19-20 October 2021

Finance in Common

MOVING TOWARDS SUSTAINABLE AGRI-FOOD SYSTEMS: ANALYSIS AND STRATEGIC SCENARIOS

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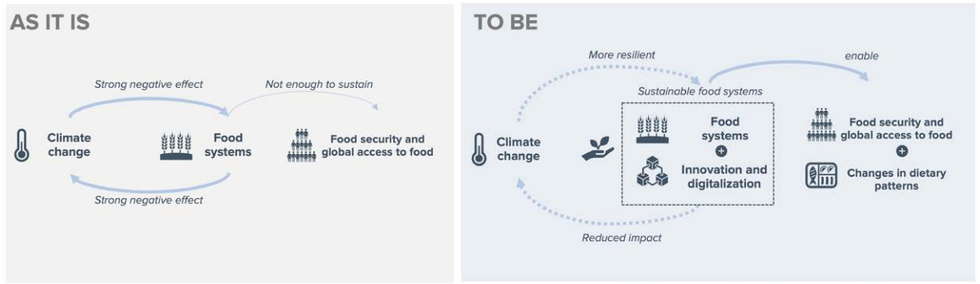
1. FINANCE IN COMMON SUMMIT: ANALYSIS AND STRATEGIC SCENARIOS

Over the next 30 years, with a population expected to reach nearly 10 billion by 2050, agriculture will face several critical issues on local, national and global food value chain endangering food security and achievement of 2030 Agenda. Food security is closely linked to the Sustainable Development Goals (SDGs) as the elimination of poverty, health and well-being, clean water, the reduction of inequalities, responsible consumption and production, action for climate change and conservation of marine and terrestrial ecosystems. Public Development Banks might contribute to move towards sustainable food and agricultural systems aiming to ensure global food security, providing economic and social opportunities, and protecting the ecosystem services.

Different factors are in a relationship of reciprocal influence with agricultural productivity such as scarcity and competition of natural resources or climate change. Climate change will not only affect food production, but also the availability of food and the stability of supplies. At the same time, food systems contribute to one third of global greenhouse gas emission. Climate-resilient agriculture can guarantee food security and reduce emissions of global warming gases. However, a climate resilient agriculture requires a technological progress to enable production practices that are environmentally sustainable also adapting to changes in dietary patterns[1] (figure 1).

FIG. 1 | THE NEED FOR SUSTAINABLE FOOD SYSTEMS



Source: CDP elaboration

The three papers of Martin Kenney (et al.), Rob Vos and Laura Viganò aim to address the main challenges and opportunities moving towards more sustainable agriculture production systems. The importance of innovation improvement, also with respect to the specific case of platformization and digitalization, represent key solutions and enablers for sustainable agrifood systems indeed[2], as well as a more efficient purposing of government agricultural policy support.

It is shown that a guided technological innovation could contribute to sustainable food system transformation allowing an increase in productivity and reduction of emissions in agri-food sector.

The evidence is that Development Banks, acting together as a system, having the objective of increasing investments, can facilitate the transition towards an inclusive and sustainable digital revolution in the agri-food system. Therefore, it is shown that stronger policy coordination is required in order to guarantee an even-handed diffusion of both technologies and financial resources between all countries.

1 Vos, R. "The mutual relationship between climate change and agri-food system, how to make agriculture and food systems part of the climate solution?", 2021

2 The present work will be presented and discussed during the second edition of Finance in Common Summit (FiCS) with the aim of shedding some lights on research findings and on the most recent trends and challenges that developed and developing countries are facing in making the agri-food system more sustainable, both from an economic and a financial perspective. One of the main objectives of 2021 FiCS is to explore the theme of agriculture, agribusiness, and food systems financing.

2. WHY AGRICULTURE AND FOOD SYSTEMS ARE THE FOCUS?

By 2050 population will increase about 25% from the actual level, but agriculture system, *as it is*, can't deliver enough output. On top of that, incomes at global level are expected to grow and therefore people will increasingly consume more resource-intensive, animal-based foods, incurring in higher level of greenhouse gas (GHG) emissions[3]. The food system at global level will have to follow two apparently opposite paths, simultaneously increasing production output while decreasing its impact on the environment. According to the World Resources Institute, three gaps should be closed to successfully feed the global population by 2050:

1. food gap: the amount of crop calories produced in 2010 are less than half of those that are expected to be needed in 2050;
2. land gap: almost 600 million hectares, more than the area covered by European Union, to be extended from 2010 level to 2050 ones;
3. emission gap: expected agricultural GHG emission by 2050 are 11 gigaton, the equivalent of almost one fifth of global GHG emission in 2016[4], higher than the those compatible with the 2°C global target.

In order to close these gaps, it is necessary to read agriculture and food systems under the lens of sustainable development.

Therefore, the need and the ambition of food systems must meet the needs of present and future generations, while ensuring profitability, environmental health, and social and economic equity[5] assuring an efficient and fair use of natural resources.

The specific issue of agriculture, agribusiness and food systems financing sits then at a critical intersection of issues that must be addressed to achieve the 2030 Agenda and the Paris Agreement, representing:

- a major source of productive livelihoods, particularly in emerging economies,
- a source of job-rich economic growth,
- a contributor to public health (through improved nutrition),
- an entry-point for the protection of biodiversity and addressing climate change.[6]

More precisely, food systems and agriculture have a wide role in achieving Sustainable Development Goals contributing substantially to all of 17 areas. It is clear the relevance of agriculture and therefore the urgency to diagnose where the main critics are and act to fix them (figure 2).

FIG. 2 | HOW CAN AGRICULTURE AND FOOD SYSTEMS AFFECT SDGS?

Source: CDP elaboration

3 World Resource Institute, "Creating a sustainable food future", July 2019
4 Our World in data, Total greenhouse gas emissions, 2020
5 FAO definition (http://www.fao.org/sustainability/en/)
6 FiCS 2021, Concept note

Focusing on agriculture, the need for improving the sector's efficiency is even more crucial for what concerns developing countries. Indeed, the structural transformation that low and middle-income countries should face in shifting to a more service-focused economy stems from an advanced and modernized agricultural sector[7]. Improvements in this sense would enable to move from the actual high weight of agricultural valued added on total GDP in low-income countries (24%) and middle-income countries (9%) to the around 1% of high-income countries[8]. A global sustainable and effectively efficient food value chain could contribute to close a fourth gap: the one between developing and developed economies.

Agriculture accounts for 3,5% of total GDP in the world but it represents more than one quarter of total employment[9]. In 2020, more than 80% of total agricultural value-added was produced in developing and emerging countries[10] but this comes with no adequate level in productivity. The highest rates of agricultural value added per worker are recorded in countries like New Zealand, North America and across Europe (with levels between 90 and 40 thousand dollars per worker); while, on the other hand, most Sub-Saharan African and South Asia countries show less than one thousand dollars in valued added per worker. These inefficiencies do not exactly match with agri-food related GHG emissions production. Even though developing countries contributes to around 40% of total agri-food related greenhouse gas emission, United States by itself represents 8% of the global impact while certainly having a higher innovative food system structure (figure 3 and 4).

FIG. 3 | AGRICULTURE VALUE ADDED PER WORKER, 2017

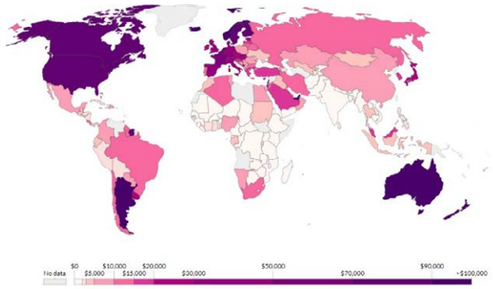
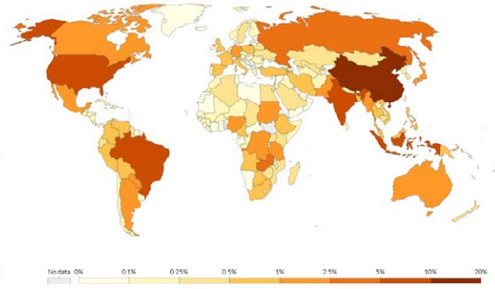


FIG. 4 | SHARE OF THE GLOBAL GREENHOUSE GAS EMISSIONS FROM FOOD SYSTEMS, 2015



Source: World Bank, Nature Food, 2021

Considering these constraints and challenges, high attention must be focused on food systems and their transition to a more sustainable model, both from a local and a global perspective.

7 IFPRI, "Agriculture is key for economic transformation, food security, and nutrition", 2018
8 World Bank, 2018
9 World Bank, 2019
10 Oxford Economics, 2021; Developed economies defined as: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxemburg, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, UK, US

3. THE NECESSITY AND THE OPPORTUNITY TO MOVE TOWARDS A MORE SUSTAINABLE AGRI-FOOD SYSTEM: THE ROLE OF PDBS IN DRIVING THE TRANSITION

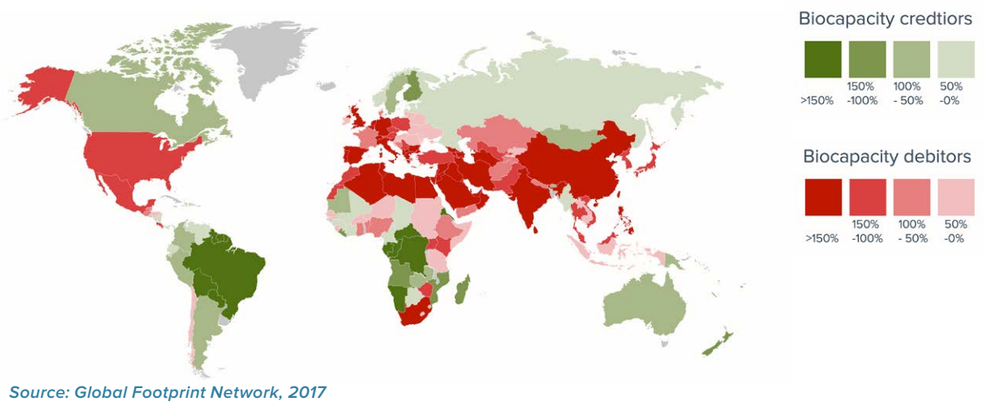
The current world production model consumes more resources than the Earth can offer and renew; at the same time, it keeps increasing its negative impact on the environment. For these reasons, in the long run the growing food demand will be left unmet, natural resources and biodiversity will be threatened while waste generation increases.

The ambition is to encourage a paradigm shift that can give life to a new development season, in which the balance between the economic, social and environmental dimensions is guaranteed while respecting the well-being of present and future generations[11].

A measure of the unsustainability of the current development model is represented by the "ecological footprint" namely "the area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces, wherever on Earth the land and water is located"[12].

The ratio between the region's ecological footprint and its biocapacity - the productivity of its ecological assets- could imply a biocapacity deficit or reserve. The biocapacity deficit or "ecological deficit" is determined when the population's ecological footprint rises above the region's capacity. In this case the ecological deficit is satisfied by importing, liquidating its own ecological assets and/or emitting carbon dioxide into the atmosphere. If a region's biocapacity exceeds its Ecological Footprint, a biocapacity reserve or "ecological surplus" is registered[13].

FIG. 5 | ECOLOGICAL DEFICITS AND RESERVES, 2017



Source: Global Footprint Network, 2017

For example, Canada, Australia, and Sweden can be considered ecological creditors to the rest of the world, as shown in figure 5. Instead, Italy and Germany consume more natural resources than it produces in per capita term (respectively about 3,5 hectares and 3 hectares per inhabitant per inhabitant). Despite its vast domestic endowment, the United States are also in an ecological debt position (4,5 hectares of excess consumption of natural resources per inhabitant).

However, when the growth of output is above the nature-constrained growth rate, it leads to environmentally degradation, climate change and agricultural failures. In particular, a high rate of growth of demand and capital stock relative to the sustainable "ecological footprint" brings ecological problems. For this reason, ecologically sustainability is essential.

11 CDP, Sustainability Framework, 2020

12 Wackernagel, Mathis and W. Rees,1996 as reported http://www.sustainablescale.org/conceptualframework/understandingscale/measuringscale/ecologicalfootprint.aspx.

13 The ecological footprint and biocapacity are expressed in global hectares and they help to determine which countries consume more natural resources than the amount produced and vice versa.

It's clear that the inverse relationship between ecological surplus or deficit and the level of production - usually the ecological footprint follows the GDP trend - doesn't imply that the crises (as pandemic or 2008 crises) necessarily represent an opportunity, reducing waste and emissions. In fact, a deep crisis leads to an acceleration in Schumpeterian "negative creative destruction", or rather, a technical regression that can make production processes obsolete, less respectful of environmental and so more emissions. Not mentioning all the others negative systemic effects that those crises lead to.

Therefore, and with respect to the neoclassical paradigm, the economic growth isn't a solution to all problems but at the same time it is not the cause of all problems as asserted by the proponents of "zero growth"[14]. In addition, the economic growth is not the enemy of development if it considers a redistribution of wealth to weaker social classes, and a prudent management of natural resources.

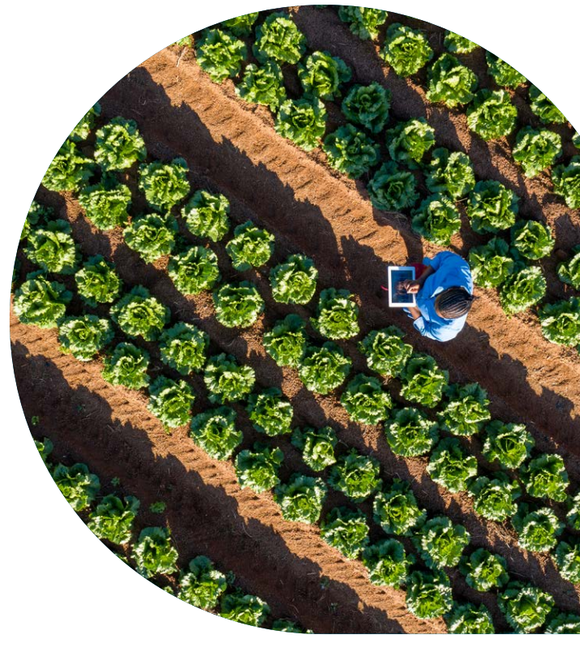
The lack of "market forces" which would adjust the market distortions and would bring growth to an environmentally sustainable growth rate, requires the intervention of public policies.

In this context, Vigano's paper highlights the specific role of Public Development Banks (PDBs) since they can:

- incentivize strategic private actors of food systems by taking specific risks and better manage these specific risks;
- face issues as incomplete markets and imperfect information;
- address market failures and they can play a countercyclical role thanks to their mixed nature, as private institutions with public nature and their use of market instruments;
- mobilize resources towards sectors unattractive but strategic (additionality), promote infrastructural development and activities that can generate positive externalities such as social services or public goods.

In fact, public intervention, together with private action, allow to address patient capital towards the achieving of development and social goals while offering preferential returns to private investors.

However, as shown in the scientific paper, achievements of PDBs towards a green, inclusive, sustainable development are still fragmented and environmental practices are not fully included in PDBs' strategies[15].



14 i.e. S. Latouche and G. Rist; as said in E. Berr, "Sustainable development in a post Keynesian perspective: why eco-development is relevant to post Keynesian economics", 2015

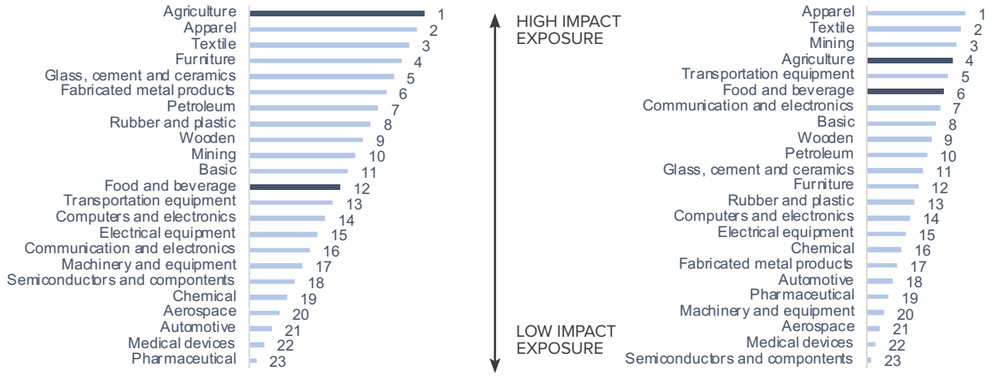
15 Viganò L., "The role of finance and Public Development Banks in promoting sustainable agriculture around the world", 2021

4. VULNERABILITIES AND CHALLENGES OF AGRI-FOOD SYSTEM. THREE KEY ASPECTS

The transition towards more sustainable agri-food systems happens in the context of a rapid change in world demographic (almost 70% of population is expected to live in urban areas by 2050 versus the actual 55%; ageing population with median age predicted to increase in all countries[16]) and evolving economic setting, both at individuals' level as well as in international trade schemes and global value chains equilibria.

Severe events related to climate change are expected to increase in intensity and frequency in the following years[17]. This implies high vulnerability for food systems since agriculture is, relatively to the other economic activities, one of the most affected by climate change related events (graphic 1).

GRAPH. 1 | VALUE CHAIN EXPOSURE TO HEAT SHOCKS (LHS) AND FLOODING (RHS), 2020



Source: Mckinsey Institute, 2020

The geographical concentration of most important crops production imply that even isolated events could have systemic effects, representing exposure for the hole global value chain. Just thinking that two of the main sources of global diets -rice and corns- see the top ten countries producing more than 65% of global output, making countries like China, US, India and Brazil the breadbaskets of the world[18].

These dynamics can strongly affect food prices volatility both at national and international level. Shocks in food prices can have devastating effects in developing countries because of the high dependency on agriculture income of the population as well as less effective government institutions in preventing social conflicts and financial markets unable to absorb income variations. Effects in advanced economies can be greater than expected, considering that they are much more integrated in global markets, therefore more vulnerable to price shocks, and have higher dependency in importing foods[19]. On top of that, these events have strong implications also in terms of migration flows.

In this context, Covid-19 crisis exacerbated some weakness of food system witnessing local and regional difficulties due to shortages caused by interruptions in agricultural labor and in logistics services.

16 FAO, Responsible investments in agriculture and food systems, 2020; Our world in data,2021

17 Vox Eu, "Global weather disruptions, food commodity prices, and economic activity: A global warning for advanced countries", August 2021

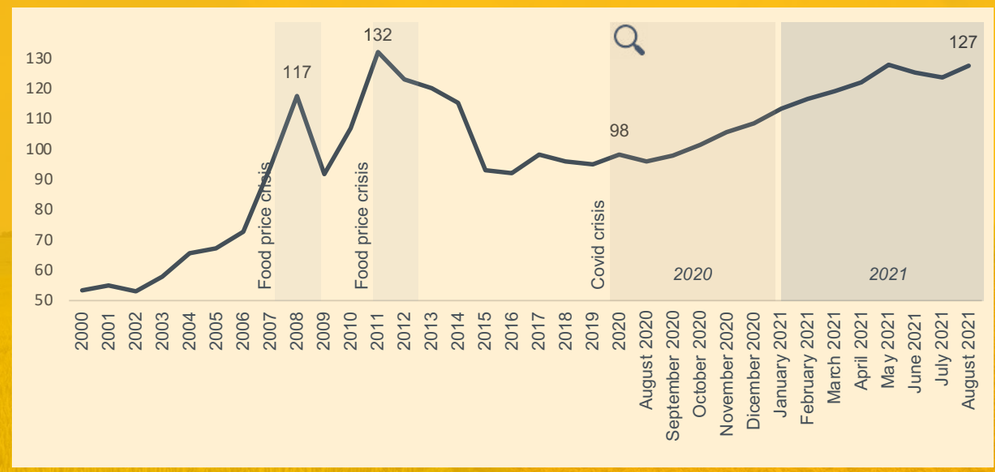
18 FAOSTAT, 2019. (Top ten countries per rice production: China, India, Indonesia, Bangladesh, Viet Nam, Thailand, Myanmar, Philippines, Pakistan, Cambodia; Top ten countries per maize production: United States of America, China, Brazil, Argentina, Ukraine, Indonesia, India, Mexico, Romania, Russian Federation)

19 Vox Eu, "Global weather disruptions, food commodity prices, and economic activity: A global warning for advanced countries", August 2021

The rising food prices' trend seen in these recent years has been thus intensified by the pandemic crisis[20]. On the one hand the actual situation is not comparable to the food prices crisis of 2007-2008 and 2011-2012 in terms of production capabilities, yet on the other hand the FAO monthly food price index is reaching levels close to these historical records in the last twenty years.

In the first eight months of 2021 the index increased by more than 14 points, reaching the rank of 127, showing an increase of 34% from pre-covid level (graphic 2). Inflation pressures driven by increases in foods prices can have strong negative effects on key aspects of SDGs, as raise of poverty and malnutrition while reducing consumption opportunities in healthcare and education, especially in developing and emerging countries.

GRAPH. 2 | FAO FOOD PRICE INDEX IN THE LAST 20 YEARS, (2014-2016=100)



Source: FAO, 2021

The underlying message to take from the actual criticalities is the vulnerability of food systems at a large scale and the necessity of improving food system resilience, acting on its major challenges. In this sense, implementing sustainability -as broadly interpreted- in the agri-food value chain may represent the key enabler.

Agri-food challenges are multiple and interrelated among them, but the most effective and systemic impact measures are those which implement climate change tackling as well as the implementation of innovation in food systems and investments and financing measure that could drive the former ones[21].

20 This happened because of multiple dynamics, like consumer prices being lifted by early lockdown measures in 2020, the effect of soaring shipping and transport costs witnessed over the last year in global international trade and finally the rise in food producer prices due to the strong demand of food products during the pandemic, the indirect effects of biofuels trading and occurrence of extreme weather events. La Niña episode (2020-2021) -a global weather event occurring every few years-has led to dry weather in key food exporting countries, including Argentina, Brazil, Russia, Ukraine, and the United States. IMF blog, "Four Facts about Soaring Consumer Food Prices", June 2021

21 Calicioglu O. et al, "The Future Challenges of Food and Agriculture: An Integrated Analysis of Trends and Solutions", 2018

In this context, if properly oriented these major challenges could work as levering effects in completing the transition. The papers by Martin Kenney (et al.), Rob Vos and Laura Viganò, focus on the three main key aspects to be addressed, providing innovative insights:

A. DIGITALIZATION AND INNOVATION

Agricultural sector digitalization is inexorable. Digitalization and platformization provides not only tools, but also resources and possibilities to generate innovations that can contribute to the attainment of many of the SDGs. The key to use digitalization and platformization to support farmers and consumers must include the provision of an appropriate and fairly governed infrastructure to ensure that the value created is not entirely siphoned away by the most powerful actors in the value chain[22].

(The challenge of the digital agricultural revolution – M. Kenney et al)

B. MITIGATION AND ADAPTATION TO CLIMATE CHANGE

First, more R&D is needed to adapt productivity-enhancing and emission-reducing innovations. Second, market incentives need to be reset for farms and food businesses to adapt and adopt the technological progress available on tap and to be developed. Third, consumers will need to adjust as well shifting dietary choices towards foods that are less resource and emission intensive to produce and healthier for people. To be effective at the global level, an even-handed diffusion of both technologies and financial resources would be needed to let all countries reap the benefits of such agricultural policy reform. International coordination is a must, if only because climate change and environmental sustainability are global priorities transcending borders and because national policies have strong international spill-over effects[23].

(Climate change and food system sustainability: challenges and solutions – R. Vos)

C. CAPABLE FINANCING

To achieve their full potential, PDBs must work to strengthen both their financial and social performance. A pre-condition for sustainable contributions is for all PDBs to break-even. Improvement in processes, risk management, accounting and accountability mechanisms are required to enhance PDBs' overall performance. In relation to their social objectives, PDBs can aim to expand their outreach while deepening their impact. Financial performance, outreach and impact would represent three equally important and mutually reinforcing perspectives. Under these conditions, the PDB community can promote investments at scale for sustainable food system transformation[24].

(The role of finance and Public Development Banks in promoting sustainable agriculture around the world – L. Viganò)

22 Extract from Kenney M., "The challenge of the "digital agricultural revolution": a comparison between advanced economies and developing countries", 2021

23 Extract from Vos R., "Climate change and food system sustainability: challenges and solutions", 2021

24 Extract from Viganò L., "The role of finance and Public Development Banks in promoting sustainable agriculture around the world", 2021

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THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

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THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

CONTENTS

ABSTRACT

The new digital technologies offer remarkable opportunities to make agriculture more sustainable and contribute to the amelioration of inequality at the local and global level. And yet, digital innovations and, in particular, the adoption of platforms risk creating further distortions among and within countries.

Digitalization could contribute to the further concentration of agriculture in a few giant firms and also lead to the rapid and unmanaged demise of subsistence farming as it is typically practiced in developing countries. Alternatively, if the implementation of the digital technologies is guided, they could help achieve sustainable development goals by increasing productivity, while reducing waste, pollution, and inequality in agriculture.

The development banks can, with their investment and stewardship, facilitate an inclusive and sustainable digital revolution in the agrifood sector at global level. In this report, we summarize the current situation in regards to digitalization and the adoption of platforms in agriculture in both the developed and developing countries.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

1. INTRODUCTION

The inclusion of digital technologies and thus, software into every part of social and economic life is having profound impacts on all aspects of the agrifood system in the developed and the developing world. These offer enormous potential to address the United Nations' Sustainable Development Goals (SDGs), even as they shift power and flows of value in ways that will impact the organization of the agrifood system and the livelihoods of agriculturalists and those in the agrifood value chain (Kenney et al. 2020). In this report, we explore the trajectories of digitalization with respect to their impacts on agriculture. The report takes a farm-centric approach and thus only briefly mentions other dramatic changes that are underway, in particular, the transformations between final consumers and supermarkets and restaurants. It is important to note the COVID-accelerated entry of vendors such as Amazon into the food retail and distribution system (for an overview of these changes, see Kenney and Visser 2021), which will almost certainly eventually affect farmers. Finally, the impacts of digitalization will differ dramatically between developing and developed countries, smallholder[1] and commercial farmers, and by crop (see, e.g., Maru et al. 2018).

At the global level, agriculture is an enormous undertaking and has a powerful impact on the environment as well as human health and well-being. In value terms, it constitutes only 3.55% of global GDP, though its impacts are far bigger. While dropping rapidly, in 2020 28% of the world population was still employed in agriculture; in developing countries, these are among the poorest citizens and even in developed nations, farm laborers, often immigrants, are among the poorest in their society. In contrast, it is estimated that food value chains contribute to 19-29% of all global greenhouse gas emissions (FAO 2015). Moreover, agricultural chemical use and runoff contribute significantly to the global safe water crisis. These facts alone suggest that agriculture, both commercial and small holder, has a vital role to play in any transition to a more sustainable society. The application of digital technologies to agriculture can increase the value created in agriculture and help address the UN SDGs (United Nations DESA 2017).

Digitalization has the potential to help agricultural systems more productive, efficient, socially inclusive, transparent, traceable, and resilient while reducing costs, waste, production losses, and agrichemical use (FAO 2017; 2019). The promise of "precision" or "smart" agriculture as a transition from industrial agriculture where chemicals were applied uniformly to an entire field to one in which chemicals are applied only where needed (variable rate technologies). Digital technologies also can allow farmers to discover and connect directly with their customers, thereby decreasing the role of intermediaries and potentially reducing the distance food must travel (Wilson et al. 2020) and food waste (Annosi et al. 2021).

Yet, as with any powerful new technology, digitalization could also result in a reinforcement of the current technological and economic trajectories, resulting in greater concentration, increased inequality, and potential joblessness in both developed and developing agrifood systems (Klerkx and Rose 2020). Of particular concern is that digitalization could centralize data in a few firms that could then exploit the other parties in the value chain. Adoption could operate to recast the linkages in the agrifood system and thus affect farmers in ways that might exacerbate inequality and increase the concentration of power in a few firms (Birner et al. 2021; Kenney et al. 2020; Prause et al. 2021).

1 Small holdings are usually farms supporting a single family with a mixture of cash crops and subsistence farming. As a country becomes more affluent, small holdings may not be self-sufficient, but may be valued for the rural lifestyle (Wikipedia 2021).

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

Our study suggests that the goals for the future evolution of agriculture and for agtech should be to deploy technology in ways that underpin sustainable development in communities and does not damage current actors in the agricultural sector, though change always has costs and risks. The challenges will be to avoid concentration and domination for narrow goals by the already enormous agricultural industry incumbents and also existing platform giants (i.e., prevent increased monopolization and the loss of smaller farmers). The current wave of entrepreneurship and innovation funded by venture capital is remarkable in its size and breadth, however many of these firms, if successful, are likely to be purchased by industry incumbents or platform giants.

To prevent increased monopolization and concentration and ensure equity and sustainable development in this arena it will be necessary for the development banks to work with communities, as a whole and to define how agtech can meet the UN SDGs. It will also be important to foresee the challenges in the planning and investment process. When funding technologies and platforms, it is vital to ensure a long-term perspective and to exercise care regarding how infrastructure funded with public monies is used by private actors, so that development bank funding does not increase the exploitation of farmers in either developed or developing nations.

The paper begins with a discussion of the unique features of agriculture that problematize the adoption of digital technologies. This is followed by an exploration of the digitalization and digitally-enabled technologies generally. We then discuss the differences between developed and developing country agriculture with particular attention to smallholders. We then discuss the enormous amount of venture capital being invested in digital agriculture technologies with the intention to disrupt the entire sector. This is followed by a discussion of the organizational experimentation underway on the introduction of online platforms to reorganize agriculture. We then reflect upon policies that development banks could adopt to ensure that investments they make in agtech and in support of platform strategies for agriculture will support communities and agriculturalists by foreseeing the outcome and dynamics of the technologies being funded. The conclusion returns to larger themes raised in the paper.

2. AGRICULTURE AS AN INDUSTRY IN THE AGRIFOOD SYSTEM

Agriculture as a sector has many unique features that make it different from other industries. First, it is not a single industry, but rather each crop should be understood as a separate industry with its unique value chain for inputs and outputs. Thus, the dynamics and adoption of digitalization within each crop is different, i.e., corn grown for animal feed is different from sweet corn, as are strawberries, as is processing and slicing tomatoes, apples, coconuts, palm oil, milk, beef, and hundreds of other crops-all differ. Crop production is embedded in different social milieus with their different capital intensities, labor relations, and value chains. For example, rice production in Texas or Arkansas differs not only from smallholder rice agriculture in Java as well as from highly mechanized small farms in Japan. Time and timing are critical for farming success. The farmer must invest in planting and wait until harvest to secure income. Further, the mature crop often must be gathered during a narrow window, which means demand for labor is variable and capital goods such as equipment may only be used during narrow time windows[2]. Farmers are dependent upon biological processes that are affected by any number of natural phenomena over which the agriculturalist has little control. These include a remarkable variety of pathogens including viruses, bacteria, fungi, and larger animals. Weather phenomena such as too much or too little rain, too cold or too hot, too much or too little humidity etc. affect plants and animals. Even in controlled environments, pathogens can ravage production-this is true in both developed or developing countries. In other words, the outcome of the farmers' investments is, in part, not under their control. The final irony is that the price of the final product is uncertain and dependent upon demand that is affected by the success and/or failure of other farmers. The greater the success of other farmers in terms of yield, ceteris paribus, the lower will be the incomes of all. Moreover, market demand continually changes the product price.

Given this environment, farmers, who may be one bad crop away from bankruptcy, are inherently conservative as they are reluctant to adopt innovations that increase risk or uncertainty because downside losses can be catastrophic[3]. Given the uncertainty, innovations that provide better information to make better business decisions are rapidly adopted-be they the Farmers' Almanac, personal computing, or improved commodity price and weather information.

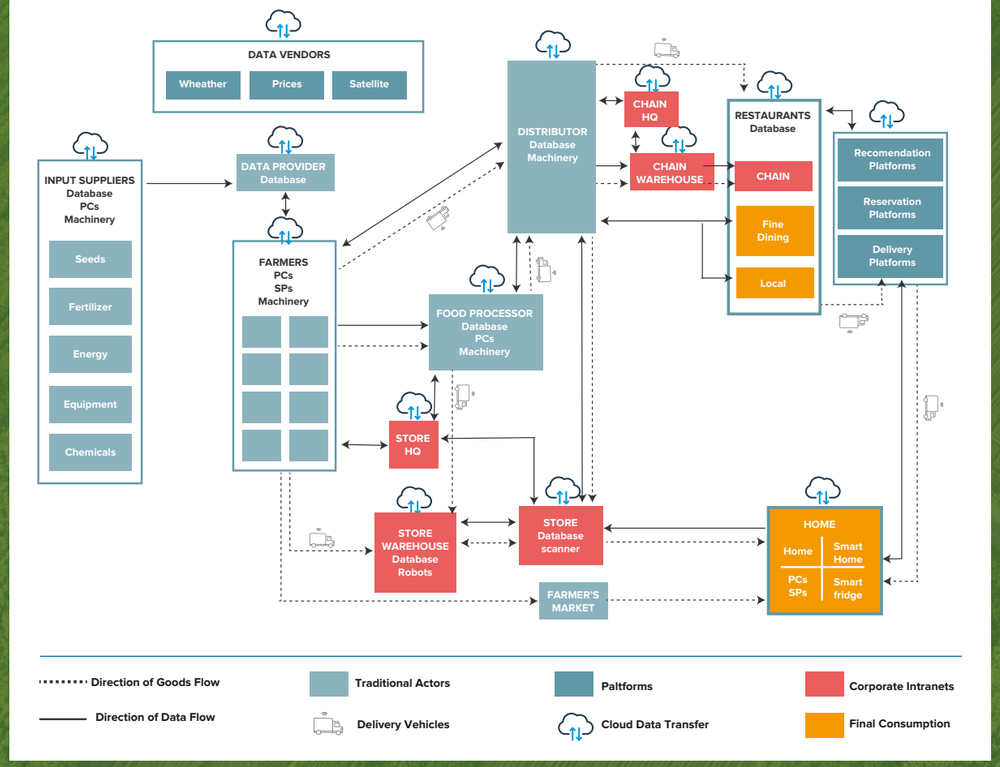
Farmers, whether in developed or developing countries, are embedded in value chains. Moreover, with few exceptions, such as plantation crops, the farmers are the smallest businesses in the chain (see Figure 1 for a stylized depiction). To illustrate, even small holder farmers (SHFs) buy inputs such as agricultural chemicals, seeds, and farm equipment from local dealers that are selling inputs produced by large, and, sometimes, enormous oligopolistic agri-input multinational firms (Sexton and Xia 2018). Similarly, farmers must often sell to powerful and, very often, oligopsonistic intermediaries that include distributors, food processors, or retailers (on concentration in the agrifood system, see for example, Clapp 2021).

2 In contrast to industry where a machine can be used year-around, much of the farm equipment sits idle for long periods. This means that the amortization of capital equipment is "lumpy" as it cannot be used year around.

3 Many governments recognize these dangers and thus provide crop insurance and other support. Obviously, in developing nations there may be less such downside risk mitigation particularly in small-holder agriculture.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

FIG. 1 | STYLIZED DEPICTION OF A AGRIFOOD VALUE CHAIN, [2021]



Source: Kenney et al. 2020

Firm size and location are crucial variables for understanding the evolution of the agrifood industry. As a generalization, from 1960 to 2000, average farm size decreased in most low- and lower-middle-income countries, whereas it increased in some upper-middle-income countries and in nearly all high-income countries (Lowder et al. 2016)-a trend that has continued in high-income countries such as the USA (USDA 2021). These divergences suggest that agriculture digitalization will differ between low- and high-income countries, as the larger farms will, almost certainly, be the first to adopt the more sophisticated digital technologies, many of which are embedded in capital goods equipped with the most sophisticated sensors and computers.

3. DIGITALIZATION OF AGRICULTURE

Invariably, major technological developments affect the relationships between businesses, social actors, and labor and capital. The ongoing innovation in, and adoption of, digitalization has led to an outpouring of writings on the future of work that is remarkable in terms of volume and scope. Some suggest that digitalization based on improvements in computing and software, including artificial intelligence applications (AI) and big data, will dramatically increase unemployment (Brynjolfsson and McAfee 2014; Frey and Osborne 2017). Even those that are less apocalyptic suggest that there will be dramatic shifts in work and employment (see, e.g., Manyika et al. 2017).

The scope and complexity of the digital technologies that will affect agriculture can only be understood by considering their ubiquity. To illustrate, a modern automobile contains more than 3,000 semiconductors, which suggests that a modern tractor is likely to have that many or more (Ewing and Boudette 2021). Similarly, in 2020 it was estimated that 40% of the value of a modern car was in its electronics including parts and software (Tingwall 2020); this is certainly the case with farm machinery. In Table 1, we list some of the most important digital technologies, their farm applications in developing country agriculture and also for SHFs in developing nations. For the most part, only SHFs have access to digitalization through their feature or low-quality smartphones. Unfortunately, coverage of rural areas by carriers remains limited.

TABLE 1 | DIGITAL TECHNOLOGIES AND FARM APPLICATIONS, [2021]

Technology	Functions	Effects	Developed Country Usage	Developing Country Smallholder Usage (ex-China)
Digitized machinery	Greater accuracy, Capable of	More efficient operation, save labor	Widespread adoption	Not used
Drones	Field mapping, Disease recognition, Pesticide application	Decrease ag chem usage, timely response to reduce losses	Many usages, owned by farmer or contractor	Many potential usages provided by government or non-profit
Robotization	In-field and post-harvest	Save labor	Early stages	Not used
Image recognition software (smartphone app)	Identify pests, diseases, ripeness, location for picking	Improved diagnosis, decrease labor usage for harvesting or weeding	Rapidly increasing	Increasing
Digital payment systems	Payment for unbanked	Greater efficiency and speed	Increasing, but outside China not large	Significant in some countries (China, Kenya)
Digital marketplaces	Buy inputs, sell outputs	Disintermediation, lower costs or increase prices	Increasing but fragmented	Amazon and local competitors, LA - MercadoLibre; Africa - Numia
Smartphone/mobile internet	Access internet, monitor equipment, buy/sell	Improve access	Ubiquitous	Usage increasing
Smartphone network coverage	Internet access	Access cloud in real-time	Good and improving	Spotty
Big data platforms	Aggregate and analyze all data generated	Greater efficiency	Limited	Not used
QR codes	Identify things	Improved security and traceability	Increasing	Not used
Sensors (moisture, nitrogen, pests, etc.)	Monitor conditions in field in real time	Improve decision making	Increasing	Not used
GPS	Location	Improved locational accuracy	Ubiquitous	Smartphone application
Farm management software	More accurate financial and other information	More efficient operations	Ubiquitous	Not used

Source: Authors

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

As Table 1 indicates, digitalization of an ever-increasing number of the activities in the agrifood system is creating ever greater flows of data that, not only, can be mined for unique insights, but also provide new opportunities for monitoring and surveillance (Zuboff 2019). These data flows are creating new intermediaries such as consultants, drone pilot firms, system integrators, etc. to create and organize this increased flow of data.4 As important, the connection of these devices, sensors, and actors to the internet results in increased transparency and the possibility of creating online platforms-a process that has already reorganized a wide variety of industries (Kenney et al. 2021).

The near universal adoption of smartphones in the developed countries, increasing access to cloud processing power, and the advent of big data permits the integration of computing power into all aspects of economic life. When considering digitalization, most observers concentrate on relatively ubiquitous products such as the smartphone (the iPhone was introduced in 2007) or tablets-these products are iconic and important. However, digitalization is far more pervasive and profound than this, as digital technologies are embedded in all manner of machinery including agricultural equipment. As Zuboff (1988) points out, the implications of this "colonization" of machines by computational capability monitor actions, thereby turning those actions into data to be analyzed. This increasing flow of data is further accelerated by rapid advances in sensor technology that make machines more capable of acting upon stimuli from the environment.

The ability of these machines to sense and interpret the environment liberates them from needing the direct control of operators. Hence, the introduction of automated milking machines, nearly autonomous tractors and combines, and variable rate chemical applicators, to name only a few sensor-laden products will result in changes in labor use and location, capital intensity, and power in the value chain.

The impact of digitalization on agriculture can be observed at three levels: micro, meso, and macro level. At the micro level, digitalization is changing the individual machines. Whether they are drones, tractors, milking machines, packaging machines in a food-processing plant, a cow with an implanted chip, or an autonomous vehicle-they all produce data that can be analyzed. However, they also change the ways within which people interact with them-they change the nature of work itself-and, of course, can make workers redundant. At the meso level, the data produced by these machines can be integrated into larger data pools on the farm, in the factory, and in the organization. The data can be integrated into cross-organizational systems, such as multi-firm supply chains and beyond. Finally, at the macro level, online platforms can be introduced to capture, organize, analyze, and use this data to optimize the entire system. At each level, questions exist as to who owns the data and how the ability to access and analyze it could transform power relationships, worker and farmer skill requirements, and ultimately value capture.

4 Helper et al. (2019) show that the increased digitalization of the auto industry has spawned an enormous industry of consultants and intermediaries to integrate the new robotic equipment.

4. DIGITALIZATION IN THE DEVELOPED AND DEVELOPING NATIONS

The digital technologies and artifacts are overwhelmingly created by and products of the developed nations and, in particular, the USA.5 We begin by arguing that the traditional distinction between developing and developed nations (when considering digital technology adoption) is no longer strictly applicable as the diversity of experiences in the developing world is important to understand. This is not to deny that there are millions of underserved small holder farmers in Africa, Latin America, and Asia. And yet, even these populations are adopting smartphones rapidly[6].

The most salient counter-example to any simplistic division between developed and developing nations is China, where the adoption of digital technologies, generally, and in agriculture specifically is advancing rapidly. For example, the integration of farmers using smartphones into direct-to-consumer platforms such as Pinduoduo is far more advanced than any similar platform in the developed world, thereby offering new sources of income.7 Pinduoduo is particularly interesting because it has a significant outreach program to train farmers on how to sell directly. For example, it sponsors "farmer entrepreneurship" online training classes taught by professionals from the China Agricultural University and the National Engineering Research Center for Information Technology in Agriculture. These classes teach farmers about smart agricultural services and equipment, pest control, sustainability, etc. (Liang and Cheah 2020: 52). The success of this program is possible because China has an enormous and extremely food-conscious, digitally-savvy consumer market. Furthermore, in the last decade, China has built a global-class logistics sector optimized for online purchasing and delivery. This is possible because the government has made massive investments in telecommunications infrastructure for the entire country. In this respect, China, while still a developing country (especially in rural areas), has built a first-world infrastructure in which smartphones are ubiquitous (Min et al. 2020; Zheng and Ma 2021)[8].

In developing countries, such as Brazil and Argentina, where corporate farmers produce for the global market, digitalization has unsurprisingly progressed significantly. To illustrate, an internet-based survey of Brazilian farmers found that nearly 80% had internet access and nearly 60% used apps and platforms to access information. Moreover, approximately 20% used apps for management and, similarly, 20% used global positioning systems and data and images from remote sensors (Bolfe et al. 2020). These results suggest that in developing nations' industrial agricultural regions, as a generalization, the use of digital technologies is similar to that in the developed world. Furthermore, countries such as Brazil have large-scale research and extension programs that assist these farmers in adopting digital technologies (Bolfe et al. 2020).

5 It is important to add that many of the raw materials that are used to make our devices are sourced from developing countries and their assembly is undertaken in developing countries, in particular, China.

6 The importance of inexpensive Chinese digital products such as smartphones, Wi-Fi routers, and network equipment in improving access in the developing world should not be underestimated.

7 For a discussion of Pinduoduo, see Chen et al. (2020).

8 Xinhua (2019) reports that 98% of rural Chinese villages have broadband access.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

Despite advances in China and commercial agriculture, lack of Internet access is a continuing obstacle to the use of digital technologies in many rural areas. In such an environment, the smartphone provides mobile internet access and is the technology necessary for extending the benefits of digitalization to small holders[9] In Table 2, we compare the situation for small-holder farmers by drawing upon and extending the work by Friederici et al. (2020: 51) that explored African digital entrepreneurship. The experiences of African digital entrepreneurs illustrates the context within which small holders are expected to begin using smartphone apps.

TABLE. 2 | DIGITALIZATION VARIABLE COMPARISON RURAL AREAS IN DEVELOPED AND DEVELOPING NATIONS, 2021

Attribute (in relationship to farmers)	Developed Nation	Developing Nation (smallholder agriculture)
Telecommunications Quality	Good	Highly variable
Telecommunications Cost/Income	Low	High
Device usability	Excellent (variety of connected devices -- IoT)	Highly variable (feature phone or smartphone)
Technical support	Good to excellent	Generally very low
Skill Levels/	Payment for unbanked	Greater efficiency and speed
Digitalization	Varying but good	Very low
Access to Capital	Medium	Very low
Logistics Infrastructure	Excellent	Weak
Government involvement	Variable but good	Variable often very weak
Trust in institutions (online transactions, banks, etc.)	High	Low
Access to credit	High (crop insurance etc.)	Very low (and often at usurious rates)

Source: Adapted from Friederici et al., 2020

The obstacles to the adoption of digital technologies in developing countries are more than simply technical. For example, Friederici et al. (2020: 54) point out that the willingness of African consumers to adopt technologies was also conditioned by an understandable lack of trust in these digital connectivity systems; though given the accelerating smartphone adoption, trust likely has increased since 2017. Yet, smallholders suffer not only from their own lack of purchasing power, but also a lack of direct access to customers and thus must go through intermediaries that capture much of the value. The opportunities thus are large, but the obstacles to adoption and use that is equitable and meets the goals of increasing sustainability are equally large.

9 It is important not to completely underestimate the importance of mobile phones in rural settings as Jensen (2007) shows Keralan fishermen used cell phones to assist them in landing their fish in ports offering better prices for their fish.

5. RECENT MASSIVE INVESTMENT IN AGTECH STARTUPS

Over the past decade, enormous amounts of venture capital have been invested in the agrifood system (Graff et al. 2020). The goal of these venture capital-financed startups is to "disrupt" various agrifood systems through the use of digital technologies and the introduction of online platforms. A remarkable number of these smaller firms have sustainability as explicit goals in their charters. During the last decade, there has been a massive wave of VC investment globally in AgTech firms; many of which explicitly state that they aim to use their technology to disrupt agriculture (Graff et al. 2020). In 2018, $16.9 billion in VC was invested across the entire agrifood system from inputs to final home delivery (AgFunder 2019). In their study, Graff et al. (2020) found that of the 4,557 firms in their database, approximately 2,000 were in software and business, online and financial services-nearly all of these were based on digital technologies. While these startups were concentrated in the US, many were also located in Europe. Moreover, the population was truly global with 102 startups located in Kenya, Nigeria, South Africa and another 173 located in Latin America, with 88 in Brazil alone.

Digital technologies, because of their inherent plasticity and generative properties, have enabled this proliferation of entrants creating and offering new products and services. The variety of entrants leveraging the digital technologies to create enterprises in the agrifood system is remarkable. At the level of the farmer, the innovations include new cyber-physical systems, pure software programs, and apps that run upon and exchange data with existing platforms. There have been an enormous number of new firms trying to reorganize the agrifood value chain (for example, becoming new intermediaries between farmers and consumers). Other startups are developing applications that use scanners and QR codes to trace food through the value chain. The key is that, due to the generativity of digital technologies, new services can be developed. For example, "Connecting Food", a French food-tech start-up, provides a smartphone application that allows consumers to scan a product's QR code and have every node in the value chain, as far back as the farmer, displayed. The app draws upon the fact that at every node in a logistics chain, scanners track the product's movement and this is all recorded in a database. The app simply taps into the cloud database through an API and this allows the chain to be displayed on the consumers' smartphone.

The sheer variety of innovations being introduced is remarkable, as the cost of development has decreased and market access through the internet is easier. Creating apps has also been simplified, as software development kits are widely available for either the Apple iOS or, more important in the developing world, Google's Android. Given the enormous number of software tools and "components" available through sites such as GitHub, much of the coding is simplified so that the developer can devote more time to securing adoption. Distribution through the app stores simplifies market entry.

The reduction in the costs of entrance and eased market access encourages increased innovation. As a result, one of the greatest obstacles to success is the sheer number and diversity of entrants. Competition is often between very similar products, all of which struggle for the same markets. There is a proliferation of apps mirroring the variety of crops and nodes in each value chain. To illustrate this proliferation in the agrifood area, a 2017 study of food waste-sharing platforms identified 91 globally. In the larger developed nations there were multiple platforms-none of which appeared to be tipping the market (Michelini 2018). Similarly, a 2019 study in Norway identified 10 online supermarkets and 44

online niche stores delivering food to consumers (Heidenstrøm and Hebrok 2021). A 2021 report by ISF-RAFLL found that there were at least 75 agricultural product and service marketplaces operating across Africa, South and Southeast Asia, and Latin America (ISF-RAFLL 2021: 4), but very few of them

served more than 100,000 customers-in other words, they are not yet close to minimum scale. Because many of the agriculture platforms operating in Africa are subsidized by development agencies and foundations, they can survive even though they have limited usage (Krishnan et al. 2020).

This proliferation of entrants results in ferocious competition with few winners emerging thus far and almost certainly financial losses. For many of these new entrants, success will likely be measured in their adoption by farmers or consumers, with the ultimate result being that the firm and its product or service will be acquired by a larger incumbent firm or an established digital firm seeking to increase its presence in the agrifood system.

Platform longevity is of critical importance for farmers because if a farm optimizes its operations for a particular digital technology and the small firm supporting it fails, the farm would be left with an "orphan" software program that, almost certainly, would no longer be upgraded or supported. Another concern for farmers is that if they adopt the small firms' technology, there is a possibility that their data will ultimately be transferred to yet another firm. With the farmer locked in, a new owner might change the terms and conditions of the relationship or have a different strategic relationship with the farmer.

In conclusion, there has been an enormous amount of entrepreneurship and VC investment in the agrifood industry globally. However, in 2021, it is difficult to identify many successful new entrants with the exception of Pinduoduo in China, those that were acquired by the incumbent agrifood industry firms, and a small number of startups that have listed on public markets. This apparent lack of success appears to be equally valid in developed and developing countries.

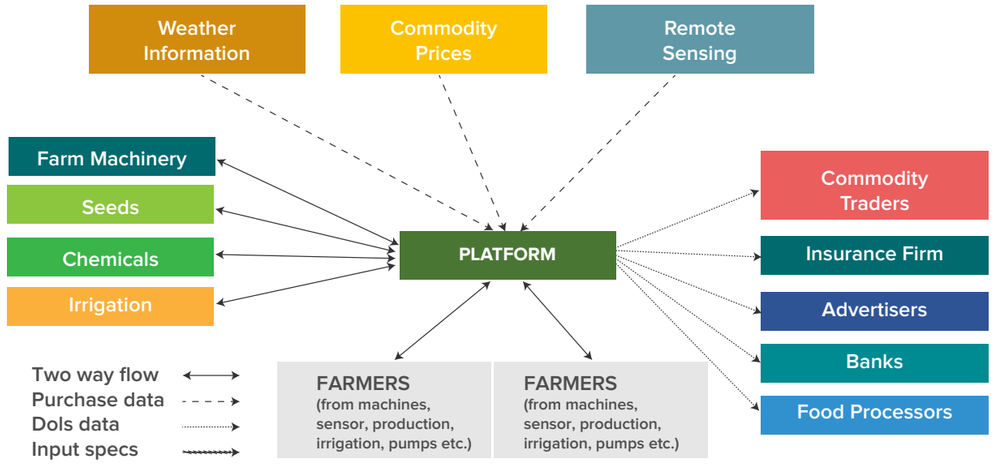
6. PLATFORMS AND DATA: OPPORTUNITIES AND PITFALLS

In previous work, Martin Kenney and John Zysman (2016; 2019; 2020; 2021) argued that the economy is being increasingly organized by online platforms. There is considerable debate regarding the definition of an online platform among those studying agriculture. For example, Runck et al. (2021: 3) adopts an expansive definition of a platform being a "group of technologies that are used as a base upon which other applications, processes or technologies are developed". For this paper, we adopt a narrower definition namely that a platform is an online site that intermediates interactions between two or more different sides. This means that platforms perform a matchmaking function and for our discussion it is this function that is of greatest significance.

In a platform-organized market, the platform is the central intermediary that has panopticon-like situational awareness of all actions taken upon it. This confers extraordinary power upon the platform owner (for further discussion of platforms, see Cusumano et al. 2019; Parker et al. 2016). This is reinforced by the winner-take-all aspects of online platforms (Schilling 2002). The conundrum of platform-organized markets is that very often they provide remarkable efficiencies and, because they must share data with ecosystem members, provide new opportunities for the development of innovative applications or what Jonathan Zittrain (2008) termed "generativity." For example, the Uber app was only possible because of the widespread adoption of smartphones and the fact that its app could integrate in Google Maps so that the customer can be easily located.

In agriculture, as in other industries, there was an initial phase in which, while computers were in use, they had little impact on everyday use. However, the inexorable progress of digitalization has now resulted in the introduction of increasingly "intelligent" machines and, this combined with the introduction of smartphones and their apps, is swelling the amount of data available and feasibility of using the cloud to combine that data with yet other data to create new services (Kenney et al. 2020). As a result of ubiquitous computing and connectivity, the farm level and the entire agrifood production and distribution system is being connected. The emergence of digital platforms in agriculture provides opportunities for entrepreneurship and innovation (Kenney et al. 2020; Nambisan 2017). Yet, at this time, these data streams are located in various silos, thereby hindering the efficiencies that could be achieved and new services that could be created were these data sources merged into a single platform (see Figure 2 for an ideal-typical, farm-centric illustration of the types of data that could be merged) in which the actors that could benefit and potentially innovate on or sell across such a platform.

FIG. 2 | IDEAL TYPICAL ILLUSTRATION OF THE TYPES OF DATA THAT COULD FLOW ACROSS AN AGRICULTURAL PLATFORM, 2020



Source: Kenney et al. 2020

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

Enormous data sets accumulated by a central platform can be used to uncover new patterns that could result in recommendations that could optimize a variety of goals, of which one would be to increase sustainability without incurring greater costs. To provide an example, if in-field, geo- and time-tagged pictures of pests were uploaded by farmers to a central platform, it would be possible to analyze the progress of an infestation and direct treatments to, not only the current location, but also to block the projected path of spread (e.g., Michels et al. 2020). This is an example of low-cost collective action solutions that small holder farmers could implement. For poor farmers, the obstacles would be their capabilities, the cost of the smartphone (assuming the farmers did not have one) and the cost of data uploading. Yet the savings would be enormous, as governments could react more efficiently with informed and targeted eradication programs. If a government would provide free knock-off smartphones, subsidize training, and photo-uploading, and effectively prosecute the pest control measures, the social return could be enormous.[10]

The business opportunities in agriculture for introducing a platform to connect actors on the various platform sides are attractive. The following sections briefly consider the variety of actors that could develop a strategy to platformize agriculture (for further information, see Kenney et al. 2020 or Birner et al. 2021). As this report is farmer-centric, the analysis of these organizations does not include food delivery platforms or ghost kitchens-new business models that, as they evolve, may change the value chain in ways that impact farmers.

6.1. INCUMBENT AGRIFOOD INDUSTRY FIRMS

The incumbent agrifood industry firms have existing relationships with farmers that they seek to leverage to build a platform where farmers become ecosystem complementors. For these firms, this is, in part, a strategy of shifting their focus from simply selling a product to capturing a continuing flow of income from services attached to their product (Roy et al., 2009; Zysman et al., 2011). To accomplish this, their emphasis has shifted to capturing more data to both optimize operations, but also find new products and services based on an analysis of this data and other data they might have. For example, a seed company would get yield data from farmer's fields and combine this with climatic and social data and then analyze all of these in conjunction with what they know about the seed's genetics to breed a superior seed for particular micro-environments. In essence, the data derived from farmers would be combined with other data or repurposed to capture even greater value or sell insights from the data to other parties. While the preponderance of the profit will be derived from commercial agriculture in the developed world, improving data communications will provide opportunities to address the needs of small holders.

6.1.A. INCUMBENT AGRICULTURAL MACHINERY MANUFACTURERS

Today, nearly all farm machines, whether for the field or dairy, have significant information capture, processing and transmission capability that ranges from positioning or self-diagnostics to product or environmental sensors. For these firms and farmers, wireless bandwidth is an issue as rural areas in extensive agricultural regimes may have a low private return, so improved connectivity may require government subsidies. Smallholder agriculture that uses relatively hand tools or simple machines may not be of great interest to the farm equipment multinationals; though two-wheel machines are used, most do not appear to be digitized at this time (e.g., Van Loon et al. 2020). Caveats to this conclusion are important. First, while the equipment is not digitized, there are contractors that provide the use of the equipment and this may be done over mobile phones. Second, there is an ever increasing use of digital technologies and they will almost certainly come to this smaller equipment eventually. Finally, it may be possible to design smartphone apps that will assist in the use of this equipment.

John Deere was one of the first firms to begin offering platform-like services, as its equipment, especially the combine, became increasingly laden with digital technologies (Miles 2019). As today's combines and tractors move through fields, their sensors collect enormous amounts of data about the plants, soil, and the environment that is either transmitted directly to the cloud or stored to be uploaded when there is sufficient bandwidth. Ideally, the software provides data and analysis so the farmer can make a decision or, as is increasingly the case, the decision is directly communicated to the machine. One example of the machine's capabilities is its ability to predict parts failure-a vital service because unexpected breakdowns during harvesting are costly, as it may require a technician to be summoned while the machinery and the operator are idle.

For equipment makers, there will be significant difficulties in tipping the market toward their platform because farmers who are not using that specific brand of equipment have little incentive to use that brand's services. However, the efficiencies generated by the continuing digitalization seem to out-weigh concerns about data ownership, repair lock-ins, and the general increase in equipment prices. The increasing capability of the suite of digital tools embedded in the newest machinery makes 24/7 operation ever more feasible and even necessary to amortize the cost of new combines. For example, GPS guidance allows farmers to harvest day-and-night, a development that might contribute to increased concentration, as the more acres a farmer harvests the more rapidly the equipment can be amortized-a particularly important consideration as the constantly improving electronics speeds obsolescence.

6.1.B. INCUMBENT CHEMICAL AND SEED FIRMS

One of the key issues in agricultural sustainability is the use of agrochemicals and concern about the lack of genetic diversity in today's monoculture. Efficient seed planting and chemical application can decrease costs, increase yields, and minimize pollution. Because of this, chemical and seed firms see an opportunity to collect and analyze farmers' data and sell back to farmers the resulting recommendations, along with seeds and chemicals. If the yield and plant response data could be collected, then farmers would be conducting field "experiments" for the industry that could then monetize the knowledge gathered over millions of plantings.

In pursuit of these opportunities, in 2013 Monsanto (now merged with Bayer), one of the largest providers of chemicals and seeds, bought the Climate Corporation, a provider of weather prediction and insurance, for $1 billion as part of its service diversification strategy. To increase its functionality, the Climate Corporation platform has added more services, including SeedAdvisor, which recommends which seeds to plant, a service that identifies plant diseases, and a plant nutrition timing service (Bayer, Inc. 2019). In 2018, Monsanto announced that the Climate Corporation platform had 100,000 customers and would be opened to ecosystem complementors (Cosgrove 2018). By 2021 it had increased from 19 apps, at its inception, to 29. In principle, ecosystem complementors should increase the value of a platform, as they offer innovative services that increase user value. The road to profitability has not been easy. In 2016, Monsanto suggested that Climate Corporation would become profitable in 2020 (Plume 2016); however, there is little evidence that it has done so.

Agri-input firms have significant advantages in terms of recognition, financial resources, and the ability to package digital services with existing product lines. However, the difficulty is there is little reason for the various competitors to cooperate. More importantly, these firms have a fundamental conflict of interest-they sell chemicals and seeds -- and want to sell more. As is the case with all of these firms, the algorithms are proprietary and thus there are natural questions as to whose interest the algorithms are serving.[11] For small holders, technologies such as smartphone image recognition could provide the information necessary to reduce agricultural chemical usage-and this could be provided by either the public sector or private sector entities.

10 In China, broadband is provided by the state-owned telecommunications firms that cross-subsidize the coverage of rural areas and have a mandate to provide low-cost service society (Fan and Zhang 2021).

11 In 2020, a farmer charged the Climate Corporation with sharing his data with the startup Tillable, which aims to connect farmland owners to potential tenants. The Climate Corporation and Tillable had announced a "partnership," which was never explained. Nevertheless, the farmer received unsolicited offers to rent the land at a specific price, and he believed that the offer had been generated from Tillable's access to the data he shared by using the Climate Corporation. The FieldView application tracks the farmer's field from sowing to harvest and thus has data that enables estimation of the farmer's income and much else about the farm. This use of the data is entirely within the purview of the terms and conditions of the contract with the farmer (Janzen, 2020).

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

6.1.C. COMMODITY-TRADING FIRMS

For commercial farmers everywhere, the ability to trade commodities is vital for profitability and already takes place online. Not surprisingly, farmers now use sophisticated software and trade either over their smartphones or personal computers. Twenty years ago, such trading platforms were only available to the global agricultural commodity traders such as Cargill and ADM, and various smaller grain traders, elevators, etc. (Bedford 2019). In October 2018, ADM and Cargill launched a grain marketing digital platform, Grainbridge, with tools that farmers could use. The platform is meant to allow farmers to consolidate their marketing and farm operations on a single platform.

This open platform is particularly interesting as it would appear to provide farmers with greater access. However, the intermediaries,ADM and Cargill, own and control the platform so they can operate it in their own interest. Were the platform to become dominant, it would provide its owners a monopoly position. Further, it would allow owners to disintermediate independent grain handling operations such as silos. This could allow farmers and the giant grain traders to reduce the local elevator to a commodity storage provider by disintermediating its importance in trading. Controlling trading platforms can be of vital importance and we return to this in the discussion of government-owned and operated platforms for smallholder agriculture.

6.2. EXISTING PLATFORM GIANTS

The US platform giants, with the exception of Amazon through its transformation of the distribution sections of the supply chain, are, at this time, only exploring the peripheries of the agrifood system. The situation in China is completely different as platform giants and buyers are now directly intermediating between farmers. In this section, we discuss not only the activities of Amazon, Google, Microsoft, and IBM, but perhaps the most significant examples thus far, which are the Chinese firms Pinduoduo (mentioned earlier) and Alibaba's Taobao. The importance of including the Chinese firms in this study is that Chinese firms have made important inroads into many developing countries in terms of infrastructure roll-out. This includes Huawei in mobile base stations, Chinese smartphone manufacturers selling low-cost Android phones globally, and the remarkable global success of Chinese mobile phone apps such as, Tiktok, Shein (clothing retailer), and Tencent games. Here, speculatively, one could imagine a firm such as Pinduoduo finding traction in middle-income countries connecting smallholder agriculture with urban consumers.

In terms of the US tech giants, there have been a number of agriculture-related initiatives, though it is too early to gauge their success. The advantages of these technology giants is that they have enormous resources and thus can tolerate significant losses for long periods on a pathway to ultimate profitability. The obvious drawbacks to these initiatives is that the agriculture-related projects are very small operations within the much larger firm.

The large firm with the most salient efforts to enter agriculture is IBM. In 2019, IBM announced that it was using its AI platform Watson to successfully predict the best date for activities, such as planting and harvesting (Dignan 2019). At the time, IBM was targeting large agribusiness firms and consultants that advise farmers (who presumably could pay for the service), rather than the farmers themselves (Miller 2019). More recently, it was announced that IBM Watson was partnering with a non-profit, Heifer International, a US-based NGO; CATIE, a Costa Rican-based regional research and teaching organization; and Honduran COPRANIL, a coffee cooperative and cocoa grower in Chocolate Halba. The plan was, to quote the press release, "to use predictive AI technology with geospatial, weather, environmental and IoT field data in a comprehensive dashboard tailored to a farmer's land. It delivers weather alerts and other information, such as optimal planting patterns and expected yields linked to market pricing" (Heifer International 2021). Then the beans will be tracked using IBM's blockchain technology that will provide supply-chain traceability, thereby presumably increasing consumer trust in the product. This and other projects suggest that IBM is investing significant resources in its efforts to supply software and cloud solution.

Microsoft introduced FarmBeats, an application on its Azure cloud computing that provides farmers with data, though at this point it is not commercialized (Wiggers 2019). In June 2020, Microsoft launched a fund to support agritech startups in India that would use FarmBeats as their backend (Ellis 2020). However, in 2021, the FarmBeats platform remains largely in beta and not yet economically viable.

Google, in many respects, also appears to be exploring its opportunities in agriculture, though this seems to have been confined to investment in VC-financed agritech startups, such as Farmers Business Network (Troitino 2018) and investment in research on agricultural technologies such as field robots (Okumura 2020). Given Google's capabilities, its ultimate goals are difficult to predict. For example, with the enormous reservoir of remote-sensing data it already has from Google Earth and Google Maps and analytical capability, it could certainly use this data as leverage to enter the agricultural space. Already, Google Android and Maps are integrated into an increasingly large percentage of the world's automobiles. It might be possible to extend this to farm equipment, thereby creating one standard to unite all the data being generated.

Of all of the tech giants, Amazon may be the most interesting, because of the range of its offerings. For example, Amazon Web Services, its cloud computing operation, appears to be developing services that are specific to the needs of the agrifood system (AgDaily 2019). In the grocery/food distribution industry, it already has a strong position, which only increased during the COVID-19 pandemic, due to the dramatic increase in online ordering from its Amazon Fresh and Whole Foods subsidiaries. It is important to recognize that it is becoming a major food retailer globally as Amazon Fresh has operations not only in the US but also in Western Europe, Japan, and India.

As Amazon has become an increasingly important distributor, retailer, and deliverer of groceries in a number of countries, it has developed relationships with other actors in the food value chain. In India, in some ways mirroring Pinduoduo's model in China, Amazon is establishing fresh produce collection centers that connect it directly with growers and Farmer Producer Organisations. These centers not only aid in procurement, but also can be used to recruit more suppliers to the Amazon supply chain (Kumar 2021). In addition to purchasing, Amazon has created a mobile app that provides alerts and addresses soil, pests, weather, disease and other crop-related queries. Further, the app includes machine-learning algorithms to detect defects in fruits and vegetables, so that farmers sort, grade, and pack produce for transport to AmazonFresh fulfillment centers (Rai 2021). This model was first introduced in India where supply chains were rudimentary, but, if successful, could be adopted in other developing countries. This initiative could improve supply chains and product quality in India and increase the prices that agricultural producers receive.

The final set of incumbent platforms impacting farmers and rural agricultural economies are Pinduoduo and Taobao (Alibaba)[12]. As mentioned earlier, both of these platforms are leveraging the government-built communications system, pervasive use of smartphones, smartphone-based payment systemS, newly developed sophisticated logistics system, and increasing interest in sustainably farmed, high-quality food among consumers to integrate farmers and rural producers, more generally, onto their platforms. Also, in contrast to most of such platforms in both the developed and developing countries, the Chinese ones appear to be successful and increase farmers' incomes (Li et al. 2021). The lessons from the Chinese success for other developing countries may be more about building the infrastructure upon which the platforms rest than on simply introducing a platform that cannot be used because the context is unprepared (Baisch and Scarfe 2020).

With the exception of Amazon, the US tech giants have shown only limited interest in the agricultural sector beyond offering cloud computing services and VC investment in agrifood system startups. Amazon, because of its increasingly significant grocery operations, is the firm one might expect to integrate further into the value chain. For example, it already offers white-label goods under the Amazon Pantry brand. Its Indian operations appear to have gone the furthest in exerting greater control over the supply chain for fruits and vegetables. What this overview shows is that Chinese platforms are by far the most advanced in developing an intermediary position between farmers and consumers. While there has been no economic analysis regarding whether the intermediation increases income for farmers, there is an assumption that it does.

6.3. COOPERATIVES

Farmers, as small business owners, are hesitant to adopt new technologies that invade their privacy or expose valuable data to outside parties that might benefit from it. Cooperatives, as they are owned by their members, might provide a collective action solution to this problem. The cooperative can operate as a trusted platform as its governance structure is composed of its members. For this reason, a cooperative can have different goals and thus price its services differently and, as important, return any efficiencies generated by establishing and operating a platform to the owners. The cooperative could collect reliable data from its members-and it would have collective power to sell the production data to other food system actors or analyze it itself. Further, if the platform data was made available to independent app makers, the platform could recoup some of the value created. Of course, if an app was particularly valuable, that functionality could be made available by the cooperative's platform[13].

12 On Taobao in agriculture, see Li (2020)

13 In other words, it would operate in the same way as any platform in the interest of its members.

Effectively, in the cooperative business model, farmers would provide their data to a platform in exchange for a share of the value generated from their data.
The goals of the cooperatives such as collective learning and sharing could be enhanced by the use of digital platforms and software (Como et al. 2016; Filippi 2014). As an example, InVivo, the enormous French cooperative of cooperatives, actively invests in digitization and the software that could form the basis for the data collection necessary to establish a platform. InVivo purchased Smag, a farm management software firm that owned Agreo and Atland, which are cloud-based agronomic data management software programs (InVivo 2016) that can be utilized from a farmer's PC or smartphone. In 2019, InVivo launched the platform Aladin.com that allows vendors to offer a wide variety of products and services, including those that are useful for alternative and sustainable products and practices. InVivo offers various kinds of software for precision farming that allow the analysis of field sensor data, seed-sowing densities, and soil fertility to inform variable rate fertilizer application.

In principle, it should be less risky for a farmer to provide data to a cooperative because even if it uses that data to increase income, it returns the income generated from the data to the farmer. In contrast to for-profit input suppliers that provide the platform as an adjunct to their main business line, cooperatives should have fewer conflicts of interest. For example, a cooperative has little incentive for recommending unnecessary repairs or chemical treatments to increase income. For farmers, ownership of software or data platforms used by members could only be sold or discontinued after the consent of its members, thereby limiting their risk.

In the multi-stakeholder examples discussed next, cooperatives are important actors because they can speak collectively for the target farmers. Cooperatives could provide a solution to the farmers' distrust of the platform and ensure that the interests of farmers are considered, thereby increasing adoption and ensuring that platform adoption did not result in exacerbated inequality-one of the key sustainable development goals.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

6.4. MULTI-STAKEHOLDER PLATFORMS

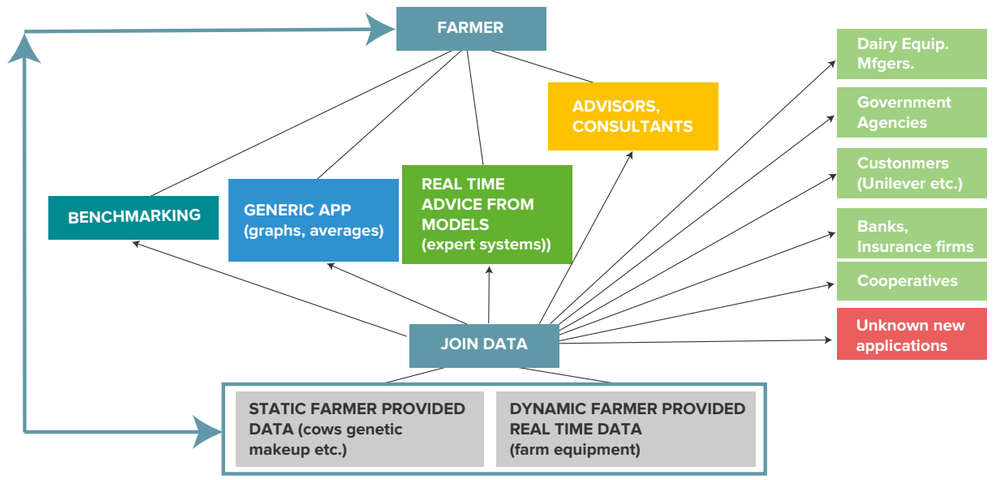
At the farm level, with the way current markets are organized, absent incentives, data sharing provides little benefit to those generating it and some risk of loss as the data could be used to, for example, assess the farm's income and deny credit. The data generated by farm equipment could have value to a number of actors, including the farm equipment maker who could use the data to improve future equipment that might be more expensive-a dynamic within which farmers would only be compensated indirectly for the value that their data made possible.
Given the value of the data and its non-excludable nature, if farmers provide data from their operations, it may be difficult for them to be directly compensated. For this reason, there has been significant experimentation with multi-stakeholder platforms, though even here there are difficulties because of the difficulty in providing incentives to all of the stakeholders.

The opportunities and difficulties in organizing effective economic arrangements to secure data sharing have led to experimentation with new business and organizational models. One model is to bring all of the stakeholders together into a consortium where the goal is to secure the benefits of a platform where data can be shared without losing control to a single self-interested platform owner.

One example of such a model is the "SmartDairy" project established in the Netherlands by a consortium that included the Dutch national research organization VNO, local universities, dairy cooperatives, dairy equipment suppliers, and, initially, seven dairy farms. The VNO created a software platform to which farmers could contribute their data, but then view all their relevant information with a single dashboard. The analytical software would analyze the uploaded data and, based on various algorithms, provide farmers with recommendations for the care and productivity of their individual cows.

In 2019, the project and its software was turned over to a newly formed clearinghouse platform, JoinData, which operated a data-broker platform business model (see Figure 3). As data brokers, farmers and firms could transfer data to each other because JoinData never owned or stored any data, acting merely as a clearinghouse. The software and platform have been successful at connecting approximately 15,000 Dutch dairies. Using this model, farmers can share their data with any interested parties: banks, insurance firms, production cooperatives, dairy machinery firms, and milk processors. In principle, the model should result in significantly improved recommendations and analysis. Like the startup Agrifind described earlier, SmartDairy operates as a clearinghouse, not a data repository.

FIG. 3 – DATA FLOW PATHWAYS FOR THE DUTCH SMARTDAIRY MULTI-STAKEHOLDER PROJECT, 2020



Source: adapted from v. d. Akker, 2020

Another European example is in Germany, where farmers are repurposing a variety of organizational models (the Ring model) developed for agricultural machinery-sharing to also provide data aggregation and analysis services. By acting together, farmers can collectively purchase high-cost machinery, such as combine-harvesters (Hastedt 2016) that, as it works the field, also collects geolocated data such as yield, moisture, and protein content that can be analyzed to provide individualized summaries and recommendations to farmers/customers (Giesler 2018). The addition of sensing and geolocation functions to its machines has increased the scope of the machinery-sharing organization from a collective-action solution for high capital-cost equipment to include valuable data generation. The data would not only have value to the farmers, but also to the equipment makers, commodity traders, government authorities such as the Ministry of Agriculture, and other entities that could combine the machinery data with yet other data sources. By accessing other data, such as weather data, the Ring organization could add further value to its offerings to farmers. The machinery's technical changes provide the opportunity for the Ring organization to evolve into a platform or a data intermediary that might also be able to offer yet other services from third-party vendors.

6.5. GOVERNMENTAL INVOLVEMENT

For the most part, digitalization and platformization has gone forward without significant direct government involvement or regulation. China is a significant exception because the telecommunications system's expansion was organized by the state-owned enterprises. In most of the rest of the world, telecommunications networks are privately owned and operated. With regard to online platforms, which scholars increasingly understand as being infrastructure (Plantin and Punathambekar 2019), there has been little discussion of nationalization or the provision of platforms by governments. In agriculture, the Nigerian government has experimented with the "platform-like" websites, but according to ISF-RAFLL (2021: 22) these are not platforms. Likely the private sector will continue to own and operate the platforms, but with increasing government regulation.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

7. OBSTACLES TO SUSTAINABLE DIGITALIZATION AND PLATFORMIZATION

Despite the increasing mobile telecommunications coverage,decreasing cost, and increased ubiquity of inexpensive smartphones, farmers - especially those with limited means- may be unable to afford access, especially in terms of data downloading. An even larger question is whether the increasing digitalization favors larger farmers and, if it does, whether this is a desirable social outcome. As important, many farmers, while accepting and even embracing increasing digitalization, are concerned about issues such as data usage/ownership and, as agricultural equipment comes pre-equipped with ever more software, whether they will be able to repair their equipment.

As we have shown, those generating the data may or may not be able to extract and capture value from it. This creates asymmetric incentives between the individual generating the data and those that can extract value from it. For example, having direct access to a farm's production data could be of great value for a loan officer considering extending a loan to a farmer or calculating the probability that the loan will default. For a large investment bank considering investing in a food products firm, knowing the response of production to weather changes could be of enormous value, while knowing production at an individual farm would be of little value.

The adoption of connected digitized machines collecting various types of data is becoming standard as digital data is easily transmissible and costless. When the data exists and is easily available, it is far more difficult to resist demands for that data. So, while a dairy farmer may be reluctant to share such data with outside parties, it may be possible to compel the sharing. For example, a loan officer could demand access or deny a loan. Further, if the loan officer received such data, could they share it with a loan aggregator? Could the corporation making the loan aggregate the production data and share it with third-party data brokers or government officials? In each of these hypotheticals, the farmer would not be compensated for the further value derived from the data.

One of the fundamental characteristics of digitalization is that it increases transparency. From a systemic perspective, increased transparency can result in greater efficiency. For example, digitalizing a supply chain can lead to the elimination of unnecessary steps, such as distributors and intermediaries, thereby decreasing costs. Of course, those disintermediated no longer have a function. Digitalization can also be used to measure carbon footprints or, with proper devices, measure agricultural chemical application and runoff. All of these would contribute to meeting SDGs. However, for farmers, these could lead to them internalizing costs that they previously externalized into the environment-a development that they likely would not welcome, absent some sort of compensation mechanism.

8. POLICIES AND INVESTMENT OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT: SOME PARTICULARS

The advances in and opportunities created by digitalization and platformization in agriculture and rural areas are enormous. However, the context and impact of digital technologies are different in developed country commercial agriculture (whether in developed countries or in developing countries such as Argentina and Brazil) and small-holder agriculture in developing nations. The myriad differences in agriculture and its various value chains mean that investments and policy initiatives must be sensitive to context and be aware that safeguards aimed at ensuring equity must be designed-in prior to initiating an intervention.

The first consideration is the mobile telecommunications infrastructure and whether it provides sufficient connectivity in terms of data capacity and cost. In the developed nations, this has become a rural-urban digital divide. In developing countries, the capacity and cost problem is exacerbated by the fact that many smallholders cannot afford the smartphones or data plans necessary for using various applications. Development banks can address such problems by subsidizing or owning the telecommunications infrastructure and providing low cost service to farmers and entrepreneurs developing technology for agriculture. They could also buy inexpensive smartphones and provide them to farmers, if a standard model was diffused it would also simplify app provision, thereby encouraging entrepreneurship and innovation. Low-cost connectivity could be rapidly extended to farmers and, if owned by the government or quasi-governmental organizations, operated at low profit margins with the goal of providing connectivity. Governmental ownership or control is vital because, very often, subsidizing private owners can lead to monopolistic or oligopolistic outcomes that eventually lead to price increases after competitors are driven from the market, then allowing the owner(s) to increase their profit margins by raising prices to whatever level the market will bear -- and this would likely not be the socially optimal price.

To develop a robust e-commerce infrastructure, it is necessary to build an effective logistics infrastructure. In countries such as China, private firms have found it sufficiently profitable to build out their logistics infrastructure. For lower-income countries in parts of Africa and Latin America, this may be more difficult. In such cases, ensuring an effective postal service could remove this obstacle and ensure that the logistics system was not entirely privatized and susceptible to monopolization.

Digital payment systems already exist in many developing countries. Unfortunately, usage differs markedly from country-to-country. Development banks may have a role to play in ensuring that their operation is transparent and well-regulated, as they have an important role to play in the extension of the benefits of digitalization to rural populations and small holder farmers. Digital identity systems, such as the Aadhaar system in India may provide benefits, but could also have negative impacts (Chaudhuri 2021; Dattani 2021).

For farmers, intermediaries such as online platforms offer remarkable opportunities. If a platform organizes and captures a market, almost invariably, power flows to the platform because of some of the attributes of network industries.[14] Inherently, all actions on a platform are visible to the platform; as the market tips, eventually the platform is able to "see" the operation of such a large portion of the market that it becomes the panopticon. For example, as Amazon grew and captured ever larger portions of the US online market, it came to understand the flow of goods in the retail market in such a way that it had greater insight than the incumbent delivery firms, such as UPS, Fedex, and US Postal Service (a similar situation is developing for postal services globally).

14 By power, we mean the ability to structure the platform, decide on who can participate, subsidize certain participants and charge others, and, most importantly, decide how much of the value created due to efficiency and its control, it wishes to retain for itself.

THE CHALLENGE OF THE DIGITAL AGRICULTURAL REVOLUTION: A COMPARISON BETWEEN ADVANCED ECONOMIES AND DEVELOPING COUNTRIES

This allowed it to build out its competitive logistics systems with minimal amounts of risk. The building of its capabilities allowed it to offer ever more services to its users. Conversely, as the platform becomes more powerful, it has ever more points of leverage to compel previous non-users to use its services. To illustrate, in 2021 in the US, it is becoming increasingly difficult to purchase books and many other retail items outside Amazon. These developments have now become central concerns for regulators, not only in the EU, but rather among governments globally.[15] As public investors consider their digitalization and platform development strategies, it is important to understand that a successful platform will benefit from network effects and WTA outcomes. Such an outcome can provide enormous benefits, but building correct governance at the outset can ensure that inequities are mitigated.

Cooperatives play a vital role in many sectors of agriculture. But, as importantly, they could provide a collective action solution to the problem of data sharing. Development banks could be catalysts for solutions that increase overall efficiency, encourage innovation, and contribute to increased equity through working with existing cooperatives and the developing countries helping to form cooperatives around small-holder agriculture. As we saw in the case of SmartDairy, cooperatives can be one component of multi-stakeholder networks that organize various stakeholders by aligning the incentives of various participants.

In the developed countries, there has been a proliferation of angel- and VC-financed platforms aimed at linking farmers directly with consumers. Most of these are local and have social purposes such as assisting organic farmers or decreasing food miles. Unfortunately, nearly all of these suffer from precarious funding. National development banks should see these efforts as attempts to build infrastructure-as Amazon is building in these countries. Funding strategies that would create a common infrastructure, which could lower the costs for these disparate local startups so that they might better compete and ensure that national markets were protected and that the locally created value was not exported, could also contribute to the retention of wealth locally and the building of entrepreneurial local ecosystems. Here, the Chinese Taobao villages or the Pinduoduo program to teach farmers how to sell online could be examples. The alternative is that firms such as Amazon, eBay, and Etsy capture the value built by these platform-enabled connections and export it to the US West Coast.

Public investors can also play a role in ensuring that there are public alternatives to the digital and platform infrastructures that are becoming the way citizens communicate, consumers buy, and producers connect to consumers and other producers.

15 See the growing number of news reports on how Amazon pressures its sellers to use its Fulfillment by Amazon delivery services. The pressure is so strong that Amazon has become one of the largest delivery services in the US threatening to become larger than UPS or FedEx.

9. CONCLUSIONS

Barring unforeseen circumstances, agricultural sector digitalization is inexorable. For developed world farmers, equipment is increasingly equipped with sensors, communication, and computational capabilities that are directed by software. For smallholders in developing nations, the smartphone is the gateway device. Digitalization and platformization provides not only tools, but also resources and possibilities to generate innovations that can contribute to the attainment of many of the SDGs. Yet, digitalization and, particularly, platformization of agrifood systems and value chains also threaten to create greater inequality, disempower farmers, and transfer value from farmers to the platform owners.

The current trajectory is resulting in ever-growing flows of data that are not only analyzable in their own right, but also can be merged with yet other data to generate further value and even unanticipated future services. Some of these data flows will be owned and controlled by the farmer, but other data, such as that from remote sensing or for the operations of a piece of agricultural equipment, may be owned by off-farm parties. The farmers' data will have value to others, but the question remains: how will society prevent the farmer and farm workers from being sacrificed in pursuit of these goals? Will they be compensated for contributing their data to potential data repositories? Farmers, as small businesses, may be unwilling to provide their data to other actors absent some compensation mechanism. As is the case with consumers using digital platforms, legal and institutional protections might be necessary to ensure that incentives and protections are aligned to ensure the privacy and ethical uses of the data.

The key to using digitalization and platformization to support farmers and consumers must include the provision of an appropriate and fairly governed infrastructure to ensure that the value created is not entirely siphoned away by the most powerful actors in the value chain. Friederici et al. (2020) correctly conclude that for Africa, at this time, the use of the mobile internet by the average small-holder farmer is limited due to the costs of access. This is true but likely only temporary, as the GSM Association (2020) estimates that, by 2025, 475 million (up from 272 million in 2019) Africans will have access to the mobile internet, and, by implication, access in rural areas will also increase. If farmers that are producing export products for the global economy, especially, form collective action groups that could brand, direct-to-consumer platforms could provide increased income because developed world consumers will be willing to pay for environmentally superior cultivation practices. Here, national and international development banks could cooperate and achieve positive outcomes for the weakest parties in the supply chain.

The development banks could fund the development of platforms that could embody other social goals beyond establishing a monopoly so as to capture the bulk of the value created by the surrounding ecosystem(s). This is vital as platforms have become central infrastructures for economic and social interaction. While the private platform firms are implementing environmental sustainability into their operations, they do not have as their core concerns meeting SDGs or other social goals. As private entities, their motivation is to expand their businesses through acquisitions or the introduction of new services in their quest to grow[16]. Development banks, perhaps, by owning an inalienable "golden share" could support multi-stakeholder partnerships that ensure that the various stakeholders share in the value created, and, as important, ensure that no platform-side is exploited as it becomes dependent on the platform for survival. Such a guarantee would encourage contributions of data-flow that could make the entire system more efficient, thereby generating value for the entire ecosystem. Such an ownership structure would make it easier for the ecosystem participants to make the difficult choices necessary to meet the ambitious SDGs and contribute to increased social equity.

16 Because they are in industries that have winner-take-all dynamics, once they succeed in one sector, the only growth path is to expand to yet another sector or extend the scale and scope in that particular market. One example is the way in which Uber expanded from initially offering limousines to the far bigger, personal car market. From offering rides to people it extended its scope to offering food delivery.

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CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

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ROB VOS

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE (IFPRI)

Paper prepared for workshop on "The mutual relationship between climate change and agri-food system, how to make agriculture and food systems part of the climate solution?" organized by the Finance in Commons Summit (FICS) and the Istituto Affari Internazionali (IAI), October 2021.

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

CONTENTS

ABSTRACT

Agricultural production is both strongly affected by climate change and a major contributor to it, with agriculture and associated land-use change and post-farm food sector activity accounting for one third of total global greenhouse gas emissions-more than for transport or industrial uses combined. Climate change is already affecting agricultural productivity, especially in tropical agriculture, putting pressure on food systems ability to meet growing and changing food demand.

Food systems have shown enormous innovative capacity in past decades, but to meet tomorrow's challenges, technological progress will need to change fundamentally to enable production practices that are climate-resilient and environmentally sustainable and are focused on efficient delivery for healthy diets. Currently, food systems benefit from substantial government support, costing at least US$720 billion per year worldwide. Past and current support have an impact on greenhouse gas emissions by influencing the composition and location of output, and production practices. This paper reviews the evidence regarding key trends in food and agriculture, technological innovations for climate-resilient food systems, and the feasibility of repurposing existing agricultural support to provide market incentives that are aligned with global societal objectives of abatement of climate change and improving food security and nutrition.

Public and multilateral development banks can reinforce the impacts of such policy reform by providing new financial solutions that would de-risk investments in sustainable, climate-smart production methods in agriculture and food systems, make such solutions accessible to small-scale producers and leverage new private investments to change food systems There is enormous potential to be tapped for reducing the ecological footprint of food systems and making these more resilient. Tapping this potential, however, will not be possible without strong international policy coordination rallied behind those common global objectives.

1. INTRODUCTION

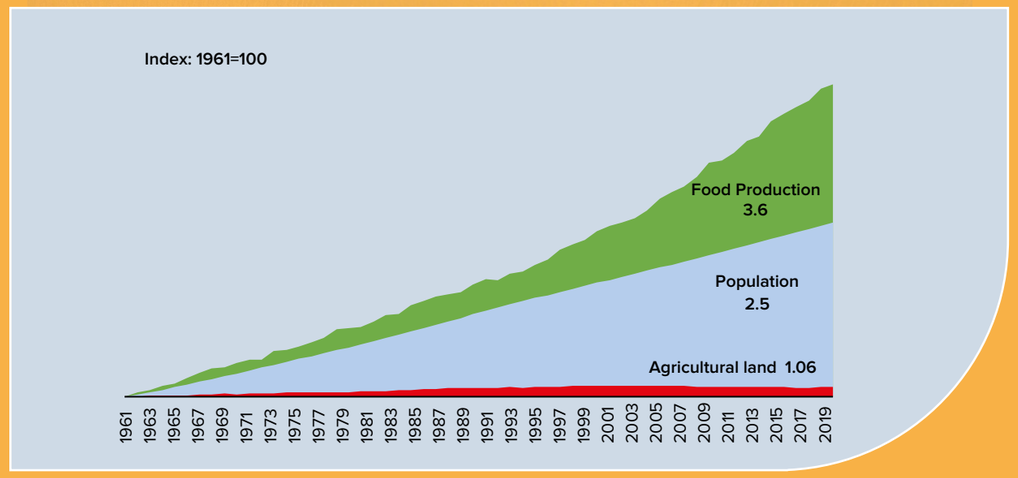
A major global challenge is to ensure affordable access to sufficient nutritious and safe food for a growing world population while reducing the environmental impacts of agriculture and addressing the threat posed by climate change. The global demand for food is expected to increase strongly between now and 2050, with rising incomes and world population projected to grow almost 10 billion by 2050. Urbanization and income growth will come with shifts in dietary preferences towards more demand for resource- and emission-intensive meat, dairy, other livestock products, and processed foods. Climate change is no longer only a distant threat, but already impacting adversely on agriculture and food production. Agri-food systems and related land use change are major contributors to global warming, generating about one third of global greenhouse gas (GHG) emissions. Climate change is already affecting agricultural productivity, especially in tropical agriculture, putting pressure on food systems ability to meet growing and changing food demand. Food systems have shown enormous innovative capacity over past century, but to meet tomorrow's challenges, technological progress will need to change fundamentally to enable production practices that are climate-resilient and environmentally sustainable and are focused on efficient delivery for healthy diets. Currently, food systems benefit from substantial government support, costing at least US$720 billion per year worldwide. Past and current support have an impact on GHG emissions by influencing the composition and location of output, and production practices. The remainder of this paper is divided in four parts. Section 2 reviews the evidence regarding key trends in food and agriculture and how these are both influenced by and are impacting on climate change. Section 3 addresses, first, the question of whether there is enough technological progress to ensure adequate productivity growth to feed a growing world population and meet changing dietary patterns. It subsequently focuses on the availability of innovations that could underpin more sustainable food production. While there are plenty of promising technologies the world is still heavily underinvesting in Research & Development (R&D) for agriculture and food systems, especially for climate-resilient practices. Section 4 addresses the question regarding how current agricultural support measures influence market incentives and implications for GHG emissions and other food system outcomes to subsequently explore options for redirecting that support for better outcomes for the global climate and human health. One key finding is that a simple removal of subsidies does not appear to have huge, beneficial impacts. This is so, in good part, because decades long support has locked in highly polluting production methods and agri-food systems which by and large will remain in place also without the present subsidies. More promising outcomes would come with greater allocations for R&D, assuming this focuses on productivity-enhancing and emission-reducing technologies for both on-farm and off-farm food system improvements. As discussed in the concluding section, enormous political hurdles stand in the way of tapping this potential and that strong international policy coordination is needed to shift policy support and market incentives to address the climate crisis and avert the existential threat of a food system that can no longer provide for human's most basic need.

2. FOOD SYSTEM CHALLENGES AND CLIMATE CHANGE

THE REMARKABLE GROWTH OF GLOBAL FOOD PRODUCTION

Global food production has expanded at a remarkable pace over the past 60 years. Per capita food production has grown by a factor of 3.6 between 1961 and 2018 (Figure 1). This expansion has been driven in good extend through the diffusion of green revolution technologies for calorie-rich staple crops, especially cereals. High-yielding varieties developed, among others, by CGIAR (the international network of agrifood research centers) have contributed to the worldwide expansion of food production during this period (see e.g., Fuglie et al., 2020). The associated agricultural productivity growth has been conducive of low staple food prices and has facilitated structural transformations of poor economies both helping reduce poverty and hunger worldwide (see e.g., Ivanic and Martin 2018). While agricultural land use also expanded during this period, this expansion has been limited vis-à-vis production and population growth, reflecting a significant increase in land productivity, but also more intensive use of land resources.

FIGURE 1 | INCREASE IN FOOD PRODUCTION, POPULATION AND AGRICULTURAL LAND, 1961-2019 (INDEX 1961=100)



Source: FAOSTAT

Looking forward, global food demand is expected to grow by 50% (from 2015 levels), considering expected population and income growth and the shifts in dietary patterns (FAO, 2017; Vos and Bellù, 2018). Moreover, a significant, additional demand pressure for agricultural produce is expected to be exerted by increased demand for biofuels.

"THE FUTURE AIN'T WHAT IT USED TO BE"

Yet, given past trends, this would not seem an unsurmountable challenge. However, to say it with Yogi Berra: 'the future ain't what it used to be'.

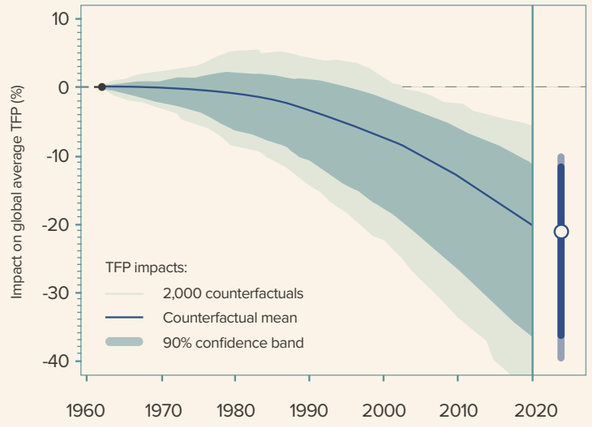
Growth in food production per capita is already showing signs of slowing down, having peaked in about 2010 (Gautam et al., 2021). More importantly, food production will have to adjust to the threat of climate change and erosion of land, water, and other natural resources. It will also have to adjust to better serve human health.

While global hunger, measured in terms of deficits in calorie-intake, remains a pressing problem affecting over 800 million people, there is in addition an estimated 3 billion people cannot afford a nutrition-adequate diet and suffer from micro-nutrient deficits or 'hidden hunger' (FAO et al., 2021). More so than for traditional staple foods like maize, rice, wheat and other cereals, efficiency gains will have to be reached in the provisioning of micro-nutrient rich foods, such as fruits, vegetables, and animal-source foods. However, with existing technologies, the production of those foods is more resource-intensive and, this holds in particular for livestock production. The latter is also notoriously big on GHG emissions.

CLIMATE CHANGE AND THE SLOWDOWN OF AGRICULTURAL PRODUCTIVITY GROWTH

The slowdown in agricultural productivity growth can be attributed in part to climate change. A recent study by Ortiz-Bobea et al. (2021) estimates that climate change has reduced global agricultural productivity growth by 21 percent since 1961, equivalent to losing roughly a decade's productivity growth. The impacts hit hardest on tropical agriculture, with productivity declines in some areas by 40 percent or more (Figure 2). Areas highly vulnerable to climate shocks, often compounded by civil strife and conflict, are witnessing rising levels of hunger and protracted food crises, affecting large parts of Africa, Central America, parts of South Asia and the Middle East (FAO et al. 2021; FSIN, 2021; Holleman et al., 2017).

FIGURE 2 | IMPACT OF CLIMATE CHANGE ON AGRICULTURAL TOTAL FACTOR PRODUCTIVITY GROWTH



Source: Ortiz-Bobea, et al. 2021.

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

Climate change affects food availability through its increasingly adverse impacts on crop yields, fish stocks and animal health and productivity, especially in sub-Saharan Africa and South Asia, where most of today's food insecure live. It limits access to food through negative impacts on rural incomes and livelihoods. Poor people, including many smallholder farmers and agricultural workers, are also more vulnerable to the impacts of extreme events. Intensified occurrence of droughts or floods will sharply reduce incomes and cause asset losses that erode future income earning capacity of those affected. In addition, to the extent that food supply is reduced by climate change, food prices will increase. Both urban and rural poor would be disproportionally affected, as they spend much higher shares of their income on food.

AGRIFOOD SYSTEMS GENERATE ONE THIRD OF GLOBAL GHG EMISSIONS

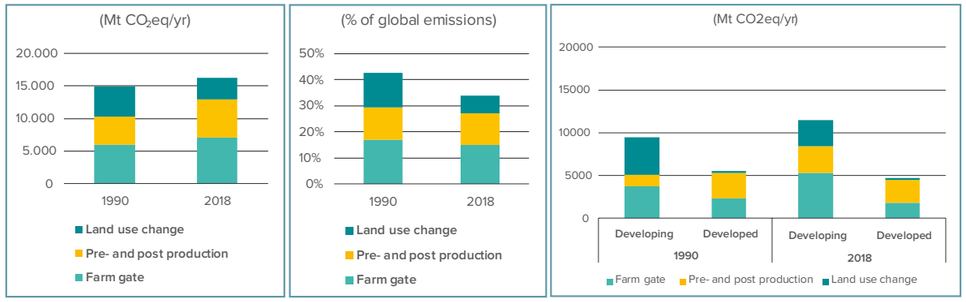
Agriculture and food systems at large are not only affected by climate change, as they are also major contributors to it. The contribution of the food system at large is larger than usually considered with available data focusing on GHG emissions from agricultural production and land use change. Recent estimates of emissions across the food system by Tubiello et al. (2021) indicate that GHG emissions from the food system were about 16 Gt CO_2eq in 2018, or one-third of the global anthropogenic total (Figure 3a).

FIGURE 3 | FOOD SYSTEM GREENHOUSE GAS EMISSIONS BY TYPE OF ACTIVITY AND COUNTRY GROUPINGS, 1990-2018

a. Food system emissions (Mt CO2eq/yr)

b. Food system emissions (% global GHG) Emissions)

c. Food system GHG emissions by country group (Mt CO2eq)



Source | Tubiello et al. 2021.
Note | Developed and developing country groupings refer to, respectively, Annex I and Non-Annex I categories of the Kyoto Protocol.

About 45% of these emissions, 7 Gt CO_2eq/year, were generated either within the farm gate and a significant additional 35%, 6 Gt CO2eq/year, pre- and post-production activities, such as agri-food manufacturing, transport, processing, and waste disposal. The remainder was generated through land use change at the conversion boundaries of natural ecosystems to agricultural land.

While the share of food system's emissions has declined from 43% to 34% as a share of global GHG emissions between 1990 and 2018, emissions increased in absolute terms from 1.2 to 7 Gt CO2eq/year (Figures 3a-b), driven mainly by increases in emissions from livestock production and energy use in post-harvest food sector activity. By contrast, emissions from land use change have decreased since 1990.

The estimates further indicate that emissions by food sectors in developing countries are far greater than those by developed countries. Pre- and post-farmgate food sector emissions generated in developing countries have increased substantially since 1990 (from 1.3 to 3.1 Gt CO2eq per year) and are now larger than such emissions in developed countries (Figure 3c).

The conversion of land from natural habitats and current agricultural practices also have other large negative externalities. Agriculture is the biggest driver of biodiversity loss, with enormous economic costs due to lost ecosystem services (World Bank 2021; FAO, UNDP and UNEP 2021). Beyond the environment, current production patterns encourage unhealthy diets with large human capital and health costs. Furthermore, production practices undermine both current and future economic growth as key resources - land, water, and energy - are degraded and misallocated, constraining the pace of structural transformation and progress on poverty reduction.

At the core of finding viable solutions to the enormous challenge of making agriculture more productive, sustainable, and nutrition-sensitive are improved technologies and practices as much as market incentives for both adoption of improved practices and shifting consumer demand. In other words, do current agricultural policies and support create the incentives for producers to make appropriate decisions for achieving the desired goals? We turn to these issues in the next two sections.

3. IMPROVED TECHNOLOGIES, PRACTICES, AND PRODUCER AND CONSUMER BEHAVIORS FOR MAKING FOOD SECTORS CLIMATE-RESILIENT

THE IMPERATIVE OF SUSTAINABLE INTENSIFICATION

In most regions, further expansion of arable land is limited. In the Middle East and Northern Africa (MENA) and parts of Central Asia and sub-Saharan Africa, potential land expansion is constrained by water scarcity. In other part of sub-Saharan Africa and Latin America, most of the still available land lies in remote areas, where the lack of infrastructure prevents its use for agricultural purposes, at least at current agricultural price levels. In all regions, agricultural land expansion could lead to further deforestation, which would be undesirable from the perspective of sustainability, inter alia because of the impact on GHG emissions and biodiversity loss. Climate change will further constrain agricultural land expansion, as reduced and more variable rainfall, as well as rising sea levels will make agriculture less viable in some areas. Crop intensification through inter-cropping can be an alternative to land expansion. However, the scope for doing so while ensuring durable soil quality is relatively limited given the present state of technology (Alexandratos and Bruinsma, 2012; Vos and Bellù, 2019). Further growth of agricultural production will mainly have to come from yield increases (Figure 4).

FIGURE 4 | FUTURE SOURCES OF AGRICULTURAL OUTPUT GROWTH UNDER A BUSINESS-AS-USUAL SCENARIO, 2012-20501961=1)

Source: Vos and Bellù (2019)

Doing so will be challenging for at least two key reasons: (i) increasing competition for water and land resources and (ii) long-term under investment in agricultural R&D.

THE INTENSIFYING BATTLE FOR LAND AND WATER

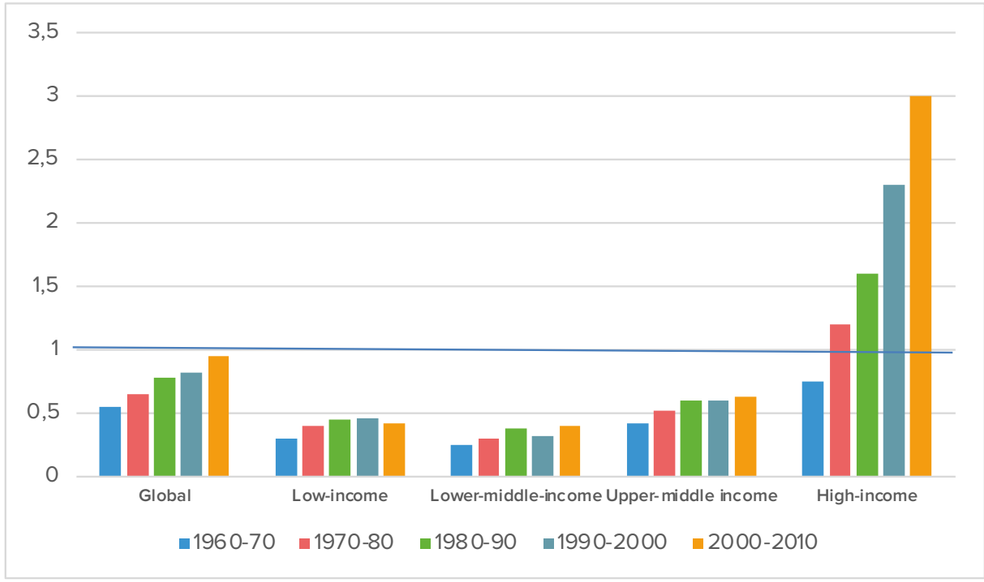
The first reason is that production and productivity growth will be hampered by growing scarcity and competition for land and water resources. Projections for 2050 confirm the likelihood of growing scarcity of agricultural land, water, forest, marine capture fisheries, and biodiversity resources. Additional land requirements for agricultural production between now and 2050 are estimated at just under 0.1 billion ha (FAO, 2017). Increased competition for land has already emerged with increases in the demand for bioenergy. The greater competition between food and non-food uses of biomass has increased the interdependence between food, feed, and energy markets. This competition may be harmful for local food security and access to land resources. Input subsidies, on energy, fertilizers, and water, as well as public purchases of agricultural produce add the unintended additional pressure on natural resources.

Water availability for agriculture will also become a growing constraint, particularly in areas that use a high proportion of their water resources, exposing systems to high environmental and social stress and limiting the potential for expanding irrigated areas. Water withdrawals for agriculture represent 70 percent of all withdrawals. More than 40 percent of the world's rural population lives in water-scarce river basins (FAO, 2017). Future water stress will not only be driven by increasing water demand for drinking water, industrial water use and irrigation of agricultural lands, but also by changes in the availability of water resources driven by climate change causing greater variability in precipitation leading to substantially higher risk of prolonged droughts as well as excessive rainfall, which both will add stress on water resources.

INVESTMENT IN AGRICULTURAL R&D HAS SLOWED DESPITE THE HIGH ECONOMIC RETURNS

The second reason why accelerating agricultural productivity is challenging is the underinvestment in the development of improved technologies in recent decades. Current levels of R&D expenditures are too low for comfort, especially for agricultural development in low-income countries. A commonly used indicator to assess countries' agricultural research efforts is the agricultural research intensity (ARI), which expresses national expenditure on public agricultural R&D as a share of agricultural GDP. Clearly, low-income countries lag far behind high-income countries and are increasingly losing ground (Figure 5). While there is no 'right' level of ARI, overall government R&D expenditure for science and technology of at least 1 percent of national GDP has been recommended (FAO, 2017). For the agriculture sector, countries in both the low-income and the lower middle-income groups are generally well below this threshold (Figure 5).

FIGURE 5 | AVERAGES OF AGRICULTURAL RESEARCH INTENSITY, BY COUNTRY INCOME GROUP, 1960-2010



Source: Pardey, Chan-Kang and Dehmer, 2014.
Note: Simple average of annual agricultural research intensity (ARI), measured as the ratio of public expenditure on agricultural R&D to agricultural GDP.

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

Meanwhile, private investment in R&D has increased, currently contributing an estimated 20 percent of total agricultural R&D expenditures (FAO, 2017). This is providing both opportunities and challenges. Recent R&D has brought many new promising "disruptive" technologies providing new solutions for efficiency gains throughout the agri-food system discussed further below. One key challenge is that most private sector research focuses on technology improvements for fully developed large-scale commercial agriculture and food businesses. In addition, transfer of many new technologies, such as biotechnologies and applications of digital technology, and their adaptation to developing country needs is hampered by restrictions emanating from intellectual property rights, while their widespread diffusion in low-income country contexts is often constrained by lack of adequate extension services, poor transport and communications infrastructure and lack of credit access among local farmers. In this regard, lessons could be drawn from the Green Revolution in Asia, whose success in accelerating productivity growth and dramatically reducing hunger and poverty was not just a result of the development of input-responsive high-yielding crop varieties, but was facilitated by major public investment in irrigation, transportation and communications infrastructure, input supply arrangements, public pricing and procurement systems and commitments to making the technology an international public good freely available to crop breeding programs worldwide. Nearly half a century later, these same technologies have failed to lift agricultural productivity growth in sub-Saharan Africa precisely because such enabling institutional arrangements and public support have been absent.

PROMISING NEW TECHNOLOGIES AND PRACTICES

As said, the perceived underinvestment in agricultural and food system R&D does not mean there has been a lack of new technological breakthroughs. In fact, there is a growing portfolio of food system innovations that could accelerate change towards sustainable food system transformation. These include numerous digital innovations including precision agriculture, robotics, and applications for e-commerce, e-procurement, e-payment systems, and product quality traceability, as well as a wide array of other innovations genomics for development of climate-resilient crop and breeding varieties, process-synthesis approaches to plant-based protein-rich foods mimicking meat structures, biodegradable coatings of fruits and vegetables, and new drying methods (see e.g., Barrett et al. 2020; Herrero et al. 2020; Reardon and Vos, 2021).

Several of these innovations have proven potential to both raise productivity and reduce emission intensity in agri-food production. On a top-ten list of new technologies and practices ranked by readiness, adoption potential, and potential impact (Barrett et al. 2021), four relate to replacement food and feed for humans, livestock, and fish through plant-based substitutes, insects, microalgae and cyanobacteria, and seaweed. Such innovations will be critical given livestock's contribution to global GHG emissions. For instance, sophisticated livestock breeding methods can help improve livestock productivity using advanced genetic and genomic selection methods have the potential to contribute to heat tolerance and to methane mitigation (Pryce and Haile-Mariam, 2020). Algal-derived feed supplements (e.g., seaweed) help reduce methanogenesis in ruminant digestive systems to enteric fermentation and methane generation, while improving productivity in the livestock sector (Mernit, 2018; McCauley et al. 2020). Another innovation is the use of insects as feed. Insects are often rich in protein and some vitamins and minerals (Henchion, 2017). Use of some insect-derived protein may reduce GHG emissions, though strong evidence on this impact remains scant (Parodi at al., 2018). In addition, methane production in rice cultivation, another major source of GHG emissions from agricultural production, can be significantly reduced through alternate wetting and drying in rice cultivation (Chidthaisong 2013). These promising new practices could reduce methane emissions from rice and cattle by up to 50%.

Switching to healthier diets with much reduced meat consumption from present levels is considered to simultaneously improve people's and planetary health (EAT Lancet Commission, 2019; Willet et al., 2019; Loken and DeClerck 2021). Global GHG emissions from agriculture could drop by as much as 80% by some estimates though impacts may vary greatly across countries depending on current levels of meat consumption and efficiency in livestock production (Springman et al., 2018). These studies do not call for a complete switch to vegetarian or vegan diets, but do recommend much reduced meat consumption for much of the world population though recognizing needs for poor to raise intake of animal-source food to meet minimum nutritional standards. Globally though huge gains for planetary health could be achieved from the consumption side. Changing dietary habits is not easy. Innovations through product innovation in the form of plant-based and cellular meat substitutes that mimic taste and texture of meat can help sway consumer demand and raise awareness of the environmental impacts of the consumption of livestock production. This is still a small but growing business. If part of a gradual process, it should allow also current livestock and feed crop producers to adjust to the desired change in the demand for proteins.

OVERCOMING HURDLES TO ADOPTION OF SUSTAINABLE TECHNOLOGIES AND PRACTICES

However, the hurdles to adoption of some of these new technologies can be formidable (see, for example, Liu 2018). Even if policy makers and policy advocates feel confident that adoption of a particular technology will reduce costs, raise productivity, and increase resilience, there remains some uncertainty about the productivity impact of that technology in any specific environment. For instance, certain innovations may need additional inputs, like in the case of Green Revolution technologies which boosted productivity where farmers could access fertilizer, irrigation and adequate market infrastructure, such as in Asia, while it did not in Africa, where such complementary inputs were difficult to access or simply unavailable. Similarly, sustainably produced foods may meet consumer resistance, for instance, if produce labelled as, say, "organic" come at a higher price or consumers consider it inferior to produce that is not. As a result, the technology cannot be brought to scale because of limited demand. Given this, any policy that encourages or requires adoption of climate-resilient technologies must recognize the risk that producers perceive these may not improve productivity enough compared with the cost of adopting these.

The increasing involvement of the private sector and the use of proprietary technologies in the face of continued widespread poverty and climate change reinforces the importance of regulation and the strengthening of public good providers such as the CGIAR system and regional and national agricultural research systems.

Importantly, also, new technologies not only need to significantly improve productivity but make sure these substantially lower emissions and underpin sustainable intensification in agriculture and low-emission energy use in post-harvest food sector activity.

A mix of emergent circular feed, controlled environment agriculture, precision fermentation, and cellular tissue engineering technologies can dramatically reduce the terrestrial and marine footprint of farming, especially in producing higher-value foods and high-quality diets. The production costs of these methods are falling fast, making them increasingly viable. Orderly substitution of capital for land in food production will require cross-sectoral coordination to: build systems for payments to landowners for biodiversity conservation, carbon sequestration and other ecosystem services; shift from production-based agricultural subsidies to incentives for rural investment in renewable energy; implement robust safety nets for those disrupted and marginalized by inevitable transitions.

It will also require raising awareness among consumers and tap their latent valuation of more sustainable and healthy foods to incentivize beneficial innovation and technology adoption. Public policies can help raise such awareness, but also can also steer change by providing tangible incentives to both consumers and producers through taxes (on high-emission or unhealthy foods), subsidies (on low-emission and healthy foods), adequate food labeling and certification, and compensatory schemes for producers to overcome the cost of switching to sustainable practices or to low-income consumers facing greater difficulties to access food should the cost of a nutrient-adequate diet rise. A good starting point will be to rethink current agricultural support policies and assess the potential for repurposing resources for more R&D and incentive schemes that would promote food security and healthy diets through sustainable production. We turn to this question in the next section.

4. REPURPOSING AGRICULTURAL SUPPORT MEASURES FOR FOOD SECURITY AND FOOD SYSTEM SUSTAINABILITY[1]

This section will discuss how existing agricultural policies have promoted the evolution of current food systems. It will subsequently summarize key findings from research by IFPRI and the World Bank on options for repurposing the massive support (globally about US$720 billion per annum) and align the support with multiple objectives, including reducing GHG emissions from agriculture and land use change, reduce rural poverty, improve food security and nutrition, and improve climate-resilience of agri-food systems. The analysis will include the identification of trade-offs between those objectives as well as how benefits would be distributed across countries and main population groups and raise political economy questions regarding the feasibility of the policy reforms implied by the repurposing scenarios.

CURRENT AGRICULTURAL SUPPORT

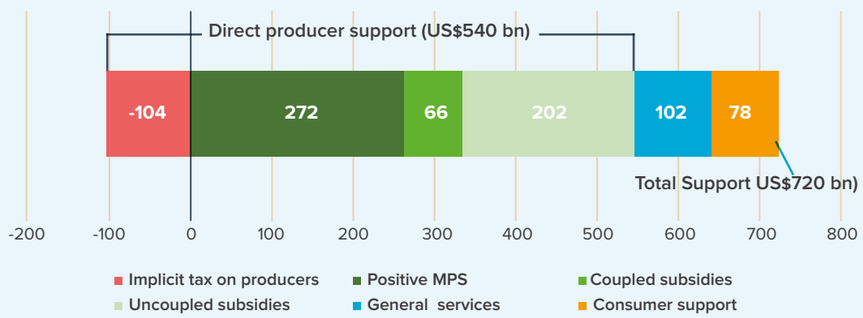
Current agricultural support provided by 54 countries for which comparable data is available amounts to about US$720 billion per year (OECD, 2021). This support is mainly provided to agricultural producers. Nearly all this support is provided by G20 countries and most of it in forms that distort incentives to producers, often promoting production processes and products that generate substantial GHG emissions. In 2018-20, governments of 54 countries with comparable data collected by the OECD provided together US$720 billion per year in transfers to agriculture, amounting to 27% of gross agricultural value added of these countries (OECD 2021 and Figure 6 below). Individual producers received US$540 billion in support per year through various support measures, including higher prices paid by consumers.

An important share of this support is delivered through measures that change domestic prices relative to world market prices. While not reflected in government expenditures per se, these measures do imply implicit transfers from consumers to producers or vice-versa, as such market price support (MPS) creates a price gap between domestic market prices and border prices for specific agricultural commodities. The border measures can take the form of, for instance, import licenses, tariffs, tariff rate quotas and minimum prices. Total 'positive' MPS amounted to US$272 billion per year in 2018-2020 (Figure 6). Some emerging and developing countries, such as Argentina, India, Viet Nam, Kazakhstan, Russia, and Indonesia, also implicitly tax producers of certain agricultural commodities through export taxes or export restrictions, which depress the domestic prices of these products, hence constituting 'negative' market price support. Overall, negative MPS amounts to more than US$104 billion per year.

1 This section is based in good part on Vos et al. 2021 and Gautam et al. 2021.

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

FIGURE 6 | AGRICULTURAL PRODUCER SUPPORT BY MAIN TYPES OF SUPPORT, 2018-20201961=1 (BILLIONS OF US$ PER YEAR)



Source: OECD 2021

Support measures involving fiscal expenses amounted to US$447 billion per year in 2018-2020. These represent transfers from taxpayers to producers, consumers, or to the sector as a whole. Three quarters of this support (US$ 268 bn) goes directly to individual farmers, of which US$66 billion in the form of subsidies coupled to levels of production and/or to input use, while US$202 billion takes the form of direct payments to farmers not explicitly tied to production and which, hence, are less distortive to market conditions. Only a small portion, that is, only one in six dollars of budgetary support is for R&D and agricultural innovation systems, infrastructure and other general support to the sector.

The support provided by countries has a long history and mostly has been grounded in perceived needs to promote agricultural productivity, protect farm incomes and/or ensure adequate and accessible food availability. In many instances the support measures have proven instrumental towards achieving these objectives. At the same time, however, they have provided incentives for modern farming systems that are a major cause of global GHG emissions and excessive pressures on land, water, and other natural resource systems.

IMPACT ON GLOBAL GHG EMISSIONS OF TODAY'S AGRICULTURAL SUPPORT MEASURES

Few of the existing agricultural support measures have been explicitly designed to meet environmental objectives, such as the reduction of GHG emissions from agriculture. In fact, some countries allocate much of their support to emission-intensive agricultural products like rice, beef and dairy, and hence unintentionally contribute to higher GHG emissions.

It would therefore be logical, although perhaps naïve, to ask the question: would the world be environmentally better off by doing away with all agricultural support? The short answer is, probably not. Despite its significant influence over time, recent global model-based analysis points to two important insights (Gautam et al. 2021).

Figure 7 below compares key results for seven scenarios. This sub-section presents the findings of the first two of these scenarios which relate to the elimination of support scenarios:

a) elimination of all domestic support ("Dom. Support"); and

b) elimination of "All Support" (domestic subsidies and market price support through border measures).

As a first, perhaps surprising, result it appears that current support measures have only a small influence on the overall (global) volume of agricultural production. This does not mean that support measures have no effect on production; they do in individual countries. When incentives are changed (e.g., by taking current support away), however, this also influences production patterns across products and between countries. Furthermore, removing subsidies increases agricultural prices, thus reducing demand and eventually also production. Therefore, on balance, the net effect on global production is limited.

As a result of the limited impact on production levels, it also appears that the current support has, on balance, a limited net impact in terms of inducing additional global GHG emissions from agricultural production and land-use change (Laborde et al., 2020 and 2021; Gautam et al., 2021). This limited impact is explained, in part, by the fact that, on average, high-emission products (such as livestock and rice) are not subsidized more relative to less emission-intensive types of agricultural production, and, in part, by the impact of agricultural trade protection on consumer prices for some high-emission products: without the protection, those prices would fall, thereby increasing demand, production and land use for those products, which in turn would induce more GHG emissions.

FIGURE7 | GLOBAL IMPLICATIONS OF REPURPOSING DOMESTIC SUPPORT
(% CHANGE RELATIVE TO BASELINE PROJECTIONS FOR 2040)

Source: Gautam et al. (2021; forthcoming).
Note: GREEN bars indicate movement towards societal goals; ORANGE/RED BARS indicate movement away from societal goals.

On balance, however, the removal of current coupled subsidies and border measures would reduce emissions, but only slightly. This gain for the environment would come, however, at the cost of lower yields and farm incomes, which in turn could affect global food security. This shows that a naïve reform, involving the abolition of all support, would not simultaneously meet multiple goals of sustainable food system transformation and generate important trade-offs between environmental, economic, and social objectives.

Consequently, agricultural policy reform needs to be carefully thought through in order to strike a proper balance across all dimensions of sustainable development countries. That is, can the substantial resources that support agriculture be repurposed in a way that, on the one hand, provides strong incentives to reduce GHG emissions and adapt to climate change, and, on the other hand, improves food system efficiency, protects farm incomes and helps combat poverty, hunger and malnutrition?

THE POTENTIAL FOR GHG EMISSION REDUCTION BY REPURPOSING SUPPORT MEASURES

Further model-based analyses (Gautam et al., 2021) point out, however, that there can be ways to repurpose the policy support in ways that would make significant progress towards achieving both global climate and food security goals. This would require shifting support towards investments in and incentives for technology improvements aimed at increasing the efficiency of production and resource use, while at the same time reducing the emission-intensities of agricultural production.

To assess this, Gautam et al. (2021) experimented with range of 'repurposing' scenarios. Figure 7 presents the results of five of these, including:

a) redistribution of support to make it uniform across agricultural products ("Uniform")

b) prioritization of support to products with low-emission intensity ("CO2 efficient crops")

c) transform coupled subsidies into direct payments to farmers, conditional upon their adoption of "organic" farming practices ("Conditionality")

d) repurposing for more investment in productivity-enhancing R&D ("Productivity")

e) repurposing of subsidies towards more investment in R&D and decoupled payments to farmers promoting adoption of improved technologies ("Repurposing for PG").

In experiment (c), changing from the current disparate pattern of subsidies to a uniform output subsidy with the same budget cost also has generally modest impacts. Surprisingly, real national income falls, albeit very slightly, representing a second-best welfare result associated with the continuing distortions in border measures. Global farm income per worker falls, while production shifts towards livestock, suggesting that livestock are, on average, less subsidized than crops-a not surprising result considering much of the support to crops is provided through input support that is crop-specific. This, in turn reduces prices of dairy products and raises their consumption levels. Emissions from agricultural production rise by 0.5%, but this increase is more than offset by a decline of 1.1% in land-use emissions.

Simulation (d) involves withdrawing support from the most emission-intensive agricultural commodities-livestock production and rice-and reallocating the available funding to all other agricultural commodities, which are mostly crops with much lower emission intensities. This scenario would reduce average real farm income only slightly and reduces world prices by around 2%, as production of highly traded grains and other non-livestock commodities expands. The cost of a healthy diet dominated by non-livestock products falls by almost 2%. Perhaps surprisingly, global GHG emissions would increase slightly in this scenario, as the decline in emissions caused by lower agricultural production would be outweighed by increased emissions from land-use change. The three final scenarios presented in Figure 7 refer to repurposing of support for the adoption of more sustainable production practices. Scenario (e) ("Conditionality") involves a scenario along the lines of agricultural policy reform that would transform coupled subsidies into direct payments to farmers, conditional upon their adoption of "organic" farming practices that reduce the use of chemical fertilizers and pesticides, along proposals by the European Union (European Commission 2020a,b). Based on available evidence (see Gautam et al. 2021), this experiment involves a "productivity penalty" owing to reduced use of modern inputs (see e.g., Seufert et al. 2012; and Smith et al. 2019). As a result, crop production would fall by more than 6% and livestock production by nearly 5%. The decline in output raises world food prices by a substantial 12.7%, which helps raise real farm income per worker. Agricultural land use would increase, as resources are drawn into the sector to offset the decline in productivity. On balance it would leave the amounts of emissions from agriculture and land-use change virtually unchanged.

The final two scenarios focus on an internationally concerted strategy promoting investments in emission-reducing agricultural productivity growth by shifting resources currently provided as distorting subsidies towards more spending on appropriate R&D, and compensating farmers for any financial loss from subsidy removal and the upfront costs of adopting more sustainable technologies and production practices in the sense discussed in the previous section. Many studies indicate that the economic returns from R&D focused on increasing agricultural productivity are extraordinarily high (see Alston et al. 2009 and Alston et al. 2020, for example) and agricultural productivity growth appears to have a much bigger impact on poverty reduction than productivity growth in other sectors, such that this has the potential to create significant simultaneous impacts in terms of climate change mitigation and adaptation, poverty reduction and improvements in global food security.Scenario (f) ("Productivity") assumes such repurposing could achieve a 30% increase in agricultural productivity.

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

In the final scenario (g) (“Repurposing for PG”) existing coupled subsidies are redirected towards greater R&D spending equivalent to 1% of the current level of support and the remainder is used to provide direct decoupled payments to farmers as incentives to adoption of improved practices (at least until the benefits of R&D start to pay off).

The results from both scenarios show significant positive impacts on overall global welfare and improvements in yields, food prices would decline, making food more affordable, with commensurate benefits in the form of less poverty and improved food security and access to healthy diets. Global GHG emissions would drop by around 40%. As a potentially sensitive trade-off, farm incomes (excluding direct farm payments) would fall with lower agricultural prices.

These findings show that smart repurposing of current agricultural support has the potential to contribute to the environmental sustainability of agriculture, while also contributing (moderately) to poverty reduction, food security and better nutrition. Key to these outcomes is ensuring that the reorientation of support leads to significant efficiency improvements (both in terms of higher yields and lower emission intensities). It is also clear that reorienting agricultural incentives in this way will not address all food system challenges in full.

WHAT ROLE FOR PUBLIC AND MULTILATERAL DEVELOPMENT BANKS?

Here is also a role for public and multilateral development banks to play. As they provide long-term finance and agricultural R&D investments pay off – at very high returns – over longer time periods, financing research and innovation projects should make economic sense, also from a banker’s perspective. Public and multilateral development banks that invest in food and agriculture as part of their portfolio currently account for almost two-thirds of the formal financing for agriculture. With estimated annual investments reaching US$1.4 trillion (Xu, Maradon, and Ru, 2020), their role can be game-changing. With such financial leverage, they could help drive the shift to more environmentally sustainable and fairer food systems delivering nutritious diets and equitable livelihoods for all. At the 2020 Finance in Common Summit, many PDBs already formally declared their commitment to shift their business strategies, investment patterns, and operating procedures to achieve the objectives of the Paris climate agreement and the United Nations Sustainable Development Goals, while helping the economic recovery from the COVID-19 pandemic through investing in sustainable development projects. What is more, public development bank finance can catalyze private sector investments in agrifood sectors. Private banks and investors often see ventures in agrifood sectors as high risk and low return, being hindered by a variety of major risks related to weather and market variability and by lack of creditworthiness of the hundreds of millions of small-scale farms and agrifood businesses that are critical to food systems of most countries. This is where public development banks can play a critical role by looking for innovative financial solutions, such as by: (i) investing in climate-smart agriculture, which is a direct mechanism for “de-risking” finance by increasing farm and agrifood business resilience to weather variability; (ii) blended finance mechanisms for de-risking investments in the sector, but especially to provide small-scale producers with more access to finance for investing in sustainable practices (see e.g., IFC, 2011; Diaz-Bonilla, 2021); and (iii) issuance of green or sustainability bonds to attract investors to the sector and help align commercial finance to food security, environmental and climate-related goals.

Such solutions could become more attractive and viable if supported by repurposing of agricultural support measures in the suggested directions as this would align market incentives with those objectives as well as enhance public resources available for R&D in technologies and innovations for making food systems much more productive, resource efficient and climate resilient.

5. CONCLUSIONS

Climate change is already adversely affecting agricultural production, which itself – along with post farmgate production and distribution processes – is also a main cause of climate change, as food systems generate one-third of GHG global emissions. There are many new, ready-to-use technologies and innovations with the potential of substantially reducing emissions (including from livestock production) and could make agri-food value chains more climate resilient. However, we should not expect these to suffice as ‘technological fixes’. First, more R&D is needed to adapt productivity-enhancing and emission-reducing innovations to a much wider array of types of production, especially tropical agriculture, as well as for innovations for climate-resilience of post-farmgate activities, which are already and will be the more dynamic parts of the food system moving, but also a growing source of GHG emissions. Second, more importantly, market players should be willing to adapt and adopt the technologies that are available and willing to develope those further. Policy support providing price or regulatory incentives for the adoption of technologies, as well as infrastructural improvements (including for wider use of digital technologies) and targeted direct farm and other producer support will also be needed to a compensate small- and medium-scale producers for startup costs when adopting new practices. Third, adjustment will also have to come at the consumer end, shifting food demand towards products that are less resource and emission intensive and rewarding (e.g., through price premia or certified standards) production that is more sustainable.

One important pathway for change in these directions could run through a reallocation of current government agricultural policy support, which – at a fiscal cost of more than US$700 billion per year worldwide – offers an obvious source for public finance for agri-food system innovations and incentives to producers and consumers. Current support programs largely impede, rather than advance, necessary innovations towards more sustainable, resilient, inclusive, and equitable agri-food systems. Only one-eighth of total government support of agriculture presently goes to R&D, inspection and control systems, and rural infrastructure-the things that promote beneficial innovation-as compared to three-quarters provided as transfers to individual producers, mostly supporting commercial and larger-scale agriculture that reinforces inequality (OECD 2021).

Hence, one centerpiece of a strategy to mobilize both public and private finance for food system transformation would involve reform of the distorted incentives created by current agricultural policy support that directly and indirectly encourage investment in practices and products that generate serious environmental and health spillovers. Such reform features high on many calls for better finance for food system transformation, such as the high-level Financing Nature report which emphasizes “harmful subsidy reform” as its top recommendation for mobilizing finance to avert the looming existential biodiversity loss crisis (Duetz et al. 2020), the Just Rural Transition coalition (Just Rural Transition) and multiple proposals submitted for the 2021 UN Food System Summit action agenda (Diaz-Bonilla, Swinnen, and Vos 2021; UNFSS Finance Lever 2021), among others.

Getting market signals right is essential to induce investors to divest from investing in unsustainable production methods and unhealthy product innovations. However, while its potential is huge, agricultural subsidy reform is also politically fraught everywhere.

As shown in this paper. border measures distort production and trade and, in the form of import measures, but penalize domestic consumers. Hence, they cannot be easily "repurposed", while low-income countries do not have the fiscal space to compensate for income losses when border measures are removed. Direct coupled subsidies also distort market prices, of course, but can be easier from a fiscal point of view to be reallocated. However, as also shown, simple removal of subsidies does not appear to have huge, bene-

CLIMATE CHANGE AND FOOD SYSTEM SUSTAINABILITY: CHALLENGES AND SOLUTIONS

ficial impacts. This is so, in good part, because decades long support has locked in highly polluting production methods and agri-food systems which by and large will remain in place also without the present subsidies.

These findings confirm the fact that current agricultural support is a very blunt and largely counterproductive set of instruments to address food system externalities like climate change and food security and nutrition. As said, more promising outcomes would come with relatively reallocations for more R&D, assuming this focuses on productivity-enhancing and emission-reducing technologies for both on-farm and off-farm food system improvements. The foster diffusion of such practices and for delivery of eco-services compensatory payments may need to be targeted to producers with insufficient means for adoption. Influencing dietary preferences and food consumption patterns is probably more effective through directly influencing consumer behavior (e.g., taxing foods with negative externalities and subsidizing and/or certifying those with positive externalities).

These are key considerations for the design of repurposed policy support. However, even the best design will face considerable political hurdles. Agricultural support policies are the prerogative of national governments. Overcoming national resistance to agricultural policy reform will be a huge challenge. National farm and agricultural policies have a long history in most countries and have established entitlements and vested interests.

Perhaps an even bigger obstacle on the way to reform is that, to be effective for global development, strong policy coordination will be need between all countries. At present agricultural support is distributed unevenly across nations. Poorer nations have less fiscal space to provide agricultural support and, also, their national agricultural research systems generally have weaker resource capacity to develop high-productivity and sustainable farm technologies and practices relevant to the local context, and their farmers and other food producers face bigger obstacles in adapting those practices. Public and multilateral development banks can play an important catalytic role here by leveraging private investments in sustainable food system transformation by de-risking such investments, inter alia, through providing finance for climate-smart agriculture, develop blended finance mechanisms accessible to small-scale agrifood producers, and issuance of new financial instruments, such as green bonds for agrifood systems. Smart repurposing of agricultural support measures as proposed would reinforce such a catalytic role by aligning market incentives behind the same objectives and by substantially increasing funding for R&D in sustainable technologies and practices.

However, to be effective at the global level, an even-handed diffusion of both technologies and financial resources would be needed to let all countries reap the benefits of such agricultural policy reform. As big as a hurdle it may pose, international coordination is a must, if only because climate change and environmental sustainability are global priorities transcending borders and because national policies have strong international spill-over effects. Hence, a major ask for the UN Food System Summit, the Finance in Common Summit, and their respective follow-ups, as well as global platforms like the G20 is to bring nations and food system actors together behind a concerted strategy for resetting global food market incentives and financing mechanisms for sustainability and healthy diets.

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19-20 October 2021

Finance in Common

THE ROLE OF FINANCE AND PUBLIC DEVELOPMENT BANKS IN PROMOTING SUSTAINABLE AGRICULTURE AROUND THE WORLD

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IFAD Investing in rural people

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CONTENTS

1. WHY THIS STUDY

In light of the current international determination to achieve a more sustainable model of development aligned with the SDGs (United Nations, Department of Economic and Social Affairs2021), food systems can play a strategic role in combating climate change and accelerating the ecological transition. Food systems should be strengthened. The Coalition of Action for Inclusive and Sustainable Food System Finance (IFAD2021) highlights a significant funding gap in these systems, despite diverse actors and instruments. Actions should be taken to enhance the opportunities for the actors of the financial ecosystem to effectively invest in food systems, at different levels, including at the level of marginalized microproducers. The G20 Matera Declaration on Food Security, Nutrition and Food Systems (G20 2021) acknowledges the need to strengthen the financial ecosystem as a whole, incorporating more sustainable financial inclusion, and stresses a specific role of public development banks (PDBs).

PDBs have been operating for decades to achieve the overall goal of human and economic development, with mixed results. Conceived as a private institutional type of actor in the hand of the government, they can have an impactful role but they are also challenged by this mixed nature. This characteristic has often been considered a liability but may now become an asset. In fact, the Matera Declaration highlights the specific role that PDBs can play in overcoming market failures and making target sectors more attractive to private funds. The document lists several possible target subjects in food systems that can be made more inclusive and resilient. It also affirms the importance of achieving sustainable food systems. Climate-related issues are now a prevailing focus of sustainable development, and rural operators of different sizes may drive the transition. Large agricultural multinational companies are currently under the lens of the international community for the impact they have but also the micro, rural operators, exposed to climate risk, often adopt inefficient techniques or even harmful environmental practices. These companies could facilitate the transition with appropriate incentives for environmentally friendly investments and activities. Actions in favour of this target also achieve wider financial inclusion. The COVID-19 pandemic makes these priorities more stringent.

PDBs, scattered geographically and diversified, should benefit from coordinating their actions through networks and partnerships that strengthen PDBs' ability to mobilize private resources targeted at investments in environmental, social and corporate governance (Finance in Common 2021). This opportunity inspired the Finance in Common Summit, the IFAD-led Finance in Common Working Group on Financing Sustainable Food Systems, the Platform -promoted by IFAD, Agence Française de Développement and Cassa Depositi e Prestiti, and the related Coalition of Action (IFAD 2021). Innovation of approaches and instruments are driving factors of these actions.

In the past decade, interest in PDBs has increased, and abundant literature has been produced by policymakers, the international community, academics and field operators. This is a background paper that systematizes relevant literature. Based on selected studies,[1] evidence and data taken from secondary sources, it highlights approaches and instruments that lead PDBs to strengthen their role for more sustainable, green and resilient food systems. It also focuses on the current internal and external obstacles and challenges. Section 2 delineates the target subjects of the PDBs' actions that are relevant for this analysis, i.e. operators in food systems with a focus on smallholders.

1 Given the growing interest in the role of PDBs in food systems, the available literature is overabundant. The aim of a thorough review was deemed redundant and unfeasible, given the time horizon of the work. Several recent qualified papers, in fact, constitute a reliable summary of the topic, suitable for achieving the objective of the paper. In addition to a selection of the most inspiring contributions in this respect, a copious set of relevant literature was also analysed.

Section 3 explores the current financial ecosystems on the supply side, institutions and instruments aimed at increasing access to finance for smallholders in food supply systems who are still under- or un-served. PDBs emerge as possible strategic actors in achieving this target. Section 4 describes the landscape of PDBs with a focus on National Development Banks (NDBs) and the available tools to catalyse additional resources and to have higher impact at the local level. Section 5 examines in more detail the specific actions targeting the environmental transition and financial inclusion. Section 6 presents the main lessons learned and Section 7 concludes. An Appendix includes some examples of good practices.

2. THE UNMET DEMAND FOR FINANCE BY THE ACTORS IN THE FOOD SYSTEMS

Sustainability and climate-related concerns and opportunities make investing in agricultural and other rural non-financial operators, including food processing and distributing operators, more attractive than ever. While climate change implies increasing challenges and new risks to face, it opens up new ways of production, consumption and living that greatly involve food systems. It implies a change in production and consumption patterns that favour a more equitable and inclusive world. In this perspective, finance is considered by the 2021 Food System Summit as a cross cutting-lever of change. Finance, in fact, should be directed to the many players in a food system, defined as a "constellation of activities involved in producing, processing, transporting and consuming food" (United Nations, Food Systems Summit 2021).

Miller and Jones (2010) stress the growing concentration of control in the agricultural sector. Economies of scale and the globalization of food chains enhance the position of multinational and other agribusinesses that want to meet the quality and safety standards demanded by higher value markets. Large companies are often the drivers in food systems and may become a source of finance for other actors in the chain. Other players may be less integrated in the food chain and have more limited access to finance, as it is the case of smallholders, producers' organizations and farmers in poor countries. Special pressure on them derives from the increase in the value of products consumed by the entire population, occurring also in the Global South. This fact requests long-term investments and long-term finance, to improve productivity, efficiency and resilience (Miller and Ono 2021). The focus of this paper is on micro, small and medium-sized enterprises (MSMEs) because they often have limited access to finance and can make significant improvements in the climate change transition.

Size, however, is not a precise measurement. Size may be measured based on different criteria, such as land extension as in Koloma (2012) or Carrol et al. (2021), or the magnitude of investments, the number of employees, the annual turnover and total assets (as in SAFIN's agri-SMEs taxonomy, SAFIN-ISF 2021). Classifications change according to the criterion used, since various elements are correlated with financial inclusion. In fact, a smaller company may have greater access to finance than larger ones if it works in a dynamic market. Therefore, size is often combined with other characteristics such as the production and marketing model, or the level of technology, as in Jessop et al. (2012) and Koloma (2021) or the formal vs. informal structure (as in SAFIN-ISF 2021). Depending on the criteria, the same types of ventures may be included in different categories or vice versa (for example, SAFIN-ISF 2021 uses ample ranges, defining SMEs as having 5-250 employees and an annual turnover of $US100,00 to US$5 million). Distinctions are complicated by the fluidity of some segments (Goldman et al. 2016). Being aware of these caveats, in this paper, prevalent attention is given to the broad group of smallholders and MSMEs.

The interest in the universe of smallholders may be related to its magnitude[2] and to its operating structure and challenges. These challenges include limited physical and financial resources, the household-farm interconnections, little income diversification, low profitability,[3] and high-risk exposure (production, marketing, price risk, including covariant risks).

2 Carrol et al. (2012) and Goldman et al. (2016) report an estimate of 450-500 million smallholders worldwide – involving around 2 billion people. Small-scale farmers with less than five hectares of land count for about 95 per cent of world's farms and cultivate 20 per cent of the global farmland, providing up to 80 per cent of the food produced in Asia and sub-Saharan Africa (Chiriac, Naran, and Falconer 2020).

3 Carrol et al. (2012) estimate an annual smallholder income of US$170-570 with only 10 per cent of smallholders involved in export value chains (2012).

These characteristics represent barriers to accessing credit especially because they are coupled with low financial literacy, lack of collateral and credit history, and high territorial dispersion that discourages lenders and increases transaction costs (Carrol et al. 2012; Brulé-Françoise et al. 2016; Sadler et al. 2016; World Bank Group 2018). Smallholders face greater chances from a value chain perspective. However, Jessop et al. (2012) find that in most developing countries, agriculture and value chains are still characterized by low performance and productivity, low yields and difficult product preservation; even risk-management strategies, although in place, are not effective in limiting crop failures. The COVID-19 pandemic has proven the vulnerability of these systems (Susantono 2021). Value chains, however, are not all the same. Miller and Jones (2010) portray a comprehensive analysis of the different business models of value chains. Carrol et al. (2012) report four types of models (exportable cash crops, captive global buyers, and organized or un-organized local staples) with different implications in terms of financing models ranging from traditional lenders to microfinance. A wide and detailed range of financial models in value chains and demand for services is presented by Jessop et al. (2012), differentiating, among other things, between working capital and long-term finance[4] (see Section 3).

The literature acknowledges the difficulty of quantifying the financing gap, but various studies attempts to estimate it. Unfortunately, the outcomes are hardly comparable because of the different targets considered in the analyses. Carrol et al. (2012) report that smallholders need a total of US$450 billion of financing, mostly unmet. A subsequent study by Goldman et al. (2016) estimates the financial needs of smallholders in the Global South to be more than US$200 billion, with a gap in supply of US$150 billion. The difference with respect to Carrol et al. (2012) is attributed to the exclusion of about 200 million farmers in China, Central Asia, and in the Middle East and North Africa, to a refined segmentation of farmers according to their commercial attitude, to their role in value chains and to the inclusion of non-agricultural financial needs. Chiriac, Naran, and Falconer (2020) report a global estimate of agricultural and household-related financial needs of small-scale farmers at US$240 billion per year. Brulé-Françoise et al. (2016) show that access to formal borrowing in eleven African and Asian countries ranges from 2 to 28 per cent with most of the countries below 7 per cent (data referred to 2009), and Jessop et al. (2012) report that the demand for seasonal credit is satisfied by 20 per cent in the countries analysed in their study.

Some of these data are not recent, and technologies have led to improvements since then, but the gap is persistent: Miller and Ono (2021) report a 2017 estimate by the International Finance Corporation of a short and long-term financial gap for micro, small and medium-sized enterprises in developing countries of over US$5 trillion. Sadler et al. (2016) confirm the shortage in long-term finance and also highlight the little access to smallholders' and SMEs' finance by women.

Miller and Ono (2021, 4) also observe that "not all of the perceived demand is effective demand" because some potential recipients may lack capacity and conditions to access this funding. On the other side, as Jessop et al. (2012) underline, farmers may self-ration because they are aware of the risks of non-repayment. In fact, Brulé-Françoise et al. (2016) find that the borrowers are subject to the same deterrents as lenders when they feel they are exposed to too many risks and they fear being deprived of the assets pledged. Jessop et al. (2012) also explains the exceeding "needs" for funds with respect to "demand" by noticing that demand becomes effective only if there is willingness and ability to pay for the service as well as an active search for that service. To put it in the perspective of the lender, "Quantifying the need for agricultural financing assumes that farmers can convert financing into income increases (cash or in-kind) that justify the cost of such financing" (Goldman et al. 2016, 5). Several contributions in the literature have stresseds the need for actions complementing the supply of finance to induce farmers to make good use of the resources, such as suitable long-term agricultural and land policies, public investments in infrastructure, research and development, or education. In fact, a self-rationing of potential borrowers may not be justified by the actual conditions but induced by the lack of financial education. Product design, then, should aim to make recipients familiar with the instruments and should be attractive. For example, timeliness of granting is often considered a must in rural areas, which explains the success of (the often very expensive) informal finance (Jessop et al. 2012). Moreover, as stressed by several studies, the clientele is interested in a whole range of services that they can use to optimize their financial management: loans, savings, payment systems and insurance (personal and non-life),[5]

4 The diversity of value chain financing is well documented by the case studies reported about the African continent in FAO and AFRACA (2020).

5 For a study on the need to consider the complementarity among these different products in farmers' risk management strategies, see Viganò and Castellani (2020).

3. TRADITIONAL AND NEW INSTRUMENTS, SUPPLIERS AND ACTORS IN FINANCE FOR FOOD SYSTEMS

While the development of rural financial markets has differed among countries, in most developing countries, especially in Africa and Asia, informal finance providers remained the only or prevailing source of finance until the mid-1900s. Subsequently, many governments decided to step in and implement extraordinary policies to foster the development of the agricultural and rural sectors, acting on structures and mechanisms beyond the financial system: pricing systems and marketing channels (for example, price regulation and monopolistic purchases of agricultural products, and state supervision and participation along the value chain - Jessop et al., 2012), technical assistance and physical infrastructure. Concerning the financial system, private commercial banks were almost absent in rural areas. Governments attempted to fill the gap through direct lending, lending to cooperative systems promoted by the government, through development banks and public/internationally sponsored projects. Multilateral agencies and banks, and bilateral aid, often facilitated the funding for these initiatives. Lines of credit in hard currency were provided at soft conditions but unhedged from foreign exchange risk (Jessop et al. 2012). In the '90s, the disappointing results observed in many countries (with high defaults on loans granted and little intended impact) put the effectiveness of agricultural/rural finance in promoting development, especially in poor areas, at the center of the debate.

Free market supporters claimed that a liberalization of the process was necessary and that market conditions would incentivize the private sector to effectively offer financial services. At the same time, others believed that subsidies, including soft loan conditions, would still be needed in order to prompt the target rural (poor) population to borrow and invest in agricultural/rural businesses. The literature is vast. Several documents analysed for this paper focus on the main challenges and on the transition from a supply-led finance approach to a demand-driven approach that puts the final user of financial services at the center (among them, Jessop et al. 2012 and Koloma 2021). Anecdotal evidence of the decade between 1990 and 2000 shows a progressive change of African private bankers' attitude towards small/medium scale agricultural and rural finance, from skepticism to growing interest in a potential business line.

Some governments succeeded in gradually stepping out from agricultural finance. For example, Axelrad (2014) and Shakhovskoy et al. (2020) present the cases of Germany (which reached the bank-based stage) and of the US (market-based stage). In order to encourage private bank financing, for example, guarantee funds were adopted to de-risk, thus allowing borrowers to progressively graduate as fully bankable. In developing countries, though, striking results were rarely achieved and private banks did not fill the gap. In fact, the transition from public to private was not easy and seldom occurred smoothly or effectively. Koloma (2021) offers a detailed discussion of the different stages of the rural/agricultural finance paradigm. In fact, over time, the limited impact of the market approach on the supply of financial services in rural areas led to reconsider some of the assumptions behind it. A debate is still open about, for example, the benefits and distortions of subsidized interest rates and of guarantee funds. Koloma (2021) shows that the transition to financial liberalization in the structural adjustment periods (1980-2000) was followed by a phase of post-adjustment, when a new joint action between the government and the private sector was promoted to reach a final phase where the government, also through its public institutions, may become a catalyst of resources. Public and international cooperation funds are now complemented by other funds from new categories of investors. This Section looks at the supply side, in terms of both finance providers and instruments, with a focus on MSMEs.

TRADITIONAL SUPPLIERS

In their cross-country study on six countries in Asia and Africa, Jessop et al. (2012) conduct a comparative analysis among providers of agricultural financial services. As further discussed below, most of their findings are similar to those offered by studies in other countries. The study finds that commercial banks play a negligible role, with the exception of the financial services for the agro-industry, trade and related activities, and some important agricultural conglomerates. Those agricultural development banks that were restructured after the period of the directed credit or new ones now play a more significant role in the sector, with (limited) use of subsidized credit, serving a wider range of clientele, including smallholders. However, often their action is insufficient and the quality of credit is low, due to poor loan analysis, as in the old times. There are some excellent cases though, as exemplified also in Koloma (2021).

Jessop et al. (2012) also find that the role of microfinance institutions (MFIs) in the rural/agricultural sector differs from country to country. MFIs emerged as an answer to the failure of the supply-led finance. These institutions are rooted in local communities. While enjoying some of the characteristics of the informal finance providers, they tend to be larger and have a defined organizational structure. These blended characteristics make MFIs an important counterpart for smallholders. This is true not only for registered MFIs but also for other operators of similar size and approach, like credit unions. Jessop et al. (2012), however, stress that MFIs tend to have an uneven spatial outreach and variable performances. Besides the physiological characteristics of their target clientele, which may make transactions inefficient despite cost- and risk-controlling strategies, some MFIs ended up behaving, on a micro-scale, as supply-leading intermediaries, dispensing credit based on the funding received by their donors. Donor dependence is less evident in cooperative-based finance operators, as they rely mostly on local financial resources and are accountable to their member depositors on how they use their funds (Viganò 1998). The mission-drift of several rural MFIs towards more profitable sectors, with a more diversified offer and a focus on individual lending, affected their impact on agriculture (Goldman et al. 2016). In contrast, those MFIs that have been successful in offering financial services to the agricultural sector (Jessop et al. 2012 quote the

case of Cambodja) are often led by a reaction to increasing competition in the sector, pushing MFIs to become more proactive (Miller and Jones 2010). The informal finance sector has been thriving despite the increasing growth of the microfinance sector. Jessop et al. (2012) find a widespread presence of informal finance in all African and Asian countries analysed. MFIs, and even more so the informal intermediaries, are characterized by micro-sized and short-term transactions. However, they could be effectively included through partnerships with formal intermediaries, also within value chains (as exemplified by Goldman et al. 2016).

VALUE CHAIN FINANCE AND FARMER FINANCE

Value chain finance has been considered a revolution in (rural) finance. It consists of "the financial services, products and support services flowing to and/or through a value chain to address the needs and constraints of those involved in that chain," not only finance, but also secure sales or risk reduction (Miller and Jones 2010, 2). Synergies and interrelations among actors within and outside the value chain are more innovative than the instruments: trader credit, input supplier credit, marketing credit, contract farming/lead firm financing, receivable financing (like advances on receivables or factoring) and finance based on physical assets (as warehouse receipts or leasing). In fact, although these instruments may not be innovative, bundling contracts along the value chain allow farmers to integrate in national and international value chains and to sell to upper-stream actors (as portrayed in Section 2). Some instruments, though, have inner innovative features, such as forfaiting of freely negotiable instruments, collateralization through repurchase agreements of securities, derivative contracts such as forward contracts, options and futures, and financing through loan securitization. In fact, variations in product prices can be hedged through options or other derivatives on commodities as in the case of Brazil, where these contracts are offered to smallholders by the Banco do Brazil, as described in Jessop et al. (2012). The authors also quote a successful case of securitization offered by Farmer Mac, although in different context, to North-American agricultural and rural communities (Farmer Mac 2021). However, even the more traditional instruments, like trader or input supplier credit, can be structured in a more innovative and advanced way. One example is the constitution of captive finance companies that can finance, for example, the purchase of agricultural inputs by farmers (Jessop et al. 2012).

Miller and Jones (2010) underline that even some traditional contracts are hardly available to, or too expensive for, smallholders. Goldman et al. (2016) report that only 7 per cent of smallholder farmers are included in tight value chains more focused on cash crops. Furthermore, advanced solutions may require the intervention of specialized entities and ad-hoc legislation. Well-functioning markets (such as commodity exchange or futures market) and market information must be reliable. Sometimes more innovative solutions only apply to standardized and high quality goods, or to non-perishable goods. Loan securitization, for example, despite being successfully applied in microfinance[6] is costly and complex, and it is challenging to implement because of the possible minimum size constraints. Three instruments described by the authors, in the context of value chains, deserve further consideration. The first is insurance. It is a very traditional instrument for risk protection, regarded as costly and requiring subsidies when intended for the agricultural sector. As a matter of fact, insurance providers are less widespread and present in low-income countries, especially the non-life business (Swiss Re Institute, 2021) and often only offer very basic insurance products. There is a growing interest in the subject, though, from the international community, and innovative solutions have been conceived (see infra). Another risk-transfer tool is the guarantee scheme, offered by private or (more often) public entities to encourage lending. Guarantee schemes may involve moral hazard (among others, Axelrad, 2014), especially when the percentage of protection is high (banks can be less selective and farmers less willing to repay), counterbalancing the expected additionality. In addition, they can originate high managerial costs and request subsidies. Guarantee schemes, therefore, may not have the intended impact and incur into losses (among others, Viganò 2002). However, success cases in schemes, also originated by development banks, are found

6 On securitization in microfinance, see the recent opinion of Muturi (2021) that highlights, among other things, that this instrument allows to make available more resources for financial inclusion of individuals and MSMEs.

in the literature. A third instrument, which is more accessible through value chains, is the joint venture. It can represent an opportunity not only to attract external, private finance but also to increase marketing opportunities, thanks to the technical assistance often embedded in such ventures, thus, reducing risk. However, venture capital is still hard to achieve by smallholders (Miller and Jones, 2010). A possible more flexible option would be involving individual business angels, also providing managerial advice.[7]

Despite the limitations, innovative solutions in value chain finance are increasingly attracting the attention of donors, other private investors and financial players, especially when a combination of private and public actors can be established. One example, offered by Jessop et al. (2012), concerns the partnership between the commercial banks in Senegal and the local public agricultural bank, aiming to serve the industrial producers, the warehouses and the seeds providers in the peanut sector. The supply of value chain financial services should, in fact, not crowd out traditional finance providers, which, in contrast, are embedded to the local ecosystem. Traditional lenders such as local commercial banks may benefit from the de-risking role that a value chain can bring about. The attractiveness of the value chain finance approach rests not only on the emerging opportunities of collaboration with different actors along the value chain, but also on the offer of different products, not limited to credit but including savings, payments and insurance to different partners, with a "holistic household view" (Miller and Jones 2010, 119). Technological advancements enhance the potential of value chain finance. One example is the credit card system issued jointly by commercial, regional and rural banks in India (KCC: Kisan Credit Card) that allows farmers to get credit, crop insurance and health insurance; another one concerns the information systems implemented by Equity Bank and m-Pesa in Kenya more than a decade ago that allow transactions among bankers, farmers, buyers and suppliers (Miller and Jones, 2010).

In their country case studies, Jessop et al. (2012) find that the value chain approach, at least in its simple forms (such as input supplier credit or contract farming), is quite widespread. The success of value chain finance depends on the quality of participants and ventures and on the quality of their relationships. It has been noted that a disparity in the capabilities of the different actors (Goldman et al. 2016) often occurs. For example, microentrepreneurs are less included than other actors. Their participation can be enhanced by constituting co-operatives - Jessop et al. 2012). Goldman et al. (2016) insists on the synergic actions among the actors and recall the concept of "farmer finance." They refer to catalyzing actors from the fields of agricultural development, financial inclusion and technology in jointly providing smallholders with financial and non-financial services, based on local value chains. Different operators (formal, semi-formal and informal) link within the chain, also through technology. Three driving pillars of this strategy are portrayed: customer centricity, creative partnerships and smart subsidies. Customer centricity was in recent years adopted as a motto by CGAP (CGAP 2021) and is one of the main conceptual outcomes based on lessons learned from the failure of supply-driven finance.

7 See, among others, the non-profit association African Business Angel Network (ABAN 2021).

THE ROLE OF FINANCE AND PUBLIC DEVELOPMENT BANKS IN PROMOTING SUSTAINABLE AGRICULTURE AROUND THE WORLD

Smart subsidies are an outcome as well. In fact, since the transition to a market-driven approach unfortunately generated a limited impact on the development of the agricultural sector, subsidies emerged again as a necessity. They are increasingly suggested as long as they do not cause distortions in the market and are aimed at specific and controllable outcomes.

FUND PROVIDED AND MAIN GAP AREAS

Flows of funds are difficult to estimate. In their analyses of smallholders, based on the selected set of countries and type of investments already described, Goldman et al. (2016) estimate that formal financial institutions provide US$14 billion to agricultural (80 per cent of the total) and non-agricultural smallholders. State banks, especially in Asia, play the greatest role (64 per cent) with US$9 billion of total financing, while MFIs provide US$3 billion. The study also estimates at US$1 billion the funds provided by commercial banks, mainly to smallholders in tight value chains. A smaller although growing amount (US$0.35 billion) is offered by social-impact driven- lenders (see infra). In their analysis, the authors also include high-touch NGOs as fund suppliers, which show a limited but impactful role.

Finance granted to commercial smallholders by value chain actors, through the various forms described above, including by multinational and informal buyers, is estimated at US$17 billion. Informal and community-based operators, provide non-agricultural lending of about US$25 billion. Overall, government and development finance institutions (at their different administrative and functional levels) and bilateral aid agencies and foundations are prevalent sources for smallholder finance. The annual contribution of international public funders with some focus on smallholders is estimated at more than US$1 billion, provided through grants or loans, mostly subsidized but also at market rates. Significant financing gaps that are still to be filled, according to Goldman et al. (2016), are post-harvest (market) and long-term finance.[8]

Carrol et al. (2012) confirm the need for more long-term finance and, in their analysis, they focus on the role of social lenders in providing export trade financing to producer organizations and agri-businesses. They argue that, because of social lenders' short-term financing preference, the impacts are limited.

Long-term finance goes beyond the farming sector. Miller and Ono (2021) underline that long-term finance should be available to manufacturing and other actors in the value chain for a variety of purposes, a new catalyst type represented by climate change investments. However, currently, investors are attracted by initiatives and sectors that are easier to assess. The authors indicate the main players in long-term finance supply: banks (public and private), investment funds and agribusiness companies. They target larger, well-established agribusinesses. Banks offer more traditional financial services: debt, leasing, guarantees and some equity or quasi-equity, and insurance. Investment funds prefer large-sized short-term equity and shorter-term debt investments. Smaller amounts, flexible. and strictly limited to the partners (both suppliers and buyers) feature agribusiness companies financing, through leasing and asset backed loans, debt and equity. Most of funds for long-term finance are currently made available by agribusiness companies while impact investment funds may see an increasing role. The latter focus on smaller and less developed agribusiness SMEs and frequently provide technical assistance. However, the relatively short-term focus of these investment funds and the preference for larger-sized investments (as also described in CSAF, 2021), with respect to what is asked by agribusiness SMEs, may represent an obstacle to their growth in long-term finance provision. Miller and Ono (2021) cite, in this respect, the case of the Fairtrade Access Fund, that invests in Latin America and Africa.

A FOCUS ON PRIVATE, SOCIAL, INSTITUTIONAL INVESTORS

The contribution of private and institutional investors is still limited. Gottschalk and Poon (2018) explain that the shortage of international financing is not just caused by the liquidity preference of institutional investors, but is also a result of the high perceived risk of the investment, the complex regulatory frameworks for cross-border investments and the short-term focus of institutional investors' reward systems. Overall, the private market tends to refrain from investing in below investment grade tools. However, new ways can be opened, attracting more funds with targeted types of interventions. For example, private investors are increasingly stimulated by the rising demand for agricultural commodities. Social investors, in turn, show a unique risk/return preference because of the type of clientele they serve, willing to swap some financial return for more social return.[9] They are considered to be promising because they provide finance to producer organizations and may become innovators of lending products, pioneering long-term ones (Carrol et al. 2012).

The international financial market is giving encouraging signals: the sustainable debt market reached $US1.7 trillion in green, social and sustainability bond issuances in 2020, almost the double of the previous year (Climate Bond Initiative 2021). Green bonds, in particular, may become an important source of finance (see section 5). Institutional investors, also motivated by a more impact-oriented clientele, may be willing to increase the share of such sustainable debt in their portfolios. Improvements could be led by more suitable conditions in terms of minimum investment size and currency risk protection. Contractual arrangements on investment instruments can also be set in order to assure an effective mix, with different share classes in a blended finance approach, combining different investors, with different risk-return expectations. Public funds and philanthropic investors would aim at holding the patient capital component, in favor of social/sustainability impact, that allows to offer preferential returns to private investors (Miller and Ono 2021). Goldman et al. (2016) report that blended finance transactions may attract up to five times (functional to risk and type of capital) the initial private investment.

TECHNOLOGICAL INNOVATION IN FUNDING AND IN PRODUCTS

Crowdfunding is one of those digital innovations regarded as direct investment strategies. Through a dedicated online platform, individuals or companies launch a campaign for funds that can be donation-, debt- or equity-based. Social investors are attracted in particular when the target has a sustainable/social impact component. Debt-based crowdfunding already has a track record in microfinance (see, for example, Kiva 2021) but is increasingly tapped for SMEs. The African Crowdfunding Association (2021) promotes crowdfunding at pan-African level with a specific focus on SMEs (Miller and Ono 2021). Crowdfunding is a perfect example of the opportunities offered by technology.

Another technical revolution, mobile banking, has a longer track record than crowdfunding and is more widespread, including in poor remote areas, even if its expansion is not uniform across countries and areas. Active account growth in 2020 was 20 per cent in East Asia and Pacific, 67 per cent in Latin America and Caribbean, 35 per cent in the Middle East and North Africa and 18 per cent in sub-Saharan Africa (Andersson-Manjang and Naghavi, 2021). Payment and, to some extent, savings services were the first to be offered through this digital channel. However, credit and insurance services, although more difficult to offer and sometimes still at a pilot stage, have been growing over the last few years. A boost to value chains may come from adopting digital payments (as happened in Ghana, Kenya and China). However, not all countries are ready as the necessary technological infrastructure is not always available or sufficiently reliable, and special regulation may be required (Koloma 2021).

RISK MANAGEMENT PRODUCTS AS ENABLERS OF FINANCING

Technology may facilitate risk management strategies. One interesting application, in fact, is the use of technological platforms for transactions in value-chains. Abraham and Schmukler (2017) portray the case of reverse factoring. The producers hold account receivable from their buyers; buyers enjoying high reputation can post their payables on the platform and financial institutions submit an offer to buy these payables for a discounted value. The producers choose the best offer. In this way fraud, credit risks and transaction costs are reduced. Reverse factoring has been offered for 20 years in Mexico upon a NAFIN initiative that has later involved development banks in Central America. In this case, lending is provided by private banks and NAFIN administers the platform (quoted from The Economist 2017 by Abraham and Schmukler 2017).

8 However, with reference to the international fund supply, Goldman et al. (2016) raise the risk of financial service providers and smallholders lacking a sufficient "absorptive capacity." Creating investment opportunities and suitable products, in fact, requires a "holistic" approach in smallholder financing ecosystems.

9 Examples of the European alternative finance Oikocredit and Triodos, or the more recently established Root Capital or ResponsAbility are portrayed in Axelrad (2014) and Goldman et al. (2016).

In terms of smallholders' risk management, an interesting process innovation concerns index-based insurance. Traditional insurance schemes that cover weather-related risks are few. Private insurers that have no access to the re-insurance market are unable to take these risks; furthermore, assessments of claims are costly and burdensome. Over the last two decades, to deal with moral hazard problems, high transaction costs, high loss adjustment expenses and covariant risk, index-based insurance has been conceived. In this contract, losses are estimated according to the performance of parameters beyond the control of the policyholders that have a sufficiently high correlation with crop yields (or livestock mortality). The product is based on a weather derivative on the index chosen. It has the advantage of clarity, low cost after the conception phase, and to remove moral hazard risks. Still, schemes intended for smallholder farming are often in a pilot phase, and subscriptions rates are unsatisfactory (Koloma 2021). Although farmers are aware of the contractual elements, one of the obstacles is a premium that is hardly affordable for a single farmer (Castellani and Viganò, 2017). One way of promoting index-based insurance is to encourage lenders to act as protection buyers on their overall loan portfolio; the cost can be added onto the price of each loan granted. In the field of disaster risk protection, along the same approach, insurance companies could be encouraged to sell disaster risk policies through catastrophe (CAT) bond issuances. CAT bonds, sold to the international investors, offer high returns for acceptance of the large-scale impact of a catastrophic event. Despite complexity, these tools can allow insurance companies, as an alternative to reinsurance, to hand over some of the risk to the international risk market while de-risking the (smallholder) end users.

4. PDB'S ROLE, FEATURES, INSTRUMENTS AND PERFORMANCE

4.1. WHY PDB NOW

Section 3 depicted the overall supply of financial products and some the solutions that may better contribute to a wider access to finance by strategic actors of food systems, especially those that are still underserved. What emerged is that no matter how innovative products are, the real change (and challenge) is to make them effective in advancing users' efficiency, quality and sustainable impact. Value chains are enablers of virtous processes but are still showing diversified performance. Complementary actions are required from financial and non-financial actors. PDBs may be strategic with their different forms, operating modalities and instruments.

PDBs have been neglected for some decades in international development policies. The debate about the role of PDBs after the failure of the supply-led finance paradigm, described in Section 3, was intense, especially with reference to their impact in the agricultural sector. In fact, (agricultural) development banks were the main channel of the supply-led approach, given the task of distributing financial resources and other non-financial services to rural areas, acting as administrative agencies, according to public guidelines. The directions given by the sponsors (donors and governments) on the use of funds were often mandatory: loan targeting and credit floors, interest rates ceilings on lending, and other contractual conditions, channels for disbursement. Pre-defined credit services were meant, on one side, to make the process uniform and simplified to the disbursing bank and, on the other side, to substitute the end users in making financial decisions, considering them as unable to assess their needs. Similarly, development banks merely executed sponsors' instructions, operating with weak governance systems and little political interference. As an outcome, many development banks experienced high management costs, extremely high default rates and heavy losses. Some of them went bankrupt or were completely restructured afterwards (Viganò 1998) in a market-based perspective. However, just relying on spontaneous actions by the intermediaries with a private orientation is not sufficient in economic environments where the risk/return profile of the potential clientele is not appealing. Microfinance has only partially filled the gap, as previously described. It is critical, in this new phase, that private funds are not crowded out but enhanced and directed with the target to promote inclusive, sustainable finance.

A common new perception about the crucial role of governmental/public interventions, in combination with private actions in achieving the new development goals, made the international community consider PDBs as ideal candidates.[10] Conceived as private institutions using market instruments with public nature and goals, expectations for their action relate to their potential to address market failures and play a countercyclical role (Xu, Marodon, and Ru 2020). They can mobilize resources towards unattractive but strategic neglected sectors and promote infrastructural development and other activities that have high externalities such as social services or public goods, including activities aiming at climate change (de Luna-Martinez and Vicente 2012; Xu, Ren, and Wu 2019; Ocampo and Ortega 2020). The increased number of PDBs in recent years, and the growth in the investment capacity of the largest multilateral development banks, confirm this new attitude.[11]

10 For an overview of the underlying literature on the role of development banks, see, among others, de Luna-Martinez et al. (2018); Xu, Ren, and Wu (2019) and Ocampo and Ortega (2020, 26). Ocampo and Ortega notice that even in the period of the "conceptual rejection of national development banks," the World Bank did not interrupt their use in several sectors.

11 Xu, Ren, and Wu (2019) list a number of newly established development finance institutions in developed and developing countries in the last ten years and underline the higher emphasis on them by policy makers.

Several recent studies and reports describe how PDBs aim at achieving an inclusive, sustainable, green and resilient world. The effectiveness varies across banks, depending on factors such as location, target or history, and not all banks have been or are successful. The Section reviews the main traits of PDBs and analyses their instruments, approaches and challenges. The analysis touches on the profitability model, the asset composition and quality, the funding strategies, the market targets and strategies, the governance and the relationship with government and donors, the impact generated.

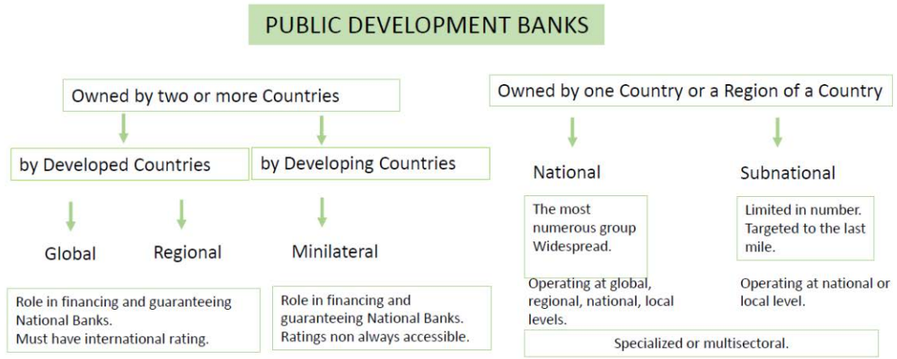
Before starting with the discussion, some terminological considerations are needed. The extensively used term "development banks" (DBs) falls into the category of "development financial institutions" (DFIs). DFIs may include a wide range of institutions, such as those offering credit guarantees, insurance services, or equity, as part of public policies (Xu, Marodon, and Ru 2020). To distinguish PDBs and DFIs from other government agencies and market-oriented financial institutions, Xu, Marodon, and Ru (2020) rely on the following characteristics: a legal status and separate financial statements, use of instruments that have a reflow seeking component, activities financed by sources other than government budget transfers, a mandate of fulfilling proactive public policy and government sponsorship in various forms (founder, shareholder, financier, member of the governance). Xu, Ren, and Wu (2019) add as a desirable feature that PDBs and DFIs should focus on the supply of medium- and long-term finance. The terminology can vary among countries. They are sometimes just denominated as public banks, but this definition encompasses also other institutional forms of banks. de Luna-Martinez et al. (2018) underline, in fact, that the distinction between a development bank and a state-owned commercial bank is not always clear. However, Gaiha (2021) elaborates on several institutional definitions and specifies that PDBs are "financial institutions with state capital (which need not be a majority share) and with a mandate to pursue developmental goals, as opposed to solely commercial objectives in its operations. This differentiates a Public Development Bank from State-owned commercial banks". On the other side, State-owned financial institutions (as in de Luna-Martinez and Vicente 2012) that are not licensed as banks may fall in a residual category of non-bank intermediaries.[12] In their survey, de Luna-Martinez et al. (2018, 12) refer to development banks as "any type of financial institution that a national government fully or partially owns or controls and has been given an explicit legal mandate to reach socioeconomic goals in a region, sector, or market segment."

Xu, Marodon, and Ru (2020 6) maintain a distinction between PDBs and DFIs. However, in their survey, they take a broad view, including several institutions in the category of PDBs and DFIs: "multilateral development banks that are owned by groups of governments, as well as (sub-) national banks or institutions owned by central banks, central governments, or local governments. It includes both development banks and guarantee-, insurance-, and equity-focused financial institutions with an official mission to promote development". Actually, the extant surveys and statistics define the population of banks they refer to for the specific research target. For example, Xu, Marodon, and Ru (2020) include some deposit-taking public institutions, often considered as a special type because of their different business model. Riaño et al. (2020) focus on a broad definition of PDBs, but distinguish, where necessary, between national and regional banks, because they can differ in terms of mandate and scope.

The simplest and most common classification of the system of development banks is between multinational (global or with a regional scope), national (with possible interventions at the global, regional, national or local level) and sub-national banks (operating at local or national level. See, for example, Xu, Marodon, and Ru 2020; Suchodolski et al. 2020). In fact, these banks can receive funds from several governments and act in several countries or restrict their action to some or one single country. Humphrey (2019) analyses a sub-category of "minilateral" (multilateral with local funding) development banks, as explained below. Another distinction is between non-sector specific PDBs and specialized ones (as it is the case of agricultural and rural development banks). Being a specialized bank does not prevent it from investing in other sectors or types of businesses (Gaiha 2021). Figure 1 summarizes this classification.

12 Specialized financial institutions, such as the Agricultural Credit Corporation of Jordan, can be included in this broad definition as well.

FIGURE 1 | THE LANDSCAPE AND SOME FEATURES OF PDBS SEE POWER POINT



Adapted from Suchodolski et al. 2020 and Xu, Marodon and Ru (2020)

4.2. OVERVIEW OF PDBS

Providing statistics and characteristics of PDBs while relying on existing literature confronts the heterogeneity of definitions and sample used. The Institute of New Structural Economics (INSE) and the Agence Française de Développement (AFD) developed an ample database (Finance in Common 2021a) of more than 540 institutions that includes both PDBs and DFIs worldwide (as detailed in Xu, Ren, and Wu 2019). Using this database, Xu, Marodon, and Ru (2020) report that the overall total assets of DFIs and PDBs stand at US$11.5 trillion. The largest seven PDBs (three of them Chinese) hold more than 50 per cent of all PDBs' assets (Bennun et al. 2021) but, with the exception of the few large institutions, the majority of PDBs consists of small banks with less than US$3 billion in assets (and 258 with less than US$1 billion). In 2018, the global investment was estimated at US$2.3 trillion (Xu, Marodon, and Ru 2020). Considering the year of establishment, it appears that there is momentum in times of crisis (for example, 35 banks were established after the collapse of the Soviet Union and 68 during the global financial crisis of 2008). Nine institutions (2 per cent of the total number) are global banks; 32 per cent of banks are based in the Asia-Pacific region, 23 per cent in Europe, 22 per cent in America and 21 per cent in Africa. However, while banks in the Asia-Pacific region stand out also in terms of total assets, African PDBs and DFIs represent only 1 per cent in this regard (Xu, Marodon, and Ru 2020). In Xu, Wang, and Ru (2021), out of 375 NDBs analysed, 122 NDBs are located in high-income countries, 120 in upper-medium-income countries, 111 in lower-medium-income countries, and 22 in low-income countries.

Although most Multilateral Development Banks (MDBs) were created between the mid-1950s and 1970s, some have been recently established. Regional Development Banks in emerging and developing countries recorded a fast growth. MDBs coverage is heterogeneous, with a prevalence in sub-Saharan Africa and South Asia, Latin America and Caribbean and non-EU15 Europe (Ocampo and Ortega 2020). Xu, Marodon, and Ru (2020) find that 336 institutions out of the total of 452 in the database are NDBs, and Xu, Wang and Ru (2021) subsequently collected data on 375 NDBs. NDBs are the focus of several studies and surveys. For example, de Luna-Martinez et al. (2018 6) analyse NDBs because they are considered the suppliers of "financial services in sectors or regions that private financial intermediaries do not serve sufficiently" and key players in addressing environmental projects. This paper, in fact, mostly refer to NDBs, although other categories are touched as well.[13]

13 The most recent and complete survey is by Xu, Ren, and Wu (2019) and its updates, and the main data emerging from it have been reported above. However, while Xu, Ren, and Wu (2019) cover PDBs and other DFIs, de Luna-Martinez et al. (2018) describe public NDBs, which make up nearly the entirety of their much smaller sample of 64 banks over the 230 members of the World Federation of Development Financing Institutions (WFDFI) as of 2017.

According to Suchodolski et al. (2020), a constitutive feature of NDBs is the equity ownership by of one national state. The WB survey by de Luna-Martinez et al. (2018) referred to 2017 reports that 85 per cent of NDBs are owned completely by governments while another 10 per cent have government equity ownership 50-99 per cent. One quarter were established as private companies, and the rest were established through acts of parliament or government decrees. Xu, Marodon, and Ru (2020) specify that a distinctive element between aid agencies and PDBs/DFIs is the fact that aid agencies are mainly financed with budgetary transfers from governments while PDBs and DFIs benefit from government credit enhancement and raise funding from the capital markets. According to the findings of de Luna-Martinez et al. (2018), NDBs are quite diversified in terms of size, objective, business model, performance and sectors of intervention. Some data on these aspects are explored further below in this Section.

Although NDBs operate in almost all countries. Xu, Ren, and Wu (2019), with reference to their large sample of National DFIs, find that DFIs are more concentrated in upper- and lower-middle-income countries, while Ocampo and Ortega (2020) specify that NDBs' presence in terms of assets is more significant in East Asia and Pacific, EU15 countries, Latin America and Caribbean. The main characteristics of the sample of 64 NDBs are reported by de Luna-Martinez et al. (2018). The average age of NDBs has been decreasing: 22 per cent were established after the year 2000, often aimed at addressing development challenges. At the end of 2015, total assets of the NDBs in the sample amounted to US$940 billion. The average size is small, since 73 per cent of NDBs reported less than US$2 billion in assets. However, Suchodolski et al. (2020), on their larger sample of DFIs drawn from the INSE-AFD database, notice that about 74 per cent of total assets are concentrated at the national level (around US$7.7 trillion) and refer to other findings in the literature, noting that several NDBs surpass MDBs banks in size, scale and scope.

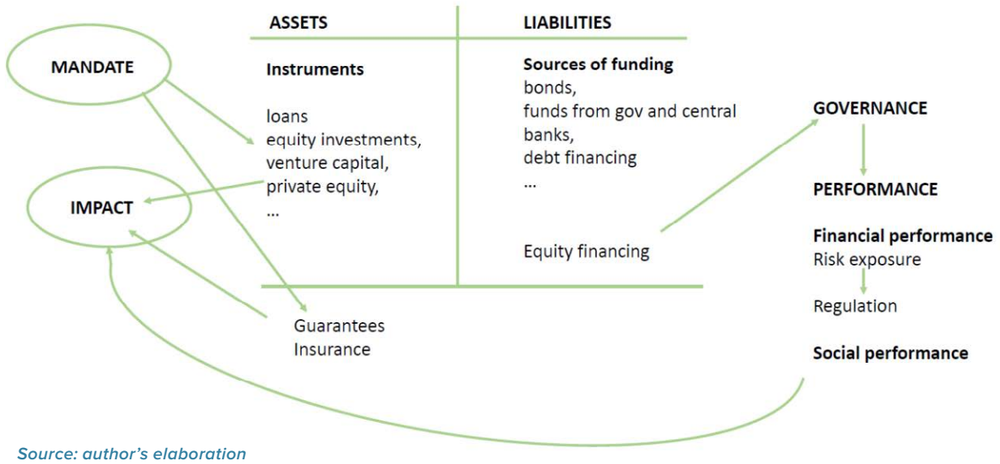
The innovative denomination of the special type of MDBs suggested by Humphrey (2019) refers to minilateral development banks (MnDBs) with their peculiar governance. While the largest multilateral banks are financed by non-borrower industrialized countries, most multilateral development banks are smaller and established and controlled by groups of developing countries, who are also the beneficiaries of their funds.

THE ROLE OF FINANCE AND PUBLIC DEVELOPMENT BANKS IN PROMOTING SUSTAINABLE AGRICULTURE AROUND THE WORLD

The author calls them MnDBs. The example of the Trade and Development Bank (TDB), the largest African MnDB, shows the positive implications of this specific arrangement. Greater operational flexibility makes MnDBs appealing to developing countries as an expression of independence and as a way of diversify funding sources. It also highlights MnDBs' limitations (see infra the part on governance). In terms of geographical coverage, Suchodolski et al. (2020) highlight the role of subnational development banks (SDBs). They operate at the last mile and, therefore, have a deep knowledge of the local environment. Therefore, they may be privileged partners to efficiently address local financial needs and achieve the SDGs. In fact, they can fill the gap left by the NDBs, especially in regions with income inequality, poverty and exposure to climate-related risks. SDBs are still low in number worldwide. The authors report 66 SDBs out of 447 total institutions (representing 15 per cent of the total DFIs in the AFD database) most of them created after the year 2000. They portray successful examples in Brazil and Vietnam and affirm the importance of partnerships of SDBs with larger DBs.

The remaining part of the Section further analyses the characteristics of development banks, mostly NDBs but also other types. The aim is to identify strengths and weaknesses of the shared strategies in order to focus on the remaining challenges. The analysis follows a logical sequence based on the main aggregates of banks' financial statements. This choice is led by the fact that PDBs are banks and their strategic and operational choices are reflected in financial statements. However, the approach is qualitative, i.e., is not a study on the current financial performance of these banks. Rather, it analyses the characterizing component types of assets and liabilities. Moreover, the business model is analysed by looking at how the structure of assets and liabilities affects profitability and operational implications, according to the logics exposed in Figure 2. NDBs' asset allocation and products, in fact, mirror their ability to fulfil their mandates and have an impact. Funding strategies affect the sizes and types of assets invested in, and they have governance implications (in particular the choice of public and private capital). Governance and the related quality of funding and investment affect profitability in all its components, mainly the financial and the risk-management perspectives. They also affect social performance, which connects to impact. The aim is to highlight the elements that hamper or favor PDBs' compliance with the double bottom line objective of satisfactory financial and social performances.[14] The presentation is based on data provided by the most recent surveys on PDBs and corroborated with some comments inspired by the relevant literature.

FIGURE 2 | A CONCEPTUAL FRAMEWORK TO ANALYZE PDB'S OPERATIONS SEE POWER POINT



Source: author's elaboration

14 In the words of Griffith-Jones et al. (2020 4), this would mean achieving a satisfactory Dual Ratio (i.e. the ratio between the sustainable developmental impact and the risks to that impact or developmental risks, subject to a minimum or positive risk adjusted financial return).

THE ROLE OF FINANCE AND PUBLIC DEVELOPMENT BANKS IN PROMOTING SUSTAINABLE AGRICULTURE AROUND THE WORLD

4.3. PDBS ANALYSED THROUGH A "FINANCIAL STATEMENT" APPROACH

4.3.1. ASSET INVESTMENTS AND INSTRUMENTS

The analysis of the asset composition reveals the main strategic choices of a financial institution because it shows where the funds collected to achieve the institutional goals are actually invested.[15] According to Xu, Wang andRu (2021), NDBs typically provide loans, whereas DFIs are more focused on equity investments, guarantees or insurance.

NDBs serve a variety of borrowers. Based on de Luna-Martinez et al. (2018), 87 per cent of NDBs serve MSMEs, 78 per cent serve large private corporations (sometimes exclusively, given their mandate), and 64 per cent serve private financial intermediaries that, in turn, lend the funds received to end borrowers (second-tier banks). Forty-three per cent of DBs lend to individuals and households, in particular the agricultural development banks as they target smallholder farmers (in some cases, also offering consumer loans in rural areas). Individual lending predominates in developing countries. NDBs target mostly the private sector, but only few of them lend exclusively to private enterprises.

Direct lending as the single type of approach characterizes 40 per cent of PDBs while exclusive second-tier lending occurs in 10 per cent of cases. The remaining 50 per cent of banks use both approaches (de Luna-Martinez et al. 2018). In developing countries, retail-only lending is more common than in developed countries. This approach implies a physical network to interact with the customers. In second-tier lending, instead, a bank can rely on a network provided by other intermediaries. PDBs may co-finance and share risks with commercial banks. According to the study by Griffith-Jones et al. (2020) aimed at portraying the combination of approaches and instruments to face different risk exposures of NDBs,[16] first-tier loans may be suitable for larger and more strategic projects, as they allow better control by the development bank while second-tier loans are suitable when local knowledge is important.

15 Data refer mainly to NDBs, given the sizable public data available in this category.

16 The study matched banks from Xu, Ren, and Wu (2019) with Bank Focus in order to have information on total assets as a proxy of bank size. Out of 220 banks retained, 50 were selected as representative NDBs.

Asymmetric information problems can be overcome through a delegated screening and monitoring of the customers.

In terms of types of loans, the sample analysed by de Luna-Martinez et al. (2018) shows that 90 per cent of banks offer long-term loans (including infrastructural projects), 80 per cent provide working capital loans, 72 per cent offer short-term loans, 66 per cent offer syndicated loans, 64 per cent offer new product loans, and 58 per cent offer loans to start-ups (which increases to 63 per cent only in developing countries). Loans include also import-export credit. These examples show that NDBs carry out different activities and can play a significant role in supporting innovation. Concerning long-term finance, Miller and Ono (2021), in their stocktaking analysis of 33 banks (of which 19 are development banks), find an average duration of loans of about 11 years for development banks. While this figure is not very different from that of commercial banks, maturities in development banks can be up to 30 years with much lower interest rates. Concessional loans or grants are not so frequent (as confirmed by Griffith-Jones et al., 2020). Seventy per cent of NDBs in the sample of Griffith-Jones et al. (2020) offer loan guarantees (individual and portfolio ones) which are more common in high- and middle-income countries; the authors stress that guarantees are aimed at facing idiosyncratic risk during periods of extreme uncertainty in the economic environment. In de Luna-Martinez et al. (2018), the overall percentage

of banks offering guarantees is 55 per cent. Miller and Ono (2021) find that 68 per cent of banks in their analysis offer guarantees for both short- and long-term loans.

Besides the lending methodology, there is a diversified range of products offered by PDBs (leasing, factoring or equity participation, and risk management tools). Mille and Ono (2021), with reference to long-term financing, portray that equity and quasi-equity are the main instruments for development banks' investments in government-owned companies or projects in priority sectors. In Griffith-Jones et al. (2020), 54 per cent of NDBs offer equity investment, which is the third instrument in importance. According to the authors, despite the risk exposure on each individual project, in equity investment, the positive high return generated by few winners can compensate for the losses on others. These potentially high profits may cross-subsidize sectors that are less attractive but have a desirable impact.

Venture capital or private equity are offered by 47 per cent of sample NDBs in de Luna-Martinez et al. (2018) and 22 per cent of sample NDBs in Griffith-Jones et al. (2020). In the latter case, none of the target firms operates in low-income countries. The authors underline the innovative power of solutions that foresee debt instruments that can be converted into equity-like instruments (warrants) to participate into profit distribution. Since these solutions are not common in low-income countries, especially in Africa, DBs could become market enhancers.

Among risk management products, insurance is used by only 10 per cent of the sample in Griffith-Jones et al. (2020), none in low-income countries. e Luna-Martinez et al. 2018 state that 10 per cent of NDBs in the sample offer micro insurance. Miller and Ono (2021) find that agribusiness insurance products (including indexed, yield, and livestock insurance) are used to manage risk in long-term finance.

This overview of the main instruments used by (national) development banks[17] is meant to highlight main traits. There is no single ideal choice or combination of instruments. By-laws, regulations, different types of actors and their technical preparedness (or lack thereof) may affect such choices (Fernandez-Arias and Xu 2020). According to Griffith-Jones et al. (2020), the question of how these instruments must be applied by different actors in different stages of development is still open. The choice also depends on the mandates received by the banks.

17 De Luna-Martinez et al. (2018) completes by adding that 5per cent of the banks analysed sell or broker property or assets. Public-private partnerships and advisory services are offered as well.

4.3.2 MANDATES ON TARGET INVESTMENTS

Mandates of MDBs are overall related to their counter-cyclical function, through the provision of facilities such as guarantee schemes, loans, grants and assistance. Ocampo and Ortega (2020) underline that, since mandates are affected by funding, the response of the institutions may be limited if they have insufficient capital. They contrast the case of the global financial crisis, when funds were largely available, to the current COVID-19 pandemic, in which funding aimed at MDBs is not generalized. In the case of MDBs, infrastructure development is one main target, although resources made available are still limited in emerging and developing countries. Also financial inclusion predominates. Production sectors are less targeted, but science and technology may be important. The authors underline that there is no evidence on MDBs' effectiveness in focusing on the most deprived regions in their target countries.

Mandates of the other types of DBs can be broad, such as the overall development of the country, or define some specific fields of action: from local development to narrower choices related to a sector, like rural/agricultural development, infrastructures, or type of target customers, such as small and medium-sized enterprises. The type of mandate is also affected by the specific focus on economic development versus social impact (de Luna-Martinez et al. 2018 and Xu, Marodon, and Ru 2020).

In the INSE-ADB database including DFIs and PDBs, general development predominates in number of institutions (36 per cent of institutions) and in asset size (64 per cent), while the main specific target in number of institutions is MSMEs promotion (35 per cent) but not in asset size (9 per cent). The agricultural sector represents almost 9 per cent in terms of number of institutions and 11 per cent in terms of asset size (Xu, Marodon, and Ru 2020). In a subsample of the same database, including 375 NDBs, Xu, Wang, and Ru (2021), find that 53 per cent of institutions have a general mandate, 18 per cent are aimed at SMEs and entrepreneurship, 11 per cent are focused on trade, and 9 per cent are focused on agricultural. Similarly, de Luna-Martinez et al. (2018) report that almost 50 per cent of the banks in their sample have a narrow mandate: 15 per cent of the institutions focus on SMEs, 13 per cent on infrastructure (a much higher percentage than that found in Xu, Marodon, and Ru [2020]), and 10 per cent on agriculture. Specialized development banks have by definition a narrow mandate. A narrow mandate allows the institution to be more focused, to mea-

sure market gaps and develop suitable monitoring, and assess the success and the impact. The broader mandate case, instead, allows for more flexibility and diversification. In a study aiming to assess the efficacy of NDBs in filling the financial gap in vulnerable areas of developing countries, Wagner (2020) finds that the heterogeneity of mandates, at times broad or narrow, does not explain the geographic allocation of credit (by income groups, regions or countries of banks). They underline that the lack of fine-tuning of mandates to the evolution of the environments in which NDBs operate and to the SDGs prevents them from magnifying their impact through specific suitable credit lines. They also find that narrow mandates are often designed with the underlying goal of keeping the banks financially safe while addressing market failures. However, this may occur (among other things) at the expense of a significant development focus and impact.

Some criticalities found in de Luna-Martinez et al. (2018) relate to the lack of periodical renovation in mandates (that entails the risk of misalignments to the actual gaps) or the lack of focus of the mandates themselves (which can induce development banks to compete with, and crowd out, the private intermediaries).

4.3.3. IMPACT OF INVESTMENTS

How access to finance may effectively change the economic conditions of the recipients (in good and bad times) is a question that often remains unanswered. Access to finance has a significant potential, but measuring its deepness does not guarantee improving economic development or achieving the SDGs, which requires impact measurement. High repayment rates on these financings could be considered an indirect indicator of success of the instruments. The performance of development banks can be used as a signal of success: a satisfactory financial performance may indicate that the bank is able to administer its resources and to make them effectively circulate in the real economy. However, the financial performance evaluation can be distorted by subsidies and the maximization of impact may affect the financial performance. Based on this, Fernandez-Arias and Xu (2020 11) affirm that “NDBs ought to maximize the value of the development impact obtained from applying the fiscal resources they are entrusted with” and, keeping in mind the social value and the developmental impact of NDBs’ investments, define the accumulation of the aggregate net returns on the investments made as the development impact of the NDB portfolio.

Griffith-Jones et al. (2020), suggest evaluating the development banks’ performance based on the Dual Ratio, in which financial returns should be balanced with the achievement of developmental impacts (as described in footnote 14), and stress the difficulties in measuring impact. Limitations arise from not having sufficient information on the beneficiaries. For example, the authors report this limitation in the case of credit guarantees. Another limitation is the difficulty comparing the situation with and without the financing, given all the external conditions affecting the target beneficiaries and their projects. In this respect, de Luna-Martinez et al. (2018) report that banks claim that data available do not measure if borrowers had access to sources of funding other than the one made available by the NDB, in order to measure additionality. However, also with these data available, external conditions would not be accounted for. This is a typical challenge in assessing the impact of microfinance projects. Randomized control trials have enabled some progress to made, but results are controversial (Morduch, 2019), and a rigorous evaluation on the actual change made is still an unresolved question.

The need for measurement emerges also from ubiquitous discussions about the countercyclical role of PDBs. Brei and Schclarek (2018), for example, in a study on 336 major banks in 31 Latin American and Caribbean countries (1995-2014), confirm the prominent role of national development and public retail-oriented banks in compensating during credit crunches amid crises. The same outcome was noted in de Luna-Martinez et al. 2018, who report an increase in NDBs’ gross loan portfolios greater than national averages in the 2010-2015 period, with prolonged expansion after it. They also recall that the preceding survey by de Luna-Martinez and Vicente (2012), in the period 2007-2009, measured a 36 per cent increase in lending by the banks in the sample, as compared to an increase by 10 per cent in the private sector. They also reiterate the negative effects of such a policy in the long run, inviting reflections on other types of interventions such as policy reforms. While the numbers confirm the countercyclical effect, they do not offer measures of effective impact of the loans granted in the periods analysed.

Notwithstanding these gaps in measurement, at the development banks’ level, monitoring and evaluation systems may be put in place to assess at least the economic effects of their interventions. However, these systems are still weak in about half of the banks, also given the absence of benchmarks. De Luna-Martinez et al. (2018) report that, in their sample, 56 per cent of NDBs declare to have a dedicated monitoring and evaluation unit, and 49 per cent assess the economic effects of products and services, relying on third parties evaluation in 37 per cent of cases. Indicators used to assess the economic effects include: survival rate of client SMEs and borrowers, increase in borrowers’ productivity, profit and sales, and new employment generated by the project financed. The information is collected through surveys of customers in 68 per cent of the NDBs that, in 21 per cent of cases, estimate effects through randomized control trials.

4.3.4. FUNDING SOURCES AND INSTRUMENTS

On the liability side of the PDB’s balance sheet, strategic elements of funding reverberate on several dimensions: quantitative and qualitative effects and impacts, financial performance and achievement of the intended goals. A survey conducted on 375 NDBs by Xu, Wang, and Ru (2021), based on the INSE-ADF database, highlights the main characteristics of liability composition of development banks, compared to commercial banks. Although NDBs can be funded by public agencies or market actors, governments mobilize funds through administrative or market-based choices.

In fact, bonds are the main funding instruments used by NDBs to access capital markets, issued by 45 per cent of the sample but only by 18 per cent in low-income countries (Xu, Wang, and Ru 2021). Governments’ support allows NDBs to obtain long-term maturities at relatively low prices that are suitable to achieving the SDGs. Governments can provide sovereign creditworthiness through explicit guarantees so that the issuances become government grade. Forty per cent of issuances are covered by governments’ full or partial guarantees, with the highest percentages in higher-income countries, especially for larger banks on issues linked to local government financing. A special case is raised by Humphrey (2019) for minilateral development banks. MnDBs being participated by local governments of developing countries that often are characterized by sub-optimal sovereign creditworthiness, it is hard for these banks to issue bonds with high ratings or even investment grade, especially in Africa. Griffith-Jones, Attridge, and Gouett (2020) underline that, if PDBs cannot obtain top ratings, under Basel III regulation, a reduction occurs in the de-risking effect that PDBs in turn offer to private investors, thus reducing the intrinsic value of the guarantee. The authors raise the issue of the suitability of rating agencies methodologies applied to development banks, given their special mandates, and of the impact of such ratings on the cost of funding. In the survey by de Luna-Martinez et al. (2018), 54 per cent of banks are subject to rating; those that are exempted are the smallest ones. In fact, in Xu, Wang, and Ru (2021), the degree of access to the bond market depends on the size of the bank (higher for larger banks, with 100 per cent for the largest). Furthermore, access is affected by the level of development of the country where the bank operates (higher in high-income countries), the bank’s mandate (with the highest percentage [71 per cent] for housing) and the status of the bond market in the country of issuance (domestic or international capital markets).

One category of bonds growing in importance is labelled bonds, where issuances are coupled with conditions designed to channel funds towards green or sustainable development objectives (green bonds, social bonds, blue bonds and SDG bonds). While this is an opportunity for PDBs, national and regional banks in particular express a limitation in the cost burden of the issuing, in follow-up, reporting and assessment phases, and in the lack of flexibility. Furthermore, the investor market is not fully ready to accept a special pricing of labelled issuances based on the additional conditions requested by these bonds. As a result, labelled bonds have acquisition prices almost equal to traditional ones (Riaño et al. 2020). The authors also confirm the inability of PDBs to obtain good credit ratings as a further barrier.

Other funds for NDBs derive directly from governments and central banks. In Xu, Wang, and Ru (2021), the government funds may be offered as share capital or other fund transfer: budgetary, government deposits or loans, trust funds (almost 9 per cent of the total sample, with 33 per cent in the case of the largest banks), subsidies (almost 13 per cent of the sample), commission fees paid on services (7.5 per cent of the sample), or other type of subsidies, also deriving from preferential taxation or from concessional terms in funding. Government funds can be matched to a specific target or sector, like the agricultural sector (11 per cent) or SMSEs (13 per cent). Another important source of funding for NDBs is represented by bor-

rowing from other NDBs in high-income countries or MDBs (9 per cent of the sample). It may happen through a government acting as the borrower with repayment responsibility (21 per cent of cases) or involving an NDB as borrower with (6 per cent) our without (21 per cent) a governmental guarantee for repayment. SMEs, housing and agriculture are the main recipient sectors of these funds. Prevalent specific purposes for on-lending are SMEs' and agriculture.

With reference to the role of MDBs in financing NDBs, worth of mention is an observation by Gottschalk and Poon (2018). The authors underline that, since the ability of MDBs to raise funds depends on their credit rating, in order to keep their risk profile acceptable to the international markets, MDBs may tend to keep a conservative approach in lending that limits their action. Newly established MDBs seem to have fewer funding restrictions and could compete in the future with established MDBs.

Equity financing is higher in NDBs than in commercial banks. The percentage of annual net income retained in NDBs is 96 per cent, as opposite to 70 per cent for commercial banks. Equity can be increased through internal financing: the ratio of retained earnings on total assets is 4.60 per cent on the total sample and 2.17 per cent for the deposit-taking banks (Xu, Wang, and Ru 2021).

The debt-financing ratio (total liabilities/total assets) is 71 per cent in NDBs, less than the 87 per cent ratio occurring in commercial banks. The ratio is higher for household deposit-taking NDBs (81 per cent) and for larger NDBs; it is lower in NDBs with a mandate to serve SMEs and entrepreneurship or to invest in housing and infrastructure, where, as Xu, Wang, and Ru (2021) underline, equity financing may be more suitable. About 52 per cent of NDBs in Xu, Wang, and Ru (2021) are household deposit takers, with almost 60 per cent of the sample having deposits for more than 50 per cent of total liabilities. In the sample of de Luna-Martinez et al. (2018), 44 per cent of NDBs offer deposit accounts (21 per cent for the general public). This strategy may be just residual (i.e., no alternative sources are available) or be meant to combine public and private funds. Pricing is stressed as a critical factor by Xu, Wang, and Ru (2021). In fact, applying market conditions in order to attract depositors can become an element of criticism. In Xu, Wang, and Ru (2021), official development assistance is received by almost 6 per cent of the sample banks, in the form of grants or concessional loans. The largest share of these measures targets environmental goals (34 per cent). In this type of intervention, technical support is included and accounts for 13 per cent. (Agriculture and

SMEs receive 13 per cent as well). In addition to the sources described, it is worth mentioning that PDBs may receive funds from commercial banks that do not fulfill their sectoral allocation obligations, targeting actions of financial inclusion, as described in Reserve Bank of India (2015). Different sources of finance increasingly combine together in blended finance solutions. The shortcomings of blended finance have already been described in Section 3: concessional sources allows the PDBs to catalyze international private funds, as they can improve the conditions offered to private investors, in terms of risk/return. Blending is favored by technology-based platforms that can be administered by the PDBs. Examples are common in green and sustainable finance (Riaño et al. 2020; see Section 5). Platforms facilitate gathering different types of contributions. For example, in public-private partnership projects (PPPs), MDBs can contribute with guarantees, insurance or technical assistance while private investors contribute in funding and equity participation (Gottschalk and Poon 2018).

4.3.5. CORPORATE GOVERNANCE AND PUBLIC DISCLOSURE

The links between the liability structure (ownership and funding), corporate governance and performance are widely explored in the managerial sciences and apply also in the case of PDBs. According to de Luna-Martinez et al. (2018), opinions are divergent on the benefits of private sector ownership in NDBs (including qualified corporate governance and management), but currently most of the NDBs are controlled by the government, and comparisons are difficult. Several implications derive from different ownership structures. For example, the peculiar ownership of minilateral development banks – owned by borrowing countries – affects their governance model, which differentiates them from the banks dominated by industrialized countries (Humphrey 2019).

The risk of political interference is often highlighted in literature, especially in banks with broader mandates (de Luna-Martinez et al. 2018). The authors find that a government body or country leader appoints board members in 74 per cent of NDBs in their sample and directors generals or CEOs in 54 per cent of cases. In 26 per cent of cases, members are appointed by the board itself. They are mostly appointed for fixed terms. In 51 per cent of cases, government representatives are the majority in the board. The remaining 49 per cent rely on a significant presence of independent board members. Managerial autonomy granted to the senior management is nuanced: approval of the annual budget and operating expenses by the government occurs in 33 per cent of cases. Governments intervene also in setting personnel salaries and in hiring decisions for senior management, or to define the internal organization. In 15 per cent of cases, it intervenes on product pricing.

Huang, Xi, and Xu (2020) conducted a study on the determinants of the level of autonomy in 62 development banks in the sample of NDBs in de Luna-Martinez et al. (2018). Based on the literature on central bank independence and leadership, they check the relationship between the political institutions and leadership and the development banks' independence, verifying if independence affects their financial and social performance. They develop a board independence index and, through principal component analysis, find that independent NDBs prevail in countries where both checks and balance and national leadership are strong. They also find that independent NDBs show an acceptable level of nonperforming ratios (not too low – not too high). A confirmation of their findings is the case of the Brazilian Development Bank (BNDES), which based on strong leadership and checks and balance is an independent and professional development bank in a corrupted national environment.

A study by Attridge, Yunnan Chen, and Mbate (2020) concentrates on the African case, analysing a sample of 33 NDBs to assess the relationship between governance of NDBs and their financial performance, measuring the impact of political influence in governance. Their emphasis on Africa derives from the overall perception of problematic governance and weak performance on the continent. Their sample banks, although heterogeneous, are largely owned by a single government entity and mostly supervised by the Central Bank. Appointment processes are subject to political influence. In terms of profitability, 30 per cent of the sample showed negative returns on assets (ROAs) coupled with high nonperforming loan (NPL) ratios (more than 10 per cent). Twenty-eight per cent of the sample showed NPL ratios equal to or higher than 25 per cent. They find political appointments as strong predictors of poor financial performance with effects on the banks' risk appetite. They also find that the higher the number of independent members of

the board, the better the performance. Moreover, they suggest that governance is more important than the type of ownership, and that banks fully public can be financially strong thanks to suitable governance arrangements. A confirmation, in this respect, is the case of the Uganda Development Bank, a 100 per cent public bank. The bank, since 2014, adopted a new business-oriented model and strong governance improvements aimed at aligning with government policies but with a good separation between policy and business, and risk management actions. The bank achieved a decrease in NPLs and reported a satisfactory return on equity (ROE) (Griffith-Jones, Attridge, and Gouett 2020).

In terms of disclosure, almost all (93 per cent) of the banks in de Luna-Martinez et al. (2018) publish an annual report available online. In their study, however, Attridge, Yunnan Chen, and Mbate (2020) find the need to strengthen transparency, also related to the ESG principles, with a focus on the social aspect that seems overlooked at. Overall, Riaño et al. (2020) confirm that although PDBs are making progress in disclosing information on sustainability and the SDGs, impact (measurement and) reporting is complex, also due to inappropriate monitoring systems.

4.3.6. PERFORMANCE

PDBs are quite diversified in their financial performance, with more frequent poor performances in lower-income countries. This feature is attributable to inefficiency, governance, loan losses and poor asset quality in general (de Luna-Martinez et al. 2018 report some studies in this respect). Data based on diversified samples of NDBs refer to average values and are not exhaustive. Xu, Marodon, and Ru (2020) find an average ROE on the banks surveyed by INSE-ADF of 2 per cent and a very low ROA, but the landscape is not uniform. In the survey conducted by de Luna-Martinez et al. (2018), positive ROAs and ROEs were reported in the period 2011-2015 by 94-98 per cent of the sample, but only 27-33 per cent outperformed their national averages. For the purpose of this paper, a rough computing on the percentage of profitable DFIs was conducted on the INSE-ADF database, counting the number of DFIs showing a Net Profit equal to or less than zero. Results are rough indicators, being aware of the limitations of this estimate. They show that non-positive results are found in 19 per cent of the DFIs reporting the information in Africa, 21 per cent in Asia-Pacific, 28 per cent in America and 18 per cent in Europe.[18]

Judging performance in development banks is controversial. A straight analysis of the financial data, with no adjustments, is misleading. In fact, both the cost of funding and the interests on loans may be affected by the practices of applying soft conditions on borrowing and lending. When a comparison is made with private banks, adjustments should enable to represent the virtual market cost of funds borrowed and loaned at below-market rates and the estimated costs of other resources made available as grants (such as technical assistance, personnel or special funds).[19] In fact, in de Luna-Martinez et al. (2018), NDBs surveyed receive low-cost lines of credit made available by donors or MDBs for on-lending at subsidized interest rates. Fifty-one per cent of the sample offers loans at subsidized interest rates (but also at market rates). Banks can break even on the subsidized operations thanks to donors' low-cost financing or through cheaper lines of credit, budget transfer and cross-subsidization from other product lines.

Fernandez-Arias and Xu (2020) maintain that a profit-maximizing development bank would crowd out private banks and risk missing developmental objectives. The opposite case, though, is also likely: crowding-out effects on the private market would derive from soft conditions on loans, or dedicated lending quotas applied by PDBs (Miller and Ono, 2021). Crowding out is undesirable if the final objective is to promote financial development and financial inclusion. The profit maximization model is questioned when considering that development banks should be more concerned about their impact. However, a binding condition is that the bank must break even, in order to nullify or at least minimize dependence[20] on continuous public injections of funds, unless justified by specific developmental actions.

18 This outcome is measured in Africa on 11 institutions out of 57 reporting the information (on a total number of 94 DFIs in the database); in Asia-Pacific on 19 DFIs out of 91 (on a total of 142), in America on 23 out of 82 institutions (on a total of 101) and in Europe on 16 institutions out of 90 (on a total of 103). Author's calculation based on INSE-AFD database (Finance in Common 2021a).

19 Computing adjusted performance is a common practice in microfinance, following standards. Ample documentation and guidelines were made available over time by CGAP (2003).

20 A very well known metric to analyse the degree of self-sustainability of a (development) bank is the Subsidy Dependence Index elaborated by Yaron (see, for example, Yaron 1992).

THE ROLE OF FINANCE AND PUBLIC DEVELOPMENT BANKS IN PROMOTING SUSTAINABLE AGRICULTURE AROUND THE WORLD

PDBs must aim to preserve operating conditions in the long run, and therefore attempt to achieve a sufficient profitability to last over time. Recent data on NDBs show that this binding condition is often breached: in de Luna-Martinez et al. (2018), 32 per cent of the sample declare to have received government funds, subsidies or other transfers in the preceding four years, to recapitalize or to cover losses.

4.3.7. RISKS

Asset quality and returns must be observed. Besides the low profitability of financial investments in government securities (as in Farazi, Feyen, and Rocha 2011, in de Luna-Martinez et al. 2018) several NDBs report substantial percentages of nonperforming loans (NPLs). About 58 per cent of the banks in de Luna-Martinez et al. (2018) show higher NPL ratios than their country's banking sector. At the end of 2015, a large percentage of the banks in the sample (61 per cent) reported NPL ratios lower than 5 per cent, but 32 per cent of banks had an NPL ratio of 5-30 per cent, and 7 per cent reported a ratio higher than 30 per cent. However, virtuous banks often outperform the private sector statistics, with one-digit NPL ratios or even 0 per cent. The lending model affects the loan portfolio quality: second-tier NDBs perform better than first-tier or combined ones (with some improvement since 2012 for the combined model). Credit risk incidence is exacerbated by the lack of risk management tools. For example, 15 per cent of the banks expressed the lack of flexibility on pricing, related to public pricing policies that do not allow for the differentiation of conditions based on risk exposure.

Credit risk is not the only burden in many development banks. Other typical bank risks affect the development banks as well. If development banks are limited in setting interest rates and in the types of investments they can make, interest rates and market risks can hardly be kept under control. The preceding representation of their operations and governance brings in the issue of operational risk. Liquidity risk exposure depends on the type of financing arrangements the banks are able to set but is to some extent unavoidable. One specific risk that affects development banks is foreign exchange risk, occurring, for example when NDBs receive funds from MDBs in hard currency to be on-lent locally. Unless the projects financed are export-enhancing and susceptible to generate hard currency, the recipient banks are exposed to the risk of local currency depreciation (Schclarek and Xu 2020). Several (market) instruments are available to hedge these risks, but they are not available to all banks.

4.3.8. REGULATING PDBS?

Overall, improper risk management hinders development banks' stability. Public ownership offers a parachute in critical situations, but the evidence reported shows that it may also negatively affect governance and managerial qualities. Therefore, solvency may become problematic to achieve, especially given the double bottom line targets of development banks that request risk tolerance.

However, Gottschalk, Castro, and Xu (2020) state that there are reasons for easing the concerns. Development banks, according to the authors, have a limited risk exposure: they offer contained or no household deposit-taking, do not operate substantially in payment systems, do not undertake sophisticated financial engineered operations, and have expertise in analysing and managing large and complex projects. Despite these qualities, the disruptive effects of the failure of a development bank justify regulating them. The opportunity to regulate PDBs in different perspectives is increasingly shared, as reported by (de Luna-Martinez et al. 2018). In their survey, 78 per cent of NDBs comply with the same standards of prudential supervision (capital requirements, loan classification and provisioning) as private commercial banks; NDBs established as companies are prevalently supervised by the same regulator as commercial banks, more than those established through an act of parliament. However, the same authors report the case of Malaysia, where a separate legal regime for development banks was enacted, also including the possibility to admit proportional regulation.

In Gottschalk, Castro, and Xu's (2020) analysis of three large second-tier NDBs aimed at assessing the suitability of the Basel III rules for NDBs, they conclude that, overall, there are minimal concerns in applying the rules. In fact, banks volunteered to undergo the regulation, also because being regulated increases the chances to access international capital markets. Three specific areas of concern, though, relate

to the comprehensiveness and complexity of the framework, and to the level and quality of capital required exacerbated by the disincentives to use internal models. In fact, the peculiar type of interventions of development banks and the risk management measures specific to these banks may make internal models more suitable. Furthermore, the typical tendency of development banks to finance large projects may collide with the new large exposure rule. The authors conclude that the regulation should limit unnecessary or detrimental measures and allow some flexibility considering the NDBs' developmental and environmental goals.

4.3.9. COORDINATION AMONG PDBS

PDBs should collaborate with several actors such as other DFIs, private investors, governments and regional banks' associations on common methodologies and standards, fostering alliances among peer banks, soliciting technical and financial external support from other stakeholders, or investing in shared systems and tools (Riaño et al. 2020). Regional PDBs' associations may activate these processes. For example, the Development Bank of Southern Africa (DBSA) collaborates with the Association of African Development Finance Institutions and governments requiring assistance. DBSA has involved other smaller DFIs to learn about their environmental and social policies, with special emphasis on sustainable, value chain-based solutions (Riaño et al. 2020). Research is another field of collaboration among PDBs, research centers and other players, such as government agencies, on specific issues and targets, like innovative products development or regulatory frameworks. The current development of a PDBs platform promoted through the Food System Summit and the Finance in Common Initiative by IFAD, ADF, and the Italian Cassa Depositi e Prestiti (CDP) is one example of the potential roles of platforms. The aim of the platform is to encourage knowledge-sharing, technical assistance and capacity-building, and other supportive actions such as impact monitoring to increase the investments in sustainable finance by PDBs.

5. A FOCUS ON GREEN AND INCLUSIVE FINANCE

5.1 PDBS AND SUSTAINABLE FINANCE

The concept of sustainable finance embraces both the socio-economic (and governance) perspective and the environmental one. The latter refers to a developmental model that not only aims at reducing the effects of climate change (mitigation) but also implements measures to reduce vulnerability and build resilience to climate (adaptation) (AFD-AFI 2020; AFI 2020; EBRD et al. 2021).[21] One special focus in climate finance refers to agri-food systems, with a target of improving efficiency in the use of resources, applying environmental friendly practices and obtaining good and healthy food (Kumar Das, 2021).

PDBs' ability to invest important amounts of money, their mixed public/private nature and their attitude toward facilitating innovations makes these banks privileged players in green finance. PDBs, in addition, can act as aggregators, linking local actors to the international level, and are provided with suitable monitoring and evaluation systems. The local focus of most of them, often operating with rural/agricultural clientele, also makes them suitable for achieving sustainability in the broader sense (Smallridge et al. 2013; Griffith-Jones at al. 2020; Bennun et al. 2021), targeting all layers of the population, according to their mandates, for inclusion in this transformative process.

5.1.1 ACTIONS AND LIMITATIONS OF PDBS IN CLIMATE FINANCE

The private sector makes the majority of funds available in climate finance, but PDBs are by far the largest public contributors, with a provision of US$132 billion in 2017-18 (Griffith-Jones, Attridge, and Gouett 2020). However, the analysis of documents from 98 NDBs conducted by Bennun et al. (2021) finds a weak incorporation in PDBs' reports of biodiversity, climate and sustainability commitments, and little disclosure, especially from the smaller banks. Griffith-Jones, Attridge, and Gouett (2020) consider this attitude as a lost opportunity to improve performances, since PDBs portfolios are affected by climate change as well. The basic mechanisms adopted by PDBs are environmental safeguards, although standards for biodiversity vary among banks, with MDBs as best performers (Bennun et al. 2021). NDBs are taking some measures trying to address the main obstacles to improving performance in this respect. Among the obstacles are the lack of PDBs' internal capacity, little professional support by consultants, and low capacity of other stakeholders (including customers and regulators), along with the difficulty of taking into account biodiversity in agricultural projects and supply chains.[22]

With reference to the most demanding and engaging task of implementing nature-based solutions, only few NDBs are committed, together with MDBs, and bilateral and regional ones. The innovative type of business, often considered with poor risk-return combinations, is one reason for PDBs' hesitancy. PDBs also find it difficult and burdensome to demonstrate biodiversity values, although progress occurred recently in data sets and methods (reported in Bennun et al. 2021). In general, PDBs must be clear on how to differentiate green actions from those that are not in order to drive the investment policy (and greenwashing risk should be duly monitored). Nature-based solutions are long-term and challenging because they request the stakeholders' engagement and are often small-scale and difficult to aggregate and structure for investment. Among possible incentives for PDBs, the authors mention the establishment of natural capital lab units within PDBs as incubators for innovative financing for nature.

21 On different views on the definition of climate finance, see Smallridge et al. (2013). On climate finance in general, see Green Finance Platform (2021).

22 Himberg, Xu, and Gallagher (2020) find that the intensity of incorporation of climate commitments and principles changes in the different parts of DFIs' project cycles.

The literature stresses some basic requirements for PDBs in order to be proactive and effective: have high quality governance and focused mandates, have access to capital and financial resources – in local (developed) capital markets and in the international market – and have the support of the international community (among others, Griffith-Jones, Attridge, and Gouett 2020). In fact, up to now, the private channel has not been sufficiently explored (Smallridge et al. 2013).

5.1.2. PDBS AS CATALYZERS OF FUNDS FOR CLIMATE FINANCE

The search for funds to be invested in climate finance is one current challenge of PDBs. A distinction should be made between NDBs and MDBs. MDBs are suppliers of climate finance through their own resources or external, managed resources. In 2019, the overall commitment by MDBs was US$61.562 million, of which 76 per cent was mitigation finance and 24 per cent was adaptation finance. Committed co-finance during 2019 amounted to US$102.683 million. Of MDBs' direct climate finance, 67 per cent is invested in low- and middle-income economies: 36 per cent is invested in Asia and Pacific and 27 per cent goes to Africa and Middle East. In these countries, 77 per cent of funds are directed to public recipients/borrowers, 69 per cent in the form of investment loans. In the same countries, MDBs invested 93 per cent of adaptation finance, with 31 per cent of resources invested in crop and food production, institutional capacity support, technical assistance, and other agricultural and ecological resources. Mitigation finance to low- and middle-income economies is committed by 59 per cent, investedmostly in renewable energy and transport (EBRD et al. 2020).

NDBs are among the recipients of funds by MDBs, but increasingly look for private finance. Among private climate funds providers (who made available an estimated US$326 billion in 2017-18), corporate actors and financial institutions prevail in capital supply while institutional investors, private equity and funds, and venture capital have a little share. Statistics, however, do not include green bonds investments held by institutional and other investors (Griffith-Jones, Attridge, and Gouett 2020). According to Smallridge et al. (2013), the perceived risk-return patterns (influenced by policy and institutional hurdles) or technology and country-specific barriers to entry are not attractive for private investors.[23] Riaño et al. (2020) emphasize the need to effectively supervise long-term risk, investing in project design, evaluation and follow-up. Another limitation in attracting private investors is the difficulty in measuring the impact of PDBs' actions in climate finance. Griffith-Jones, Attridge, and Gouett (2020) and Sadler et al. (2016), underline that (risk and) impact assessment methodologies are not well developed yet, and important tools are lacking (for example, the spatial data on investments). Moreover, capital markets in several developing countries are weak.

The role of public funds, then, would be to incentivize the private sector by taking specific risks that public investors can manage better than the private sector can. As reported in Section 4, NDBs can contact funders and donors (public and private) and blend finance with different characteristics so that they can widen terms and conditions on their funding in order to attract private investors. Sadler et al. (2016), in fact, suggest that innovative investment vehicles can offer layered capital structures. In this respect, platforms are facilitating the coordination. The authors also include public-private partnerships as climate investment facilitators through the mapping of financially significant initiatives and the creation of portfolios suitable for different investors. (See Box 1 in the Appendix.) One point raised by Riaño et al. (2020) is the educational role of platforms, achieved when some criteria in the agreement have an encouraging effect on PDBs to enhance their sustainable performance (impact indicators, for example).

PDBs may have access to multilateral climate funds such as the Global Environment Facility, the Climate Investment Funds, the Adaptation Fund or Green Climate Fund.[24]

23 Cherbonnier and Hege (2020) also raise the issue of differentiating the financial market regulation on climate finance (both mitigating and adapting strategies) in order to make it more attractive and increase the offer of climate-related investments.

24 For further details on these funds, see Smallridge et al. (2013) and Griffith-Jones at al. (2020a).

These funds are financed by different sources and, in turn, invest through implementing banks and other institutions, with the usual instruments: grants and loans at concessional rates and, to a lesser extent, equity, co-financing and guarantees. They also offer technical assistance. However, NDBs have little access to these funds even if accreditations have recently increased. Complex accreditation processes may represent one obstacle (Griffith-Jones, Attridge, and Gouett 2020). One important strategic step to have NDBs more involved is to have a bankable project pipeline, which facilitates obtaining finance from climate funds. For example, DBSA has established a Project Preparation Fund. MDBs, regional development banks, or international climate funds may also contribute to these project development phases through grants (Smallridge et al. 2013; Griffith-Jones Attridge, and Gouett 2020).

Aggregation of projects and pipelines can also improve NDB's access to green bond markets. Bond issuance is adopted by the largest NDBs but it is still underutilized by the remaining ones. The reasons behind this relate to lack of bankable green projects or to the difficulty of aggregating smaller projects, and to the difficulty of obtaining ratings (Griffith-Jones, Attridge, and Gouett 2020), as in the general case described in Section 4. There are, however, successful examples in which NDBs not only use bonds as a prevailing source of funding but also recognize other positive spillovers in terms of learning process and of catalyzing other private funds (Riaño et al. 2020, Smallridge 2019).[25] These positive effects are exemplified in Box 2. In order to encourage these bond issuances and local private investment, local-currency bond markets should be developed. Griffith-Jones, Attridge, and Gouett (2020) report an estimated 84–88 per cent of total emerging-market debt between 2011 and 2017 in local currency, mainly in large countries like China or Russia, but also in African countries. MDBs and regional development banks can support the creations of bond markets and foster the role of NDBs.[26]

NDBs could also include among the funding strategies some "innovations," although consolidated in other fields, such as resorting to securitization of their loans, in order to increase liquidity, considering that climate investment is often long-term. BNDES, for example, in a climate-related infrastructural project, financed the construction phase and securitized the operational phase (Morgado et al. 2019 quoted in Griffith-Jones, Attridge, and Gouett 2020).

25 It should be stressed that some authors, even if reporting satisfactory developments of (green) sustainable bond issuances, put forward a question regarding their real additionality and added value and on their actual innovative potential (Riaño et al. 2020).

26 An analysis of how global development banks operate on the climate perspective is offered in Ocampo and Ortega (2020).

5.1.3. PDBS VS. GREEN BANKS: COMPETITION OR COLLABORATION?

In the panorama of actors currently involved in green finance, green banks are emerging as targeted financial intermediaries. They share some characteristics of PDBs but also have some peculiarities differentiating them (See Box 3). From the description in Becerra Cid et al. (2020), it can be concluded that, while green banks may be competitors of PDBs in the green finance arena, some of their characteristics, like the focused mandate and the consequent specialization of staff, represent elements to be valued in a collaborative perspective with other market operators. As a signal in this direction, in a meeting organized by the IDB in June 2017 in Mexico, on "National Development Banks and Grand Green Banks," wishes for collaborations emerged based on acknowledged qualities of green banks, which have "limited mandates, green sector-specific technical abilities, and deep knowledge of the risks of green projects and the most effective mechanisms for structuring them" (CPI and IDB 2017 8).

5.1.4. PDBS AS INVESTORS AND PROMOTERS OF CLIMATE FINANCE

NDBs' climate financing occurs through traditional (first and second tier lending, guarantees) and innovative products for pre-investment and investment purposes (Smallridge et al. 2013). Grants may be used as well, to offer subsidies (temporarily) on targeted special projects that are not viable in the short-term but have positive externalities (Griffith-Jones, Attridge, and Gouett 2020). The same source, reporting data from the International Development Finance Club on its members, finds that 81 per cent are non-concessional, mostly direct, loans. Sometimes they are co-financed by other public or private lenders. The use of guarantees is minimized because NDBs state they are less attracted by guarantees, which are complex to set up and monitor. However, guarantees may also be effective as incentives to private investors (See Box 4). As far as equity investments are concerned, NDBs finance technology companies and projects, directly or through venture capital and seed funds, sometimes in a second-tier model. For example, BANCOLDEX Capital (Colombia), invests in venture funds managed by private fund managers. This contributes to attract additional local and international capital (Smallridge et al. 2013).

With the specific interest in climate adaptation strategies, Pillay, Aakre, Torvanger (2017) include among the innovations, approaches and tools, the comprehensive theme of disaster risk financing aiming at climate adaptation policies with instruments focused on target users. Micro-insurance should be aimed at the lower socio-economic groups, and, on the opposite side, catastrophe bonds to institutional investors. On both perspectives, PDBs can successfully intervene: among local actions aimed at reaching the smallest (and often less-included) customer segment with microinsurance, and in international markets for securitizing (also through MDBs) catastrophic risk and incentivizing private capital with de-risking.

5.2. A COMPREHENSIVE GREEN, INCLUSIVE, AGRICULTURAL FINANCE

As stated in the introduction to this Section, the socio-economic perspective is one of the two pillars of sustainable finance. PDBs are therefore called upon to embrace a holistic approach and, while being involved in achieving climate-related targets, must design actions that are at the same time inclusive of those sectors that are not sufficiently served by financial intermediaries. Box 5 portrays three examples of projects that couple a green target with financial inclusion.

5.2.1. INCLUSIVE CLIMATE FINANCE FOR FOOD-SYSTEMS

Inclusive, green finance is significant for agriculture and is strategic for poverty reduction. Farmers rely on natural resources, and their activity depends on the climate (Gaiha, 2021). Smallholders, in particular, are very vulnerable to the negative consequences of climate change, because they cannot count on suitable risk management tools. At the same time, they might contribute to increasing greenhouse gas emissions, although it seems that the impact depends on types of production and is overall not significant (Cardoso and Zook 2016). Literature analysed (among others, Sadler et al. 2016) stresses the still-limited attention given by rural operators themselves and other actors involved in the agricultural/rural sector to their climatic and environmental (positive and negative) spillovers and to the potential they have to contribute to the climate transition. Climate-smart agriculture is considered an innovative approach that foresees a variety of actions aimed at achieving a triple bottom line: increased productivity and sustainability, farmers' climate adaptation and reduced greenhouse emissions.

Among adaptation practices, innovative techniques would include more resilient food crops, improved weather information and forecasting, weather index insurance and solar-powered tools, such as irrigation pumps (Cardoso and Zook 2016). These interventions need finance, but only 1.7 per cent of total climate finance is invested with smallholders in developing countries (Kumar Das 2021).[27] The prevalence of public financing resulting from the statistics is probably affected by the lack of data on private investment but also reflects the lack of pipelines for attractive projects in small-scale agriculture (Chiriac, Naran, and Falconer 2019). Therefore, measures should be taken to improve connections between smallholders and financial intermediaries. Improved risk management, for the former, optimization of transaction costs for the latter, and technical assistance for both are among the suggested measures. Technical assistance for lenders would aim at strengthening knowledge on greening agricultural development, developing suitable and innovative products, and possibly overcoming the lack of alternative collateral. On the smallholders' side, for example, the aim would be to increase households' and farms' income diversification, speed up the adaptation process and increase smallholders' awareness of green finance products (Kumar Das 2021; Sadler et al. 2016).

Matching and merging the environmental target with financial inclusion remains challenging.[28] Farmers' reluctance to venture in adaptation and mitigation initiatives may derive from the extremely precariousness of their activities and the fear that any change would undermine their weak equilibria. Daily concerns on how to run a business may prevail over an ideal, but uncertain, path. The transition may be long and can benefit from (market) incentives (Eustace, 2015) and the demonstrative effect of successful cases.

27 Chiriac Naran, and Falconer (2019) report that only 3 per cent of global climate finance in 2017-2018 was invested in agriculture, forestry and land use. Out of these funds (US$20 billion), US$8.1 billion targets small-scale farmers, agricultural entrepreneurs and related value chain actors, and US$1.72 billion is targeted at renewable energy generation, rural sustainable transport and water management.

28 For a rich overview of documents available on green (inclusive) finance for agriculture and food systems, see Von During and Turillazzi (2021).

An interesting combination of a green bond issuance and an inclusive, agricultural financing is reported in Box 6. Overall, in smallholders' finance, PDBs have a multifaceted reputation: some of them have developed excellent approaches to smallholders and MSMEs, also on a long-term basis,[29] while other are still suffering from the burden of past supply-led experiences.

According to Miller and Ono (2021) agricultural development banks may effectively provide smaller loans for SMEs and producer groups. Jessop et al. (2012) find PDBs to be providers of agricultural finance in their sample, even if not all do it effectively.

Section 3 shows that innovation in providing finance in the agricultural-rural sector is growing and increasingly effective. However, public and private banks need to potentiate their role in the value-chain perspective. In fact, while the private banks are still insufficiently attracted by the sector, other non-bank financial solutions, such as leasing, or microfinance intermediaries are only targeting specific market segments. Fragmented actions need to be coordinated. PDBs may intervene with their products and services and favor coordination among actors.

29 Without specific reference to the agricultural and rural sectors, Xu, Ren, and Wu (2019) conduct systematical examinations on the effectiveness of DFIs focused on SMEs and suggest that SME-focused DFIs can perform better than private or public commercial banks in serving SMEs. .

5.2.2. FARMERS' INCLUSIONS THROUGH RISK MITIGATION

On the inclusion perspective, approaching smallholders and MSMEs that are poorly served in rural areas does not differ from the traditional mandates of most PDBs, especially those that operate with local rural communities. Instruments and best practices are well known. The barriers to the access to financial services by smallholders summarized in Section 2 increase the investors' perception of local risk and add to several other financial risks that especially international investors must bear (Pharo and Oppenheim, eds. 2019). However, with reference to MSMEs, Eustace (2015) underlines that the lack of awareness and information in the relationships between customers and the financial intermediary may affect this perception and induce lenders to deem their risk exposure even stronger than what it is in real terms. Several instruments, as portrayed in Section 3, can be deployed and provided or supported by PDBs to attenuate risk exposure and perception. Among these, index-based weather insurance or other types of insurance can cover specific risks. Price risk exposure can be mitigated through value-chain agreements or through access to price hedging instruments such as options on commodities. Warehouse financing or movable collateral increase the possibility to collateralize the loans (Miller, 2019). Encouraging the development of such products could be promoted by enablers such as governments and donors (see an example in Box 7).

Financial education, technical assistance and complementary services are also effective in attenuating risk and risk perceptions. In fact, the contemporary strengthening of borrowers' financial and technical knowledge allows the reduction in risk exposure through a double target. It reduces the idiosyncratic risk related to the customers' inability to assess their project, and better technical awareness assures more effective and impactful investments. Jessop et al. (2012) report the successful case of Tunisia, where the combined offer of such services and credit had a positive impact on farmers' productivity. PDBs may offer such services. However, they are normally offered to borrowers for free and represent a burden on banks' profitability because they are demanding in terms of organization and procedures when offered internally by the banks themselves. For this reason, governments and donors can finance these activities and offer organizational support as well, for example by financing the intervention of other public/private service providers or NGOs that complement PDB's actions (see Box 8).

5.2.3. KNOW YOUR CUSTOMER: STRENGTHENING PDBS' NETWORKS AND PROXIMITY TO CUSTOMERS

On the financial institutions' side, effectively serving rural customers entails physical proximity. Enhancing the branch network, in the case of first tier banks, demands investments. In terms of costs and effectiveness, it should be compared to the use of other financial intermediaries as a channel for reaching customers, as in the second-tier model. In principle, a first-tier model should allow closer links to the end-users of services. However, PDBs are not always equipped with large branch networks and have difficulty reaching customers. PDBs should avoid relying on public administration agencies in a "false integration" model (Masini Ed. 1989) but can develop useful links with other operators in the fields that are effectively interacting with end users (such as cooperatives or microfinance intermediaries, producers' organizations or even informal groups) in linkage models (as in Pagura, ed. 2008) that also decrease transaction costs. The more institutionalized the partner is, the closer the model becomes to the second-tier approach. In this solution, the overall knowledge of the customer is acquired by or, better, delegated to the entity involved on the ground. In order to verify the intended outcomes of such arrangements, Griffith-Jones et al. (2020) stress that the agreement with partner banks should have clear aims (e.g. loans for green transformation), and rely on effective monitoring tools. In terms of types of PDBs, Suchodolski et al. (2020) stress the comparative advantage in territorial coverage and customer knowledge of subnational development banks. In the case of innovative distribution channels such as mobile phones, the benefit of such a cost-effective solution for reaching customers must be balanced with the informational and motivational advantages of an approach based on relationship-lending (as stressed in Abraham and Schmukler 2017).

5.2.4. PROCESSES, CONDITIONS AND A HOLISTIC APPROACH TO CUSTOMERS

Financial institutions have varying degrees of specialization in serving agricultural and rural customers. PDBs may have a specific mandate and receive targeted funding to serve such clientele. The effectiveness of specialized institutions in past supply-led finance experiences showed that specialization alone is not enough to serve customers efficiently. An appropriate managerial approach is necessary both in private and in public banks.

One critical area to focus on is credit risk management. Sound credit processes must be made more flexible to deal with smallholders without loss of quality. In fact, PDBs often focus on customers who are creditworthy but who cannot demonstrate it according to standard banking evaluation criteria, such as with reliable financial data. It is then appropriate to develop ad hoc credit evaluation methods adapting to the type of information available (for example, based on credit scoring using mainly qualitative, non-financial information or on big data – see Box 9). These innovations are enhanced by enabling initiatives such as the creation of public databases on farmers and rural customers and of ad hoc credit bureaus, like the Servir project launched in 2005 in Ecuador by Red Financiera Rural (Sadler et al 2016).

Credit risk can also be kept under control through adequate pricing and other loan conditions. The dominant practice in the first phase of agricultural/rural development banks was based on soft interest rates imposed by governments to PDBs. Fixed, subsidized interest rates do not allow pricing to be aligned with customers' individual risk. Furthermore, they favor large borrowers and penalize small ones (Gonzalez-Vega, 1984); they do not facilitate debtors' repayment but, rather, may induce banks to finance inefficient farmers and induce farmers to consider these loans as quasi-grants, reducing their willingness to repay (Viganò, 1993). Besides, they jeopardize banks' profitability and their ability to attract external resources. These findings have been commonly shared by a large portion of literature,[30] but the vexed question about subsidized interest rates is not set yet. Horus (2012), Jessop et al. (2012), and Griffith-Jones et al. (2020), while acknowledging the distortions implied in such policies, maintain that success cases may occur, under specific conditions, such as, respectively, with accompanying measures, when meant to encourage financial innovations, or when the insufficient financial returns are compensated by positive socio-environmental externalities. Axelrad (2014) portrays specific, limited situations in which these policies may have an impact. Similarly, monitoring loan use, a common measure applied to minimize credit risk, proved to be quite ineffective because of money fungibility (Von Pischke and Adams, 1980), even when the loan is in kind because the good received as a loan can be sold.

So, PDBs have to be put in a position to set adequate contractual conditions that adjust to the customer's preferences while allowing for a suitable control of credit risk. Furthermore, a holistic offer of financial products (not only credit but payments and, when possible, savings products) increases PDBs' chances to achieve financial inclusion (among others, Koloma 2021). Savings products are often more important than credit to people who are unserved. Customers value having a safe place to put money and minimize the requests of family members to use it. Smallholders save smaller amounts, and banks are hardly interested in this money. However, in the banks' perspective, observing saving behaviors can be very helpful to assess customers' risks, in view of possible future lending (Viganò 1998). Offering savings services enables women's inclusion, given the high presence of women in informal savings. One successful example of an overall strategy of being close to customers to serve them is the BAAC of Thailand (see Box 10). The bank achieved financial and social performance and inclusion.

30 The title of a seminal book "Undermining rural development with cheap credit," by Adams, Graham, and Von Pischke (eds. 1984), is self-explaining in this respect.

5.2.5. ENABLING MEASURES

This focus on inclusion drafted some key barriers and some recommendations. Synergic actions should be put forward by enablers. For example, farmers' risk mitigation would benefit from the development of irrigation and water storage systems or from more price transparency and price risk support mechanisms. Index-based insurance product development requires having reliable meteorological-station systems. Credit risk management improves if credit bureaus or movable collateral registries are developed or thanks to and effective intervention of aggregating structures like producers' organizations that could be encouraged. Standardizing national systems for mobile financial transactions smooths the development of fintech solutions. Regulation must innovate in parallel with the different products and services, especially the most innovative ones, such as those along the value chain, index-based insurance or fintech services.

6. SHARED VIEWS, CHALLENGES AND WAYS FORWARD

This paper has analysed PDBs in their structural, organizational and managerial aspects, mandates and targets and has reported the outcome of studies on their overall performance, both from a financial perspective and in achieving intended developmental and inclusion goals. Besides some incontrovertible worldwide trends, when data are derived from studies based on samples, results are affected by their composition. Therefore, trends can be inferred by numbers but should be corroborated by the documented qualitative judgements and statements expressed by the actors involved and by relevant observers. Based on this evidence, some key areas of consensus emerge on the achievements of PDBs. They are covered in the next section, coupled with some highlights on the remaining challenges for PDBs in effectively achieving their mandates.

6.1. A RECAP OF ACHIEVEMENTS, AREAS OF CONSENSUS AND BARRIERS

6.1.1. PDBS' FUNCTIONS

PDBs are commonly said to be countercyclical, to be able to provide long-term finance, to have a developmental role and to promote projects with high social and environmental value. Overall, they contribute to overcoming market failures and supporting countries' economies and development. PDBs' countercyclical role is measured by the increased lending in periods of crisis. Data show an increase in the banks' leverage (liabilities/equity) and in their lending after the global financial crisis: on one side, PDBs were able to increase their funding and, on the other side, they expanded their lending.

However, not all the PDBs experienced such trends, and the numbers of disbursements alone do not testify to the actual quality of lending or impact of funds. Other functions are controversial. For example, even if infrastructural financing and other long-term financial needs are increasingly satisfied, providing sufficient long-term finance is still a challenge, at least in some areas of the world, and especially for rural smallholders.

6.1.2. MANDATES

Mandates of PDBs are quite diverse. A current prevailing overall mandate of PDBs is sustainable development and inclusive finance. On the environmental perspective, their contribution to climate-related finance is the highest among public funding. In terms of inclusion, large numbers of NDBs serve MSMEs. Studies focused on the rural-agricultural sector confirm that PDBs have potentiated the actions towards this target and have innovated the approach in sustaining the actors in the sectors, also through a value chain approach.

One weakness found in literature is the little adjustment in mandates in order to fine-tune them to the evolution of the priorities. Although PDBs have made efforts, achievements in the broad mandate to pursue green, inclusive sustainable development are still fragmented, and environmental practices are not yet fully incorporated into PDBs' strategies. Even the single target of the green transition shows several successful cases, but is not pervasively attained. Actions and innovative practices are dispersed and not systematized. Annual reports increasingly include information on sustainability and the SDGs, but a proper impact measurement, besides being conceptually complex, is hampered by the lack of information and appropriate monitoring systems.

Related to inclusive food systems, agriculture in general is not a predominating sector (with the exception of the case of agricultural development banks and rural banks) even if PDBs are among the main providers of this type of finance in the financial markets. MSMEs, despite being targeted by large numbers of PDBs are actually found to be underserved also in the short-term. There are banks that still operate on a demand-following basis, which is often ineffective in attaining the developmental goals and leads to inefficiencies.

6.1.3 LEVERAGE AND ASSET QUALITY

Increased leverage is a positive characteristic, but to avoid banks' instability, it should be coupled with a satisfactory profitability of assets (ROA) and satisfactory returns on equity (ROE). At the same time, the quality of assets, in the case of public banks, should also assure, even more so than in the private sector, the effectiveness of their action in terms of impact on the recipients. In the case of PDBs, and NDBs in particular, literature confirms average positive ROAs in the samples analysed.

However, most PDBs do not outperform national averages, and the situation varies greatly across regions and types of NDBs. The quality of asset is also an issue. For example, credit portfolio quality is still very low and a matter of concern for PDBs, even if there are some llent cases. Impact is not systematically measured.

6.1.4. PERFORMANCE AND RISK EXPOSURE

As stated above, PDBs' performances are quite diversie. The public ownership provides some back-up on risk exposures of PDBs. However, their private institutional form requests that PDBs achieve a financial performance allowing to persevere in the long run.

Nonperforming loans dominate as a problem, but other managerial (financial and operational) and external risks also affect PDBs. Insurance protection is not always available or suitable, and access to derivative markets to address financial (and weather or catastrophic) risk exposures is seldom affordable. Still, a non-negligible number of banks are not profitable. Regulation may incentivize banks to keep risks and the related capital under control, but open issues remain on the suitability of applying standard regulation designed for private banks to PDBs. The market channel role in controlling banks' perfromance through banks' disclosures is addressed by the banks through the publication of annual reports but still seem weak, especially when considering both financial and social disclosure.

6.1.5. RANGE OF FINANCIAL INSTRUMENTS OFFERED

It is a common opinion that PDBs are experienced in using several financial instruments and that they know the economic and social environment well – especially those that operate at the local level. In fact, they can adapt their intervention according to the target clientele and combine traditional products (such as loans and guarantees) with innovative products (such as equity investment and venture capital) and technical assistance facilities. Successful examples testify to this characteristic.

On the other hand, several banks are still relying mostly on traditional instruments that, in turn, have some drawbacks (for example, moral hazard problems in the case of guarantees). Furthermore, innovations are not always accessible to all banks, especially in low-income countries, and also some traditional products, such as insurance, are not yet offered at a large scale.

6.1.6. NDBS' DISTRIBUTION NETWORKS

Knowledge of the environment and of their target clientele, upon which to propose suitable products, depends on the banks' direct network, in the case of first-tier banks, or in the effective choice of the partnering institution/entity, in the case of second-tier banks. Advantages, limitations and examples of both strategies are described in literature.

Regardless of the strategy adopted, the need to potentiate PDBs' ability to reach the last mile is underlined.

6.1.7. DE-RISKING AND FUNDING

A peculiar role of multilateral or regional development banks is to provide funding to NDBs through loans or guarantees. Guarantees allow the banks or the local governments to improve their rating and obtain lower cost credit in the international markets.

However, issuing debt in these markets is not feasible for smaller banks, which are the majority of NDBs, especially in lower-income countries. In some cases, the de-risking role of the regional banks is limited by their nature, as in the case of the minilateral ones. Another critical point found in the literature concerns the conservative approach of MDBs in lending, driven by the need to keep a high international rating to lower the cost of their funding. This fact, coupled with the short-term focus and limited risk appetite of institutional investors, reduces the funds available to PDBs.

6.1.8. GOVERNANCE

Governments' role in the governance of PDBs varies. The current situation, as it emerges from the surveys on NDBs, shows that almost half of the banks now have a significant presence of independent board members.

However, the remaining show that governments still exercise relevant influence on the banks, for example on pricing. The situation happens to be quite critical in Africa.

6.2.ACTIONS AND INSTRUMENTS TO SUPPORT PDBS FOR AN INCLUSIVE, ENVIRONMENTAL IMPACT IN FOOD SYSTEMS

The next points are based on the preceding considerations to draw some concluding suggestions for future action of PDBs. Overall, the emerging picture is of a composite world that has strong potentialities, especially when accompanied by suitable enabling measures, but it should address issues that may concern some types of PDBs or specific actions. A summary table of points raised is reported in Table 1 at the end of the Section.

6.2.1. OVERALL MANDATE AND RELATED ACTIONS

PDBs have to incorporate the concept of systemic change into their strategic goals, processes and operations. PDBs must integrate the SDGs into their overall, long-term strategies and translate them into pervasive actions.[31] It is not just a matter of setting suitable operational manuals but of ensuring that the governance model incentivizes the embedding of selected principles at all internal levels, implementing instruments and performance indicators (as well detailed in Riaño et al. 2020).

31 Riaño et al. (2020), in their study aiming at assessing the PDBs' financial potential to contribute to the SDGs' implementation, find that PDBs often overlook the comprehensiveness of such an approach and limit themselves to focus on ESGs. Best practices to achieve integration of the SDGs are available for the climate case, such as those published by the I4CE (2021, as reported by Riaño et al. 2020) and can be extended to other targets.

As one step in this direction, the same source underlines partnerships between MDBs and NDBs, where MDBs set binding criteria based on underlying socio-environmental values to be respected by the NDBs in order to release the assistance. While these are mandatory measures, the wish is that, progressively, they become voluntary choices.

Furthermore, PDBs should make sure that, besides specific investments made to align with green and sustainable objectives, they internalize these values in their daily operations, aiming at a governance model and internal policies (for example, on staff or on the choice of suppliers) and procedures that consider all the relevant aspects and take specific actions for making the banks themselves inclusive, green and sustainable. Finally, a continuous fine-tuning of mandates is advised.

6.2.2. EXPECTED FOCUS ON STRATEGIC TARGET SECTORS

One of the main missions of PDBs is to promote inclusive, green finance. The MSMEs and smallholders in the agri-rural sector incorporate these two dimensions. The climate profile is currently more subject to innovative actions, although mostly focused on mitigation strategies. More active adaptation strategies must be emphasized. From the inclusion perspective, if the limitation would only be represented by scarcity of funds, the focus on green finance embraced by the international community may open the door to more funding (Sadler et al. 2016). The real barrier, however, is the hesitation of farmers to implement climate-friendly techniques. Non-distortive incentives should then be foreseen (for example, sharing the transition risk, price signals or technical support) for an inclusive, environmental impact and should represent the focus of more specific actions by PDBs. Lessons learned from past experiences, and best practices and current success cases are increasingly available from both the climate and the inclusion perspective, and on how to achieve them together (as reported in the boxes in the Appendix).

6.2.3. BANK-CUSTOMER RELATIONSHIPS

Suggestions from the literature, also regarding green, inclusive finance, relate to fostering the relationship of the PDBs with their target customers, and to developing a 360° knowledge of the ground level. Current and potential customers' risks and preferences in terms of most suitable financial products and main challenges facedshould be analysed. For this purpose, the various stakeholders must also be consulted (Riaño et al. 2020). These measures are aligned with the most successful marketing strategies and help in being more effective in the provision of financial services. In the case of lending they contribute to keeping credit risk under control. Besides, they also are aligned to the best practices to achieve inclusion and the SDGs.

The commonly quoted ability of PDBs to know the environment in which they operate is nuanced depending on the distribution model they use: first-tier or second-tier. In case of first-tier banks, branch network extension is expensive but can be a step towards a more managerial approach. Government and donors may consider contributing to expanding branch networks as a type of smart subsidy. In case of second-tier banks, besides a preliminary quality verification on the partners, (commercial banks or other entities) PDBs should set clear agreements defining incentive mechanisms and roles and responsibilities with these partners.

6.2.4. FINANCIAL INNOVATIONS AND TECHNICAL ASSISTANCE

The focus on pure lending may be widened to the whole range of actions that PDBs can make available. However, sometimes the innovation lies more in the process than in the instrument. The example of value chain lending is illustrative in this respect: interconnections among actors allow de-risking and higher effectiveness.

The offer of (effective) technical assistance to the recipients of funds is strategic for having a greater chance of financing successful investments. Technical assistance is a key factor when the project has an explicit aim of making the recipients shift their type of business in order to become climate-friendly, particularly for those customers that are targeted for inclusion. Lending could become an "easy task," when an in-depth knowledge of the customers is acquired and assistance is offered to customers to make them more creditworthy and attractive also in terms of risk-return combinations.

6.2.5. PDBS' RISK MANAGEMENT, FINANCIAL AND SOCIAL PERFORMANCE

Volume of funds provided to target sectors is not a sufficient indicator of the quality of PDBs' actions. Growth in lending and other investments increases the leverage and must be coupled with wise investment policies on the asset side. No matter which type of technical tool is used, PDBs' funds must be invested efficiently, i.e. customers should make good use of resources and repay, with at least no loss for the bank. In direct lending, this implies having a qualified lending process. In second-tier models, it means operating an appropriate selection of partnering intermediaries. "False integration," which occurs when banks are not equipped and rely on external (public) non-specialized entities for financial products delivery, fails in credit risk control particularly when the network is neither professional nor motivated. In PDBs, the high rate of NPLs, although not pervasive, is a matter of concern: high NPLs imply unwanted donations to final recipients that are probably not the most deserving ones.

Therefore, the usual recommendations in a managerial perspective for such cases apply: revising lending process, putting in place sound operational procedures in all phases of the process (with the related checks and balances), defining roles and responsibilities and consequent incentive systems, developing suitable creditworthiness evaluation tools (which may range from very wide, individual project evaluations, to ad hoc standardized methods for the micro-small ones) and setting monitoring and recovery procedures.

Overall, PDBs should implement effective risk management tools that embrace all their activity. For example, a less covered issue in the literature analysed is the evaluation of the general asset quality. In fact, a suitable combination of investments with loans and other financial tools, in different sectors, may provide better risk diversification. It is also an effective means to combine the characteristics of assets and liabilities in terms of maturity. Risk management also includes being in a position to use suitable risk protection measures.

On the profitability side, the possible critical effects of interest rate subsidies on the PDB's income can be at least partially offset by the low cost of funding offered by investors, when available. However, as explained in the paper, indirect costs of such a policy may derive from their potentially distortive behavioral incentives and from the lack of flexibility in product design and pricing. Administering funds made available with developmental goals may increase overhead, especially when the quality of the internal organization and governance is poor.[32] The accountability of the subsidized elements managed by the bank is of utmost importance. In any case, PDBs must be driven by the break-even principle to continue operating in the long run.

Lending quality and effectiveness should also be assessed in terms of intended social, sustainable impact. This is essential for PDBs, although it is increasingly part of the overall strategy for commercial banks as well. As stressed in Section 4, this is still an open issue. In some PDBs, internal information systems must be fostered and oriented to impact measurement, and specialized units must be put in place for this task. The final, although still ambitious, aim is to achieve the measurement of additionality. One incentive to improve impact measurement comes from the dedicated bond market, where the issuer is requested to develop internal impact indicators and to measure the contributions to development in order to be accredited. In any case, at least monitoring and evaluation systems should be strong.[33] Investment targets (lending and other forms) must be linked to the double bottom line of financial and social performance that should catalyze the increase of funds. Efforts are worthwhile if the PDBs' investment quality is aligned with the overall objectives.

6.2.6. FUNDING STRATEGIES

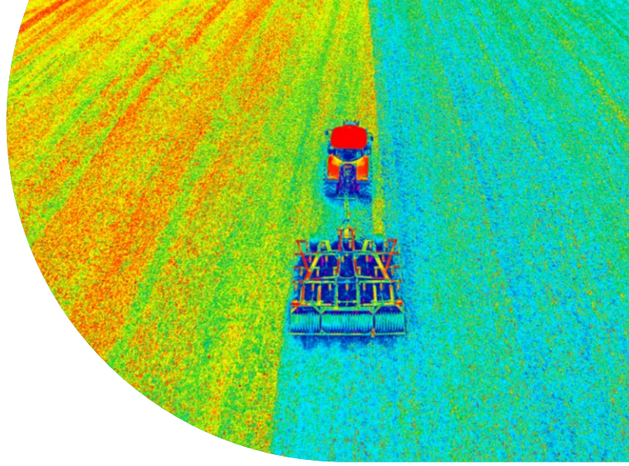
PDBs rely on traditional and more innovative instruments. Bond issuances may be supported by guarantees made available to NDBs and other local development banks by governments or MDBs. Since bonds are not extensively utilized, the guarantors should work closely with the guaranteed banks to smooth the process and increase the accessibility to such a form of support to funding.

Among specialized bonds, labelled bonds aim at green and sustainable targets. The green type is developed more than other types. The high costs in the issuing and monitoring phases still discourage PDBs, especially when the funds request explicit impact measures throughout the accreditation process. Incentives may come from market price signals in favor of green investments.

The limitations in available private funds, due to short-term and low risk preferences by investors, can be overcome through issuances of bonds with different ratings to satisfy diversified investors' risk-returns expectations. The growth of social investors may give impetus to bond issuances if they are less demanding on the yield and they accept less attractive risk-return combinations when compensated by sustainability achievements. This would allow PDBs to keep the funding costs under reasonable terms. In fact, social investors or sustainable private equity funds can become interesting partners. Impetus to the market should derive for extensive use of sustainable (not only environmental) ratings that can be combined by the investors with the traditional ratings based on a risk-return principle.

32 The challenges identified by the banks in the survey by de Luna-Martinez et al. (2018 42) are the need to "strengthen their risk management capacity," "become financially self-sustainable," "improve corporate governance and transparency," "acquire more flexibility to hire and retain highly qualified staff," and "reduce undue political interference." These challenges are not different from what emerged after the failure of (agricultural) development banks.

33 In de Luna-Martinez et al. (2018), recommendations for sound evaluation systems are covered.



Blended finance partnerships are meant to cap the cost of funding. They can be efficiently organized through platforms. In all these cases, it would be strategic for PDBs to play a role as motivators of the private and social investors, by reassuring them both of the intended impact and the financial returns.

6.2.7. SPECIALIZED VS. MULTISECTORAL PDBS

Among the studies on PDBs, one emerging question relates to the relative advantage of specialized versus multisectoral banks. Linked to this question is the choice between "greening" old development banks or creating new green development banks (Griffith-Jones, Attridge, and Gouett 2020). On this last question, the authors report the position of Smallridge et al. (2019) that base the answer on the analysis of mandates, performance and governance of NDBs. Narrow mandates, in fact, may prevent a bank from investing in climate projects. However, if the NDB is sound and effective, a possible extension to the climate cause would be best. It should be stressed that the question does not even arise if the ecological transition is pervasive and involves all types of institutions. The more general questions of comparing specialized banks with multisectoral ones, as in the previous case, should be answered by referring to the specific situation. Specialized banks are more focused and experienced on the single sector but have limited diversification. Banks with larger mandates, in this respect, may achieve more diversification and attain equally valuable sectoral targets. Both types can be ideal, but the actual choice depends on mandates, performance and governance and the bank's operating environment.[34]

The case of the possible collaboration among NDBs and green banks leads towards a landscape in which specialized and more diversified banks, public and private, operate at the same time. The aim should be to widen the extent of private and public intermediaries' impact rather than implementing measures that may induce crowding-out effects from PDBs. Competition and collaboration can coexist thanks to incentives in terms of specific targets achievable by each partner, based on transparency and information flows.

6.2.8. PUBLIC VS. PRIVATE CAPITAL IN PDBS

In their analysis on governance of PDBs, de Luna-Martinez et al. (2018) conclude by asking whether private sector participation in the ownership structure is suitable and what can be the best governance arrangements to avoid undue political interference. The cases and studies portrayed, in this respect, conclude that the choice between private and public proprietorship may not be influential on the quality of the governance, provided that suitable checks and balances, processes and procedures are established.

34 In Viganò (1998), a checklist of elements to consider when deciding to close or to restructure (public) banks is offered. Seibel (2001) and Seibel, Giehler, and Karduck (2005) have a similar approach and propose a detailed checklist of actions to be taken. In answering the questions, these studies reach a similar conclusion that there is no one choice, as the solution depends mostly on the feasibility of a proper restructuring process provided that the outcoming option leads to a healthy, efficient and effective bank. The current discussion on the ideal model for PDBs is different, but the overall suggestion is still valuable. Some measures inspired by these authors are incorporated in table 1.

8. THE "TRIANGLE" OF PDBS: FINANCIAL SUSTAINABILITY, IMPACT AND GOVERNANCE

On top of the points raised above, PDBs must be healthy and effective. The PDBs' system must invest in a rehabilitation of those PDBs that are undergoing weaknesses that do not allow them to fully unfold a transformative role. Financial health is vital. This does not mean equating the PDBs' to private banks. Borrowing from a well-known concept in microfinance, like MFIs, PDBs too should consider three driving forces in their actions that can be traced as three angles of a triangle (Zeller and Meyer, ed. 2002): financial sustainability, outreach and impact. All three dimensions are equally essential, and there might be trade-offs in achieving them all together. Trying to enlarge outreach is costly, as it may require investing in the most destitute smallholders; prioritizing high impact may require taking expensive actions to leverage the effects of finance; and pushing towards both wider outreach and greater impact may drive an MFI farther from sustainability. Sustainability, in turn, is a binding condition in order to achieve the other two targets. To overcome this conflict, in microfinance, innovations (technical, in processes and approaches) are considered the winning strategy.

With a focus on wider clientele targets, possibly including microfinance customers but also larger type of clients, PDBs can benefit from such a conceptual frame in analysing the delicate equilibrium that governs their existence. PDBs can be more flexible than private banks in accepting less ambitious risk-return combinations in favor of social and developmental goals, yet they must care about keeping a balance among financial break-even, outreach and sustainability. The means to achieve this balance can include technological innovation and financial technology. Furthermore, it is necessary to focus on innovative processes (for example, in the financial service production, control and delivery phases and in customer relationships) and on fine-tuning in governance. PDBs can be supported thanks to sharing of experiences and collaboration through platforms. These measures should be addressed in the short term to make the PDBs system solid and consistent, because fresh inflows of funds alone are not sufficient to strengthen them. Incentives to make all PDBs successful can be linked to accountability: PDBs' actions and performance must be evaluated along the three perspectives of the "triangle of PDBs." Under these conditions, the PDBs' system may definitely switch from the traditional role of fund dispenser to the one of strategic enabler of sustainable transformation.

TABLE 1: SELECTED CRITICAL POINTS AND SUGGESTIONS FOR IMPROVEMENTS OF PDBS' EFFECTIVENESS

NETWORK	CHALLENGES	MEASURES
FUNCTION AND MANDATE	Lack of renovation and fine tuning Little incorporation of SDGs	Update mandates to evolving environments Embed SDGs in mandates
OWNERSHIP AND GOVERNANCE	Governments' ownership and interference in strategy, governance and operational choices	Separation of ownership from management Suitable selection of qualified and motivated personnel
FUNDING	Inability to access bonds markets by the smaller NDBs (the majority) Weaker ability to catalyze external funding Private investors seeking for suitable risk-return combinations New opportunities in green finance?	MDBs and RDBs must support NDBs Coordination among NDBs, Platforms NDBs' access to local financial resources. Local deposit mobilization when allowed Blended finance solutions and diversified risk-return combinations Strategies to access green bond markets (e.g. project pipelines and aggregations)
NETWORK AND BANK-CUSTOMER RELATIONSHIP	Need to strengthen customer relationship Critical choice between 1st tier and 2nd tier models Investments in branch networks for 1st tier? Critical choice of banks or other entities as partners in 2nd tier.	Donors' and governments' support to branch networking (smart subsidy) False integration avoidance: financial responsibility separated from the distribution of goods / technical assistance Careful selection of partners and accurate partnership agreements (roles and responsibilities) Linkage with grassroot entities
PRODUCTS	Traditional lending as main product Guarantees with de-risking function but subject to moral hazard and with little value in banks with low rating Little experience and opportunities on new products, especially for smaller banks	Diversify products and services offered through value chains Technical assistance offered by donors to develop and experiment new products (ex. innovative insurance) Limit guarantees to specific, well monitored situations Holistic offer of financial products (not only credit)
INCLUSIVE, GREEN TARGETS	Good coverage of MSMEs but limited investment in agriculture. Individuals and households financed by specialized banks. Adaptation finance for smallholders still underdeveloped Scarcity of long-term finance	Education and technical assistance to target customers to enhance investment impact Risk-management solutions for target customers Demonstration effects of successful cases and collaboration among NDBs (platforms) Look for (private) investors in long-term finance
LEVERAGE AND PORTFOLIO QUALITY	High leverage considered as an indicator of attaining the function of investing in the economy. High leverage is fine if the quality of assets is good but several banks have low asset (loan) portfolio quality	Improve credit processes focused on customers' accountability Credit analysis and pricing/conditions tailored to actual customers' status Contracts clear, understandable and agreed with customers. Rigorous recovery procedures Non-creditworthy recipients assisted with other measures than credit (smart subsidies)
FINANCIAL ND SOCIAL PERFORMANCE	Break-even still a challenge for some banks Impact measurement difficult to implement	Managerial approach and risk management tools Suitable bank performance evaluation criteria Improve impact measurement (if possible) and set effective monitoring and evaluation systems. Diversification for risk reduction More focus of (public and private) investors on banks' overall performance.
SYSTEMIC ISSUES	PDBs' crowding-out of private banks and vice-versa Different types of PDBs with different roles Green banks may be competitor	Healthy competition and collaboration in win-win solutions Transparency and clarity as a base for relationships.

Source: author's elaboration

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APPENDIX

BOX 1: PUBLIC PRIVATE PARTNERSHIPS IN CLIMATE FINANCE

Combinations of instruments may create attractive risk-return profiles for the private investors. In this respect, DBSA (Development Bank of South Africa), other institutions and the Green Climate Fund established the Climate Finance Facility, with the purpose of supplying different credit-enhancement measures, like subordination clauses, to co-financing local private banks (as in Morgado et al. 2019, quoted by Griffith-Jones, Attridge, and Gouett 2020).
The example of the Investment Accelerator launched by the NGO REEEP is offered by Eustace (2015). MSMEs and other ventures with potential in the green energy field are selected by REEEP. Provided with training, mentoring, and de-risking, they connect with private investors.

BOX 2: SUCCESSFUL CASES OF GREEN BONDS

One well-known case of green bond issuance is the Fiji Sovereign Green Bond. The issuance produced direct spillovers in terms of best practices adopted, increased advocacy, enhanced transparency and disclosure in the use of public funds. It was based on effective collaboration with governments and stakeholders. It also stimulated the response of the financial sector in terms of products targeting inclusion and the promotion of enabling conditions by the Reserve Bank of Fiji (AFD-AFI 2020).
Riaño et al. (2020), mention the successful case of the Banco de Desenvolvimento de Minas Gerais. The Banco launched a Sustainability Bond Framework with the aim of guiding the allocation of funds collected via sustainable bonds towards projects with clear and relevant environmental and social impacts, aligned with the SDGs.

BOX 3 – GREEN BANKS VS PDBS

Based on the State of Green Banks 2020 report (Becerra Cid et al. 2020), these banks operate in about two dozen countries. The can take different institutional forms. At present, most of them are publicly owned but commercially operated. Sources of funds are domestic institutional investors, sovereign wealth funds and international investors, including MDBs and climate funds. Similarly to PDBs, they aim at attaining climate change and SDGs, they address market barriers and contribute to create market conditions through funds mobilization. Differently from PDBs, though, after receiving seed capital from governments, multilateral and bilateral assistance, and from the private sector, in most cases, they do not receive additional concessional finance and must rely on their own forces. Like PDBs, they provide loans, equity, and de-risking through guarantees or credit enhancements. They maintain to have local market knowledge, specific expertise on climate technical innovations, access to project pipelines. They also attribute to the flexibility of their mandates the ability to structure suitable deals. They currently operate in high-income countries, because of the easier access to finance in these countries but they are looking for further opportunities to be funded by (and receive technical assistance from) MDBs or other sources in which also PDBs are tapping. They underline to have a tight focus on governance (Becerra Cid et al. 2020).

BOX 4 - INCENTIVES TO CLIMATE FINANCING THROUGH GUARANTEE FUNDS

FIRA (Fideicomisos Instituidos en Relación con la Agricultura), a Mexican second-tier development bank, operates mainly through guarantees. In 2011, with the aim of encouraging the involvement of reluctant financial intermediaries in green investments, because of lack of familiarity with the technologies involved, FIRA promoted the FONAGA Verde guarantee fund. Between 2010 and 2011 FONAGA Verde, offered 1.4 million US$ in guarantees to several projects in Mexico that have resulted in over 11.2 million US$ of direct investment in renewable energy and biofuel generation.

BOX 5 - GREEN AND INCLUSIVE

Renewable Energy Independent Power Producer Procurement Programme (South Africa)
This programme has been implemented through DBSA and IDC (Industrial Development Corporation). In addition to financing made available for the renewable energy projects, the communities residing in the area are given a parallel loan to constitute a trust. This trust is meant to include the communities and allow them to buy equity in the project. The loan is repaid using the dividends accrued to the trust (to this purpose, a grace period till the project is operational is granted). Griffith-Jones at al. (2020)

Corporación Financiera de Desarrollo (COFIDE – Peru)
With the aim of having an impact on the communities, COFIDE provided second-tier funds to local banks in order to encourage loans for the conversion to natural gas fuel of taxis and buses, with lower carbon emissions. Loan collections occurred at the gas stations. COFIDE provided also the necessary technology platform. Besides the reduction in greenhouse gas emissions, the program favored better access to financial products by taxi drivers, that were able to build their credit. An increase in the number of participating financial intermediaries was recorded (Smallridge et al. 2013).

FMO (Netherland's Development Finance Company)
Riaño et al. (2020) offer one example of venture capital, a program initiated by FMO (bilateral Dutch development bank), focused on young entrepreneurs and local businesses, vulnerable communities and sustainable development. Through a combination of arrangements (a guarantee agreement with the European Commission, blended capital and technical assistance) the program allows to achieve a variety of targets, among which, financial inclusion, renewable energy, education, health and digital commerce.

BOX 6 - BAAC'S FORESTRY GARDENING CREDIT THROUGH GREEN BOND ISSUANCE

The Bank for Agriculture and Cooperatives (BAAC) of Thailand, offers a credit product aimed at increasing forestry areas. Types of collateral, besides physical collateral, include joint group liability or guarantors. Loan amounts are up to US$10,000. Eligible borrowers can be farmers, individuals, groups, community enterprises, entrepreneurs and agricultural cooperatives. Maturity is up to 18 months for working capital and up to 20 years for investment loans. Loans are administered locally by BAAC's branches.
The environmental spillovers are increased forestry gardening and a more sustainable, climate-friendly society. In terms of inclusion, customers enjoy job and savings opportunities and become more resilient. Furthermore, the trees obtained can be used as a collateral. Other indirect effects are an increased reputation and further market expansion of BAAC. The investing community, in turn, should be satisfied by the double bottom line achievement of investing in effective inclusive green finance (Finance in Common Working Group 2021).

BOX 7: SUSTAINING INDEX BASED INSURANCE PRODUCTS

The International Finance Corporation (IFC), supported by the Global Index Insurance Facility, launched the Weather Index Insurance project on climate risks with Green Delta Insurance Company (GDIC), in Bangladesh. IFC developed a customized weather index insurance for the tomato farmers. Insurance is sold through a value chain bundled approach; the insurance company links with one or more finance or input providers. This reduces transaction costs, increases volumes, and creates a network effect. The scheme, after some pilot initiatives, compensated the farmers in some cases and is considered a success. Strategic factors are the availability of a weather data grid, to design and monitor the products and quickly settle claims. Slow introduction and constant awareness building measures are considered important as well (GIIF, 2018).

BOX 8 – EFFECTIVE SUPPLY OF TECHNICAL ASSISTANCE

Technical assistance to farmers in Moldova
Jessop et al. (2012) found in Moldova a strong correlation between the provision of technical assistance and the agricultural performance, with positive effects on farmers' repayment capacity. Technical assistance is supported by the government but the service is provided by private operators. This is a transparent and smart way of subsidizing, softening the organizational burden of the bank involved. Getting qualified support is preferable to budget replenishments on banks that incurred losses by providing technical assistance.
Peru's smalholder farmers form cooperatives through technical assistance
Smallholders prevail (70%) in Peru's coffee market. Micro land extensions and lack of ownership titles make it difficult for them to access credit. A recent increase in the percentage of farmers aggregated in cooperatives is the outcome of technical assistance provision. Being members in a cooperative helps achieving better prices and access to financing, improving quality, obtaining the certification and increasing export. Providers of technical assistance are funded by grants/donor funding (Carrol et al. 2012).

BOX 9 – CREDIT ANALYSIS FOR SMALLHOLDERS - MSMES

Credit scoring
The use of credit scoring allows to cut the costs of, and to fine tune, credit risk assessment. While this technique is usually referred to as based merely on quantitative, financial information, it can also be developed on qualitative information. This is particularly important when financial data are often lacking.
One pilot attempt was conducted in 1991 at the Caisse Nationale de Crédit Agricole of Burkina Faso. The experimental credit scoring model developed demonstrated to be able to detect high risk borrowers exclusively based on qualitative and non-financial information (Viganò 1993). With the same approach, the Grameen Foundation established a partnership with the Andean Coffee Cooperative of Colombia and developed a model that allows to obtain credit scoring on farmers with no credit history, based on farm characteristics. This is currently used as a support to the traditional loan analysis but could transform into an automated procedure (reported in Koloma 2021).

The "360 degree" approach of ICICI India
ICICI Bank runs an MSME program providing non-traditional finance. They assess credit risk through market segmentation and a 360 degree approach. They elaborate credit scorecards (with reference to industries, linkages, market segments), customer value analyses, site visits and personal references are put together to evaluate creditworthiness. The bank has almost 1 million client enterprises (Eustace 2015).

Credit assessment based on big data
Big data based credit assessment use advanced data analytics instead of traditional analysis. "Big Data, Small Credit" (BDSC), in fact, relies on non-traditional data sources (customers' social media information, mobile call records and payment patterns, for example). One example is the company Cignifi (2021). This method enables to make tailor-made products, cuts the costs and increases inclusion of those customer that could not provide traditional information on their credit risk. BDSC has great potential for the financial inclusion of otherwise excluded segments, and to deliver better and cheaper financial services (Sadler et al. 2016).

BOX 10 - BAAC: EFFICIENT MANAGEMENT FOR SOCIAL GOALS

The Bank for Agriculture and Cooperatives (BAAC) is a government- owned bank in Thailand. Covering the vast majority of farmers' household is the main actor in the agricultural-rural and food sectors. It is a well known case in literature as it is among those agricultural specialized lending institutions that were able to prosper after being transformed in a diversified rural bank. Over time, it expanded its operations from lending to individuals through joint liability groups, to a larger variety, including savings mobilization. In Seibel (2001)' analysis, the ability to combine outreach and financial viability were made possible by the large operational autonomy from the government, a corporate culture aiming at qualitative and quantitative financial performance (cost effectiveness, productivity and efficiency), proximity to customers through branches operating as profit center, products and innovation respectful of the local culture.
Based on Miller and Ono (2021)'s more recent data, BAAC serves more than 5.8 million farmer borrowers and almost 2 million households, members of cooperatives. The collect savings from more than 28 million depositors. The bank fulfills its developmental objectives through a comprehensive approach beyond financial services, emphasizing capacity, competitiveness, and value addition. For example, worth of attention is the promotion of a new generation of "smart farmers" (based on modern technology and innovation in agri-business) which has covered over 138,000 farmers. Young people and students are among the beneficiaries. The strategy of the bank is to enhance aggregation structures, such as cooperatives, community enterprises, farmer associations, entrepreneurs and village associations. These structures are considered as "drivers" and organizers in their value chains, especially for collecting farmers' products. The bank operates in short and long-term finance, also through special programs, including a green one. According to the analysis, key positive features are related to the client-centric approach (clients are segmented to match suitable products, technical assistance and incentives), to accurate loan assessment and monitoring, to a value chain approach (behavioral incentives are offered to customers within the chain and training on value chain is given to the personnel).

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