-hiring services allow smallholders to use specialized machinery without bearing high fixed acquisition costs. This implies that inclusive mechanization can be promoted through service markets rather than through policies encouraging every farmer to purchase expensive equipment. Keil et al. (2015) complement this institutional perspective by showing that zero-tillage wheat can reduce production costs and improve efficiency under actual farmer conditions while supporting more resource-conserving production. Their findings indicate that sustainable technologies can become economically attractive when they simultaneously reduce costs and improve resource use. Kumar et al. (2020) broaden the question of access by showing that technological diffusion after development interventions depends on local networks, institutional continuity, and complementary services. Initial adoption may therefore fail to become durable when external support disappears. Ragasa and Mazunda (2018) similarly emphasize that farmers' access to useful extension advice determines whether technologies and inputs generate effective outcomes. Together, these contributions imply that technology promotion should focus not only on the characteristics of innovations themselves but also on the institutions through which farmers access, learn about, and continue using them. Service markets, extension systems, local networks, and institutional continuity can reduce adoption barriers and support diffusion beyond the duration of individual projects.

Arndt et al. (2016) demonstrate that agricultural subsidies produce effects beyond participating farms by influencing production, prices, public expenditure, and intersectoral linkages. Their findings imply that the evaluation of subsidy programs should include economy-wide opportunity costs rather than concentrate exclusively on immediate changes in yields or input use. Ricker-Gilbert and Jayne (2017) reinforce the importance of longer-term evaluation by showing that subsidized fertilizer can influence subsequent commercial demand, while also potentially displacing purchases that would have occurred without public support. Messina et al. (2017) add that the productivity response to subsidized inputs is heterogeneous across locations and farming conditions, suggesting that uniform allocation may generate weak returns in areas where agronomic constraints limit fertilizer effectiveness. Wossen et al. (2017) demonstrate



that improved delivery through electronic vouchers can nevertheless strengthen productivity and welfare outcomes when administrative systems improve farmers' access to inputs. Taken together, these contributions imply that the effectiveness of agricultural subsidies depends on several layers of policy design. Delivery mechanisms can improve access, but economic returns also depend on local production conditions, additional rather than displaced input use, and the fiscal resources absorbed by the program. Governments should therefore compare subsidy expenditures with alternative investments and direct scarce support toward farmers and locations where complementary conditions make substantial productivity gains more likely.

Kumar et al. (2020) emphasize that the sustainability of agricultural technology adoption depends on whether local institutions, farmer networks, and complementary services continue functioning after externally financed interventions end. This implies that successful project-level adoption should not be confused with durable technological diffusion. Keil et al. (2016) provide a related institutional mechanism by showing that machinery-service markets can enable small farms to access profitable technologies without purchasing capital-intensive equipment individually. Such arrangements can lower entry barriers and create locally embedded channels through which technology use persists. Ragasa and Mazunda (2018) further show that extension quality affects whether farmers are able to make effective use of agricultural technologies and subsidized inputs, highlighting the importance of continuous knowledge support. Keil et al. (2015) add that technologies introduced under real farming conditions need to generate economic as well as environmental advantages, as illustrated by zero tillage that can reduce costs while improving production efficiency. Together, these contributions imply that lasting diffusion depends on a combination of economic attractiveness and institutional persistence. Technologies are more likely to remain in use when they reduce costs or improve returns and when farmers retain access to information, machinery services, and locally embedded support systems. Agricultural development programs should therefore build institutions capable of surviving beyond the initial intervention rather than relying on temporary project structures to sustain adoption.

Messina et al. (2017) show that differences in soil conditions, rainfall, farmer characteristics, and farming systems generate substantial variation in the yield response to subsidized inputs. This implies that spatially uniform agricultural support can allocate public resources inefficiently when production constraints differ across locations. Jayne et al. (2018) reach a compatible conclusion by emphasizing that low yield responses, targeting problems, and the absence of complementary technologies can substantially reduce the welfare and productivity effects of fertilizer subsidies. Arndt et al. (2016) extend these concerns to the broader economy by demonstrating that agricultural subsidies involve fiscal costs and alter markets, prices, and economic incentives. Kumar et al. (2020) further indicate that technological interventions require institutional continuity and local networks if adoption is to persist after donor or public support declines. Taken together, these contributions imply that agricultural policy should move from standardized input distribution toward differentiated and institutionally supported interventions. Spatial information can help identify where specific technologies are likely to generate stronger returns, while local institutions can sustain diffusion and adaptation after initial support ends. Public expenditure can therefore become more effective when targeting reflects agronomic and socioeconomic heterogeneity and when temporary subsidies are complemented by investments in knowledge systems, service provision, and locally embedded institutions capable of supporting longer-term productivity improvements.

### **3.2. Digital agriculture, information, mobile finance and insurance**

Deichmann et al. (2016) argue that digital technologies can reduce information and transaction costs, improve coordination, and facilitate access to services, but only when they are supported



by infrastructure, skills, institutions, and competitive markets. This implies that digitalization should be viewed as a complement to conventional rural-development investment rather than as a substitute for it. Aker and Ksoll (2016) provide experimental evidence consistent with this interpretation, showing that mobile-based information and training can influence certain production decisions, including crop diversification, without transforming every agricultural market outcome. Their findings indicate that information gains remain constrained when farmers continue to face problems involving transport, credit, physical inputs, or market power. Fabregas et al. (2019) nevertheless show that digital agricultural advice can improve technology adoption and agricultural performance at relatively low communication cost, particularly where conventional extension systems struggle to reach dispersed farmers. Rajkhowa and Qaim (2021) extend this implication by showing that personalized digital extension is associated with greater input use, diversification, productivity, and crop income. Taken together, these contributions imply that digital extension is most effective when information is relevant to farm-specific conditions and when complementary infrastructure and institutions allow farmers to act on the advice they receive rather than merely increasing their exposure to agricultural information.

Baumüller (2018) cautions against assuming that mobile-phone-enabled services automatically generate sustained improvements in smallholder productivity or income, emphasizing that rigorous evidence remains uneven across different digital applications. This implication encourages evaluation of actual use, behavioral responses, distributional effects, and persistence beyond pilot interventions rather than relying on initial adoption figures. Cole and Fernando (2021) reinforce the importance of behavioral responses by showing that mobile agricultural advice can alter farming practices and that knowledge can spread beyond directly treated farmers through social networks. Such diffusion implies that the effects of digital extension are partly embedded in existing rural relationships rather than confined to individual users. Fabregas et al. (2019) similarly emphasize that mobile advice works best when recommendations are locally relevant, trusted, and supported by mechanisms allowing farmers to respond or seek clarification. Aker and Ksoll (2016) add that information interventions cannot compensate for missing infrastructure or weak markets even when they succeed in changing selected production decisions. Together, these studies imply that digital agriculture should be assessed as part of a wider information and institutional system. Its effectiveness depends on whether farmers trust the advice, communicate with other producers, possess complementary resources, and operate in markets where improved information can actually be converted into more productive decisions and sustained welfare gains.

Suri and Jack (2016) show that mobile money can reduce extreme poverty and strengthen households' capacity to transfer resources, manage shocks, and reallocate labor, with particularly important effects for women. Although these mechanisms extend beyond farming itself, they imply that digital finance can improve the flexibility of rural household financial management where agricultural incomes are seasonal and social networks are geographically dispersed. Batista and Vicente (2020) provide a more direct agricultural mechanism by showing that access to mobile savings can encourage smallholders to invest more in farming, including fertilizer expenditure. Their findings suggest that digital savings help households transfer resources across seasons and address liquidity constraints without relying on conventional bank branches. Carter et al. (2017) broaden the financial-risk perspective by emphasizing that agricultural insurance can protect assets and encourage investment in profitable but uncertain technologies, although basis risk and product cost remain significant constraints. Deichmann et al. (2016) place these financial services within a wider digital ecosystem in which connectivity, institutions, infrastructure, and competitive markets condition effectiveness. Together, these contributions imply that digital finance can support agricultural development through savings,



transfers, liquidity management, and risk sharing, but its developmental contribution depends on broader financial and institutional conditions that determine whether rural households can transform improved financial flexibility into productive agricultural investment.

Carter et al. (2017) emphasize that agricultural insurance is most effective when it forms part of a broader risk-management architecture combining credit, savings, stress-tolerant technologies, and other instruments. This implies that insurance alone cannot resolve the multiple sources of uncertainty facing smallholders, particularly when basis risk or high premiums weaken effective protection. Suri and Jack (2016) demonstrate how mobile financial systems can complement such mechanisms by facilitating resource transfers and risk sharing across households and locations. Batista and Vicente (2020) add that mobile savings can address another dimension of vulnerability by enabling farmers to preserve income from one period for productive expenditure in a later agricultural season. Rajkhowa and Qaim (2021) show that personalized digital extension can simultaneously influence input use, diversification, productivity, and income by improving the relevance of technical information available to farmers. Taken together, these contributions imply that digital and financial innovations can become mutually reinforcing when they address different constraints within the same production system. Savings can strengthen liquidity, mobile transfers can support informal insurance, formal insurance can limit downside risk, and personalized advice can improve investment decisions. Agricultural policy can therefore obtain stronger results by integrating these instruments instead of treating finance, information, and risk management as separate components of rural development.

Cole and Fernando (2021) show that mobile agricultural information can diffuse through farmer networks, implying that the social returns to digital extension may exceed the effects observed among direct recipients. This diffusion mechanism suggests that rural social structures can amplify information interventions when farmers exchange knowledge and observe one another's practices. Rajkhowa and Qaim (2021) complement this perspective by emphasizing personalization, showing that digital advisory services are more useful when recommendations reflect differences in crops, soils, resources, and market conditions. Fabregas et al. (2019) similarly argue that digital extension should supplement rather than replace conventional advisory systems because local agronomic knowledge and farmer trust remain central to effective communication. Baumüller (2018), however, cautions that enthusiasm for mobile services should not exceed the available evidence on sustained productivity and income effects. Together, these contributions imply that the value of digital extension lies less in the simple transmission of larger quantities of information than in the quality, relevance, credibility, and circulation of that information. Effective programs need to combine scalable communication technologies with local expertise and farmer networks while monitoring whether adoption and productivity effects persist. Such an approach can expand extension coverage without assuming that standardized mobile messages alone are sufficient to address the heterogeneous information needs of smallholders.

Aker and Ksoll (2016) demonstrate that mobile-based information can influence certain agricultural decisions but does not remove constraints related to credit, transport, market power, or access to inputs. Their findings imply that digital technologies have their strongest effects when the underlying problem is genuinely informational. Deichmann et al. (2016) generalize this limitation by emphasizing the need for analog complements such as roads, electricity, skills, institutions, and functioning markets if digital tools are to produce broader developmental effects. Batista and Vicente (2020) show how digital finance can address one of these complementary constraints by helping farmers manage seasonal liquidity and increase agricultural investment through mobile savings. Suri and Jack (2016) further demonstrate that mobile money can strengthen household risk sharing and reduce poverty by lowering the cost of transferring and



reallocating financial resources. Taken together, these contributions imply that digital agriculture should be understood as an interconnected system rather than a collection of isolated applications. Information services can improve decisions, while digital finance can strengthen farmers' capacity to act on those decisions, but both remain dependent on physical and institutional conditions outside the digital sphere. Agricultural digitalization is therefore more likely to support food security and rural development when communication technologies, financial services, infrastructure, markets, and complementary productive resources evolve together.

### **3.3. Nutrition-sensitive agriculture, dietary diversity and sustainable food systems**

Ruel et al. (2018) show that agricultural interventions generate stronger nutritional outcomes when nutrition objectives are explicitly incorporated and supported by complementary measures such as behavior-change communication and women's empowerment. This implies that increases in agricultural output or income should not be expected to translate automatically into improved nutrition. Carletto et al. (2015) reinforce this interpretation by identifying several pathways through which agriculture affects nutrition, including own-food production, agricultural income, food prices, and women's influence over household decisions. Their framework suggests that the nutritional effects of agricultural change depend on how additional production or income modifies consumption and intrahousehold allocation. Chegere and Stage (2020) add that greater production diversity can improve dietary diversity, while effects on final nutritional status remain more limited because income, education, health, care practices, and nutrient absorption also matter. Sibhatu and Qaim (2018) similarly find that production diversity is positively associated with dietary diversity, but the average effect is relatively small and varies across contexts. Together, these contributions imply that nutrition-sensitive agriculture requires a broader policy framework than production expansion alone. Agricultural interventions can improve access to diverse foods, but stronger nutritional outcomes depend on household purchasing power, health conditions, decision-making, education, and complementary social measures that determine how agricultural gains are converted into actual improvements in human nutrition.

Sibhatu et al. (2015) demonstrate that greater farm-production diversity can improve dietary diversity among smallholders, but the relationship is modest and may be weaker than the effect of improved market access. This implies that requiring every household to produce a wide range of foods is not necessarily the most effective route to better diets. Koppmair et al. (2017) strengthen this conclusion by showing in Malawi that market access can be at least as important as on-farm diversity because agricultural technologies and commercialization raise income that households can use to purchase foods they do not produce. Ogutu et al. (2020) extend this mechanism by demonstrating that commercialization can improve calorie and micronutrient consumption through higher income and greater reliance on purchased foods without necessarily eliminating the nutritional contribution of own production. Jones (2017), however, shows that crop-species richness remains positively associated with dietary diversity and quality, particularly in contexts where household orientation and local market conditions make own production important. Taken together, these studies imply that specialization and diversification should not be treated as universally competing strategies. Their relative nutritional value depends on market access, household production orientation, purchasing power, and the availability of nutritious foods. Policy should therefore support diversified food markets while preserving strategic production diversity where market access remains weak or unreliable.

Ogutu et al. (2020) show that agricultural commercialization can improve calorie and micronutrient consumption by increasing household income and access to purchased foods. This implies



that stronger market orientation does not necessarily undermine household nutrition by shifting land away from subsistence food production. Koppmair et al. (2017) provide a compatible explanation by showing that market access enables households to obtain diverse foods that they do not produce themselves, making income and market functioning important components of dietary improvement. Sibhatu and Qaim (2018) reinforce this interpretation through their meta-analysis, which indicates that commercialization and market access can generate stronger dietary improvements than production diversification in many settings. Carletto et al. (2015), however, emphasize that agricultural income is only one pathway linking agriculture to nutrition and that changes in food prices, own production, and intrahousehold decision-making can alter final outcomes. Together, these contributions imply that commercialization can strengthen nutrition when income gains are accompanied by accessible and well-functioning food markets. Greater agricultural earnings increase purchasing power, but the nutritional effect depends on whether households can obtain affordable and diverse foods and whether additional resources are allocated toward improved diets. Agricultural-market policies should therefore connect commercialization with food-market development rather than assuming that higher cash income alone guarantees better nutritional outcomes.

Jones (2017) demonstrates that greater crop-species richness can improve dietary diversity and quality, implying that own production remains an important nutritional pathway even among households participating in markets. This finding cautions against assuming that greater specialization is always preferable once commercialization expands. Sibhatu et al. (2015), however, show that the association between production diversity and dietary diversity is relatively modest and that improved market access can sometimes generate larger nutritional benefits. Chegere and Stage (2020) provide another qualification by showing that production diversity can improve dietary diversity without necessarily producing equally strong improvements in nutritional status. Their findings imply that greater food variety at the household level is only one step toward improved nutrition. Ruel et al. (2018) explain this gap by emphasizing that final nutritional outcomes also depend on care practices, health, sanitation, women's empowerment, and behavioral responses. Together, these contributions imply that production diversification should be promoted selectively rather than as a universal prescription. It can improve access to nutritious foods where markets are weak or where households depend heavily on own production, but its contribution to final nutritional status depends on complementary conditions. Nutrition-sensitive agriculture should therefore combine context-specific production strategies with health, education, sanitation, and household-level interventions capable of converting improved dietary access into better nutritional outcomes.

Sibhatu and Qaim (2018) show that the positive relationship between production diversity and dietary diversity varies considerably across settings, implying that agricultural policy should account for differences in market integration and comparative advantage. Encouraging every farmer to maximize crop diversity may impose economic costs where specialization can generate higher income and markets provide reliable access to diverse foods. Ogotu et al. (2020) reinforce this argument by demonstrating that commercialization can raise calorie and micronutrient consumption through increased income and food purchases. Jones (2017), nevertheless, shows that crop diversity continues to contribute positively to diet quality, indicating that own-production pathways remain relevant under certain household and market conditions. Koppmair et al. (2017) connect these perspectives by showing that both farm production and market access shape dietary diversity in Malawi, with market access often exerting a particularly important influence. Taken together, these findings imply that nutrition-sensitive agricultural policy should avoid choosing rigidly between diversification and specialization. The appropriate balance depends on the strength of local food markets, production conditions, house-



hold preferences, and income opportunities. Strategic diversification can protect access to nutritious foods where markets are incomplete, while profitable specialization can support dietary diversity through higher purchasing power when markets function efficiently and offer an adequate range of affordable foods.

Carletto et al. (2015) emphasize that agriculture influences nutrition through multiple channels and that changes in farm production should be linked explicitly to the mechanisms through which they affect diets and nutritional status. This implies that evaluating agricultural programs only through yields or household income can overlook whether additional resources actually improve food consumption and health. Ruel et al. (2018) reinforce this point by showing that stronger nutritional effects emerge when agricultural programs integrate nutrition objectives, women's empowerment, and behavior-change components. Chegere and Stage (2020) further demonstrate that improvements in dietary diversity do not necessarily translate proportionally into better nutritional status, because health conditions, education, care practices, and nutrient absorption remain important. Ogutu et al. (2020) add that commercialization can improve both calorie and micronutrient consumption when higher agricultural income allows households to purchase more diverse foods. Together, these contributions imply that the agriculture–nutrition relationship should be treated as a sequence of interconnected mechanisms rather than a direct production-to-nutrition effect. Agricultural growth can increase food availability and purchasing power, but the eventual nutritional outcome depends on market access, household allocation, care practices, health conditions, and women's agency. Effective policy therefore requires coordination between agriculture, nutrition, health, and social interventions so that production and income gains translate more consistently into improved diets and human welfare.

#### **4. Discussion**

The literature first indicates that agricultural productivity remains an important determinant of food security, but its effects depend on the economic and institutional conditions surrounding technological adoption. Emerick et al. (2016) show that agricultural technologies can influence farmers not only by increasing expected yields but also by reducing downside production risk, thereby encouraging greater productive investment. Kassie et al. (2015) similarly demonstrate that agricultural practices differ in their productivity, risk, and food-security effects and that adoption decisions frequently involve combinations of technologies rather than isolated innovations. Manda et al. (2016) further show that improved crop technologies combined with sustainable agricultural practices can increase productivity and household income. However, Suri and Udry (2022) emphasize that low adoption cannot always be attributed to information failures or inadequate access to finance, because expected returns differ substantially across households and locations. Kathage et al. (2016) likewise show that nonadoption may reflect limited local profitability. These findings suggest that agricultural modernization requires differentiated policies that recognize variations in profitability, risk, liquidity, and institutional support. This conclusion becomes more important under climate change. Ortiz-Bobea et al. (2021), Ray et al. (2019), Zhao et al. (2017), and Lesk et al. (2016) show that rising temperatures and extreme climatic events are already reducing agricultural productivity and increasing production instability, making resilience a central component of agricultural policy.

A second major finding concerns the relationship between agricultural development and rural poverty reduction. Ivanic and Martin (2018) show that agricultural productivity growth can generate stronger poverty-reduction effects than comparable growth in other sectors in poorer economies, particularly where disadvantaged households remain closely connected to agriculture. Ligon and Sadoulet (2018) similarly find that agricultural growth can produce relatively large expenditure gains among poorer households. Dorosh and Thurlow (2018) broaden this mechanism by showing that agricultural expansion stimulates processing, trade, services, and



other nonfarm activities through rural demand and employment linkages. Agricultural growth therefore contributes to poverty reduction through both direct farm income and indirect intersectoral effects. Nevertheless, Diao and McMillan (2018) emphasize that structural transformation is beneficial only when workers move toward activities that offer sufficiently high productivity. Christiaensen and Martin (2018) likewise argue that declining agricultural employment should not itself be interpreted as successful transformation. The Moroccan contributions of El Hamidi (2023) and Makhrouf et al. (2024) reinforce this distributional perspective by emphasizing that economic growth becomes more inclusive when institutional quality, employment, education, redistribution, and social inclusion enable poorer households to participate in expanding economic opportunities. Agricultural development therefore reduces rural poverty more effectively when productivity gains are accompanied by broader institutional and structural conditions that support their distribution across households.

The third finding is that agricultural development is fundamentally institutional and multidimensional. Jayne et al. (2018) show that agricultural input subsidies may increase fertilizer use and production, but their effectiveness is often reduced by targeting problems, crowding out, weak yield responses, and fiscal costs. Ragasa and Mazunda (2018) demonstrate that extension services influence whether farmers use agricultural inputs effectively, while Wossen et al. (2017) show that improved delivery mechanisms can strengthen productivity and welfare outcomes. Digital technologies create similar conditional effects. Deichmann et al. (2016) argue that digital agriculture depends on infrastructure, skills, institutions, and functioning markets, while Fabregas et al. (2019) and Rajkhowa and Qaim (2021) show that digital extension can improve agricultural decisions when information is relevant, credible, and sufficiently adapted to farmers' conditions. These institutional mechanisms are also linked to household welfare. Kassie et al. (2020) and Seymour (2017) show that women's empowerment affects dietary outcomes and agricultural efficiency, while Ruel et al. (2018) and Carletto et al. (2015) demonstrate that agricultural production and income increases do not automatically improve nutrition. Sibhatu et al. (2015) and Koppmair et al. (2017) further show that market access can sometimes influence dietary diversity more strongly than farm-level production diversity. Agricultural development therefore requires coordination between production policy, markets, institutions, gender inclusion, finance, and nutrition.

## Conclusion

The analysis shows that food security, rural poverty, and agricultural development are connected through a set of interdependent productive, economic, institutional, and environmental mechanisms. Agricultural productivity remains an important basis for improving rural welfare because higher and more stable production can increase food availability, household income, and opportunities for participation in wider markets. However, the benefits of technological change depend on farmers' capacity to finance, adopt, and effectively use agricultural innovations under heterogeneous production conditions. Market access, extension services, infrastructure, and local profitability strongly influence these outcomes. Climate change introduces additional constraints by weakening productivity growth and increasing exposure to production shocks, requiring adaptation and resilience to become integrated into agricultural-development strategies. Commercialization and participation in agricultural value chains can strengthen household purchasing power and reduce poverty, but their effects remain dependent on household assets, market institutions, and the ability of producers to meet changing commercial requirements. Agricultural development should therefore not be assessed solely through increases in output or input use. Sustainable improvements in food security require a broader



policy framework combining productivity, climate adaptation, market development, institutional support, infrastructure, access to finance, and mechanisms that protect households against production and price risks.

The findings also indicate that rural poverty reduction requires agricultural policies to operate within a wider process of structural and social transformation. Agricultural productivity can stimulate nonfarm employment and generate significant poverty-reduction effects, but its distributional consequences depend on land access, labor mobility, human capital, gender relations, and institutional quality. Women's control over productive resources and participation in household decisions influence both agricultural efficiency and the way production and income gains are converted into household welfare. Livelihood diversification, migration, social transfers, and agricultural insurance also strengthen households' capacity to stabilize consumption and manage uncertainty. Digital technologies and mobile financial services can facilitate access to information, savings, transfers, and agricultural advice, but their contribution remains dependent on infrastructure and effective institutions. Nutrition-sensitive agriculture further shows that increased agricultural production or income is insufficient when gains do not translate into improved diets and nutritional outcomes. Sustainable rural development in emerging economies therefore requires coordination across agriculture, markets, social protection, infrastructure, finance, gender policy, and nutrition. The effectiveness of agricultural transformation ultimately depends on whether productivity growth is converted into greater resilience, broader economic participation, lower poverty, and improved living conditions among rural households.

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