Independent Commission for Aid Impact

UK aid to agriculture in a time of climate change

Literature review

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Abbreviations

AR4D	Agricultural research for development
CGIAR	Formerly the Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Centre for the Improvement of Maize and Wheat
CSA	Climate-smart agriculture
DFID	Department for International Development (merged with the Foreign and Commonwealth Office in September 2020)
FAO	Food and Agriculture Organisation
FCDO	Foreign, Commonwealth and Development Office (established after the merger of the Department for International Development and the Foreign and Commonwealth Office in September 2020)
HYV	High-yield variety
ICT	Information and communication technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IITA	International Institute for Tropical Agriculture
IRRI	International Rice Research Institute
LAC	Latin America and the Caribbean
M4P	Making markets work for the poor
NGO	Non-governmental organisation
NSA	Nutrition-sensitive agriculture
NSmartAg	Nutrition-smart agriculture
ODA	Official development assistance
SDG	Sustainable Development Goal
UNCTAD	United Nations Conference on Trade and Development
WFP	World Food Programme

1. Introduction

1.1 Scope, structure and definitions

This literature review provides evidence and conceptual background to inform the Independent Commission for Aid Impact's (ICAI) review on UK aid to agriculture in a time of climate change. It offers an informative, rather than systematic, overview of key and contemporary debates on agricultural development during an era of climate change, with a key focus on good practice. The scope is defined by the ICAI review, which focuses on specific aspects of, and themes relevant to, the UK government's official development assistance (ODA) approach to agriculture.1 Its overall purpose is to summarise available evidence to answer two key questions:

- What kind of agricultural development improves food and nutrition security, poverty reduction and economic growth, and climate outcomes?
- What is the role of bilateral donor agencies in supporting such development?

Report structure and definitions

After the introduction, the literature review is divided into five further chapters. The introduction first defines the two overall terms 'agriculture' and 'food security', before providing a chapter overview with definitions of key terms used in each chapter.

Defining agriculture: The term ***agriculture*** throughout this paper refers to farming and supply chains of agricultural inputs and produce related to crop and livestock production. While agriculture is broadly understood as economic activities involving crop raising, animal husbandry, forestry, and artisanal fisheries (HLPE, 2013, p. 2), the ICAI review excludes forestry and fisheries from its scope.

Defining food security: While agriculture is often discussed in terms of achieving food security, the term 'food security' has broader connotations. ***Food security*** consists of: the physical availability of food through agriculture and trade; economic and physical access to food shaped by prices, markets, and distribution; the body's ability to utilise nutrients in food; and the stability of these three factors over time (World Bank, 2022; FAO, 2018, p. 1).

Chapter 2 provides an overview of the state of agriculture in the Global South, discourse and trends in agricultural ODA since 1950, and current challenges.

Chapter 3 looks at smallholder commercialisation, which has been a significant focus of the UK's support to agriculture during the review period. The UK Foreign, Commonwealth and Development Office's (FCDO) *Conceptual framework on agriculture* (DFID, 2015) and *Economic development strategy* (DFID, 2017) identify support for commercial agriculture, particularly engaging smallholders in commercial activities, as a core component of its strategy for agricultural development and inclusive economic growth (CABI, 2021). There are no agreed definitions of what constitutes a small farm or a smallholder farmer. Comparisons of farm size are relative and context-specific (Lowder et al., 2016); what is considered a small farm in a Latin American context is different from a small farm in an African or Asian context. The term 'smallholder' often refers not only to the size of land held, but also to available resources and assets. It should also be noted that countries adopt different definitions for measuring smallholders nationally, making cross-country comparisons difficult (HLPE, 2013). For the purposes of this literature review, acknowledging the limitations of this definition, the term ***smallholder*** will refer to farmers on 'small-scale' farms (using the FAO definition of farms that are under two hectares in size (Wolfenson, 2013)) who have limited capital, few assets, and low access to inputs (Chamberlin, 2007; HLPE, 2013). In developing countries, such farms are typically worked mostly by a family's own labour to produce a large share of their income and have limited resources for increasing their productivity, such as labour, technology, or inputs (HLPE, 2013). ***Smallholder commercialisation*** refers to smallholders transitioning from largely subsistence activities – growing food for their own consumption – to growing food for sale to markets, and thereby contributing momentum to broader economic growth (World Bank, 2008). **Chapter 3** examines the available evidence on smallholder commercialisation to answer three questions:

[1] See *UK aid to agriculture in a time of climate change: approach paper*, Independent Commission for Aid Impact, February 2023, link.

- What have been the key approaches taken to smallholder commercialisation and market system development?
- How does commercialisation affect rural communities and different actors within them?
- What good practices have evolved out of ODA programmes to enable smallholder commercialisation and develop agricultural market systems?

Chapter 4 explores agriculture, climate change and the environment. Environmental sustainability and climate-smart agriculture is a cross-cutting priority for FCDO's approach to agriculture (DFID, 2015). Generally, agriculture is a climate-vulnerable sector and has been a major contributor to climate change (FAO, 2013a). In this literature review, ***climate-smart agriculture (CSA)*** refers to approaches that simultaneously improve agricultural productivity and incomes, strengthen resilience to climate shocks and/or adapt to changing conditions, and reduce and/or remove greenhouse gas emissions where possible (Lipper and Zilberman, 2018; Grist, 2015). **Chapter 4** summarises the available evidence on CSA to address the following questions:

- What is CSA and what are its main strategies and interventions?
- What are the potential benefits and costs associated with CSA?
- What good practices have evolved out of CSA ODA programmes and to what extent have they been promoted?

Chapter 5 focuses on the provision of nutritious and safe food, another cross-cutting priority for FCDO's work on agriculture (DFID, 2015). ICAI's *Assessing DFID's results in nutrition* recommended that FCDO should scale up work on making nutritious diets available to all through nutrition-sensitive agriculture (ICAI, 2020). Nutrition-sensitive strategies engage not only with dietary practices, but also with the enabling environments surrounding access to nutritious foods. ***Nutrition-sensitive agriculture (NSA)*** can include interventions anywhere in the food system, from production to processing and distribution, to improve nutrition outcomes (SPRING, 2015). **Chapter 5** summarises evidence on NSA to answer three questions:

- What approaches and practices have been applied to agricultural production and value chains to make them 'nutrition-sensitive'?
- How does climate change affect the nutritional quality of food and how, in turn, do diet and nutrition affect resilience to climate change?
- What good practices have evolved out of nutrition-sensitive ODA programmes and to what extent have they been promoted?

Chapter 6 looks at the state of agricultural research. Approximately half of UK ODA to agriculture was spent on research over the review period.[2] Over the last century, research has enabled unprecedented agricultural productivity gains (Mellor, 2017). For the purpose of this literature review, ***agricultural research*** includes any activity aimed at innovation in food systems. This includes activities as varied as laboratory-based advanced biosciences; multidisciplinary field research examining links between agricultural, ecological, and social systems; and economic and policy research focused on expanding the uptake of new technologies or reforming food markets. **Chapter 6** looks at agricultural research to address the questions:

- Is agricultural research a relevant and effective use of ODA expenditure?
- Why is investing in agricultural research relevant to agricultural development in a time of climate change?

1.2 Methods and approaches

Literature review approach

The literature review involved conducting online searches through Google Scholar, exploring online publications from development, climate change and agriculture-focused organisations, and conducting informal and open-ended interviews with three thematic experts to source relevant literature. The literature included peer-reviewed books and journals, as well as policy research reports and publications from research institutes and international

[2] OECD Creditor Reporting System online database, link.

organisations like the Food and Agriculture Organisation (FAO), the World Bank, UN agencies and government departments like FCDO. To avoid secondary researcher bias, theoretical triangulation was used to ensure the paper captured different sides of debates. 257 sources were reviewed to draft this paper.

Gaps and limitations of the literature review

One of the main limitations in evaluating the impact of agriculture interventions is a lack of robust and high-quality data at the national level. Agricultural and food security data are often fraught with gaps and quality issues from their collection to their interpretation (Carletto, 2021; James and Job, 2015; Ammar et al., 2022). National data collection, through national surveys and censuses, is often under-resourced and reliant on farmers self-reporting. This often results in measurement errors due to a variety of practical and structural irregularities, such as crop and seed misclassifications (Carletto, 2021). Lack of qualified staff to analyse data often results in years of delays and gaps in published data (Carletto, 2021; Ammar et al., 2022).

The lack of consistent, robust and high-quality data makes comparative analyses on countries and global estimates difficult. Many of the non-state-sourced statistics referenced come from multiple datasets based on a variety of parameters and assumptions (James and Job, 2015; Carletto, 2021). Therefore, the information on farm sizes, land tenure, land use, irrigation, labour and agricultural inputs are rough approximations based on generous assumptions (FAO, 2022; Lowder et al., 2021; FAO, 2021a). This limits both researchers' ability to draw broad conclusions on the agricultural strategies needed to drive economic growth and development and policymakers' ability to develop empirically based policies. Complex questions on effective pathways to development are best addressed through a context-specific lens which accounts for limitations in data collection and interpretation.

2. The state of agriculture

2.1 Why agriculture matters

Global food prices have been highly volatile in recent years. This has been due largely to global events such as the COVID-19 pandemic, rising fuel prices, global recession, and the Russian invasion of Ukraine (Rice et al., 2022; Glauben et al., 2022; Taghizadeh-Hesary, 2019). Current and earlier studies show that high food prices are felt most acutely by poor food consumers across developing countries, who often experience increased hunger and lower-quality diets as a result (FAO, IFAD, UNICEF, WFP and WHO, 2022; Braun, 2007; Ivanic and Martin, 2014; IFPRI, 2007). During the food price shock of 2007-08, the negative impacts of high food prices on poor people drew more attention to official development assistance (ODA) for agriculture (Ivanic and Martin, 2014; IFPRI, 2007).

Agricultural development supports the second Sustainable Development Goal (SDG): the elimination of all forms of hunger everywhere by 2030. Increasing agricultural yields contributes to increased food supply, which is a necessary component of achieving food security (Hafner, 2003; Southgate, 2009). Investments in agricultural development have long focused on productivity gains. This investment helped to grow global food supply between 1950 and 2010 much faster than the global population grew (Hafner, 2003; Tian and Yu, 2019; Tomlinson, 2013; Southgate, 2009). However, two decades into the 21st century, hundreds of millions of people face hunger and malnutrition.

Most poor people remain rural, and agriculture is the foundation of rural economies (World Bank, 2008). Improving agricultural productivity supports rural poverty reduction through increased income and employment. It can also ease the poverty of food consumers everywhere by bringing down food prices (Southgate, 2009). Improved food and nutrition security also contributes to improving other markers of poverty, especially human health, child mortality, and educational outcomes (FAO, IFAD, UNICEF, WFP and WHO, 2022). The poverty reduction targets of the Millennium Development Goals and SDGs have concentrated minds on how to stimulate rapid economic growth and transformation in low-income countries (UN, 2015; UN, 2022). In recent decades, there has been a growing argument that agriculture can be an engine for broader economic growth, contributing to trade and growth in the industrial and service sectors (Guarin et al., 2022; Fan and Rue, 2020; Kariuki, 2006).

As a climate-vulnerable sector, agriculture's contribution to food security, poverty reduction and economic growth depends on climate adaptation and resilience (Collier and Dercon, 2014; Williams, 2020; Kori and Kori, 2022; Shiferaw et al., 2009). There are also opportunities for agriculture to help mitigate climate emissions. Although most emissions come from the Global North, and there is general agreement that poor farmers should not bear the cost of mitigation efforts, agriculture is a significant source of emissions in many low-income countries (FAO, 2014). The ecological and biodiversity crisis creates parallel concerns, given that land use conversion for agriculture and agricultural waste are major drivers of ecological degradation (Lynch et al., 2021; FAO, 2014; Vermeulen et al., 2012). This raises questions of how agricultural production can be intensified sustainably without placing the burden on the poor.

There remains a need to understand 'what works' and how ODA can best contribute to effective agricultural development. As described above, investment in agricultural development can, in principle, contribute to food and nutrition security, poverty reduction and climate outcomes. Yet in contrast to the dramatic investments in agriculture during the Green Revolution (see **Section 2.3**) much recent ODA spending on agriculture has been criticised as unambitious, slow and ineffective, subsidising the poorest subsistence farmers without achieving transformative results for either poverty reduction or economic growth (Thornton et al., 2022). Partially in response to such debates, the UK's ODA to agricultural development has refocused on commercial agriculture for stimulating inclusive economic growth at pace (DFID, 2015; DFID, 2017).

2.2 Data and geography

Trends in population, food and hunger

The world's population has grown rapidly over the last century, and will continue to grow, particularly in developing countries. The global population increased from 3.1 billion to 7.9 billion between 1961 and 2021 (UNDESA, 2022). Growth has been strongest in developing regions. The numbers of people in Asia and Latin America and the Caribbean (LAC) almost tripled over this period, from 1.7 billion to 4.7 billion in Asia and from 226 million to 656 million in LAC. In Africa the population rose from 291 million to 1.4 billion, more than 450% (UNDESA, 2022). While global growth rates are slowing, the world's population is expected to continue to rise at least until 2050, with particularly strong growth in Africa (UNDESA, 2022).

Agricultural output has dramatically outstripped population growth. Compared to global population growth of 254% between 1961 and 2021 (UNDESA, 2022), agricultural production increased by 366% between 1961 and 2020 (FAO, 2022). Food production per capita grew globally by 47% between 1961 and 2020, and in every major developing region except the Caribbean (see **Table 1**). The increase in production of staple cereals has been particularly important for meeting the world's growing calorific needs (see **Table 2**).

Table 1: Estimated food gross per capita production index number, 1961-2020 (2010-15 = 100)[3]

	1961	2020	Change in per capita food production*
World	68.92	101.37	47%
Africa	86.89	98.7	14%
Asia	44.04	102.82	133%
Caribbean	131.36	91.3	-30%
Central America	58.96	104.72	78%
South America	49.41	105.22	113%

Source: FAO (2022) Food gross per capita production index number (P3.FEED.FAO.ESS.GPCPIN.FOOD), production indices dataset. FAOSTAT Database. Food and Agriculture Organisation of the United Nations, Rome.
*Authors' calculation

[3] The index in Table 1 displays estimated per capita food production in terms of change relative to a reference value (100) in a reference period (2010-15). So, for example, in Asia, food production rose from 44.04 to 100 between 1961 and 2010-15, and from 100 to 102.82 by 2020, meaning that 133% more food was being produced per capita. By contrast, per capita food production in the Caribbean fell from 131.36 in 1962 to 100 in 2010-15, and then to 91.3 in 2020, meaning that there was a 30% decline in per capita food production.

Table 2: Production estimates of staple cereal crops 1961-2021 for key regions (millions of tons)

	Year	World	Africa	Asia	LAC
Maize	1961	205	16	32	24
	2021	1,210	97	379	194
	*Change**	*590%*	*598%*	*1199%*	*804%*
Rice	1961	216	4	199	8
	2021	787	37	708	29
	*Change**	*365%*	*863%*	*356%*	*358%*
Wheat	1961	222	5	46	10
	2021	771	29	340	33
	*Change**	*347%*	*571%*	*743%*	*342%*

Source: FAO (2022) Crops and livestock dataset. FAOSTAT Database. Food and Agriculture Organisation of the United Nations, Rome.
*Authors' calculation

Some regions in Africa have lagged behind. Within Africa, per capita food production fell in eastern, central and southern regions between 1961 and 2021 (Wiggins and Leturque, 2010; FAO, 2022). Growth in the yields of African cereals has been unimpressive, reaching 1.5 tons per hectare on average compared to over 4 tons per hectare in Asia (Tian and Yu, 2019). Food production in Asia has generally become more intensive, while food production in Africa has mostly increased through the cultivation of more land (Wiggins and Leturque, 2010).

Hunger and food security

The acceleration in agricultural productivity has contributed to long-term improvements in global metrics of food security and hunger. Key indices of global food prices and global food price volatility showed long-term downward trends throughout the last century, meaning that food supplies have become more affordable and reliable for poor people (Southgate, 2009; Fuglie et al., 2020). Key statistics on food security, malnutrition, and hunger all showed significant medium-term declines between 2000 and 2021 (UNICEF, WHO and World Bank, 2021; FAO, IFAD, UNICEF, WFP and WHO, 2022).

Progress has not been even and there are signs it may be slowing down or falling back. Contrary to global trends, the number of stunted children – those under the age of five with low height for their age[4] – in Africa increased from 54.4 million to 61.4 million between 2000 and 2021, although the proportion of stunted children fell (UNICEF, WHO and World Bank, 2021). Similarly, despite positive long-term trends, over the last decade global per capita output has begun to fall, food price volatility has increased (Fuglie et al., 2020), and indices and estimates of global hunger and food insecurity have begun to rise (FAO, IFAD, UNICEF, WFP and WHO, 2022). Also, globally and in every region, prevalence of food insecurity is higher among women than men. This gap has widened even further in recent years (FAO, IFAD, UNICEF, WFP and WHO, 2022).

Despite substantial progress, hundreds of millions of people remain hungry two decades into the 21st century, and the world is not on track to the meet the Sustainable Development Goal of zero hunger by 2030. In 2021, an estimated 278 million people in Africa, 425 million people in Asia, and 57 million people in Latin America and the Caribbean were affected by hunger (FAO, IFAD, UNICEF, WFP and WHO, 2022).

Rural poverty

The last four decades have seen dramatic falls in global poverty. Between 1981 and 2019 the proportion of people living in poverty[5] globally fell from 43.6% to 8.4% (World Bank, 2022). The numbers of people living in extreme poverty also fell, from 1.9 billion to 736 million (FAO, 2019, p. 1). Progress was even faster in low- and

[4] WHO defines stunting as the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median.
[5] The proportion of people living in poverty was redefined in 2022 as those who live on less than $2.15 per person per day.

middle-income countries (from 51.7% to 10.2%) (World Bank, 2022a) and Asia (from 58.1% to 8.5%) (World Bank, 2022b).

Extreme poverty has become disproportionately African. In sub-Saharan Africa, the incidence of poverty increased from 53.3% in 1990 to 58.7% in 1994, and only then began falling to reach 35% by 2019 (World Bank, 2022c). Africa was the only region where the number of people living in extreme poverty actually rose, from 278 million in 1990 to 413 million in 2015 (World Bank, 2018). All but one of the world's 28 poorest countries are in Africa, all with poverty rates over 30% (World Bank, 2018).

Extreme poverty remains overwhelmingly rural. Globally, extremely poor people often live in rural areas, have a larger number of children, have low levels of educational attainment, and work in agriculture (Castaneda et al., 2018). While holding only 54% of the world's population, rural areas are home to 79% of those living in extreme poverty, two-thirds of whom are agricultural workers (World Bank, 2018). Rural poverty rates in Africa greatly exceed those in other regions. The World Bank has calculated that in 2013, 56% of Africa's rural people lived in extreme poverty by simple monetary definitions,[6] rising to 82% when using the multidimensional poverty index (World Bank, 2018). This compares to 21% and 34% for the world as a whole, and 15% and 33% for Asia (World Bank, 2018).

Smallholders

Most farms are small. Of the world's estimated 608 million farms, 84% are less than two hectares in size and occupy 12% of agricultural land (FAO, 2021a). Around 70% of all farms are less than one hectare and occupy 7% of the world's agricultural land (FAO, 2021a). By contrast, 70% of the world's agricultural land is held by just 1% of farms larger than 50 hectares (FAO, 2021a). Small farms are more common and tend to occupy more agricultural land in low- and low-middle-income countries than in higher-income countries (Lowder et al., 2021). In Africa and Asia average farm sizes became smaller between 1950 and 2010 (Masters et al., 2013), while in higher-income regions there is a tendency for farms to become larger (Lowder et al., 2021).

Smallholders produce a disproportionate amount of food. Recent estimates suggest that smallholders produce between 30 to 35% of the world's food on just 12% of the world's land (Ricciardi et al., 2018; Lowder et al., 2016; FAO, 2021; Lowder et al., 2021). Mellor (2017) argues that in low- and middle-income countries a distinction should be made between subsistence and commercial smallholders, with commercial smallholders generating the bulk of agricultural output and rural economic growth. These broad trends do not necessarily apply across all commodities, however. For example, a small number of large farms occupying 7% of Tanzania's agricultural land produce 80% of the country's wheat and 63% of its tea (FAO, 2021a).

2.3 Agriculture in international development

Agriculture's contribution to international development goals has been understood and framed in different ways, by different people, and at different times (Andersson and Rohne-Till, 2018). This is due not least to changing framings of development goals (Unger, 2018). Of particular relevance to this paper are changing understandings of agriculture's role in achieving food security, economic growth, and poverty reduction. Academic debates have informed policy, which has in turn shaped the justifications for, objectives of, and volumes of ODA directed at agricultural development. This section briefly summarises this history to provide a context for current approaches to ODA for agriculture.

Agriculture and food production: the Green Revolution

India and Pakistan experienced bad harvests in the mid-1960s. Domestic policymakers inferred that their agricultural production systems might not be capable of feeding rapidly growing populations and that famine could be imminent (Freebairn, 1995). They found allies in US policymakers troubled by the possibilities of mass starvation and hunger-driven popular insurgencies in South Asia yet reluctant to extend expensive post-war humanitarian food programmes (Cleaver, 1972). In response, international development organisations and the

[6] Defined as those who live on less than $1.90 per person per day.

governments of India and Pakistan initiated a programme of interventions that collectively became known as the Green Revolution.

The Green Revolution's strategy was to achieve food self-sufficiency by intensifying agricultural production. Technology packages comprising high-yield variety (HYV) seeds, chemical fertiliser, pesticides, irrigation and mechanisation were the main vehicle, supported by public investment in agricultural extension services and capacities for processing, storage and trade (Evenson and Gollin, 2003; Hazell, 2009; Kolawole, 2012). This package of interventions had been developed through a US-funded, Mexican-based wheat research project running since the 1940s. The research had produced breakthroughs that would become signatures of the Green Revolution strategy. First was the use of new breeding methodologies to produce locally adapted, high-yielding and disease-resistant varieties (Rajaram, 1995). Second was the technology package. HYV seeds alone did not produce significantly greater harvests, but when applied together with fertiliser, pesticides and, especially, irrigation, these new seed technologies dramatically increased yields (Cleaver, 1972).

The Green Revolution spread out from India and Pakistan, particularly to other parts of Asia. Budgets grew for agricultural research to develop HYVs (Wiggins et al., 2010). The Consultative Group on International Agricultural Research (now known as CGIAR) grew from four research institutes in 1972[7] to 13 by 1982. There was rapid growth in the yields of key staple crops in Asia. Between 1967 and 1982 the annual production rate of wheat increased by an average of 5.4%, maize by an average of 4.6%, and rice by an average of 3.3% (Hazell, 2009). Between 1970 and 1995, Asian cereal production grew so much faster than the Asian population that almost 30% more calories became available per person, and rice and wheat prices fell (Hazell, 2009).

The Green Revolution made slower inroads in Africa. While a wide range of improved crop varieties were introduced to sub-Saharan Africa starting in the 1960s, uptake by farmers was limited (Bryceson et al., 2010; Evenson and Gollin, 2003). By 1998, improved varieties covered just 27% of the planted area in Africa, compared to 82% in Asia (Pingali, 2012). Increases in production were only about half that in Latin America and Asia, and yields in Africa increased only minimally during the 1980s and 1990s (Evenson and Gollin, 2003; Bryceson et al., 2010). Per capita agricultural productivity fell in Africa between the 1960s and 1990s (Frankema, 2014).

There appear to be several factors underlying this poorer performance. These include donor underinvestment in breeding HYVs specifically adapted to Africa's diverse agroecosystems (Evenson and Gollin, 2003; Kolawole, 2012) or relevant to African smallholders, such as sorghum, cassava and millet (Pingali, 2012), a focus on intensive monocropping rather than traditional African mixed-cropping strategies that better managed climate risk (Chambers et al., 1989), and Africa lacking the infrastructure, markets and services needed to sustain the Green Revolution's technology package. Compared to Asian countries, most African countries did not have extensive irrigated areas, efficient markets for supplying agricultural inputs, or effective systems for delivering agricultural extension services, such as technical advice and training (Kolawole, 2012, p. 302).

Africa has begun to catch up in recent decades. African farmers' use of fertiliser and HYVs has accelerated since 1990 (AGRA, 2016; Pingali, 2012; Walker and Alwang, 2015). In turn, this has contributed to higher agricultural productivity, particularly since 2000 (Frankema, 2014). While it still lags behind Asia and Latin America in terms of yields and productivity, there is growing confidence that Africa can and will achieve a Green Revolution (AGRA, 2021). This is partly because Africa's infrastructure, markets and services have transformed since the 1970s (Jayne et al., 2018), but also because there is growing focus on adapting the Green Revolution package to better suit Africa's needs (Hazell, 2009; Pingali, 2012).

The huge successes of the Green Revolution have not been evenly distributed, or without cost. Increasing global and regional food supplies faster than population growth has led to, on average, more calories available per person, falling food prices, and gains in food security, nutrition and poverty reduction (Hazell, 2009; Pingali, 2012). The Green Revolution concentrated investment and incomes in agriculturally favourable areas, however, particularly those with enough water for irrigation (Freebairn, 1995; Evenson and Gollin, 2003). As these areas

7 The four research centres that originally came together to make the CGIAR in 1971 were International Centre for the Improvement of Maize and Wheat (CIMMYT, formed 1963), the International Rice Research Institute (IRRI, formed 1960), the International Centre for Tropical Agriculture (CIAT, formed 1967), and the International Institute for Tropical Agriculture (IITA, formed 1967).

boomed, more marginal regions were left behind, widening disparities and inequalities, and even deepening poverty in some areas (Freebairn, 1995; Evenson and Gollin, 2003; Pingali, 2012).

Agriculture and economic growth: the place of smallholders

In the 1950s and 1960s, development theory saw industrialisation as the main path to prosperity in 'underdeveloped' economies. Large-scale, 'modernised' agriculture – commercial plantations, state farms, collectivised agriculture – able to achieve economies of scale would take its place alongside manufacturing industries (Ellis and Biggs, 2001). Smallholder agriculture was predominantly viewed as a source of surplus labour for industrialisation (Ellis and Biggs, 2001; Mellor, 2017; Andersson and Rohne-Till, 2018). Western development assistance to rural areas during this period focused on health, education and infrastructure (Bryceson et al., 2010), and support for agriculture was largely framed in terms of reaching marginalised groups to alleviate poverty and hunger (Andersson and Rohne-Till, 2018).

In the 1970s, however, the World Bank and other donors began emphasising the role of smallholders in economic growth and poverty reduction. Efforts to achieve economies of scale through large-scale agriculture had underwhelming results in Asia and had not been sustained in sub-Saharan Africa (World Bank, 2008). Meanwhile the Green Revolution was demonstrating that smallholders could drastically increase yields so long as they could access HYV seeds, fertiliser, pesticides and water (Freebairn, 1995; Ellis and Biggs, 2001; Andersson and Rohne-Till, 2018).

Academic research had also produced new evidence which challenged the prevailing view of smallholders as unproductive and 'backwards'. In this new framing, smallholders were efficient but poor (Schultz, 1964) private sector actors exchanging goods, services and capital with local industry and services (Johnston and Mellor, 1961), and thus driving pro-poor growth (Wiggins et al., 2010; Mellor, 2017; Andersson and Rohne-Till, 2018). These ideas came together for Western donors newly focused on reducing poverty by investing in the small enterprises of the poor, such as farms (Wiggins et al., 2010). Governments and donors increased agricultural budgets to fund irrigation, roads, fertiliser subsidies, agricultural extension and credit services so that smallholders could access and use HYV seeds (Wiggins et al., 2010).

This emphasis was significantly rolled back as the Washington Consensus emerged. Starting in the 1970s, a series of macroeconomic stabilisation programmes were implemented in developing economies to tackle crises caused by trade deficits, debt and inflation (Ellis and Biggs, 2001; Wiggins et al., 2010). These programmes provided governments with bailout loans on the condition that they liberalise markets, reduce public spending, and privatise state enterprises (Ellis and Biggs, 2001; Wiggins et al., 2010). Accordingly, in countries undergoing structural adjustment, the state's role in managing agriculture shrank, agricultural research and extension services were reduced, and agricultural input subsidies fell (Kydd and Dorward, 2001; Ellis and Biggs, 2001; Wiggins et al., 2010). The effects varied markedly between countries. The consensus of the literature is that the impacts of structural adjustment in any given country depended on how well measures, individually and collectively, addressed barriers to agricultural growth, and how fully and effectively they were implemented (Ahmed and Lipton, 1997; Archibong et al., 2021). In Uganda's coffee industry and Ghana's cocoa industry, for example, liberalisation improved the farm-gate prices farmers received, contributing to a boom in production and poverty reduction in producing regions (Akiyama, 2001; Varangis and Schreiber, 2001; Baffes, 2006; Wiggins et al., 2010). By contrast, in some other countries, unlocking agricultural growth depended on continued public investment in transportation infrastructure, fertiliser subsidies and extension services (Bryceson et al., 2010; Lopes, 2012). In some such cases, the consequences of structural adjustment were low productivity growth and increases in rural poverty, at least in the short term.

Leaving agriculture to private sector investors, donor interest declined during the late 1980s and 1990s. Agriculture's share of ODA spending doubled from 6% to 12% between 1970 and 1985 before falling steadily to just 3% by 2005 (Andersson and Rohne-Till, 2018). This was not a 'neglect' of agriculture by donors so much as an intentional attempt to generate faster agricultural growth by unshackling the private sector (Ellis, 2013). Donor attention and funding shifted towards addressing poverty by improving access to healthcare and education, and issues of gender and the environment; agriculture virtually disappeared from the development agenda (Wiggins et al., 2010; Dethier and Effenburger, 2011).

The first Millennium Development Goal's ambition to halve global poverty and hunger and achieve full employment helped refocus minds on smallholder agriculture. After all, poverty and hunger were concentrated in rural areas where agriculture was the dominant source of livelihoods and jobs (Wiggins et al., 2010; Andersson and Rohne-Till, 2018). Renewed attention was given to evidence for smallholders as key drivers of rural economic growth and poverty reduction (Johnston and Mellor, 1961; Ellis and Biggs, 2001; Dorward et al., 2004). There was also increasing consensus that the downsizing of state involvement in agriculture during the 1980s and 1990s had been too radical; successful smallholder agriculture required targeted public sector support (Ellis and Biggs, 2001; Kydd and Dorward, 2001; Dorward et al., 2004; Mellor, 2017). ODA to agriculture rose from around $3 billion to $5 billion between 2006 and 2009, or from 3% to 4% of total ODA flows, and remained at that level until 2015 (Andersson and Rohne-Till, 2018).

The attraction was the potential contribution of commercial smallholder agriculture to off-farm rural job creation. This was based on both theory and observations that, having obtained cash from selling their produce to market, commercially oriented smallholders were more likely to spend that cash on local goods and services, stimulating demand and job creation in the off-farm rural economy (World Bank, 2008; Mellor, 2017). Policymakers wanted to create rural jobs to absorb rapid rural population growth, and a dynamic rural economy able to offer higher-paying jobs both on- and off-farm was seen as the solution (World Bank, 2008). While recognising that there was no one-size-fits-all solution to rural growth and poverty across diverse settings, there was a broad consensus that helping smallholders to access markets and engage in commercial activities could drive growth, particularly rural growth (Wiggins et al., 2010). USAID's agriculture strategy (2004), the former UK Department for International Development's (DFID) agriculture policy (2005) and the 2008 *World development report* (World Bank, 2008) exemplified this thinking (see **Chapter 3**).

Not everyone was convinced, however. Contrasting 'farmer-first' and 'farmer-sceptic' arguments can be over-simplified and unhelpful; debates around agriculture's potential to drive growth are less polarised, more interwoven, and not so easily divided into discrete chunks of time as this section may suggest (Andersson and Rohne-Till, 2018). Over the past 25 years, it has been widely agreed that including smallholders in agri-food value chains will drive inclusive economic growth (Guarin et al., 2022; Fan and Rue 2020; Kariuki, 2006). Transitions will see most rural people leave agriculture for off-farm jobs in industry or services (World Bank, 2008; Dorward, 2009; Wiggins and Keats, 2015). Based on the Green Revolution's success in Asia, it is expected that equitable agricultural growth can provide the stimuli to fuel the non-farm economy (Hazell, 2009). The question is whether that growth and those jobs will come from agriculture or other sectors. Despite this 'smallholder positivity', others like Collier and Dercon (2014) have argued that agriculture-led growth would be too slow to justify investments based on poverty reduction. They questioned the extent to which smallholders can drive economic growth and poverty reduction by arguing that, in many countries, large commercial farms can offer faster routes to growth (Collier and Dercon, 2014).

DFID's 2015 *Conceptual framework on agriculture* drew from Dorward's 'hanging in, stepping up and stepping out' smallholder livelihood typology. Dorward's (2009) typology addressed the choices faced by smallholders who could:

- 'step out' of agriculture towards better-paid, off-farm jobs
- 'step up' and diversify their activities through capital investments in productivity
- 'hang-in' for subsistence or low wages if they were unable to do either of the above.

The *Framework* translated this typology of livelihood choices into a graduation model for smallholders, encouraging them to move from semi-subsistence production to increasingly commercial farming and then eventually, for many, to a self-financed, beneficial exit from agriculture (DFID, 2015; FAO, 2017). At the scale of rural and national economies it also implies livelihoods becoming increasingly diversified, non-farm activities becoming more important, and growing urbanisation (Hellin and Fisher, 2018). Because smallholders' ability to make sustainable and effective choices is shaped by their socio-economic environments and access to assets and market opportunities (Dorward et al., 2009), it also implies the need for public investment and support for the context in which smallholder agriculture takes place (Fan et al., 2015).

Agriculture and gender

Farming and food preparation are deeply gendered activities (Doss, 2018). Limited gender differentiation in the available statistics limits understanding of gendered constraints experienced by both women and men (Doss, 2018; Doss et al., 2018). For example, women's responsibilities for domestic livestock or kitchen gardens may not be measured in agricultural statistics, despite contributions to household food security and nutrition (Twyman, García and Muriel, 2015).

Women most likely account for around 50% of agricultural labour, and this figure is rising in many places. This 'feminisation of agriculture' arises from structural inequalities and higher rates of male outmigration (Boserup et al., 2007; Farhall and Rickards, 2021). Men are more likely to step up and step out of agriculture through diversification and migration into cities, leaving women behind to operate farms (Boserup et al., 2007). While women make up a large and growing share of the agricultural labour force, they are under-represented in the off-farm sector and are less likely to access and keep off-farm employment (Van den Broeck and Kilic, 2019; Farhall and Rickards, 2021). Even when women are engaged in off-farm activities, not enough attention is paid to this activity in productivity initiatives (Doss, 2018).

Compared to men, women farmers often experience social and institutional barriers to increasing their productivity. This may be due to unequal access to factors including: finance; productive farm inputs such as fertilisers, pesticides and farming tools; support from extension services such as technical advice and training; and access to markets (ActionAid, 2011; Banerjee et al., 2014; Oluwatoyin, 2022). Despite a paucity of data (Doss, 2018), women are also thought to be less likely to own land or have secure tenure, exacerbating these challenges and limiting their control over farm management decisions and their ability to adapt to climate change (ActionAid, 2011; FAO, 2018).

Greater understanding of gendered barriers to agricultural development is needed to guide effective policies and interventions for improving food security and nutrition. Doss et al. (2018) dismiss four 'myths' about women working in agriculture that persist despite the lack of evidence. These include narratives overstating the poverty, vulnerability and productivity of women compared to men, which consequently reduce women's agency and overlook shared burdens and often complex social and power dynamics between the genders. Gender-blind policies and interventions may overlook important barriers and opportunities, but so will those which have been developed based on overly simplistic narratives about gender dynamics (Doss et al., 2018).

Agriculture and climate change

Greenhouse gas emissions linked to food production are a significant contributor to climate change (Lynch et al., 2021). Food systems account for between 21% and 37% of total anthropogenic emissions, with 10-14% deriving directly from agricultural production, 5-14% from agriculture-related land use changes, and 5-10% from post-harvest food processing, distribution and consumption (Mbow et al., 2019). Methane, particularly from livestock, is the single largest source of agricultural emissions (CCAC Secretariat, 2021; Vermeulen et al., 2012), and other sources include CO_2 from crops and ploughing, and N_2O from fertiliser application (Mbow et al., 2019). Agriculture, already accounting for 38% of global land (FAO, 2020), is a major driver of land use change, and the consequent deforestation and wetland degradation both releases stored carbon (Mbow et al., 2019) and degrades ecosystem services for sequestering carbon (Lynch et al., 2021). Off-farm agricultural activities contribute directly to CO_2 emissions (Lynch et al., 2021; FAO, 2022; Vermeulen et al., 2012). For example, the production of agricultural inputs, such as animal feeds and fertilisers, and post-harvest food processing, transport and retail are all heavily dependent on fossil fuels (Vermeulen et al., 2012). Emissions from agriculture are not evenly distributed, but are most intense in South, Southeast and East Asia, Europe, and North America's Midwest, and are generally low in sub-Saharan Africa, Central Asia, and much of Latin America (Mbow et al., 2019).

Agriculture has wider environmental impacts beyond climate change. The widespread use and over-use of chemical fertilisers and pesticides contributes to pollution and ecosystem degradation (Mbow et al., 2019; Erisman et al., 2013; Bernhard et al., 2010; FAO, 2022). Deforestation for agricultural expansion contributes to biodiversity loss and soil erosion (Dasgupta, 2021) (see **Chapter 4**) and agriculture is the main driver of global deforestation and land conversion worldwide, much of it illegal (ICAI, 2021). Increasing food production while reducing agriculture's environmental and climatic externalities is a significant challenge (FAO, 2020).

Climate change also affects food production and security. As average global temperatures increase to 1.5°C above pre-industrial levels, the frequency of medium-to-large-scale disaster events is projected to increase by 40% between 2015 and 2030 (UNDRR, 2022). Since agricultural production is highly dependent on climatic conditions, rising temperatures, increased rainfall, prolonged droughts and other seasonal irregularities can negatively affect crop and livestock yields and food prices (Hasegawa et al., 2022; Dasgupta, 2021; FAO, 2020). In parts of sub-Saharan Africa, South Asia and Latin America, for example, floods and drought-related disasters have led to a rise in acute food insecurity and malnutrition (Bezner Kerr et al., 2022). Crop yields for staple crops like maize, soybean, rice and wheat will decline over the 21st century unless measures are taken to adapt and build resilience to climate change (Hasegawa et al., 2022; Bezner Kerr et al., 2022). There are concerns that, particularly in warmer regions, climate change impacts may depress crop yields despite adaptation efforts (Bezner Kerr et al., 2022).

More investments into climate resilience building and the adoption of sustainable agricultural innovations, like crop varieties, farming practices and equipment, will be needed. Over the past 50 years, large commercial farms have benefited from greater access and uptake of technological, financial and logistical innovations than smallholders (Collier and Dercon, 2014). Enthusiasts for large commercial agriculture claim that resource-constrained smallholders have limited access to skills and knowledge, are less able to absorb the costs of adaptation, and may be reluctant to take on the risk of experimentation (Collier and Dercon, 2014; Williams et al., 2020; Kori and Kori, 2022). Nonetheless, there is substantial evidence of climate adaptation by small-scale farmers. Small-scale farmers in the Sahel region have employed traditional agroforestry practices over the past 30 years to adapt to recurrent drought, for example, and this is recognised as an agroecological success story (Magrath, 2020).

Questions of who will pay for these investments into climate resilience and environmentally friendly farming practices are entwined with issues of equity. While some argue that more investment is needed from local, district and national governments (Chambwera et al., 2011), others argue that the costs of adaptation and mitigation should not be borne by those who have contributed least to the climate crisis (Khan, 2015). Nevertheless, the inclusion of smallholder farmers in adaptation strategies and cost-benefit analyses is crucial since they are most vulnerable to, and affected by, climate change (Williams et al., 2020; Akinyi et al., 2022; Kori and Kori, 2022) (see Chapter 4).

3. Smallholder commercialisation and market system development

Agricultural commercialisation is an integral part of a wider process of structural transformation which must take place for an economy to grow. As outlined above, agricultural commercialisation is associated with increased productivity of land and labour. Farmers move away from subsistence farming towards market-oriented farming, thereby increasing their market participation with subsequent higher incomes and living standards (OECD, 2012a; Neme and Tefera, 2021). Smallholder commercialisation has a potential multiplying effect, injecting additional income into the rural economy, creating jobs and demand for goods and services, and further supporting wider economic development (Mellor, 2017; World Bank, 2008; Wiggins et al., 2011). There are various opportunities for some, but not all, smallholders to ‘step up’ by commercialising (OECD, 2012a). Others will ‘step out’ and move on to other activities outside the agriculture sector, which implies a need to strengthen opportunities outside as well as within farming (OECD, 2012a).

3.1 Key approaches taken to smallholder commercialisation and market system development

Smallholder farmers wishing to engage in commercial agriculture require support to overcome significant barriers. These often include land and water constraints, lack of inputs and access to finance, poor links to quality markets, high transaction costs, and lack of infrastructure, which considerably alter production and market-participation decisions in the commercialisation of smallholder farming (Pingali, 2012; FAO, 2013; Poulton et al., 2010). Common challenges for governments and development agencies are to determine which constraints or risks are most critical in holding back smallholders from market participation in a given context, and how interventions should be prioritised and sequenced to result in lasting impact (FAO, 2013; Said and Vencatachellum, 2018).

Not all small farms will succeed as commercial farms in the future. Those that have a chance of succeeding need the right kinds of support, while those that are unlikely to succeed need different types of assistance. The Alliance for a Green Revolution in Africa identifies a typology of four types of smallholder farms, with each type requiring different kinds of support (AGRA, 2017, p. 10):

- commercial (farming as business)
- pre-commercial (stepping up to commercialisation)
- transition (stepping out of agriculture)
- subsistence (social protection as a holding strategy).

Smallholder commercialisation approaches and interventions generally focus on commercial and pre-commercial smallholder farmer groups. These are farms with viable market prospects that need to be supported as a business proposition. Support for smallholder commercialisation generally includes interventions to improve the reliability, quantity and quality of production and/or interventions to improve access to markets (see below). Much of this assistance will be geared towards higher-value production and oriented towards achieving commercial and financial sustainability (AGRA, 2017; Hazell and Rahman, 2014).

Transition and subsistence smallholder farm groups need other forms of support, such as help to acquire necessary knowledge and skills to improve their farm production or diversify to non-farm activities. Also, subsidies and safety nets are often needed for those with fewer opportunities to move up or out of farming. This may be especially important for many women and young farmers (AGRA, 2017; Hazell and Rahman, 2014).

Improving smallholders’ productivity

Low yields and low-quality produce can constrain smallholder profitability. Many smallholder commercialisation interventions therefore focus on strengthening the factors underlying smallholders’ productivity.

Improving farmers’ access to innovation and new technologies, such as improved crop varieties and farming practices, is a long-standing practice in agricultural development (Ellis and Biggs, 2001). The Food and Agriculture Organisation (FAO), CGIAR, and other development organisations support initiatives strengthening innovation systems in developing countries (for example, Schut et al., 2018), and many smallholder commercialisation programmes include interventions to disseminate technologies such as improved crop varieties.

Smallholder commercialisation initiatives often include interventions which support farmer education and training. Provision of agricultural extension[8] helps to disseminate practical information, including on the use of technologies and agricultural practices, to improve productivity and quality of produce. Traditionally funded and provided by public sector and development organisations, agricultural extension services (or the lack thereof) are considered by many to be a long-standing challenge in agricultural development (Wiggins at al., 2021). Private sector extension services are increasingly common in developing countries, particularly catering to commercial farmers, including smallholders (Mellor, 2017; Wiggins at al., 2021). Some smallholder commercialisation interventions collaborate with public extension services, while others focus on improving smallholders’ access to private extension agents. Not all innovation on farms comes from external sources, of course: farmers try out new methods and inputs based on their experience and learning from other farmers (Wiggins at al., 2021).

Investment in infrastructure. Irrigation is perhaps the most significant single intervention to increase yields and transform farmers’ market opportunities (Wiggins et al., 2011; Fan et al., 2010). Improving access to expensive irrigation infrastructure and equipment is therefore a long-standing road to support agricultural

[8] Agriculture extension – the transfer of agricultural information and technology to farmers, and information from farmers to researchers. Agriculture extension is a broad term that might include, for example, education, access to information (including on new technology and innovation, new practices, and markets), training, and technical assistance to improve smallholder farming techniques and production.

commercialisation. In many African countries, for example, public investment in dams and irrigation works has been a component of agricultural development projects since colonial times, and continues alongside rising private investment in small-scale irrigation (Oates et al., 2015).

Ensuring smallholder-friendly financing. Smallholders need finance to invest in increased productivity, such as through capital spending on farm equipment and infrastructure and purchasing inputs (seeds, fertilisers). Smallholder farms face considerable difficulties in accessing finance, however, due to remoteness from services, difficulties raising collateral, and the low risk tolerance of lenders. Women farmers face even greater disadvantages than their male counterparts. Improving access to innovative financial services (credit and savings products, value chain finance, rural leasing, loan guarantee funds, transfer services, insurance, etc.) helps to expand opportunities for smallholders and allow for improved planning for risk (Fan et al., 2013; IFAD, 2016; AGRA, 2017).

The development and diffusion of information and communication technology (ICT) has been changing the agricultural finance landscape. A growing number of smallholder farmers are gaining access to payment services through mobile telephones, which are also used in agricultural transactions. Formal financial institutions also deploy ICT and new business models to reach dispersed rural populations. In addition, use of ICT is increasingly helping smallholders to access information about markets, including prices, which support their links to markets and improve their negotiation power (AGRA, 2017).

Improving smallholders' access to markets

Improving productivity factors does not generate commercial activity unless there are worthwhile market opportunities (Wiggins et al., 2011). Growing and urbanising populations mean that there is rising demand for food, and many commercialisation initiatives focus on connecting smallholders with markets supplying this demand. Investment in transportation infrastructure, trade, and other related sectors can make major contributions to linking agricultural supply with demand for food, although this is rarely justified exclusively in terms of supporting smallholder commercialisation. Development programmes and investments focusing on linking smallholders with markets more commonly focus on institutional aspects of supply chains.

Centralised high-value supply chains are difficult for smallholders to access. Wiggins et al. (2011, p. 36) identify two broad types of supply chains. The first type is decentralised and often fragmented – chains linking smallholders to domestic markets for perishable products. Smallholders in these chains often sell to small-scale traders who deliver to consumers and shops. Supply chains managed by small-scale traders are generally accessible to smallholders and are often highly efficient, aggregating and marketing disparate products from small farms at a low unit cost (Shepherd, 2007). The second type of supply chain, however, is more centralised and integrated – a smallholder sells a product to a larger business that adds value through processing and/or packaging and delivers products to wholesalers, larger retailers, or exporters. Costs associated with these chains (in terms of price for coordination, management, processing and so on) are often higher, requiring larger quantities to be supplied (Wiggins et al., 2011). Due to the high transaction costs of commercial buyers, smallholders may be excluded from these markets in favour of larger farms (Hazell et al., 2010).

Commercialisation programmes frequently focus on improving smallholders' access to such centralised and high-value supply chains. In addition to the potential for such supply chains to generate more income for smallholders, increasing supply to medium and large firms in food processing, packaging, and distribution also contributes to growth and value addition in the off-farm formal economy (Woodhill et al., 2020). Such interventions target the key barriers that smallholders face, which typically include meeting strict quality standards, reducing unit costs by ensuring a high and reliable volume of produce, and logistics specifications (Fan et al., 2013). One approach is to promote collective smallholder action such as forming cooperatives or associations, or establish collection centres, which then become a vehicle for aggregating larger quantities of supply (Hazell and Rahman, 2014). Another approach is to use contract farming or out-grower models. These are arrangements between a buying company and a smallholder in which the terms of the sale are specified in advance. It is seen as an efficient mechanism to link smallholder farmers to centralised high-value supply chains, including domestic and international buyers (Nguyen, Dzator and Nadolny, 2015). Contract farming can reduce risk, and barriers such as high transaction costs, lack of finance and information, by linking smallholders with output markets for high-value crops and guaranteeing a market for their produce. Buyers can improve their control over crop supply, often at pre-agreed prices, as well as crop quality standards (Eaton and Shepherd, 2001). Both collectivisation and contract farming models frequently integrate elements to boost smallholder productivity and improve the quality of produce, such as providing technologies and extension advice.

Market system development

Market system development is an approach to understanding and intervening in market systems so that they perform better for poor people. 'Making markets work for the poor' (M4P) approaches, adopted by a number of international organisations and donors including the UK's Foreign, Commonwealth and Development Office, emphasise creating opportunities for the poor by increasing their access to markets, achieving more equitable and remunerative prices for goods and services, and reducing risk (Dorward and Poole, 2004; Springfield Centre, 2008). A market system here refers to the networks of producers, buyers, consumers, and other actors and institutions involved in the functioning of a market (Springfield Centre, 2008). While models vary, market system approaches generally emphasise working with all these actors, their 'enabling environment' which sets the 'rules' (government, policy and regulatory framework, and cultural norms), and 'market services' (infrastructure, information, technology, finance, standards and skills). This contrasts with 'value chain' approaches (USAID, n.d.), which map how value is added at each link in a chain of businesses in bringing a product from farm to its final sale. Value chain approaches, by considering only business-to-business relationships, can underestimate the role of non-market actors, such as governments, and understate the importance of market services for sustained competitiveness (Springfield Centre, 2008). The smallholder commercialisation approaches highlighted above – supporting either smallholders' productivity or their access to markets – align with the objectives of, and may be included among interventions of, market system development programmes. Market system development programmes may also include interventions targeting policy and regulatory reform, widening opportunities for private sector engagement (FAO, 2016), and supporting inclusion of women, poor and/or marginalised groups into markets (ADB, 2012).

3.2 Effects of commercialisation on smallholder farms and rural communities

Smallholder commercialisation provides benefits across the rural economy. Smallholder farmers typically spend a large portion of their income in the local community. Improving smallholders' access to markets and increasing their income therefore increases demand for goods and services and fosters growth in the local economy (Mellor, 2017; Wiggins et al., 2011). Smallholder commercialisation tends to increase the demand for labour in the farm sector and also creates jobs downstream in the processing, trading and storage of farm produce (Wiggins at al., 2011). This again supports poverty reduction and rural economic growth.

Smallholder commercialisation has been successful at creating jobs and raising incomes in rural areas. For example, a study in Tanzania found that intensifying commercialisation created jobs in the local rural economy, to the benefit of the landless and marginalised farmers unable to take full advantage of the opportunities of commercialisation. The study indicated the growth in hired labour markets across villages where farmers hire and get hired, with upward trends in wage rates (Mutabazi at al., 2013). There is strong evidence that increased household income as a result of agricultural commercialisation results in positive effects on food security, poverty reduction and welfare (Jaleta et al., 2009). In Zimbabwe, Mahofa et al. (2022) observed that agricultural commercialisation through participation in soybean and tobacco markets, high-value 'cash crops', resulted in significantly increased farm income. Commercialisation based on growing different food crops (such as maize) also led to increases in farm income, but less so than for those participating in high-value markets. Other studies have also shown that agricultural commercialisation is positively associated with income, asset accumulation and poverty reduction (Muriithi and Matz, 2015; Aida et al., 2022).

Effects of commercialisation on smallholder household income are not experienced evenly. There are substantial differences across smallholder households in terms of access to land, capital, labour, skills, and external services, and the processes of agricultural commercialisation are experienced unevenly (Wiggins et al., 2011). In terms of contract farming, studies have shown that levels of education, gender and scale of production impact on farmers' ability to sell directly to companies. For example, better educated male farmers are more likely to secure contracts and access company channels (Dzanku and Hodey, 2022; Maertens et al., 2012) and therefore likely to experience more positive impacts from commercialisation.

The uneven effects of commercialisation affect women disproportionately. Women account for a large portion of the agricultural labour force (FAO, 2011). However, women (either in female-headed households or within male-headed households) can face limited access to productive resources, titles to land, finance and agricultural inputs. This reflects a gender gap embedded in social norms that are specific to certain cultures and geographical regions (Gupta, Pingali and Pinstrup-Andersen, 2017). Such gender disparities in access can result in women achieving lower levels of agricultural productivity, having less control of household income and decisions, and having a greater burden of responsibility for domestic work that does not generate income (Mahofa at al., 2022a; Doss, 2018).

3.3 'What works' to enable smallholder commercialisation and agriculture market system development

The literature on aid for smallholder commercialisation includes numerous studies assessing the impact of programme packages or individual interventions. Drawing on the available evidence to identify 'what works' is complicated, however, as programme effectiveness is determined as much by the skill and determination with which it is implemented as on the fit between design and local needs and the local context. Furthermore, the availability of systematic reviews of specific interventions is limited. Nonetheless, this section attempts to provide an overview of some lessons learned on support for smallholder commercialisation, particularly improving access to markets through collectivisation, contract farming, and market system development approaches.

Smallholder access to markets

Combinations of interventions tend to be more efficient in enhancing farmers' connection to markets, as smallholder farmers often suffer from several types of market access constraints. Studies from IFAD (2016), the World Bank (2004) and Oxfam (through Farmers Income Lab, 2018) all conclude that flexible intervention tools allowing adaptation to local contexts and needs led to greater achievements of programmes and investments. IFAD (2016) notes that programmes focused on value chains tended to be more impactful than those which simply focused on supporting smallholder productivity. However, it is not uncommon for single interventions addressing critical barriers to be highly successful if they enable farmers and other actors to then solve other, smaller problems. For example, constructing a road can sufficiently lower transportation costs so that small-scale traders begin supplying agricultural inputs to, and purchasing produce from, previously remote areas (Pinstrup-Andersen and Shimokawa, 2008).

Long-term interventions and funding are important. Most studies agree that interventions supporting smallholder commercialisation need long-term funding and support to achieve transformational and sustainable results, often beyond a single project funding cycle. This needs to be considered when designing programmes and exit strategies (IFAD, 2016; World Bank, 2004).

Some aspects of a country's political economy[9] can leave smallholder farmers at a disadvantage and make interventions less likely to succeed unless considered properly. The choice of approach to promote smallholder commercialisation must consider what can be realistically achieved in the context of a particular political economy. This includes considering how decision-making structures and administrative capacity in the public sector may hinder the intervention's effectiveness, and whether and how such hindrances can be addressed. The sequencing of measures is as important as technical considerations of ideal approaches (Wiggins et al., 2011).

Governments have important roles in supporting enabling environments for smallholder commercialisation through smart financial regulations, targeted and effective agricultural finance policies, and well-established financial infrastructure (AGRA, 2017). Other interventions, such as promoting public-private partnerships to help deliver financial services to smallholder farms, supporting contract farming, and organising smallholder farms into groups for marketing purposes, have been encouraged as a way to support smallholder farms (AGRA, 2017). Access to insurance can enable smallholders to make riskier and potentially more profitable

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[9] Social, economic and political factors that structure, sustain and transform constellations of public and private actors, and their interests and power relations. Politics often determines how resources are used and policies are made, and who benefits.

investments, while climate risk insurance can stimulate investment in adaptation (IFAD, 2022). However, agricultural insurance markets are generally undersupplied by the private sector in developing countries and often suffer from market inefficiencies. Governments and donors therefore have an important role to play in supporting the development of agricultural insurance markets and widening the access of agricultural and climate risk insurance to smallholder farmers (World Bank, 2015).

Considering gender in designing programme interventions helps improve women's position in the market system. Oxfam, for example, uses gendered market mapping to identify economically viable products and market opportunities that are profitable for women. The market map is a visual representation of the different steps and actors in a particular value chain that shows the external factors affecting the chain and the market services needed to enable the chain to function. This helps to identify how women can move up the market chain when designing interventions (Baden et al., 2011). In Zimbabwe, Mahofa et al. (2022a) analysed the relationship between commercialisation and women's empowerment, highlighting that smallholder agricultural commercialisation is associated with women losing control of income and management of commercialised crops. Crop diversification, on the other hand, contributed to women's empowerment, which may imply that households that produce a variety of crops are more likely to empower women.

Smallholders benefit from access to diverse financial products. For example, the One Acre Fund worked with farmers in sub-Saharan Africa to extend credit for farm inputs, which freed up cash to allow farmers to make other productive investments (One Acre Fund, 2016). Other interventions may provide flexible loans with repayment terms aligned with planting and harvest cycles (Finance Income Lab, 2018; IFAD, 2016; World Bank, 2004); promote mobile and internet financial technology; or improve access to affordable insurance, payment, savings, and credit services for smallholders (AGRA, 2017; Fan at al., 2013; IFAD, 2022). Successful interventions also often involve collectives or farmers' groups acting as a central loan distributor for smallholders to benefit from economies of scale (World Bank, 2004).

Contract farming or out-grower farming

The role of contract farming (production by farmers under agreement with buyers for their output) is often promoted by development organisations, but evidence of its impact is mixed. Studies have found that smallholders actively participate in contract farming schemes and earn a higher income as a result. Often, these studies have found that farmers benefit from better access to inputs and new technology, leading to improved farm productivity (Warning and Key, 2002; Minten et al., 2009; Barrett et al., 2012). However, other sources have reported evidence of smallholder exclusion, delayed payments and a lack of compensation for crop losses in contract farming schemes (Tuyen et al., 2022). A World Bank and United Nations Conference on Trade and Development study examining 24 contract schemes found that only 1.5% of such contracts were signed with women (Mirza et al., 2014). The conditions under which contract farming is feasible are quite limited and can exclude certain crops, areas and farmers, and in most countries no more than 10% of produce is sold under contract (Ton et al., 2016; Meemken and Bellemare, 2020; Cotula et al., 2021).

Contracts are extremely diverse, reflecting the varied and complex realities of commercial agriculture. Contracts can be formal or informal, with terms varying widely depending on the commodities, geographies and value chains involved (FAO, 2013). Some contracts subsidise production through provision of seasonal credit on inputs (for example, seeds or fertilisers that either can't be obtained locally or don't leverage economies of scale) and provide technical assistance and support for compliance with market standards, price guarantees and, occasionally, insurance (FAO, 2013; Wiggins et al., 2011; ADB, 2012).

Some findings on contracting highlighted by several studies and reviews (AgDevCo, 2017; Barrett et al., 2011; Wiggins and Keats, 2013; FAO, 2013; Ton et al., 2016; Cotula et al., 2021) are listed below:

1. Smallholders do not necessarily benefit from contracting schemes, and contracts must be highly efficient if the benefits to smallholders are to outweigh their loss of agency and autonomy in production and marketing (Ton et al., 2016; Meemken and Bellemare, 2020; Cotula et al., 2021). Informal or voluntary contracting schemes with small-scale business can offer the same or more benefits to smallholders than formal schemes with large producers, especially when formal contracts entail binding participation (Ton et al., 2016; Meemkind and Bellemare, 2020).

2. As contracts can severely constrain smallholders' agency, initiatives to support contract farming should be driven by smallholders' aspirations (World Bank, 2018; Cotula et al., 2021). Support from third parties (intermediaries), such as public interest lawyers or non-governmental organisations, can help mitigate power differences between parties and lead to more effective contracts (World Bank, 2018; Cotula et al., 2021).
3. Smallholders organised in cooperatives or other groupings are generally better able than individual farmers to negotiate effective contracts and gain favourable terms, particularly where the collective has previous experience of marketing (Ton et al., 2016; AgDevCo, 2017). Access to post-harvest storage and rural infrastructure can also grant smallholders and collectives more autonomy and enable them to negotiate better contract terms (Cotula et al., 2021).
4. Commercial and financial viability supports partners to develop a culture of loyalty to each other and reduce the risk of either side defaulting (Bienabe et al., 2018). Strong relationships between smallholders and their business partners better enables them to continue operations, and even expand, after donor support ends (AgDevCo, 2017). AgDevCo (2017) also found that more successful contract schemes often put effort into networking with local stakeholders, such as local government leaders.
5. Early and realistic assessments of investor capabilities and their business models improves sustainability. Experience from World Bank programmes showed that many investors faced financial and/or operational difficulties, especially when introducing new business models or crops, and this exposed smallholders who depended on investors as buyers for their produce to risk (World Bank, 2018).
6. Successful contract schemes provide agricultural inputs and training support. For example, a World Bank study of contract farming of cassava in Ghana demonstrated that smallholders' decisions to participate in contract farming were more dependent on access to improved technologies and input supply arrangements, supported by technical assistance (Amevenku et al., 2012). Consideration also needs to be given to timing, and changes need to be introduced on a gradual, step-by-step basis over a number of years (Shepherd, 2018).
7. Contracts not considering and mitigating potential risks, such as weather, disease, price fluctuation or contract breach, can damage both parties and are less likely to be sustainable (Shepherd, 2018). Effective contract agreements include clear mechanisms for monitoring, dispute resolution, and/or redressing grievances (Bienabe et al., 2018; AgDevCo, 2017; Shepherd, 2018).

Smallholder collective action and institutions

Collective action through formal and informal groups can support commercialisation of smallholder farmers. In principle, pooling their financial, labour and social resources helps farmers to improve their position in markets by aggregating supply, reaching economies of scale, and increasing their bargaining power (Sally, 2013). Collectivisation can also help reduce costs of accessing agricultural inputs, finance, and extension services, making members more competitive (FAO, 2013; Wiggins et al., 2011). These benefits can enable farmers to sell in new domestic or international markets which may be out of reach to individual smallholders (Ferris et al., 2006). A study in rural Ghana, for example, found that collective action had promoted business development in rural areas and corrected market imperfections (Kaganzi et al., 2009).

In practice, however, there is varied evidence of cooperatives delivering on high expectations. Collective action among farmers is difficult to organise, coordinate and manage, and there is an extensive and well-reviewed history of failure in collective farming models. Even if organisational challenges are overcome, cooperatives may not address market imperfections. In Ethiopia, for example, cooperatives commercialise less than 10% of agricultural surplus despite accounting for 90% of modern input supply (Tadesse et al., 2018).

Some findings on successful collective action include the following:

1. Collective action is more likely to be effective when cooperation among farmers is willing, voluntary, and oriented towards an agreed common goal. Studies have found that social benefits are important components of collectives, and that successful collectives are more likely to be successful when social factors are included in implementation (for example, Gyau et al., 2012). Group characteristics, such as group size and norms, are also critical to success. In general, small groups with a high level of accountability are more likely to be successful (Sally, 2013).

2. Smallholder collectives benefit from patient and realistic external support. Studies highlight that pathways to maturity for smallholder collectives or organisations are usually long, often lasting decades before organisations reach maturity and sustainability (for example, Donovan et al., 2008). Sustainability is more likely where collectives receive supportive investment with carefully planned and sequenced services and clear exit strategies (Poole and France, 2010).
3. Collective action alone is not effective for achieving smallholder commercialisation. Commercialisation is more likely to be achieved when collective action is combined with other interventions addressing aspects of the enabling environment, such as policies and regulations, access to finance, training and market information, and creating linkages to value chains (Sally, 2013; IFAD, 2016).

Limitations of the commercial agriculture approach

The benefits of commercial agriculture are not equally shared, and may not reach all smallholders. There are debates about the future viability of smallholder farms (Hazell et al., 2007). Many, including international development agencies, believe that the commercialisation of smallholder agriculture is uniquely positioned to deliver broad-based growth in rural areas (where most poor people live). However, there are others who argue that strategies for commercialising agriculture will not bring benefits to the majority of the poorest rural households. There is a concern that efforts to promote commercial agriculture will primarily benefit medium- or large-scale farms or a minority of the most commercially viable smallholders (Leavy and Poulton, 2008). A study from Tanzania focused on the intensification of rice production observed that positive impacts were felt less by farmers living in villages without electricity, female farmers, and farmers with small farm holdings (Aida et al., 2022). While accelerated growth in agriculture is seen by many as critical in Africa, others (Poole et al., 2013) argue that the focus on smallholder commercialisation can become a 'meta-narrative' – an overarching tale that obscures important local differences.

Smallholder commercialisation alone will not help the poorest in rural areas. As noted at the start of this chapter, smallholder commercialisation approaches mostly target two groups within the typology of smallholders: commercial and pre-commercial farms. If all public sector support is allocated towards smallholder commercialisation, other types of smallholders may fall behind. There are some examples of programmes, such as Building Resilience and Adapting to Climate Change in Malawi, that offer a more nuanced approach, both supporting smallholder commercialisation and offering social protection to subsistence farm groups in order to 'leave no one behind' in the smallholder farm communities (Leavy et al., 2022).

4. Agriculture, climate change and the environment

4.1 Climate-smart agriculture strategies and interventions

Climate-smart agriculture (CSA) is presented as a 'triple-win' approach to ensuring resilient food production in an era of climate change (FAO, 2013a). The concept positions the agriculture sector as a key component of climate action, due to agriculture's extreme vulnerability to climatic changes and its role in exacerbating the climate crisis (Lipper and Zilberman, 2018). To address these two realities, the CSA framework works to improve food security through actions across three integrated pillars:

i. increasing agricultural productivity
ii. enhancing adaptation and resilience to climate change
iii. mitigating the effects of climate change by reducing greenhouse gas emissions.

Many of the practices proposed by climate-smart interventions build on established sustainable agriculture strategies which have long been practised by farmers in the Global South (Lipper and Zilberman, 2018). Sustainable intensification, a defining principle of both approaches, works to increase agricultural productivity through improved efficiency (Campbell, 2014). This allows for higher yields with reduced inputs such as land, fertiliser and water, thus conserving the natural resources integral to agriculture production (Campbell et al., 2014). Sustainable intensification can have secondary benefits in mitigation and embody the 'triple-win' nature of CSA (FAO, 2013a).

CSA differs from conventional sustainable agriculture in its focus on developing new financing mechanisms for agriculture, emphasis on climate change, and commitment to managing the trade-offs of mitigation, adaptation and productivity (World Bank, 2021). Before the conception of 'climate-smart' agriculture, food security interventions had begun to consider climate change a primary concern and agricultural adaptation was positioned as key to ensuring future food availability (Lipper and Zilberman, 2018). At the same time, the agricultural sector faced increased pressure to incorporate mitigation within its practices to address both the sector's contribution to greenhouse gas emissions and its potential to mitigate emissions through carbon capture. Acknowledging that agriculture plays a pivotal role in both food security and climate change, CSA was introduced as a means of connecting concerns over food security with finance for agricultural adaptation and mitigation in developing countries (FAO, 2009; Lipper and Zilberman, 2018). Proponents claim CSA can effectively link climate finance with funding gaps in adaptation and provide development donors with a cost-effective way to address integrated climate-development challenges (Lipper and Zilberman, 2018; Ellis and Tschakert, 2019).

The notion of CSA has been embraced within the international policy arena. However, CSA has been framed in multiple ways, and opinions differ on which agricultural practices should be considered 'climate-smart' (Lipper and Zilberman, 2018; Chandra et al., 2018). There is general agreement that practices delivering on all three pillars – productivity, adaptation and mitigation – should be considered climate-smart (Grist, 2015). Difference arises as to whether interventions integrating just one or two of these can be considered climate-smart (CABI, 2021). For example, since there is widespread agreement that smallholders in the Global South should not bear the burden of mitigation efforts, many argue that practices focusing on productivity and adaptation but not mitigation should be considered CSA (Grist, 2015). Others refer to such approaches as climate-resilient agriculture, retaining 'climate-smart' only for those interventions which also integrate mitigation (Grist, 2015; Ogunyiola et al., 2022; Chandra et al., 2018). Though framed as a global concept, CSA is site-specific, and the approach taken is adapted to local contexts, rather than an established set of practices, adjusted to available markets, farm size, historical context and social structure (FAO, 2013a; Thornton et al., 2018). However, some key features of CSA approaches clarify its main strategies, as set out in the rest of this section.

CSA works across the agricultural sector, including forestry, crop production, livestock production, fisheries and aquaculture (FAO, 2013a). These production systems can be targeted simultaneously by combining production forms, as seen in agroforestry, or individually (FAO, 2013a). CSA interventions can be specialised to fit identified entry points, to directly target or work in collaboration with water, soil and energy management (FAO, 2013a; Climate Technology Centre and Network, 2017). Entry points are targeted through technical adaptation, financing mechanisms, and policy changes ranging from the farm level to wider food system value chains (FAO, 2013a). Common interventions in this area include climate information services, index-based insurance, policy changes, and gender and social inclusion (FAO, 2013a; Climate Technology Centre and Network, 2017). Improving access to weather forecasting and early warning systems has been particularly important for managing risk in rain-fed agriculture (Climate Technology Centre and Network, 2017).

CSA can include a wide range of approaches, including crop diversification, use of improved crop and livestock varieties, integrated management of pests and soils, and agroecology (FAO, 2013a). Many CSA projects also reference conservation agriculture as a CSA strategy. The three main principles of conservation agriculture are minimum soil disturbance, crop rotations and permanent soil cover (FAO, 2022a). Diversification can be further divided into agroforestry, intercropping, crop rotation and mixed farming (crops and livestock) (FAO, 2013a; Vernooy, 2022).

Resilience as a core component of CSA aims to reduce the agriculture sector's vulnerability to the impacts of climatic shocks (FAO, 2013). Successful attempts to improve resilience focus on making communities more capable of preparing for, and subsequently recovering from, climatic events (Vernooy, 2022). Diversification has been highlighted as a key approach within CSA due to its ability to improve resilience to not only weather, disease and pest variability, but also to market fluctuations (Vernooy, 2022). Because species and varieties respond differently to environmental changes, diversity ensures harvests are not dependent on the success of a single crop (Vernooy, 2022).

4.2 What are the benefit and cost trade-offs of climate-smart agriculture for climate, environment and society?

Contradictions have developed around how well the synergies and trade-offs built into CSA's integrated framework have been managed (Lipper and Zilberman, 2018). Some critics have argued that by actively pursuing links with climate finance, mitigation is prioritised within the CSA approach (Lipper and Zilberman, 2018). Because climate-smart interventions often target low- and middle-income countries, this has been viewed as pushing climate mitigation burdens on smallholder farmers who do not significantly contribute to greenhouse gas emissions (Ogunyiola et al., 2022). In response, many organisations which support the CSA framework emphasise that emission reduction should be targeted 'where possible' (FAO, n.d.). The Food and Agriculture Organisation (FAO), CGIAR and the World Bank have deployed cost-benefit analysis and ranking systems to help determine which variations of CSA should be applied, and when. The rest of this section will discuss the trade-offs found in CSA interventions, how mismanagement can lead to maladaptation, and how trade-offs are managed through prioritisation frameworks.

Trade-offs between mitigation, adaptation and resilience stem from competing objectives between dimensions of sustainability, time and spatial scales, and social context (Adolph, 2020). Producers have long managed conflicting costs and benefits at the farm level and are often forced to choose between competing environmental, economic and social objectives (Adolph, 2020). Agricultural practices that offer immediate increases in productivity and financial gain, such as the use of fertiliser, can compromise long-term sustainability (Adolph, 2020). Despite benefits to food production and resilience, food-insecure households may be less likely to adopt some CSA practices due to shortfalls in capital, labour or access to technology. Investing in some CSA measures may be less attractive as longer-term risks associated with climate change are contrasted with addressing more immediate concerns including poverty and food security (FAO, 2013a). While some CSA approaches can successfully deliver the synergies outlined in its three-pillar approach, they are still constrained by the time and special scales that dictate rate of return. Farmers have to weigh the timescales required to obtain the benefits of different CSA practices; for example, use of improved crop varieties may lead to productivity increases in a shorter timescale than using agroforestry techniques (FAO, 2021; Hellin and Fischer, 2018). Additionally, it is necessary to consider the dimensions of poverty that extend beyond income, such as gender equality and nutrition, when evaluating CSA's full impact on poverty reduction (Feliciano, 2019). Labour-intensive strategies such as conservation agriculture can increase women's work burden and are not suitable for the elderly (Vernooy, 2022).

Although many actions can be taken to mitigate trade-offs, the risk management strategies available to producers are ultimately determined by enabling environments, which include market access, financing mechanisms, land tenure, and insurance opportunities. The market price of agricultural products and costs of inputs influence on-farm practices. Approaches such as farm diversification have introduced trade-offs with farm income by increasing production costs (Awiti et al., 2022; Mzyece and Ng'ombe, 2020). Opportunity costs can also be a determining factor in the uptake of CSA. For example, carbon-offsetting pilot projects in Kenya found that the key incentives for smallholders came not from payments for carbon sequestration through sustainable land management but through consequent improvements to resilience and productivity (Shames, 2013; Tamba et al., 2021). The high costs of monitoring, reporting and verification, potential loss of income from intensive production, and low market price of carbon have not yet created sufficient incentives for such approaches to be taken to scale (Shames, 2013; Tamba et al., 2021; FAO, 2021). While mitigating the costs associated with CSA through policy and market incentives can manage trade-offs, interventions should consider how enabling environments vary based on social standing and gender (FAO, 2013a; FAO, 2021). Landless agricultural workers may lack capacity to engage with CSA strategies, and households without land tenure security have proven to be less likely to practise agroforestry (Kurgat et al., 2020) or less able to engage with carbon sequestration projects (Shames, 2013; Tamba, 2021). Comparatively, women are more likely to practise agroforestry due to the secondary benefits, including sourcing wood for fuel (Hellin and Fischer, 2018; Kurgat et al., 2020). Effective targeting and project design is needed to link climate-smart interventions with differing livelihood pathways and poverty reduction mechanisms (Hellin and Fisher, 2018).

CSA approaches need to strike a delicate balance to promote climatic, environmental, social and economic sustainability. CSA can tackle broader environmental challenges by increasing soil health and improving water and nutrient management. For example, the low tillage and cover crop mechanisms of conservation agriculture enhance soil health and reduce water and fertiliser use, while crop diversification has a significant positive influence on pollination, pest control, nutrient cycling and water regulation (FAO, 2013; Snapp et al., 2021). Some CSA approaches may, however, stay 'environment-blind' and can have negative impacts on environmental management. A particular area of contention is water management, as irrigation may improve agricultural productivity but drain or pollute valuable wetland areas (McDermid et al., 2021). Similarly, a study in Malawi found that farmers perceived potential trade-offs in terms of poverty reduction, equity and ecological health when implementing and upscaling CSA approaches on top of existing landscape management practices (Schaafsma et al., 2018). Additionally, efforts to reduce greenhouse gas emissions through sustainable intensification may reduce emissions per kilo of yield but overlook other factors that determine the suitability of crops, such as agroecological interdependencies. Studies in Tanzania found that interventions labelled as CSA using improved crop varieties without consideration of natural enemy feedback loops led to increased vulnerability to pests on neighbouring farms that continued to use local varieties (Tripathi et al., 2022). However, interventions such as these may not be considered as genuinely 'climate-smart' if they have not considered all environmental factors and are not therefore sustainable.

Maladaptation in CSA is connected to increased climate vulnerability. While CSA's main objective is to be climate-adaptive and resilient, some interventions have instead been maladaptive and led to an increase of, or shift in, climate vulnerability (Schipper, 2020). For example, poorly planned irrigation systems can drain water sources for upstream communities and increase flood risk in riverbed areas (Schipper, 2020). Long-term infrastructure projects of this nature present a risk of maladaptation 'locking-in' vulnerability, exacerbating climate vulnerability for multiple seasons or even generations (Schipper, 2020). Short-term maladaptation might include harvesting date and seed variety recommendations based on forecasting models that are not localised to farm-level context, resulting in a negative impact on yield (Warnatzsch and Reay, 2020). Agricultural and climate insurance can become an institutional maladaptation by reinforcing risk systems and inhibiting adaptive change (O'Hare et al., 2016; Schipper, 2020). An EU-wide research project found that when flood insurance schemes focus on returning the policyholder to baseline measures of flood risk, this can increase moral hazard, prevent transformative change and undermine long-term resilience (O'Hare et al., 2016).

Prioritisation frameworks[10] help manage the fundamental trade-offs within the ambitious goals of CSA and the "underlying social complexities of achieving triple-wins in practice" (Ellis and Tschakert, 2019, p. 167; Lipper and Zilberman, 2018). It is critical to make sure that decision making is transparent when trade-offs are made between the costs and benefits of CSA (Galafassi et al., 2017). Some development practitioners have used the 'climate-smart village approach', which evaluates trade-offs from the farmer, community, and landscape perspective (Aggarwal et al., 2018). This approach is often able to better align with local knowledge, as well as identify maladaptation early (Aggarwal et al., 2018). Others have argued that the CSA approach does not require each intervention to contribute to food security, adaptation and mitigation (Lipper et al., 2014). Instead, these objectives should be met at broader spatial and temporal scales through 'climate-smart landscapes' (Lipper et al., 2014; Scherr et al., 2012). While prioritisation frameworks may vary in scale, they are a needed step in considering how agricultural practices that mitigate climate change may invoke trade-offs with environmental and social sustainability.

4.3 'What works' in putting climate-smart agriculture into practice

This section reviews good practice in the application of CSA interventions with examples from various donor countries and development organisations.

Climate-smart technologies, such as heat- and drought-resistant crop varieties, have been able to generate positive outcomes in multiple countries. Field trials in Zimbabwe found that heat-resistant maize varieties

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10 A prioritisation framework is a tool used to identify CSA options and assess trade-offs, barriers, and costs and benefits to adoption. For an example of a CSA prioritisation framework, please see: Corner-Dollof, C., Jarvis, A., Loboguerrero, A. M., Lizarazo, M., Nowak, A., Andrieu, N., Howland, F., Smith, C., Maldonado, J., Gomez, J., Bonilla, O., Rosenstock, T., Martinez Baron, D. and Girvetz, E. (2015) *Climate-Smart Agriculture Prioritization Framework*. Palmira, Colombia, link.

developed by a CGIAR research programme were the only crop successfully harvested during the 2015-16 season, after other crops failed due to heat stress from the El Niño weather system (Climate Technology Centre and Network, 2017). These varieties could become increasingly important, particularly in sub-Saharan Africa, as average maize yields are projected to decrease by 7.4% for every degree increase in global mean temperature (Zhao et al., 2017). Additionally, drought-resistant varieties have been used to adapt to increasing weather variability (Tesfaye et al., 2018). Currently, drought contributes to approximately half of grain yield reduction in West and Central Africa (Tofa et al., 2021). The use of drought-resistant technology in other crops has also been successful and an International Fund for Agricultural Development (IFAD)-funded initiative in Nepal found that drought-tolerant rice varieties were able to increase yield and reduce yield variance, even in non-drought years (Vaiknoras et al., 2020).

Various forms of diversification showed success across several projects and countries (FAO, 2013). These included, for example, agroforestry, intercropping, crop rotations and mixed farming. Beillouin's (2019) review of 3,700 field experiments found that farm diversification regularly led to increased yields, especially in rice, maize and wheat cropping systems. The benefits of diversification, particularly agroforestry, have a long-cited history, due to their centrality to the agroecology movement (Vernooy, 2022). In Malawi, intercropping different legumes was particularly useful for smallholder farms with limited farmland and improved soil fertility in land previously used for cereal monocropping (Vernooy, 2022). Multiple diversification projects have also found success through the protection and development of genetic diversity (Vernooy, 2022). In Mali and Uganda, mixing different varieties of the same crop and increasing the use of neglected varieties correlated with improved productivity and income generation (Vernooy, 2022).

The benefits of CSA can extend to women's livelihood development when gender is considered in project design (FAO, 2013a; FAO, 2022b). Having different roles on farms and in households, men and women are affected by and perceive climate change differently (Twyman et al., 2014). Many studies have found gender differences in awareness and adoption of CSA practices (Twyman et al., 2014). Transitioning from *gender-blind* to *gender-responsive* approaches to climate change can better consider how adaptive capacities differ based on gender (FAO, 2013). The appropriateness of CSA approaches is dependent on site-specific social structures. For example, CSA interventions in Zambia recognised that women held valuable knowledge on seed production and management, and expanded roles for women in seed networks (FAO, 2022b). It is important to establish gender-sensitive indicators to assess how the costs and benefits of CSA projects are distributed (FAO, 2013).

Many CSA approaches focus on 'climate-smart' technologies, which on their own will not be sufficient to transform agriculture in a way that reduces poverty and builds climate adaptation fast enough. Vernooy (2022) highlighted the need to give more attention to political dimensions of resilience and remove institutional barriers to empower smallholder farmers and communities to make the right choices. Engaging with local institutions can overcome many of the socio-economic barriers to scaling up CSA and support inclusive access to and adoption of climate-smart approaches (FAO, 2013a). Looking at how enabling environments support CSA projects offers insights into best practices to equitably manage trade-offs.

The success of CSA is dependent on "greater coherence, coordination and integration among the various sectors dealing with climate change" (FAO, 2013, p. 480). The Economics and Policy Innovations for Climate-Smart Agriculture Programme has generated a policy assessment framework that works to improve coherence by examining governmental priorities and climatic trends and identifying which policies affect farmer decisions. This programme has supported coordination between governmental sectors by establishing 'CSA core teams' with members from different agencies (FAO, 2013a). For example, the Zambia core team includes representatives from the Ministry of Agriculture and Livestock and the Ministry of Lands, Natural Resources and Environmental Protection (FAO, 2013a). Inter-ministerial collaboration has encouraged CSA uptake by aligning national and sectoral policy documents (FAO, 2013a). Additionally, these teams can identify where and how to engage the private sector and non-governmental organisations (NGOs). Engagement with civil society actors has been identified as a key component of scaling up CSA due to their influence on knowledge sharing and investment (FAO, 2013a). This has been observed in the expansion of the Africa Climate-Smart Agriculture Alliance, which was supported by numerous international NGOs including Oxfam and World Vision.

Climate-smart landscape approaches have been highlighted for their success in stimulating cross-sectoral solutions and improving policy coherence. Engaging with the varying stakeholders who depend on natural resources in an ecosystem, landscape approaches can better identify and manage the social and ecological impacts of climate change. For example, the Kagera River Basin Management Project is a transboundary landscape approach that works with communities in Burundi, Rwanda, Tanzania and Uganda to manage more than 50 micro-watersheds. The project deploys continuous consultations with stakeholders to examine where land degradation is occurring, and adaptation practices have been exchanged via farmer field schools (FAO, 2014). This collaboration has helped producers map affected areas, identify potential CSA approaches, and compare their success rates at varying scales (FAO, 2014).

Engaging with local knowledge systems improves the effectiveness of adaptations by aligning them with local contexts (Snapp, 2021; Grist, 2015). Evidence shows that approaches which are co-produced with local people and aligned with existing social structures allow technology adaptations to become site-specific, which can prevent maladaptation and increase adoption and continuation rates (Grist, 2015). Existing social networks can be used to disseminate information, as seen in Nepal where the leaders of women's cooperatives used folk songs, dance, radio and training manuals in local languages to exchange information (Grist, 2015). FAO's Globally Important Agricultural Heritage Systems programme illustrates how investing in what is already known and used can make agriculture more climate-smart. Examples from the programme include an initiative that supported the conservation of important indigenous potato varieties and the use of the traditional terracing system in Peru, which minimises land degradation and maintains soil fertility (FAO, 2014).

As climate and weather variability grows, monitoring environmental conditions is a key component of CSA implementation (FAO, 2022). Many CSA interventions, such as heat-resistant varieties, are implemented based on the findings of forecasting models. Assessment, monitoring and evaluation of CSA projects will not only identify maladaptation early but will determine how the actual impacts of climate change differ from predicted impacts (FAO, 2013). Similarly, evaluating what resilience looks like in action and establishing clear indicators for adoption helps to replicate CSA success in different contexts (FCDO, 2021).

There are many examples of successful CSA interventions across countries and regions, providing valuable examples of good practice. There is, however, still comparatively very little experience in taking CSA to scale. Intervention in CSA still represents a relatively small part of funding to agriculture, and may often fall behind in innovative and transformative opportunities highlighted by research programmes. A review of the 80 programmes within the UK Foreign, Commonwealth and Development Office's commercial agriculture portfolio found some level of inclusion of CSA approaches in half of its programming. Closer scrutiny found that these interventions often support only one aspect of CSA (production, adaptation or mitigation) or climate knowledge and information (CABI, 2021).

5. Nutrition-sensitive agriculture

5.1 What is nutrition-sensitive agricultural production and why is it important?

Malnutrition is one of the main challenges to global health and development. The agricultural sector can play an important role in addressing malnutrition through increased production and access to nutrient-rich diets. Development donors have largely agreed that nutrition-specific interventions, which target the immediate determinants of nutrition, are not enough on their own to address malnutrition (Hossain et al., 2017). Nutrition-sensitive agriculture (NSA) has emerged as a way to target the multi-sectoral, underlying determinants of malnutrition, by incorporating nutrition objectives and actions in the design of agricultural interventions (FAO, 2013). This section (5.1) sets out what NSA entails and why it is important. This is followed by an overview of the relationship between climate change, nutrition and food security (5.2) and an account of the evidence on 'what works' in promoting NSA in a time of climate change (5.3).

Malnutrition's impact on health and development outcomes only adds to nutrition's status as a priority goal for development donors. Malnutrition manifests itself in many forms, including undernutrition (wasting, stunting, being underweight), obesity, and acute micronutrient deficiency (WHO, 2021). Globally, nutrition is the biggest risk factor of illness and death and can severely weaken the immune system, particularly in children (WHO, 2021).

Global progress towards Sustainable Development Goal (SDG) 2, to end malnutrition by 2030, has been constrained by limited political prioritisation and action, in part due to competing global challenges, such as the climate emergency, the COVID-19 pandemic, and food price volatility (FAO, 2021). It is important to note, however, that there has long been a funding gap for nutrition, even before recent crises (Global Nutrition Report, 2021), and funding for many long-term interventions has plateaued since 2015 (R4D, 2022). It should also be noted that the various measurement metrics do not all tell a consistent story in terms of progress on hunger and malnutrition. According to the UN, the number of people affected by hunger rose from 618 million in 2019 to 768 million in 2021, while the prevalence of stunting – a key indicator for malnutrition – has continued to decline, albeit at a slowing rate, from 23% in 2017 to 22% in 2021 (FAO, IFAD, UNICEF, WFP and WHO, 2022). Nevertheless, despite differences across measures and indicators, all agree that levels of malnutrition worldwide are worryingly high (Global Nutrition Report, 2021). Following the 2021 Nutrition for Growth summit in Tokyo, the UK government pledged to integrate nutrition objectives across its official development assistance (ODA) portfolio, including climate and economic development sectors (Beecher, 2022).

NSA is a food-based approach to agricultural development that puts nutritionally rich foods and dietary diversity at the heart of overcoming hunger and malnutrition. NSA focuses on the entire food system, from production to consumption and waste (FAO, 2017). The Food and Agriculture Organisation's (FAO) 'nutrition-sensitive food systems' model positions agriculture and food supply chains as one determinant of the quality, quantity, diversity and safety of diets (FAO, 2017). Interventions to further NSA can be divided into three pathways for impact, focusing on:

i. agriculture as a source of food
ii. agriculture as a source of income to acquire food
iii. agricultural policies that change the conditions surrounding food prices and affordability (Kadiyala et al., 2014).

Strategies within these impact pathways include increasing supply of and demand for nutritious foods, enhancing nutritional value, and improving food utilisation (FAO, 2017).

At the production level, food-sensitive approaches have been applied to crop and livestock production, forestry, and aquaculture (FAO, 2021). Nutrition-sensitive interventions in crop production have included farm diversification, home gardens, biofortification, industrial fortification, and sustainable intensification (Wijeratna, 2013; FAO, 2017). At the market level, farm diversification is able to increase the availability of nutritious foods and lower market cost in local contexts, indicating a significant positive relationship between farm production diversity and consumer dietary diversity (FAO, 2017; Ecker, 2018). At the farm level, diversification can improve dietary diversity and increase access to micronutrients, which previously had been too expensive or difficult to acquire (FAO, 2017). For example, the increased production of leafy vegetables in Ghana has had positive nutrition outcomes as these contain more minerals and vitamins than staple crops and require less water to grow (FAO, 2021). Home gardens can reduce malnutrition in urban areas, where nutritious foods are often too expensive for low-income households (Wijeratna, 2013).

Biofortification interventions can increase the bioavailability of nutrients within food crops (FAO, 2017). Apart from some notable examples developed through the HarvestPlus programme, such as the orange-fleshed sweet potato (Foley et al., 2021), there have been few instances where biofortification interventions have been successfully adopted at scale. Over the last two decades, although large biofortification programmes have delivered to increasing populations in low- and middle-income countries, technical and logistical barriers continue to challenge large-scale adoption (Osendarp et al., 2018).

As many essential nutrients and proteins are available in animal-sourced foods, nutrition-sensitive interventions increasing the availability of meat, milk and eggs can significantly reduce stunting, improve growth, and reduce micronutrient deficiencies (FAO, 2021).

NSA interventions aimed at enhancing demand have included increasing the promotion of nutritious foods through marketing and behavioural change campaigns and strengthening consumer purchasing power.

Behaviour approaches in development economics argue for an increased focus on education and better consumption practices (Stevano et al., 2020) and many studies provide theoretical bases for improved nutrition strategies, based on behavioural economic theory (for example, Cory et al., 2021, Just et al., 2007). Development in this area should also consider the role of the private sector, as the food industry has a notable influence on nutrition narratives and food companies can use and shape nutrition discourse in positive but also, all too often, in negative ways (Stevano et al., 2020; Sathyamala, 2016). This may be best illustrated by the increased availability and advertising of ultra-processed foods in low- and middle-income countries, where obesity rates have soared, and overnutrition is now a common problem (Monteiro and Cannon, 2019; Popkin et al., 2012).

Efforts to improve supply are often directed at access to better inputs, technical assistance, and improved efficiency of production to increase the availability of nutritious food (de la Peña et al., 2020). Other supply-side interventions might look at improving value chains, in order to increase the local supply of nutritious foods at competitive prices or improve the regularity of access. These sorts of supply-side interventions are usually considered to be enablers, or facilitators, for NSA (Di Prima et al., 2022).

Gender inclusion and the role of women is a critical component of nutrition-smart agriculture strategies. Many NSA interventions have targeted child nutrition from conception to a child's second birthday, known as the first 1,000 days (WHO, 2021). Tackling malnutrition has also been integral to women's empowerment initiatives, as the role of women in household decision making and maternal employment in agriculture are key determinants of both maternal and child nutrition (Kadiyala et al., 2014). Some literature suggests that centring nutrition as a women's issue rather than a maternal issue can improve intervention outcomes (Nichols, 2021).

5.2 The relationship between climate change, nutrition and food security

Climate change impacts can reduce food nutrition and threaten food security. Agriculture is one of the most vulnerable sectors to climate change and has a direct relationship with nutrition. Changing climate conditions will therefore increase food insecurity and malnutrition. Regions with increasing weather variability, flooding and drought are already seeing a rise in malnutrition, particularly in children (Niles et al., 2021). By affecting food availability, climate change can reduce diet diversity and available income for off-farm food purchases (Niles et al., 2021). Since the 1990s, studies have found that higher CO_2 levels reduce the content of zinc, iron and protein in staple food crops such as wheat and barley (Meyers et al., 2014). Pathogens may also proliferate in warmer climates, making food and water less safe (FAO, 2021). The increasing economic impacts of climate disasters and high adaptation costs may also reduce public budgets for investment in health, water and sanitation (FAO, 2017). As arid and semi-arid lands increasingly suffer from droughts and volatile weather patterns, diets that are dependent on livestock and rain-fed agriculture may suffer acute nutrient deficiency and undernourishment (FAO, 2013). Children who are already afflicted by malnutrition are less resilient to the impacts of climate shocks: the 45 million children suffering from wasting already face an increased risk of death by up to 12 times (FAO, IFAD, UNICEF, WFP and WHO, 2022).

The pervasiveness of malnutrition and the scale of food system transitions needed to reach SDG2 have been recognised by global leaders as the effects of climate change on diets and nutrient quality continue to increase. The diverse development concerns surrounding malnutrition were discussed at the COP27 climate summit, which introduced its first food systems and agriculture pavilion and discussed methods for incorporating nutrition into nationally determined contributions. Additionally, nutrition-sensitive interventions have started to target climate resilience. For example, the SHOUHARDO programme in Bangladesh works in areas prone to cyclones and flooding that suffer from uniquely adverse agro-climatic conditions (Smith et al., 2011). Directly targeting vulnerable areas reduced malnutrition at a rate much higher than country-wide efforts (Smith et al., 2011). This project worked with regional partners and agricultural networks to train producers on climate-resistant farming approaches, including demonstrations on making silage (RIMES, n.d.). This process ferments and retains nutrients in cut grasses and provides feed for livestock when pasture is not available due to extreme weather events (RIMES, n.d.).

5.3 'What works' in nutrition-sensitive agriculture interventions

This section reviews good practice in the application of NSA interventions with examples from various donor countries and development organisations.

Determining good practice in nutrition-sensitive ODA programmes requires a set of indicators to evaluate project success (FAO, 2016). Due to the wide range of underlying factors impacting nutrition, evaluating how nutrition is addressed within NSA interventions has been challenging (Di Prima et al., 2022). The literature on nutrition-sensitive value chain interventions often fails to establish robust evaluation mechanisms for linking intervention outcomes to nutrition impacts (Di Prima et al., 2022). A recent review identifying key contextual and external factors affecting NSA efficacy found that evaluation timelines were often too short to assess the impact of interventions aimed at changing behaviours and strengthening local structures (Di Prima et al., 2022). This has improved since the Organisation for Economic Cooperation and Development's (OECD) nutrition policy marker was developed in 2020 with technical support from Action Against Hunger and endorsed by the Scaling Up Nutrition donor network. This marker allows for the tracking of nutrition investments across sectors, categorised by the degree to which nutrition is targeted by the intervention objectives. At the 2021 Nutrition for Growth summit, the UK committed to adopting this marker across its programme profile (Beecher, 2022). Additionally, FAO has developed a compendium of indicators for NSA which includes individual diet, household food access, income, women's empowerment, and nutritional knowledge (FAO, 2016). The choice of indicator is heavily affected by context: what information needs to be gathered, how rigorous the measurement should be, and what is practically achievable. For instance, field studies have revealed that some indicators are more specific and sensitive, while others are easier to gather and, in some cases, may be a more feasible option. For example, dietary indicators may be more specific, and sensitive to changes in food availability and access. They can also be simpler to track, in that they require smaller sample sizes than nutritional status (Verger et al., 2019). These indicators are often technically challenging to gather and measure, however. In many cases – such as humanitarian situations and community-based interventions – an easier-to-gather method such as the mid-upper arm circumference test provides a reliable and simple indicator for measuring nutritional status, and can be taught to mothers for use in community-based screening programmes (ALIMA, 2016).

Recently, the focus of ODA on nutrition has shifted to the development of nutrition-sensitive value chains. Interventions that target the value chain can better address the enabling factors that determine access to nutritious foods (FAO, 2021). By understanding how nutrition is affected at each stage of the value chain – for instance, by determining food availability or nutritional quality, interventions can be better targeted to address specific opportunities and barriers at each stage of the chain (de la Peña et al., 2020). Efforts to enhance nutritional content can target food waste and loss at all stages of the food supply chain (FAO, 2020). Development agencies such as the World Food Programme (WFP), the International Fund for Agricultural Development (IFAD) and FAO have highlighted nutrition-sensitive value chains as a key pathway to ending malnutrition (FAO, 2017). FAO has also developed a framework for nutrition-sensitive value chains that applies nutritional, rather than strictly economic, value to supply chains and looks at opportunities to add value at each level (FAO, 2017).

Nutrition-sensitive approaches should be broad-based and address smallholder farmers, as they produce 80% of the food in developing countries while also making up about 75% of the world's hungry (FAO, IFAD, UNICEF, WFP and WHO, 2022). When faced with decisions surrounding which crops to sell, producers will usually select commodities with the highest market value, often without considering nutritional value, while securing the majority of their own diet from local markets (de la Peña et al., 2020). Many studies have thus argued that interventions should work in and through markets used by the poor, including informal markets, to address how market conditions constrain nutrition and food security (Humphry and Robinson, 2015). This is the foundational basis of nutrition-smart agriculture (NSmartAg), which has gained popularity among international donors. NSmartAg is defined as a set of agricultural practices and technologies that both increase nutrition and, at the same time, raise productivity and revenue (World Bank, 2020). While NSA is a comprehensive approach, looking at meeting the dietary requirements of a population, NSmartAg is primarily focused on the production side of the value chain – producers and farmers. NSmartAg implements strategies that encourage the availability of nutritious foods by highlighting the importance of nutrition and food quality, rather than quantity (World Bank, 2020).

A review of NSA found that the most effective interventions included water, sanitation and hygiene, micronutrient fortification, nutrition and health behaviour change communication, and women's empowerment within project design (Ruel et al., 2018). However, it is critical to examine how women interact with different behaviour-change messages to ensure community engagement is both effective and ethical (Nichols, 2021). As gender equity becomes mainstream in development assistance, participatory learning and project design can account for power dynamics better than traditional behavioural change methods (Nichols, 2021). For example, women groups in India felt diet diversity was more actionable and relevant to their lives than other interventions (Nichols, 2021). NSA programmes can fill this implementation gap by facilitating conversations around the gendered components of both health and diet (Nichols, 2021).

A review found appropriateness, characterised by an intervention's knowledge of and sensitivity to local language, beliefs, practices, and existing community structures, to be a strong determinant of NSmartAg intervention effectiveness (Di Prima et al., 2022). Working with established rural service providers who were trusted within the community was a recognised success factor, particularly in remote communities (Di Prima et al., 2022). For example, an approach to combat high anaemia rates in Senegal connected local dairy producers in remote locations with local food processors to create iron-fortified yoghurt, and prevalence of anaemia dropped from 80% at baseline to 60% (Le Port, 2017). Taking such nutritional interventions to scale is frequently dependent on the presence of enabling factors such as government policies and access to finance (Wijeratna, 2013) However, even where such factors are less well developed, localised low-cost measures such as home gardens and livestock rearing are very likely to have a positive impact on household nutrition (Wijeratna, 2013).

Nutrition-sensitive approaches that centre resilience have had lasting effects on community nutrition indicators (FAO, 2020). Farmer field schools in Kenya were made nutrition-sensitive by adding nutrition outcome indicators and producing foods with high nutritional value. This project targeted a region with a refugee camp and aimed to improve nutrition of refugees and the host community by providing training sessions on crop and livestock production, processing and preparation (FAO, 2020). Previous interventions in this area had provided direct food assistance but had failed to strengthen local food systems (FAO, 2020). The project found that women's dietary diversity increased from 39% to 45% in the camp and from 40% to 48% in the host community, and the solar drying technique used to preserve fruit was adopted by over 16,000 people, more than half of them women (FAO, 2020). This intervention also succeeded in producing resilient knowledge networks, as the trained local facilitators received requests for training after the project ended (FAO, 2020).

6. Agriculture research

6.1 The relevance of agricultural research for socio-economic development

Agricultural research for development (AR4D), and research for development more generally, potentially contributes to three broad outcomes: scientific results, development impacts, and scientific capacity strengthening (OECD, 2011; Newman, 2014). Different funders, programmes and projects may place different emphasis on each and on mixtures of these outcomes (OECD, 2011; McLean and Sen, 2018). It is generally recognised, however, that research integrating impact and capacity-strengthening elements is likely to have greater developmental relevance than research focused on generating new knowledge and scientific results alone (McLean and Sen, 2018; Temple et al., 2018).

The Green Revolution demonstrated the potential impact of scientific research and technology development to improve agricultural productivity (Evenson and Gollin, 2003; Hazell, 2009). Improved maize varieties, for example, have contributed to improved yields, strengthened drought resilience, and poverty reduction (Newman, 2014). This, in turn, has led to rising calorie intake, better health outcomes, and economic benefits to producers and consumers (Evenson and Gollin, 2003).

Economists have shown that AR4D makes a positive and, by some estimates, a very strong contribution to economic growth by stimulating technical innovation (Alston et al., 2000a; Fuglie and Heisey, 2007). A substantial body of literature has attempted to establish the economic returns from AR4D spending by governments. One meta-analysis of 292 AR4D projects found the mean internal rate of return from investment was 81.3%, albeit with substantial variation (Alston et al., 2000). More recent meta-analyses have found mean internal rates of return of 45% (Rao et al., 2019) and 59% (Rao et al., 2020), while noting that these more modest outcomes still represent good value for money from public investment in research spending (Rao et al., 2019).

Donors increasingly expect research and agricultural research institutions to demonstrate the impacts of their work beyond the generation of research outputs (Faure et al., 2020). For example, in 2014 the UK added assessments of research utility for industry, policymakers and civil society to its regular assessment of university research excellence for the first time (Stern, 2016). Impacts from AR4D might include adopting and expanding the uptake of a practice or technology by a user group, or informing or influencing policy change (Newman, 2014; Thornton et al., 2017). Although there has been a long and widely held assumption that research focused on utility is likely to have less scientific rigour, this has been contradicted by a recent meta-analysis of 130 research for development projects (McLean and Sen, 2018).

A body of literature attempts to identify the pathways and multi-causal processes by which AR4D contributes to such impacts (Reed et al., 2021). For example, the French Agricultural Research Centre for International Development has created an impact assessment tool, Impact of Research in the South (ImpresS), to measure how research contributes to long-term development outcomes (Faure et al., 2020). Similarly, CGIAR has been mainstreaming the use of theory of change approaches in its work (Thornton et al., 2017; Thornton et al., 2022). By asking not only 'what has happened', but 'how or why did it happen', such tools and approaches help researchers to conceptualise and design impactful research and help donors to target funding towards projects more likely to achieve development impact (Thornton et al., 2022).

The key conclusion from this literature is that pathways from scientific results to the kind of societal benefits that would justify official development assistance (ODA) funding are indirect, long, unreliable and highly complex (Faure et al., 2020; Reed et al., 2021; Thornton et al., 2022). Research impact is highly dependent on a range of factors such as institutional preparedness to take up results, and attributing impact to an individual piece of research is rare; more commonly, impact arises from multiple streams of research over many years and involves a wide range of stakeholders other than researchers (Reed et al., 2021). These challenges are particularly true for 'basic' or 'discovery' research, where the pathways from discovery to impact are significantly longer than for field-based applied research (Bornmann, 2012). There is general acceptance in the literature that applied research is more likely to be developmentally relevant, particularly when research questions and design are informed by research end users and tailored to specific contexts and impact pathways (Georgeou and Hawksley, 2020; Cassola et al., 2022).

Over decades, such findings have helped ODA research donors to concentrate funding on research and approaches likely to be developmentally relevant and effective, such as by prioritising transdisciplinary research and supporting communities of practice (Tilley and Cao, 2017). Funding from Canada's International Development Research Centre (IDRC), for example, prioritises research leadership from the Global South. This position reflects evidence demonstrating that Southern-led research is more relevant to development challenges, and more effective in addressing them, than research led from the Global North (Mendez, 2012; Lebel and McLean, 2018; McLean and Sen, 2018).

Finally, increasing individual, organisational and institutional research capacity in developing countries has become best practice in international research for development (Altink et al., 2022). Analysis by IDRC has found that, contrary to general assumptions, there is a positive correlation rather than a trade-off between capacity building and scientific rigour in research for development (Lebel and McLean, 2018; McLean and Sen, 2018). The ultimate goal is to strengthen developing countries' ability to fund, manage and deliver high-quality research which supports economic growth and social development (OECD, 2011). Several routes for capacity building through AR4D are recognised, including developing networks, transferring research and non-research skills and expertise, provisioning of equipment and capital, and organisational development (OECD, 2011; Newman, 2014).

6.2 AR4D in a time of climate change

Although the world has benefited enormously from increased productivity due to agriculture research, the global development agenda no longer considers productivity gains the gold standard of success in AR4D (Alston, 2010; Hulot and Hiller, 2020). CGIAR positioned climate change as the central pillar of its ten-year strategy to improve food security and has called for AR4D funding to double from 2018 levels to address climate-related pressures on food systems (CGIAR, 2020). Climate change mandates a new era of AR4D that incorporates alternative standards of success beyond yield and income, such as indicators of climate resilience, carbon sequestration, and ecological integrity (Hulot and Hiller, 2020; Tripathi et al., 2022). This view holds that failure to prioritise resilience outcomes in AR4D risks exacerbating poverty levels as the climate crisis increases in severity (Hulot and Hiller, 2020). Expanding metrics of success in research has encouraged organisations like CGIAR to transition from *centres of excellence* to strategic *facilitators of innovation* (Watts, 2008).

The literature on agricultural adaptation research argues that effective responses to climate change will require institutional reforms to facilitate more effective innovation (Zilberman et al., 2018), such as appropriate knowledge sharing and funding platforms and mechanisms. This is particularly important in sub-Saharan Africa, where agriculture research expenditure is especially volatile and the risks of climate vulnerability are highest (Stads and Beintema, 2015). Development institutions have therefore argued that future donor funding for sub-Saharan Africa should align with national priorities to support long-term capacity building (Stads and Beintema, 2015).

6.3 'What works' for effective agricultural research for development

Conducting research

Some research approaches deliver on societal goals better than others (Weißhuhn et al., 2018). Over the last 60 years AR4D, and research for development more generally, has seen an increasing use of multi- and interdisciplinary approaches. Agronomic research focused on developing new technologies – such as high-yield varieties – has produced significant gains in productivity (Evenson and Gollin, 2003). While such research continues, it is generally recognised both that complex social problems are rarely solved by the generation of new ideas and technologies alone, and that the greatest innovation happens at intersections between different scientific disciplines (interdisciplinarity) and between science and application (transdisciplinarity) (Blackwell et al., 2009). Interdisciplinary and transdisciplinary applied research is therefore more likely to be effective in generating novel solutions to development challenges than approaches based in single disciplines.

The greater inclusion of social science perspectives in AR4D has made key contributions to understanding farmers' challenges and constraints, informing both the problems AR4D projects focus on and efforts to improve rates of technology adoption and productivity gains (for example, Watts et al., 2008; Newman, 2014; Macken-Walsh et al., 2022). Interdisciplinary approaches integrating social and agricultural sciences have been a particularly important aspect of long-term efforts to inform policies and practices with evidence (Watts, 2008; Macken-Walsh et al., 2022). For example, the increased inclusion of gender perspectives in work on agriculture and climate change has been instrumental in clarifying gender differentials in climate vulnerability and improving the access of both poor men and poor women to markets, information and technology (Kristjanson et al., 2017). Interdisciplinary approaches therefore serve a policy context in which research is increasingly expected to demonstrate social impact rather than simply generate new ideas (Temple et al., 2018), particularly when using ODA funds (ICAI, 2017). Funders of AR4D now generally encourage the integration of economic, sociological, gender, political and environmental analysis within applications of physical science research (Macken-Walsh et al., 2022).

Clearly, if AR4D results are to achieve impact, they need to be adopted and used by non-researchers, such as farmers, agribusinesses or policymakers (Newman, 2014). Understanding how this can be achieved effectively has been a long-standing area of enquiry and refinement of practice (Douthwaite et al., 2008; Watts, 2008; Faure et al., 2018). For example, numerous studies have demonstrated the role of agricultural extension services in translating agricultural research findings for farmers and thereby increasing productivity and poverty reduction (Alene and Coulibaly, 2009). It is common for AR4D projects to include components to engage with and communicate results to key stakeholders, such as through policy briefs, farmer training, and dissemination workshops. Done well, this can improve the likelihood of findings being taken up in policy and practice (Newman, 2014).

Best practice in AR4D has shifted to emphasise research as one stage of an 'innovation process' (Watts, 2008). This model is based on evidence demonstrating that research uptake and impact results from complex processes of interactions, rather than a linear process of research, dissemination and adoption (Watts, 2008; Faure et al., 2018; Schut et al., 2018; Temple et al., 2018; Douthwaite et al., 2022). Rather than relying on the dissemination of research results, innovation-based approaches engage with non-research stakeholders in the definition of problems, experimentation, and evaluation of findings, a hallmark of transdisciplinary research (Schut et al., 2018;

Dinesh et al., 2021). These approaches have been shown to improve the relevance of research to intended beneficiaries, enhance the utility of research findings, and demonstrate that research results are reaching end users (Watts, 2008; Schut et al., 2018; Dinesh et al., 2021). ICAI's 2013 report on the former UK Department for International Development's (DFID) support to agricultural research reflected similar concerns, finding that agricultural research programmes often did not "work sufficiently with or learn from DFID country programmes and other departments to ensure research outputs are delivered to farmers" (ICAI, 2013, p. 1). ICAI's recommendation to better collaborate with farmers echoes arguments from agricultural research donors and experts that reciprocal learning is integral to innovation processes (for example, Patton and Horton, 2008; CARRIA, 2017).

Funding research

The increasing focus on, and enquiry into, research impact has also opened up discourse on how research donors can improve their developmental effectiveness (McLean and Sen, 2018). In regions where investment in agricultural research is particularly unstable, diversifying funding sources, for example through the commercialisation of research technologies, can help absorb funding shocks (Stads and Beintema, 2015). This is likely to be particularly important in an era of climate change, as agricultural practices face increased pressure to mitigate the impacts of climate change and increase farmer resilience (Lipper and Zilberman, 2018). Cyclical shifts in the funding of agricultural research have created a volatile investment arena. The literature agrees that stable funding is needed to realise the 'slow magic' benefit structure of agricultural research (Rawat, 2020; Stads and Beintema, 2015). There is also a need to increase transparency and address the incentive structures within research life cycles (Jones et al., 2018). The current model of commissioning research follows a single-stage proposal-to-selection process (Jones et al., 2018). In this model, the design of research programmes is heavily influenced by the interests of research funders rather than localised adaptation priorities (Jones et al., 2018). New innovations in research design have instead encouraged multi-stage, flexible funding structures that promote collaboration and 'seeding ideas' (Jones et al., 2018).

In particular, traditional assumptions about 'research excellence' and the relative value of researchers from developed and developing countries have been re-examined in the light of experience and new evidence. The traditional approach to selecting research proposals for funding, particularly in the UK, has been informed by the Haldane Principle: that research should be funded based on scientific merit determined through peer-review by scientists (DfE and BEIS, 2016). In a context of increased expectations that research will contribute to social impact, this approach has been criticised for introducing a perceived trade-off between 'research excellence' and 'developmental excellence' (Penfield, 2014). However, a recent meta-analysis of 130 research for development projects found a strong correlation between utility and scientific rigour rather than a trade-off (McLean and Sen, 2018; Lebel and McLean, 2018). This finding resonates with arguments that, while not all 'excellent' research is developmentally relevant (see **Section 6.1**), in transdisciplinary research 'developmental excellence' *is* 'research excellence' (McLean and Sen, 2018), and that identifying potentially impactful AR4D requires engaging with a broad range of expertise, including from non-researchers (for example, Shut et al., 2018). Another long-held assumption has been that researchers from developed countries bring intrinsic benefits to AR4D by virtue of the higher quality of research institutions in the Global North and their potential to build capacity in Southern research institutions. Again, analysis has shown that this is not necessarily the case. McLean and Sen (2018) found that Southern research for development projects demonstrated superior research quality to either Northern research projects or North-South research partnerships.

If North-South research partnerships do not necessarily generate higher-quality research, these partnerships can support other strategic objectives such as nurturing international networks (McLean and Sen, 2018). It is considered good practice for donors to support greater equity between Southern and Northern research partners, although there is less consensus on emphasising the leadership of Southern researchers (Harvey et al., 2022; Cassola et al., 2022). Designated leadership roles for Southern researchers within international research consortia have been shown to often be tokenistic in nature, with scoping, project design, budgeting and evaluation allocated to Global North researchers and institutions (Harvey et al., 2021). Leadership imbalances have especially been noted in climate science, where Global North institutions continue to lead agenda setting (Harvey et al., 2021). This practice has repercussions for the efficacy and suitability of research outcomes, as it prioritises the interests of Northern researchers and deprioritises the interests of those closest to, and better able to address, development challenges (Jones et al., 2018; Lebel and McLean, 2018). Funding Southern research institutions directly, without intermediation through Northern institutions, improves equity in partnerships, contributes to long-term capacity building, and is considered good practice (UKCDR, 2022; UKCDR, 2023).

The focus on research impact has also led to new approaches to monitoring and evaluating AR4D. Approaches which assume that downstream impact will arise from the delivery of planned outputs (Watts, 2008) have been largely supplanted by more sophisticated methods in best practice. For example, more donors now require researchers to develop theories of change that articulate processes of engagement and influence through which research may contribute to development (Newman, 2014). CGIAR's Climate Change, Agriculture and Food Security Programme found that theories of change enhanced scientists' capacity to work with non-research partners and across disciplines (Thornton et al., 2017). This echoes literature on research capacity building, which emphasises the connection between research capacity and research impact (Posthumus et al., 2012).

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