sustainability

MDPI

Review

Scaling Up Pro-Poor Agrobiodiversity Interventions as a Development Option

Agnès Bernis-Fonteneau [1,2,*], Rima Alcadi [3], Marco Frangella [4] and Devra I. Jarvis [2,5,6]

[1] Department of Environmental Biology, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185 Rome, Italy
[2] Platform for Agrobiodiversity Research (PAR), The Raffaella Foundation, 80 Myer Creek Rd, Twisp, WA 98856, USA; d.jarvis@agrobiodiversitypar.org
[3] Independent Researcher, Via Fonteiana 126, 00152 Rome, Italy
[4] ICiTy—Social Urban Experience s.r.l., Viale Giulio Cesare 71, 00192 Rome, Italy
[5] Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164, USA
[6] Bioversity International, Via di San Domenico 1, 00153 Rome, Italy
* Correspondence: agnes.bernisfonteneau@uniroma1.it

Abstract: Pro-poor interventions that use agrobiodiversity for development actions are widely considered relevant only at small scales. Agrobiodiversity interventions are often left out of national-level/large-scale development planning. Scaling-up modalities include adaptation, diffusion, replication, value addition, and temporal scaling up. We undertook a review of 119 interventions that use agrobiodiversity for both the crop and the livestock sector. The interventions ranged from improving the availability of materials and information through management and market-oriented actions to changing norms and enabling policies. The interventions are also organized in accordance with farming-community goals and constraints. The open-access multilingual Diversity Assessment Tool for Agrobiodiversity and Resilience (DATAR) was created as a framework to systemize and structure agrobiodiversity interventions under different scaling-up modalities for the on-the-ground field assessment and scaling-up of agrobiodiversity interventions. The use of the framework enabled the scaling up of small-scale interventions that use agrobiodiversity to have impact on agricultural development at larger spatial and temporal scales.

Keywords: farming communities; climate adaptation; poverty alleviation and empowerment; social environmental conditions; crop varieties; livestock breeds

Citation: Bernis-Fonteneau, A.; Alcadi, R.; Frangella, M.; Jarvis, D.I. Scaling Up Pro-Poor Agrobiodiversity Interventions as a Development Option. *Sustainability* **2023**, *15*, 10526. https://doi.org/10.3390/su151310526

Academic Editors: Gianfranco Romanazzi, Carla Moretti and Saverio Senni

Received: 15 May 2023
Revised: 29 June 2023
Accepted: 29 June 2023
Published: 4 July 2023

1. Introduction

"Pro-poor interventions" are interventions specifically dedicated to poverty alleviation for the populations living below national standards [1,2]. In these programs, the target group is deliberately selected as poor rural people, and the relevance and effectiveness of these programs are determined by their (potential or actual) benefits to this target group. Interventions are monitored to determine whether they benefit poor rural people, and, if not, corrective actions are taken to ensure that they are targeted and become beneficiaries.

Investments in pro-poor interventions for sustainable agriculture systems focus on rural poor farmers, herders, and fisherfolk. These investments tend to be species-based, i.e., decisions are made to determine which species of crops, livestock or aquatic animal would be best adapted for use for poverty alleviation under local socio-environmental conditions. Stopping at the species level to determine pro-poor interventions has caused the neglect of the potential role of within-species diversity, or intra-specific diversity, in the form of diverse sets of local crop varieties, livestock breeds, and farmed aquatic animals, within the process of developing pro-poor interventions. However, it is this component of agricultural biodiversity or agrobiodiversity, this within-species diversity, together with species diversity, that continues to support over one billion people living in extreme poverty [3–6].

Agricultural biodiversity, or agrobiodiversity, includes the variety and variability of plants, animals, and microorganisms at the genetic, species, and ecosystem levels that are relevant to the production of goods in agricultural systems. This agrobiodiversity is necessary to sustain key ecological functions, such as energy, nutrient and water cycles, structures, and processes in the agroecosystem [4,7,8]. This intra-specific diversity continues to be maintained in the food systems of small-scale farmers, livestock keepers, and fishers, and it is key to their productivity and income, as well as insuring against unpredictable fluctuations in climatic and economic conditions [5,9–14].

Areas with high levels of agrobiodiversity are commonly correlated with primary and secondary centers of domestication for crop or livestock species [15]. Poorer households in rural areas, especially those in marginal and harsh farming conditions, tend to be highly dependent on the agrobiodiversity within their production systems [16–18]. These families are generally not in a position to afford substitutes [4,19]. Farmers often use agrobiodiversity to manage risks because of limited access to agricultural inputs, such as pesticides, fertilizers, and irrigation systems [5,20–24]. The use of diverse sets of crop varieties and livestock breeds has ensured sustainable production under conditions of unpredictable rainfall patterns, droughts, storms, and floods [4]. Livestock keepers have selected breeds within species that are adapted to local conditions and to available sources of feed [25,26]. The promotion and commercialization of local varieties and breeds have had important positive effects on incomes, food security, food safety, nutrition, health, local cultural identity, and self-esteem [26–33].

Due to climate change, poor rural people's dependence on cultivated and wild biodiversity is likely to increase. It is forecasted that developing countries will endure the greatest losses in annual rainfall and the sharpest increases in its variability [34] and, considering their geographic locations, their vulnerability, and their direct reliance on ecosystem services, the poorest communities in developing countries will be affected the most heavily [35]. As a result, poor rural people's ability to act as custodians of this rich agrobiodiversity, for their own survival as well as for humanity at large, is at risk. Because of these characteristics, interventions related to agrobiodiversity are highly relevant to pro-poor development.

Over the last three decades, interventions that improve the access to and use of this agrobiodiversity, in the form of diverse sets of crop varieties and animal breeds, have been successfully used to improve the welfare of a limited number of farmers at specific sites around the world [10,25,36–48]. Interventions that use local crop varieties or landraces and locally adapted or indigenous breeds are extremely relevant to rural poverty reduction, as they are produced and consumed locally and are therefore easily accessible to people in rural areas, where the largest proportion of malnourished people live. However, because these interventions often rely on locally adapted crop and livestock genetic resources, they are often not considered up-scalable. Pro-poor interventions that use agrobiodiversity for development actions have been widely considered relevant only at small scales and, as a result, the use of agrobiodiversity interventions is often left out of national-level and large-scale development planning.

Donors, policy makers, and civil society are increasingly concerned that many relevant pro-poor technologies, including the improved use of agrobiodiversity, are not achieving their full potential impact owing to the lack of modalities or of a framework for their up-scaling and widescale adoption [49,50]. Through a review of 119 pro-poor interventions that use agrobiodiversity for both the crop and livestock sectors, and under various climatic conditions, we identified key issues and modalities, and proposed a framework for scaling up interventions to the regional and national levels. We developed an open-access multilingual IT tool as a framework to scale up interventions based on the assessment and use of local agrobiodiversity linked to farmers' constraints and goals. We argue that not only is the scaling up of pro-poor actions based on the use of agrobiodiversity and the knowledge surrounding this resource possible, but its inclusion in development planning can significantly help farming communities to benefit within food systems.

In this study, we carried out an extensive literature review to identify and characterize key scaling-up modalities and constraints. Our analysis led to the development of a comprehensive framework and multilingual IT tool to facilitate the scaling up of pro-poor interventions in the agrobiodiversity sector.

2. Scaling-Up Process

2.1. Issues Related to the Definition of Scaling Up

Scaling-up interventions are currently considered among the greatest challenges that development practitioners face [51]. Scaling-up proponents frame the concept as central to efficiency, cost-effectiveness, value for money, risk management, and political credibility [52]. The term scaling up first appeared in research on rural development in the 1990s [53]. The definition has evolved into the concept of expanding, adapting, and sustaining successful projects, programs, or policies in different ways and, over time, for greater development impact [52,54–57]. Although this definition of scaling up has arguably been useful for policy advocacy and engagement, it is still imprecise, with concepts that require disentangling for development practitioners to grasp and operationalize the process and for academics to rigorously analyze its components [58].

The definition of scaling up has remained unclear with regard to many issues, including: (i) the goals to be achieved by scaling-up; (ii) the processes that should be scaled up; (iii) the reasons why these should be scaled up; (iv) to whom they should be scaled up; (v) how they should be scaled up; (vi) by whom they should be scaled up; and (vii) how to establish whether scaling up has been successful. It is not clear whether "impact" refers to reaching a greater number of people or whether it refers to more qualitative aspects, such as making the same number of people less vulnerable to climate change, increasing their education, or making them wealthier [58]. Furthermore, the "successful" descriptor is unclear, while development practitioners' capacity to evaluate performance is still embarrassingly poor [59], an issue that is highly relevant to the deployment of agricultural biodiversity, which affects many different aspects of human livelihoods and for which it is difficult to separate out the benefits and rigorously demonstrate the causal relationships between them [60].

Many of the criteria, conceptual frameworks, checklists, how-to notes, and guidelines that have been developed fail to disaggregate the various concepts currently implied in the definition of scaling up [57]. Following these guidelines can be a daunting task in the small programs that pilot projects. There also seems to be confusion regarding the scaling-up process and the type of intervention to be implemented in relation to processes that are institutional, related to a product, or organizational. In the literature review, we found the expression "vertical scaling up"; this expression is misleading, as a distinction is needed between the institutional transformation that is required for all stages of the adoption and implementation of interventions, including scaling up, and the scaling up of an institutional transformation. We also found "horizontal scaling up," which includes an excessive number of disparate processes (e.g., replication, diffusion, and adaptation; see Table 1).

Table 1. Scaling-up modalities.

Scaling Up Modality	Description Moving from Local to National to International Scale
ADAPTATION	An intervention is scaled up by adapting it to other geographical contexts, different beneficiaries and farming communities, and various target agricultural species.
DIFFUSION	An existing intervention is scaled up by communicating it to new stakeholders and by improving the collaboration and partnership among various stakeholders.
REPLICATION	An existing intervention is scaled up to new stakeholders at different sites.
VALUE ADDITION	An intervention is scaled up so that the same people, performing the same task, can earn more and obtain access to new market opportunities.
TEMPORAL SCALING UP	An intervention which is supposed to be introduced for a limited amount of time is scaled up over a longer time frame.

2.2. Issues Related to the Drivers of Scaling Up

The recommendation to scale up an intervention may not always be a good idea. Development practitioners need to consider why and whether it is desirable to scale up, as some commonly implemented development interventions are meant to address a specific issue in a specific context that is not applicable on a wider scale. Moreover, although it is assumed that increasing the scale of development programs can drive down per-unit costs through economies of scale [52], this is not always the case, as there are cases in which diseconomies of scale may prevail, or in which economies of scale may bring about fewer or even negative effects on development. A technology may be successful on a small scale, and it may still retain its desirable characteristics without being scaled up to more farmers [3]. For example, unless there is a large market, the expansion of the production of a specific crop would probably result in a fall in prices and reduced, rather than increased, income for smallholder farmers [49]. This was the case with quinoa in Latin America. In other circumstances, it may be true that unless a new technology is scaled up, it is likely to be of little use, and this is especially the case when network externalities exist [61,62].

The context and the type of intervention matter in determining whether and how to scale up. has Approaches that work in one locality or region may not be successfully replicated elsewhere due to a range of environmental, social, political, historical, cultural, and/or managerial reasons [51,53,63–65]. Furthermore, approaches that work at one scale may not work at another scale—this is termed the "ecological fallacy" [49]. Heterogeneity is a recurrent feature in the management of natural resources, and it is also a major barrier to reaching a wider audience [51]. If the intervention includes a new technology, it appears that the stage of development of the technology matters, especially regarding the spontaneous replication or adoption of technologies. For example, Pachico and Fujisaka [49] found that when a technology first becomes available, usually, a small group of farmers, referred to "early adopters," adopt it immediately and, as time passes, a larger group of farmers, referred to "mainstream adopters," adopt it in turn. Early adopters create a positive externality for others in terms of knowledge spillovers on the existence, features, and performance of the new technology [61,66].

Interventions can be risky to introduce if, for instance, they are not adapted to specific circumstances, if they are difficult to implement, or if their potential benefits do not materialize [67]. Farmers are risk-averse, and the level of risk and uncertainty in a new practice or technology can lead to low rates of adoption, especially when farmers are unable to buffer risks [68]. Some interventions are mutually exclusive, so adoption decisions are influenced by relative (and perceived) costs and/or benefits [69]. This may not matter in one context, such as those in which viable alternatives exist, but it may matter in another context. Some interventions are simple to adopt and replicate and others are not. The scaling up of innovations in agroforestry has often proved difficult. One of the main reasons put forth to explain this is that these innovations are knowledge-intensive, making their dissemination and adoption processes more difficult [70]. The choice of which pro-poor agrobiodiversity interventions to implement and to scale up depends on the local situation, socio-economic conditions, and site-specific information [3,49,57].

The decision to scale up requires an initial reflection on whether the program should operate on a national, provincial, or local level [54,55]. A key recommendation found in the literature on scaling up is to consider scaling up from the beginning of the research-and-planning process and include a scaling-up strategy in project proposals, as scaling up should form an integral part of the development process [49,54,55]. The decision to scale up needs to be based on evidence of whether the intervention is "successful," leading to a paradox in how the scaling-up approach is defined [57]. This presupposes that scaling up is a planned process, whereas it may be a spontaneous process, in which the organization originally supporting the intervention has little influence over or even knowledge of the scaling-up process. This issue is further complicated by the fact that scaling up is typically viewed as a long-term process that can take up to 15 years [54–56]. This long time horizon poses great challenges as priorities shift, governments change, funding becomes irregular, staff turnover in partner organizations occurs [54,55], and technologies and practices themselves change.

3. Methodology

3.1. Gathering Evidence: Identifying the Main Modalities of Scaling Up

We carried out a review of 119 interventions that use agrobiodiversity for both the crop and livestock sectors to gain a better understanding of how pro-poor interventions that use or give access to agrobiodiversity are scaled up, together with the impact of these interventions on improving the livelihoods of small-hold farmers. The full list of interventions is available in Table S1 of the Supplementary Materials.

Five questions guided the review: (i) How can interventions for the sustainable use and conservation of agrobiodiversity contribute to rural poverty reduction? (ii) What are the key issues in scaling up? (iii) What are the main modalities of scaling up? (iv) Which systemic tool is needed to allocate the correct scaling-up modality to interventions and to implement them where and when they are most needed? (v) What are the important variables to consider that influence scaling up processes?

Interventions include improving the availability of materials and information, identifying better management or market-oriented actions, changing of norms, and creating enabling policies. We employed the ten categories of intervention identified by Jarvis et al. [37] for crops, which we then expanded to categorize interventions for livestock: (i) improving availability of genetic materials; (ii) improving information and availability of information on local crops and breeds; (iii) improving traditional materials through participatory breeding or (iv) through better management of local materials; (v) improving processing; (vi) market creation and market promotion; (vii) building new partnerships and trust; (viii) changing local and national norms; (ix) alternatives to and modification to certification systems; and (x) promoting ecological land management practices. Policy and market-oriented interventions are well represented in these categories, as are interventions to support the implementation of adapted farming practices that demonstrate their contribution to poverty reduction and sustainable rural development. This is the case in organic farming, agroforestry, and no-tillage and other agricultural conservation practices [71–77].

Drawing on the analysis of these interventions, implemented in the crop and livestock sectors that use agrobiodiversity, we identified five main ways in which scaling up has been undertaken. We defined these methods as "scaling up modalities": (i) scaling up through adaptation of an intervention; (ii) scaling up through diffusion of an intervention; (iii) scaling up through replication of an intervention; (iv) scaling up through value addition of an intervention; and (v) temporal scaling up of an intervention. The scaling-up modalities are further described in Table 1.

3.2. Developing a Framework and Multilingual IT Tool for Scaling Up Agrobiodiversity Interventions

The diversity of types of interventions and their relevance, depending on the context and the audience, make the scaling-up process complex for agrobiodiversity interventions. The process requires selection of a portfolio of interventions based on goal setting, assessment of available agrobiodiversity, and constraints on the use of this diversity to achieve the selected goals. Up-scaling of the selected intervention, or portfolio of interventions, therefore requires determination of whether the intervention is up-scalable and, if so, establishment of the modality under which to achieve this: adaptation, diffusion, replication, value addition, or temporal scaling up.

Based on the last 25 years of collaborative pro-poor agrobiodiversity-development interventions (See Supplementary Materials Table S2 for a list of national collaborating institutes and organizations organized by country) with national partners, a framework and supporting multi-lingual tool was developed to systematically scale up agrobiodiversity interventions. These national partners included the following. Africa: Mali, Niger, Burkina Faso, Uganda, Malawi, Tanzania, Ethiopia. The Americas: Mexico, Peru, Ecuador, Bolivia, Cuba, USA; in S and SE Asia: Nepal, China, India, Vietnam, Bhutan. North Africa and the Middle East: Morocco, Egypt, Syria, Jordan, and Iran; in Europe: France, Italy, and Armenia. Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Released in 2021 as an initial prototype, the Diversity Assessment Tool for Agrobiodiversity and Resilience (DATAR (DATAR (www.datar-par.org, accessed on 28 June 2023) is owned and managed by the Platform for Agrobiodiversity Research (PAR) www.agrobiodiversitypar.org, accessed on 28 June 2023)) was further refined through interactive engagement with partners with multiple tests and improvements from Niger, Uganda, Tanzania, Ethiopia, Malawi, Nepal, China, Jordan, Morocco, Uzbekistan, Cuba, Mexico, and Italy. The DATAR software platform (version 1.9.3) was developed to include a web interface, the DATAR web portal (freely available upon registration), and an Android App, which can be used off-line by field researchers and communities, and which includes free prior informed consent (FPIC) forms to sign when working with farmer communities. The tool is open-access and can be customized so that it is adapted based on the available time and resources of the user and language, and it is flexible in that it allows further refinement based on feedback and needs of users and stakeholders.

The DATAR system follows a protocol of linking the outputs of focus-group discussions, household surveys, and empirical data to allow the identification and location of intra-species-level crop and livestock agrobiodiversity across the landscape, in order for communities to set their sustainable development goals (Figure 1). The information is then analyzed and fed into a heuristic decision-making framework [36], which then points the community to a subset of over 100 pro-poor agrobiodiversity interventions that support enhanced productivity and resilience in a given social–ecological–economic context. The tool was developed to scale up agrobiodiversity interventions through (i) assessment of intraspecific crop and livestock diversity, (ii) the constraints encountered by farmers and farming communities on their ability to benefit from the use of their own local crops and animal biodiversity, and (iii) provision of suitable and adapted interventions for farming communities to benefit from the use of this diversity and improve local agricultural productivity and agroecosystem resilience.

The DATAR protocol ensures that project sites are described, indicating location, minimum and maximum GPS coordinates, and agroecological zones. Areas planted with the target species or where livestock species are kept are also added from information on national agricultural census. Once the sites of a project are defined, project coordinators and farming communities identify and set the goals and subgoals they wish to achieve during Step 1. Participatory approaches and surveys are at the center of Step 2 for data collection. Information collected offline in the field is uploaded to the server during Step 3. It is then organized, synthesized, and analyzed during Step 4 and presented and discussed with farming communities for validation during Step 5. Step 6 consists in the identification of constraints on and selection of interventions by communities and other stakeholders. Constraints are identified with communities using a heuristic framework adapted from Jarvis et al. [37] to determine whether the constraints are due to the following: (i) a lack of sufficient diversity in crop varieties and animal breeds within the production system to meet their goals; (ii) a lack of access to existing diversity to information about this diversity for farmers; (iii) limitations on the performance of the available varieties of breeds; (iv) farmers and livestock keepers not receiving the full economic or social benefits from the materials they manage and use. Scaling-up modalities are identified in Step 7. The last step in the DATAR protocol (Step 8) consists in measuring the level of achievement for the different goals and subgoals selected and monitoring the beneficiaries.

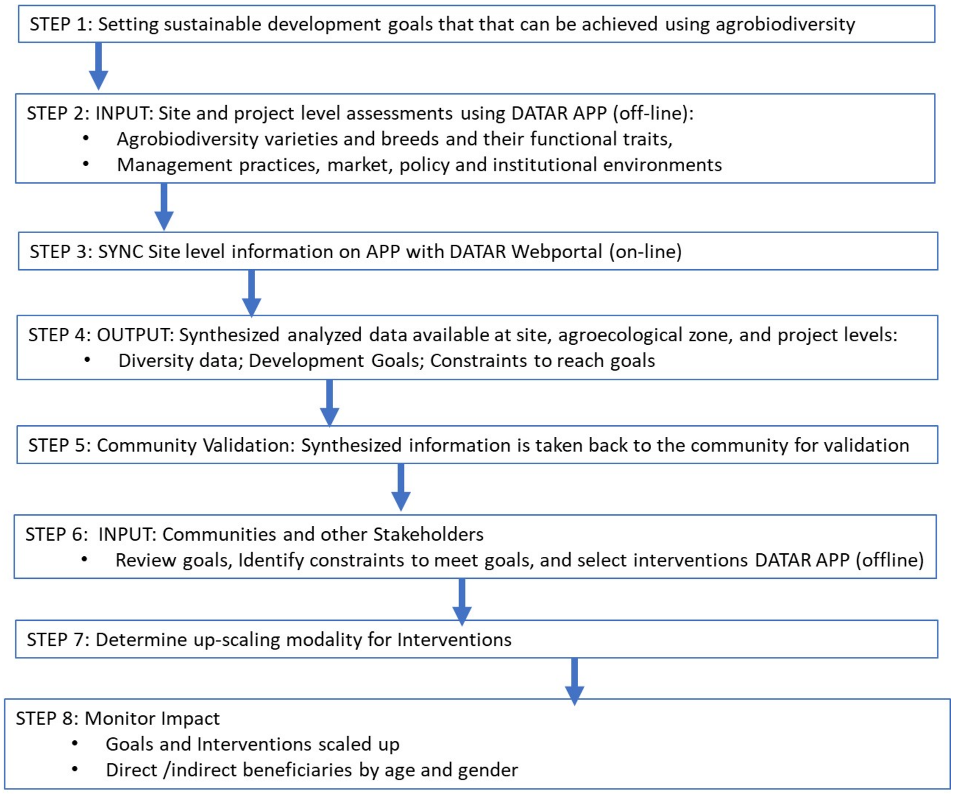

Figure 1. Schematic of the DATAR system's protocol.

4. Results

The wide range and type of data collected using the DATAR tools enables users to assess information on crop varieties, livestock breeds, and their functional traits, identify and describe public and private genetic-material providers who supply crop seeds, animal breeds, and aquatic farmed types to local communities, and assess the managerial, market, policy, and institutional constraints encountered by crop, livestock, and aquatic food producers. This, in turn, directs users to a portfolio of age- and gender-appropriate interventions targeted at using this diversity to meet the goals of the community, while also identifying the appropriate scaling-up modality or modalities, adaptation, diffusion, replication, value addition, or temporal, for wider impact. Using this stepwise tool, national programs, local governments, non-government development agencies, and community-based organizations determine the constraints with farmers, livestock keepers, and pastoralists and, therefore, establish the interventions needed to achieve their livelihood goals at the local-site and country-project levels.

A sample of interventions in both the crop and livestock sectors demonstrates the different modalities needed for scaling up. Some interventions can have multiple scaling-up modalities. These interventions, and explanations of how they fit in the different modalities, are presented in Table 2.

Table 2. Examples of interventions for the crop and livestock sectors and how they fit in the scaling-up modalities.

Scaling Up Modality	Crop	Livestock
ADAPTATION	***Improved processing***—Shift retailers to use different processing equipment that can use diversified materials [78]. *A machine for de-husking rice is adapted to tiny millet seeds, reducing female labor.*	***Improving traditional breed materials and their management***—Community-based breeding program, animal identification, and pedigree recording [79–82]. *Breeding and selection is based on adapted traits for different environments.*

Table 2. *Cont.*

Scaling Up Modality	Crop	Livestock
	Improving availability of materials—Diversity Field Fora (DFF) and Diversity Field School (DFS) [83,84]. *Farmer field schools are adapted to use genetic diversity.*	***Improving availability of materials***—Livestock fairs, exhibitions, and shows/agricultural fairs [85,86]. *Livestock fairs exhibit indigenous and locally adapted livestock breeds or technologies adapted to local breeds.*
	Improving traditional variety materials and their management—Planting of intra-specific mixtures to reduce pests and diseases [87,88]. *Integrated pest management includes crop-variety diversity.*	
	Improving traditional-variety materials and their management—Participatory crop improvement (grassroots breeding; participatory plant breeding (PPB); participatory varietal selection (PVS)) [89–97]. *Participatory and conventional breeding use locally adapted materials.*	
DIFFUSION	***Improving availability of materials***—Seed cooperative for collection, distribution, and multiplication of seeds or community seed bank [98,99]. *Diverse sets of varieties taken up by more farmers.*	***Improving availability of materials***—Cross- and/or pilot-site visits for farmers and local extension workers [100–102]. *Livestock keepers and extension workers are convinced by the quality of local breeds and adopt them more widely.*
	Changing norms—Strengthen and/or establish training programs and extension services that include intra-specific diversity [94]. *Extension services/colleagues have materials that include the use of varietal diversity.*	***Improving information and availability of information***—Painting and art competitions that reward farmer groups for knowledge and descriptions of agricultural diversity [103,104]. *Livestock keepers and farming communities are convinced by the quality of local breeds and adopt them more widely.*
	Improving availability of materials—Community seed bank [98]. *Community Seed banks and* diversity *registries are linked to national genebanks.*	
	Building Partnerships and Trust—Private and public partnership for the construction of small infrastructure for the production of a better-quality product [105,106]. *Private and public seed suppliers diversify their varietal portfolios.*	
REPLICATION	***Improving availability of materials***—Community seed bank (https://alliancebioversityciat.org/stories/uzbek-farmers-get-livelihood-boost-local-fruit-tree-conservation, accessed on 28 June 2023) [107–109]. *Community seed banks: Central Asian fruit-tree nurseries with high diversity.*	***Improving traditional breed materials and their management***—Micro credit facilities to set up technical activities, particularly for rural men and women [110,111]. *Micro credit opportunities allow the replication of interventions in different places.*
	Alternatives and modification to seed-certification systems—Geographic indications [112–114]. *GIAHS site certification.*	***Alternatives to certification schemes relevant to livestock***—Geographic indications or quality-assured producer and product [41,115]. *Geographic certifications are adapted at different sites.*
	Promoting ecological land-management practices—Agricultural biodiversity included in environmental impact assessment of individual projects, policies, and programs [107]. *Restoration of degraded land with locally adapted varieties.*	

Table 2. *Cont.*

Scaling Up Modality	Crop	Livestock
VALUE ADDITION	***Promoting ecological land management practices***—Agrobiodiversity ecotourism [116–118]. *The conservation of agrobiodiversity becomes an added source of value for tourism.*	***Improved processing***—Improved processing of animal-derived products [119,120]. *Livestock keepers improve their incomes by improved processing of their livestock products.*
	Alternatives and modification to seed certification systems—Links between intellectual property rights protection and benefit-sharing [92,99,121,122]. *Policy supports benefit sharing for diversity custodians.*	***Market creation and promotion***—Market creation for indigenous or locally adapted breeds or their products, including niche markets [123]. *New markets for added value of local breeds.*
TEMPORAL SCALING UP	***Improving availability of materials***—Diversity fairs [124–126]. *Diversity fairs become annual events.*	***Improving availability of materials***—Livestock fairs, exhibitions, and shows/agricultural fairs [41,127]. *Livestock fairs exhibit indigenous and locally adapted livestock breeds or technologies adapted to local breeds.*
	Changing norms—Strengthen and/or establish training programs and extension services that include intra-specific diversity [128–131]. *A training course becomes an annual course; middle schools take on new courses teaching young breeders.*	***Promoting ecological land management practices***—Payment for environmental services (PES) schemes are established or reinforced [132,133]. *Establishment of PES allows the long-term adoption of ecological land management.*

5. Discussion

From the literature review on “scaling up” and agrobiodiversity interventions, we identified important variables to consider that influence scaling-up processes. Because “scaling up” is a very broad concept encompassing multiple definitions, it is to be expected that a plethora of drivers and variables affect its implementation and success. The analyses and the literature review confirmed this, as several potential explanatory variables were identified that may be related to the different scaling-up modalities described above, such as the scaling-up objective (i.e., the developmental impact sought); the features and/or types of interventions, including practices or technologies, under consideration; the context; leadership capacities; social capital and networks; the duration of the project; policies; and access to information.

When determining the important variables that influence scaling up, it is necessary to consider who is responsible, or instrumental, in the scaling-up process. For some types of intervention, such as political or institutional interventions, a high level of commitment from country leaders may be required [56]. However, this commitment may not be important for spontaneous replication, whereas it is much more important to ensure that the intervention is perceived by prospective adopters as highly beneficial and that the barriers to adoption are low [57]. Poor people’s assessment criteria may differ from those of development practitioners, who mostly assume that farmers’ main underlying priority is the maximization of yields [51]. Studies have shown that small-hold farmers have a wide range of goals, and many may be concerned about dimensions of poverty such as vulnerability, seasonality, powerlessness, and humiliation, which may not be perceived as relevant by development practitioners [134].

For interventions that are expensive to scale up, significant donor commitment is more important than it may be for organizational or institutional innovations, which may require commitment from staff in terms of changing routines or intensifying information/knowledge flows. When donors have scaled up innovative NGO programs without investing in further building the NGO’s organizational and human capacity, the results have been counterproductive. For example, a rapid infusion of donor money, accompanied by an imperative to scale up, seriously undermined the pastoralist land-rights movement in Tanzania, with communities becoming the “commodities” of an international NGO industry, rather than active participants [135]. It is important to note, however, that most of the research on scaling up emphasizes the important role of establishing and developing partnerships, including the private sector, civil society organizations (CSOs), government agencies, donors, and research institutions, for several purposes. Enhanced cooperation and collaboration among these various stakeholders are acknowledged as effective in the adoption and scalability of interventions [49,70,136]. Scaling up is thus not merely technological, but also institutional [57].

The development of DATAR as a framework for identifying goals and constraints and, subsequently, for proposing a portfolio of adapted interventions, allows an adapted scaling-up process, which follows one or several of the modalities detailed above for pro-poor agrobiodiversity innovations. In this case, innovation is used in the sense that new applications of agrobiodiversity interventions are offered and scaled up to achieve improved livelihoods in farming communities.

The process of innovation is described as collective [137,138] and interactive, with knowledge acquisition and learning taking place through extensive linkages with different knowledge sources [139] in multiple social networks [130]. Heterogeneity in the partnership base is particularly beneficial [138,140] and successful innovations are usually based on the merging of ideas from various actors, including scientists, users, intermediaries, and others. These characteristics are also parts of DATAR and the way in which it has been developed as an iterative and interactive process involving users, technical staff, and IT developers. Testing with national partners (see Table S2 in the Supplementary Materials) led to the following features of the tool. It was necessary that the tool be used in the field without a connection for the collection of data, which could be later linked, compiled, and synthesized with a web platform for coordinators to monitor and evaluate the actions implemented. The tool needed to support participatory approaches, not replace them, enhancing the speed and quality of the data collection. It needed to be flexible to apply to all the types of production system (list) in any agroecological zone and set of climatic conditions, but with standardized descriptors for variety and breed description, management, market, and policy descriptors allowing comparison across sites and species. All the descriptors needed to have age and gender sensitivity to ensure the possibility of determining the links between different age groups or genders, specific descriptors, and specific values for each descriptor. The descriptors and surveys used in the data collection had to be configured in formats to ensure that the collected information, using the framework, would link agrobiodiversity-related goals and constraints to the portfolios of adapted interventions.

The resulting system links data collection and decision-making, allows users to systematically collect and securely keep data, and saves time in data analysis, indicating the key role of DATAR tools in the scaling up of agrobiodiversity interventions in agricultural development. With development practitioners claiming that any innovation, including in agriculture, is a failure unless it can be scaled up to affect the lives of many poor people, tools that upscale interventions based on the knowledge and management of local resources are key to the development process [57]. The DATAR system integrates the goals and constraints of farming communities and has, in itself, the sustainable use of agrobiodiversity at its heart, together with the use of diversity in the place of unsustainable management practices, i.e., practices with a negative impact on the health and functions of agroecosystems, or practices that cause the depletion of resources, including agrobiodiversity capital. These aspects are crucial, as pro-poor interventions are largely considered successful when they take into account community needs and the successful use of local resources.

6. Conclusions

Agrobiodiversity interventions for pro-poor development can be up-scaled from small-scale actions to national level/large-scale development planning when the correct modality for scaling up is identified. The scaling-up modalities, identified through a thorough literature review and analysis on crop and livestock interventions, included adaptation, diffusion, replication, value addition, and temporal scaling up. Through systemizing and structuring agrobiodiversity interventions under different scaling-up modalities, the Diversity Assessment Tool for Agrobiodiversity and Resilience (DATAR) provides a framework, based on on-the-ground field assessments and community goals, for scaling up small-scale interventions, using crop and livestock agrobiodiversity, to provincial, agroecological-zone, and national levels.

The characterization of why and whether an intervention should be scaled up, the type of intervention, the context in which it is introduced, and who is responsible for or instrumental in scaling up highlighted the need for an innovative framework supporting the scaling-up process. The focus of efforts should not only be on creating, diffusing, and utilizing knowledge, but also on shaping the attitudes and practices that are conducive to developing more effective relationships and interactions between different organizations [139]. A sharper definition of scaling up, which disentangles the various concepts currently implicit in its definition and that bridges the gap between its principles and practices, can lead to clearer recommendations for development practitioners and policy makers.

Scaling up is not only a matter of technology transfer, but also requires the development of process knowledge on how to build local capacity to innovate. We conclude that interventions using agrobiodiversity can be scaled up and have a wide impact on agricultural development to improve the livelihoods of farming communities when associated with the appropriate scaling-up modality and adapted framework.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su151310526/s1. Table S1: Lists of interventions for the crop and the livestock sectors. Table S2: List of institutes/organizations by country which have collaborated in pro-poor agrobiodiversity assessments and interventions.

Author Contributions: Conceptualization, A.B.-F., R.A. and D.I.J.; methodology, D.I.J., M.F., A.B.-F. and R.A.; software, M.F.; validation, A.B.-F. and D.I.J.; formal analysis, A.B.-F. and D.I.J.; investigation, A.B.-F. and D.I.J.; data curation, A.B.-F. and M.F.; writing—original draft preparation, R.A., A.B.-F. and D.I.J.; writing—review and editing, A.B.-F. and D.I.J.; funding acquisition, D.I.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Global Environmental Facility (GEF)—International Fund for Agricultural Development (IFAD) and the United National Environmental Program (UNEP): Cross-cutting capacity building, knowledge services and coordination project for the Food Security Integrated Approach Pilot Program—GEF project 9140.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from the senior author on reasonable request.

Acknowledgments: We wish to sincerely thank Rose Nankya, Elisabetta Rossetti, and Paola De Santis for their technical inputs and testing the DATAR tools with national partners in Africa and Latin America. We also wish to thank Toby Hodgkin, Anthony H.D. Brown, Devendra Gauchan, Keyu Bai, Muhabbat Turdieva, Kim Ahn Tempelman-Mezzara, Isabel Lopez Noriega, Rami Khalil, Paolo Colangelo, Nadia Bergamini, Loubna Belqadi, Diana Lope Alzina, Laura Lewis, Simone Mori, and Fabio Attorre for their technical insights in the development of DATAR. We thank the Alliance of Bioversity International and CIAT, The Platform for Agrobiodiversity Research, and The Raffaella Foundation for their technical and administrative assistance, and the anonymous reviewers for their careful evaluation of our manuscript and their insightful comments and suggestions.

Conflicts of Interest: The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Asiamah, G. Pro-Poor Development Strategie. In *No Poverty*; Leal Filho, W., Azul, A.M., Brandli, L., Lange Salvia, A., Özuyar, P.G., Wall, T., Eds.; Encyclopedia of the UN Sustainable Development Goals; Springer: Cham, Switzerland, 2021; pp. 716–729. [CrossRef]
2. Callan, T.; Nolan, B. Concepts of poverty and the poverty line. *J. Econ. Surv.* **1991**, *5*, 243–261. [CrossRef]
3. Conway, G. *One Billion Hungry—Can We Feed the World?* Cornell University Press: Ithaca, NY, USA, 2012.

4. CBD. *Biodiversity, Development and Poverty Alleviation: Recognizing the Role of Biodiversity for Human Well-Being—International Day for Biological Diversity*; Secretariat of the Convention on Biological Diversity: Montreal, QC, Canada, 2010.
5. United Nations Environment Programme. *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature—A Synthesis of the Approach, Conclusions and Recommendations*; United Nations Environment Programme: Nairobi, Kenya, 2010.
6. Gumma, M.K.; Gauchan, D.; Nelson, A.; Pandey, S.; Rala, A. Temporal changes in rice-growing area and their impact on livelihood over a decade: A case study of Nepal. *Agric. Ecosyst. Environ.* **2011**, *142*, 382–392. [CrossRef]
7. Hartmann, M.; Six, J. Soil structure and microbiome functions in agroecosystems. *Nat. Rev. Earth Environ.* **2022**, *4*, 4–18. [CrossRef]
8. Viglizzo, E.F.; Pordomingo, A.J.; Castro, M.G.; Lértora, F.A.; Bernardos, J.N. Scale-dependent controls on ecological functions in agroecosystems of Argentina. *Agric. Ecosyst. Environ.* **2004**, *101*, 39–51. [CrossRef]
9. Rege, J.E.O.; Gibson, J.P. Animal genetic resources and economic development: Issues in relation to economic valuation. *Eco. Econ.* **2003**, *45*, 319–330. [CrossRef]
10. Halwart, M. Biodiversity and nutrition in rice-based aquatic ecosystems. *J. Food Compos. Anal.* **2006**, *19*, 747–751. [CrossRef]
11. Roe, D.; Walpole, M.; Elliott, J. Linking Biodiversity Conservation and Poverty Reduction—What, Why and How? In Proceedings of the Summary Report of a Symposium Held at the Zoological Society of London, London, UK, 28–29 April 2010.
12. Fenzi, M.; Couix, N. Growing maize landraces in industrialized countries: From the search for seeds to the emergence of new practices and values. *Int. J. Agric. Sustain.* **2022**, *20*, 327–345. [CrossRef]
13. Jarvis, D.I.; Brown, A.H.D.; Cuong, P.H.; Collado-Panduro, L.; Latournerie-Moreno, L.; Gyawali, S.; Tanto, T.; Sawadogo, M.; Mar, I.; Sadiki, M.; et al. A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 5326–5331. [CrossRef]
14. Thomas, M.; Verzelen, N.; Barbillon, P.; Coomes, O.T.; Caillon, S.; McKey, D.; Elias, M.; Garine, E.; Raimond, C.; Dounias, E.; et al. A Network-Based Method to Detect Patterns of Local Crop Biodiversity: Validation at the Species and Infra-Species Levels. *Adv. Ecol. Res.* **2015**, *53*, 259–320. [CrossRef]
15. Pironon, S.; Borrell, J.S.; Ondo, I.; Douglas, R.; Phillips, C.; Khoury, C.K.; Kantar, M.B.; Fumia, N.; Soto Gomez, M.; Viruel, J.; et al. Toward Unifying Global Hotspots of Wild and Domesticated Biodiversity. *Plants* **2022**, *9*, 1128. [CrossRef]
16. Pimbert, M. *Sustaining the Multiple Functions of Agricultural Biodiversity*; FAO: Rome, Italy, 1999.
17. Mijatović, D.; van Oudenhoven, F.; Eyzaguirre, P.; Hodgkin, T. The role of agricultural biodiversity in strengthening resilience to climate change: Towards an analytical framework. *Int. J. Agric. Sustain.* **2013**, *11*, 95–107. [CrossRef]
18. Kahane, R.; Hodgkin, T.; Jaenicke, H.; Hoogendoorn, C.; Hermann, M.; Dyno Keatinge, J.D.H.; D'Arros Hughes, J.; Padulosi, S.; Looney, N. Agrobiodiversity for food security, health and income. *Agron. Sustain. Dev.* **2013**, *33*, 671–693. [CrossRef]
19. Luck, G.W.; Harrington, R.; Harrison, P.A.; Kremen, C.; Berry, P.M.; Bugter, R.; Dawson, T.P.; de Bello, F.; Díaz, S.; Feld, C.K.; et al. Quantifying the contribution of organisms to the provision of ecosystem services. *BioScience* **2009**, *59*, 223–235. [CrossRef]
20. Vitale, J.D.; Sanders, J.H. New markets and technological change for the traditional cereals in semiarid Sub-Saharan Africa: The Malian case. *Agric. Econ.* **2005**, *32*, 111–129. [CrossRef]
21. Mulumba, J.W.; Nankya, R.; Adokorach, J.; Kiwuka, C.; Fadda, C.; De Santis, P.; Jarvis, D.I. A risk-minimizing argument for traditional crop varietal diversity use to reduce pest and disease damage in agricultural ecosystems of Uganda. *Agric. Ecosyst. Environ.* **2012**, *157*, 70–86. [CrossRef]
22. Li, J.; Jiggins, J.; Van Bueren, E.T.L.; Leeuwis, C. Towards a regime change in the organization of the seed supply system in China. *Exp. Agric.* **2013**, *49*, 114–133. [CrossRef]
23. Ssekandi, W.; Mulumba, J.W.; Colangelo, P.; Nankya, R.; Fadda, C.; Karungi, J.; Otim, M.; De Santis, P.; Jarvis, D.I. The use of common bean (*Phaseolus vulgaris*) traditional varieties and their mixtures with commercial varieties to manage bean fly (*Ophiomyia* Spp.) infestations in Uganda. *J. Pest. Sci.* **2016**, *89*, 45–57. [CrossRef]
24. Wall, J.; Köse, C.; Köse, N.; Okan, T.; Aksoy, E.B.; Jarvis, D.; Allred, S. The role of traditional livelihood practices and local ethnobotanical knowledge in mitigating chestnut disease and pest severity in Turkey. *Forests* **2019**, *10*, 571. [CrossRef]
25. Barker, J.S.F. Conservation and management of genetic diversity: A domestic animal perspective. *Can. J. For. Res.* **2001**, *31*, 588–595. [CrossRef]
26. Leroy, G.; Baumung, R.; Boettcher, P.; Besbes, B.; From, T.; Hoffmann, I. Animal genetic resources diversity and ecosystem services. *Glob. Food Sec.* **2018**, *17*, 84–91. [CrossRef]
27. Nankya, R.; Mulumba, J.W.; Lwandasa, H.; Matovu, M.; Isabirye, B.; De Santis, P.; Jarvis, D.I. Diversity in nutrient content and consumer preferences of sensory attributes of peanut (*Arachis hypogaea* L.) varieties in Ugandan agroecosystems. *Sustainability* **2021**, *13*, 2658. [CrossRef]
28. Padulosi, S.; Hoeschle-Zeledon, I. Underutilized Plant Species: What Are They? *LEISA Magazine*, March 2004.
29. Padulosi, S.; Eyzaquirre, P.; Hodgkin, T. *Challenges and Strategies in Promoting Conservation and Use of Neglected and Underutilized Crop Species*; ASHS Press: Alexandria, VA, USA, 1999.
30. Buerkert, A.; Gebauer, J. (Eds.) *Agrobiodiversity and Genetic Erosion*; Contributions in Honor of Prof. Dr. Karl Hammer; Kassel University Press: Kassel, Germany, 2009.
31. Rojas, W.; Valdivia, R.; Padulosi, S.; Pinto, M.; Soto, J.; Alcócer, E.; Guzmán, L.; Estrada, R.; Apaza, V.; Bravo, R. From neglect to limelight: Issues, methods and approaches in enhancing sustainable conservation and use of Andean grains in Bolivia and Peru. *J. Agric. Rural. Dev. Trop. Subtrop.* **2009**, *92*, 1–32.

32. Mal, B.; Padulosi, S.; Ravi, S. *Minor Millets in South Asia: Learnings from IFAD-NUS Project in India and Nepal*; Bioversity International: Rome, Italy, 2010.
33. Hoffmann, I.; From, T.; Boerma, D. *Ecosystem Services Provided by Livestock Species and Breeds, with Special Consideration to the Contributions of Small-Scale Livestock Keepers and Pastoralists*; FAO: Rome, Italy, 2014; Volume 66. [CrossRef]
34. Malik, K. Human Development Report: The rise of the south analysis on Cambodia. In *Human Development Report*; UNDP: New York, NY, USA, 2013.
35. IPCC. *Climate Change 2007: An Assessment of the Intergovernmental Panel on Climate Change*; IPCC: Geneva, Switzerland, 2007; Volume 446.
36. Jarvis, D.I.; Padoch, C.; Cooper, H.D. Biodiversity, agriculture, and ecosystem services. In *Managing Biodiversity in Agricultural Ecosystems*; Jarvis, D.I., Padoch, C., Cooper, H.D., Eds.; Columbia University Press: New York, NY, USA, 2007; Volume 365, pp. 1–12.
37. Jarvis, D.I.; Hodgkin, T.; Sthapit, B.R.; Fadda, C.; Lopez-Noriega, I. An heuristic framework for identifying multiple ways of supporting the conservation and use of traditional crop varieties within the agricultural production system. *CRC Crit. Rev. Plant. Sci.* **2011**, *30*, 125–176. [CrossRef]
38. Galluzzi, G.; Van Duijvendijk, C.; Collette, L. *Biodiversity for Food and Agriculture. Contributing to Food Security and Sustainability in a Changing World*; PAR Platform; FAO: Rome, Italy, 2011.
39. Hajjar, R.; Jarvis, D.I.; Gemmill-Herren, B. The Utility of Crop Genetic Diversity in Maintaining Ecosystem Services. *Agric. Ecosyst. Environ.* **2008**, *123*, 261–270. [CrossRef]
40. Lazard, J.; Baruthio, A.; Mathé, S.; Rey-Valette, H.; Chia, E.; Clément, O.; Aubin, J.; Morissens, P.; Mikolasek, O.; Legendre, M.; et al. Aquaculture System Diversity and Sustainable Development: Fish Farms and Their Representation. *Aquat. Living Resour.* **2010**, *23*, 187–198. [CrossRef]
41. FAO. *Adding Value to Livestock Diversity—Marketing to Promote Local Breeds and Improve Livelihoods*; FAO Animal Prod. and Health Paper No. 168; FAO: Rome, Italy, 2010.
42. FAO. *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*; FAO: Rome, Italy, 2010.
43. FAO. *The State of World Fisheries and Aquaculture*; FAO: Rome, Italy, 2020.
44. Köhler-Rollefson, I. Indigenous practices of animal genetic resource management and their relevance for the conservation of domestic animal diversity in developing countries. *J. Anim. Breed. Genet.* **1997**, *114*, 231–238. [CrossRef]
45. Köhler-Rollefson, I.; Mathias, E. Animating diversity: Supporting endogenous development of livestock keepers. *Development* **2010**, *53*, 425–428. [CrossRef]
46. Lind, C.; Ponzoni, R.; Nguyen, N.; Khaw, H. Selective breeding in fish and conservation of genetic resources for aquaculture. *Reprod. Domest. Anim.* **2012**, *47*, 255–263. [CrossRef]
47. Lind, C.E.; Brummett, R.E.; Ponzoni, R.W. Exploitation and conservation of fish genetic resources in africa: Issues and priorities for aquaculture development and research. *Rev. Aquac.* **2012**, *4*, 125–141. [CrossRef]
48. Nankya, R.; Mulumba, J.; Caracciolo, F.; Raimondo, M.; Schiavello, F.; Gotor, E.; Kikulwe, E.; Jarvis, D. Yield perceptions, determinants and adoption impact of on farm varietal mixtures for common bean and banana in Uganda. *Sustainability* **2017**, *9*, 1321. [CrossRef]
49. Pachico, D.; Fujisaka, S. *Scaling up and Out: Achieving Widespread impact Through Agricultural Research, Economics and Impact Series 3*; CIAT: Cali, Colombia, 2004.
50. Hall, A. Partnerships in Agricultural Innovation: Who Puts Them Together and Are They Enough? In Proceedings of the OECD Conference Improving Agricultural Knowledge and Innovation Systems, Paris, France, 15–17 June 2011.
51. Snapp, S.; Heong, K.L. Scaling up and out. In *Managing Natural Resources for Sustainable Livelihoods*; McDougall, C., Pound, B., Eds.; Routledge: London, UK, 2003; pp. 67–87.
52. Chandy, L.; Linn, J.F. *Taking Development Activities to Scale in Fragile and Low Capacity Environments*; Global Economy and Development: Washington, DC, USA, 2011.
53. Millar, J.; Connell, J. Strategies for scaling out impacts from agricultural systems change: The case of forages and livestock production in Laos. *Agric. Human. Values* **2010**, *27*, 213–225. [CrossRef]
54. Hartmann, A.; Linn, J.F. *Scaling up Through Aid—The Real Challenge*; Policy Brief; Brookings Institution: Washington, DC, USA, 2008.
55. Hartmann, A.; Linn, J.F. *Scaling up: A Path to Effective Development*; Focus Brief; International Food Policy Research Institute: Washington, DC, USA, 2007.
56. Binswanger-Mkhize, H.P.; De Regt, J.P.; Spector, S. Scaling up local & community driven development (LCDD). In *A Real World Guide to Its Theory and Practice*; Binswanger-Mkhize, H.P., de Regt, J.P., Spector, S., Eds.; The World Bank: Washington, DC, USA, 2009.
57. Holcombe, S. *Lessons from Practice: Assessing Scalability*; The World Bank: Washington, DC, USA, 2012.
58. Hancock, J. *Scaling up the Impact of Good Practices in Rural Development: A Working Paper to Support Implementation of the World bank's Rural Development Strategy*; Report No. 26031; The World Bank: Washington, DC, USA, 2003.
59. Brainard, L. Investing in knowledge for development: The role of science & technology in the fight against global poverty. In Proceedings of the Thirtieth Annual AAAS Forum on Science and Technology Policy, Washington, DC, USA, 21–22 April 2005.

60. Frison, E.A.; Cherfas, J.; Hodgkin, T. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. *Sustainability* **2011**, *3*, 238–253. [CrossRef]
61. Jaffe, A.B.; Newell, R.G.; Stavins, R.N. A tale of two market failures: Technology and environmental policy. *Ecol. Econ.* **2005**, *54*, 164–174. [CrossRef]
62. Schreinemachers, P.; Berger, T.; Aune, J.B. Simulating soil fertility and poverty dynamics in Uganda: A bio-economic multi-agent systems approach. *Ecol. Econ.* **2007**, *64*, 387–401. [CrossRef]
63. Johnson, N.L.; Ruttan, V.W. Why are farms so small? *World Dev.* **1994**, *22*, 691–706. [CrossRef]
64. Thrupp, L.A.; Cabarle, B.; Zazueta, A. Participatory methods in planning & political processes: Linking the grassroots & policies for sustainable development. *Agric. Human. Values* **1994**, *11*, 77–84. [CrossRef]
65. Edquist, C. Systems of innovation—Technologies, institutions and organization. In *Science, Technology and the International Political Economy*; Program of Research on International Management and Economy (PRIME): Ottawa, ON, Canada, 1997.
66. Garnsey, E.; Heffernan, P. High-technology clustering through spin-out and attraction: The Cambridge case. *Reg. Stud.* **2005**, *39*, 1127–1144. [CrossRef]
67. OECD. *Agricultural Innovation Systems—A Framework for Analysing the Role of the Government*; OECD: Paris, France, 2013.
68. Dethier, J.J.; Effenberger, A. Agriculture and development: A brief review of the literature. *Agric. Nat. Resour. Econ. Ejournal* **2011**, *36*, 175–205. [CrossRef]
69. Pardey, P.G.; Alston, J.M.; Ruttan, V.W. Chapter 22—The economics of innovation and technical change in agriculture. In *Handbook of the Economics of Innovation*; Hall, B.H., Rosenberg, N., Eds.; North Holland: Amsterdam, The Netherlands, 2010; Volume 2, pp. 939–984. [CrossRef]
70. Johansson, K.-E.; Axelsson, R.; Kimanzu, N.; Sassi, S.; Bwana, E.; Otsyina, R. The pattern and process of adoption and scaling up: Variation in project outcome reveals the importance of multilevel collaboration in agroforestry development. *Sustainability* **2013**, *5*, 5195–5224. [CrossRef]
71. Dinesh, D.; Frid-Nielsen, S.; Norman, J.; Mutamba, M.; Loboguerrero Rodriguez, A.M.; Campbell, B.M. *Is Climate-Smart Agriculture Effective? A Review of Selected Cases*; CCAFS Working Paper no. 129; CGIAR Research Programme on Climate Change, Agriculture and Food Security (CCAFS): Copenhagen, Denmark, 2015.
72. Kilcher, L. How organic agriculture contributes to sustainable development. *J. Agric. Res. Trop.* **2007**, *89*, 31–49.
73. Leakey, R. Chapter 20—Agroforestry: A delivery mechanism for multi-functional agriculture. In *Handbook on Agroforestry: Management Practices*; Kellimore, L.R., Ed.; Environmental Science, Engineering and Technology Series; Nova Science Publishers: Hauppaug, NY, USA, 2010; pp. 978–979.
74. Ahmad, F. Sustainable agriculture system in Malaysia. In Proceedings of the Regional Workshop on Integrated Plant Nutrition System (IPNS), Development in Rural Poverty Alleviation, Bangkok, Thailand, 18–20 September 2001.
75. Pieri, C.; Evers, G.; Landers, J.; O'Connell, P.; Terry, E. *No-Till Farming for Sustainable Rural Development*; The International Bank for Reconstruction and Development Rural Development Department: Washington, DC, USA, 2002.
76. United Nations Department of Economic and Social Affairs. *Circular Agriculture for Sustainable Rural Development—The Environmental Impact of Conventional Agriculture*; Policy Brief. #105; UN DESA: New York, NY, USA, 2021. [CrossRef]
77. Anderberg, S. The contribution of organic agriculture to poverty reduction. In *Vulnerability of Agricultural Production Networks and Global Food Value Chains Due to Natural Disasters*; Breiling, M., Anbumozhi, V., Eds.; Economic Research Institute for ASEAN and East Asia: Jakarta, Indonezia, 2020; pp. 42–72.
78. Finckh, M.R. Integration of breeding and technology into diversification strategies for disease control in modern agriculture. In *Sustainable Disease Management in a European Context*; Collinge, D.B., Mink, L., Cooke, B.M., Eds.; Springer: Berlin/Heidelberg, Germany, 2008; pp. 399–409. [CrossRef]
79. Gwaza, D.S.; Gambo, D. Application of radio frequency identification to selection for genetic improvement of rural livestock breeds in developing countries. *J. Anim. Husb. Dairy Sci.* **2017**, *1*, 38–52.
80. Monau, P.; Raphaka, K.; Zvinorova-Chimboza, P.; Gondwe, T. Sustainable utilization of indigenous goats in Southern Africa. *Diversity* **2020**, *12*, 20. [CrossRef]
81. Kahi, A.K.; Rewe, T.O.; Kosgey, I.S. Sustainable community-based organizations for the genetic improvement of livestock in developing countries. *Outlook Agric.* **2005**, *34*, 261–270. [CrossRef]
82. FAO. *Development of Integrated Multipurpose Animal Recording Systems*; FAO Animal Production and Health Guidelines; No. 19; FAO: Rome, Italy, 2016.
83. Smale, M.; Diakite, L.; Sidibe, A.; Grum, M.; Jones, H.; Traore, I.S.; Guindo, H. The impact of participation in diversity field fora on farmer management of millet and sorghum varieties in Mali. *Afr. J. Agric. Resour. Econ.* **2010**, *4*, 23–47. [CrossRef]
84. Sidibé, A.; Meldrum, G.; Coulibaly, H.; Padulosi, S.; Traore, I.; Diawara, G.; Sangaré, A.R.; Mbosso, C. Revitalizing cultivation and strengthening the seed systems of fonio and bambara groundnut in Mali through a community biodiversity management approach. *Plant. Genet. Resour.* **2020**, *18*, 31–48. [CrossRef]
85. ASAL-APRP Exhibition of Indigenous Chicken Technologies at Nakuru Show. Available online: https://www.kalro.org/asal-aprp/Nakuru%20show (accessed on 11 October 2022).
86. FAO. Livestock Show and Agricultural Exhibition to Promote Food Security. Available online: https://www.fao.org/south-sudan/news/detail-events/en/c/1258579/ (accessed on 11 October 2022).

87. Abate, T.; Van Huis, A.; Ampofo, J.K.O. Pest management strategies in traditional agriculture: An African perspective. *Annu. Rev. Entomol.* **2000**, *45*, 631–659. [CrossRef]
88. Van den Berg, H.; Jiggins, J. Investing in farmers—The impacts of farmer field schools in relation to integrated pest management. *World Dev.* **2007**, *35*, 663–686. [CrossRef]
89. Gyawali, S.; Sthapit, B.; Joshi, B.K.; Mudwari, A.; Bajracharya, J. Participatory Plant Breeding (PPB): A strategy of enhancing and maintaining crop diversity. In *Good Practices: On-Farm Management of Agricultural Biodiversity in Nepal*; Sthapit, B.R., Shrestha, P.K.U.M.P., Eds.; NARC, LI-BIRD, International Plant Genetic Resources Institute, IDRC: Kathmandu, Nepal, 2006.
90. FAO. *Plant Breeding and Farmer Participation*; Ceccarelli, S., Guimaraes, E.P., Weltzien, E., Eds.; FAO: Rome, Italy, 2009.
91. Ceccarelli, S.; Grando, S. Decentralized-participatory plant breeding: An example of demand driven research. *Euphytica* **2007**, *155*, 349–360. [CrossRef]
92. Halewood, M.; Deupmann, P.; Sthapit, B.R.; Vernooy, R.; Ceccarelli, S. *Participatory Plant Breeding to Promote Farmers' Rights*; Bioversity International: Rome, Italy, 2007.
93. Valdivia Bernal, R.; De Jesús, F.; Velarde, C.; Catón, M.O.; Betancourt Vallejo, A.; Ortega Corona, A.; Vidal Martínez, A.; Calderón, A.E. Participatory development of maize synthetic hybrids and seed production by farmers. *Agric. Técnica En México* **2007**, *33*, 135–143.
94. Witcombe, J.R.; Joshi, A.; Joshi, K.D.; Sthapit, B.R. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. *Exp. Agric.* **1996**, *32*, 445–460. [CrossRef]
95. Witcombe, J.R.; Joshi, K.D.; Gyawali, S.; Musa, A.M.; Johansen, C.; Virk, D.S.; Sthapit, B.R. Participatory plant breeding is better described as highly client oriented plant breeding. I. Four indicators of client orientation in plant breeding. *Exp. Agric.* **2005**, *41*, 299–319. [CrossRef]
96. Witcombe, J.R.; Hollington, P.A.; Howarth, C.J.; Reader, S.; Steele, K.A. Breeding for abiotic stresses for sustainable agriculture. *Philos. Trans. R. Soc. B Biol. Sci.* **2008**, *363*, 703–716. [CrossRef]
97. Witcombe, J.R.; Gyawali, S.; Sunwar, S.; Sthapit, B.R.; Joshi, K.D. participatory plant breeding is better described as highly client-oriented II. Optional farmer collaboration in the segregating generations. *Exp. Agric.* **2006**, *42*, 79–90. [CrossRef]
98. Bioversity International. *Community Seed Banks—Origins, Evolution and Prospects*; Vernooy, R., Shrestha, P., Sthapit, B.R., Eds.; Routledge: Abingdon, UK, 2015.
99. Vernooy, R.; Sthapit, B.; Otieno, G.; Shrestha, P.; Gupta, A. The roles of community seed banks in climate change adaption. *Dev. Pract.* **2017**, *27*, 316–327. [CrossRef]
100. FAO. *Farmer Field Schools for Small-Scale Livestock Producers—A Guide for Decision Makers on Improving Livelihoods*; FAO Animal Production and Health Guidelines No. 20; FAO: Rome, Italy, 2018.
101. CGIAR. Farms of the Future: A Two-Way Learning Exchange. Available online: https://ccafs.cgiar.org/news/farms-future-two-way-learning-exchange (accessed on 11 October 2022).
102. COMACO. Farmer Exchange Visits: Learning from Each Other to Protect the Environment. Available online: https://itswild.org/farmer-exchange-visit/ (accessed on 11 October 2022).
103. Nguyen, C. Art Competition Showcases Public View of Livestock Development in Vietnam. Available online: https://www.ilri.org/news/art-competition-showcases-public-view-livestock-development-vietnam (accessed on 18 July 2022).
104. ILRI. Livestock Development in Vietnam from Artists' and Farmers' Perspectives. Available online: https://livestockpanorama.ilri.org/en (accessed on 11 October 2022).
105. Giuliani, A. *Developing Markets for Agrobiodiversity Securing Livelihoods in Dryland Areas*; Earthscan Research Editions: London, UK, 2007.
106. Kruijssen, F.; Keizer, M.; Giuliani, A. Collective action for small-scale producers of agricultural biodiversity products. *Food Policy* **2009**, *34*, 46–52. [CrossRef]
107. Vinceti, B.; Elias, M.; Azimov, R.; Turdieva, M.; Aaliev, S.; Bobokalonov, F.; Butkov, E.; Kaparova, E.; Mukhsimov, N.; Shamuradova, S.; et al. Home gardens of Central Asia: Reservoirs of diversity of fruit and nut tree species. *PLoS ONE* **2022**, *17*, e0271398. [CrossRef]
108. Gotor, E.; Caracciolo, F.; Elias, M. *Livelihood Implications of in Situ-On Farm Conservation Strategies of Wild Fruit Species in Uzbekistan*; Bioversity International series of Impact Assessment Briefs; Bioversity International: Maccarese, Italy, 2015.
109. Turdieva, M.K.; Kayimov, A.K.; Baymetov, K.I.; Mustafina, F.U.; Butkov, E.A. Conservation and Sustainable Use of Biodiversity of Fruit Crops and Wild Fruit Species. In Proceedings of the International Scientific and Practical Conference, Tashkent, Uzbekistan, 23–26 August 2011.
110. Asnawi, A.; Amrawaty, A.A. A study of effect agribusiness micro finance for beef cattle farmers in South Sulawesi Indonesia. *Earth Environ. Sci.* **2019**, *334*, 012052. [CrossRef]
111. Kher, B.M. The role of rural banks in the development of rural socio-economy. *Int. J. Res. Humanit. Soc. Sci.* **2013**, *22*, 25–40.
112. Ramakrishnappa, K. Geographical indications: A legal tool for protection of traditional varieties. *Biomedicine* **2006**, *1*, 91–93.
113. Garcia, C.; Marie-Vivien, D.; Kushalappa, C.G.; Chengappa, P.G.; Nanaya, K.M. Geographical indications and biodiversity in the western ghats, India. *Mt. Res. Dev.* **2007**, *27*, 206–210. [CrossRef]
114. Agnoletti, M.; Santoro, A. Agricultural heritage systems and agrobiodiversity. *Biodivers. Conserv.* **2022**, *31*, 2231–2241. [CrossRef]
115. African Union. *Continental Strategy for Geographical Indications in Africa 2018–2023*; African Union: Addis Ababa, Ethiopia, 2019.

116. Argumedo, A. The Potato Park, Peru: Conserving Agrobiodiversity in An Andean Indigenous Biocultural Heritage Area. *Prot. Landsc. Agrobiodiversity Values* **2008**, *1*, 45–58.
117. Tapia, M.E. Mountain agrobiodiversity in Peru. *Mt. Res. Dev.* **2000**, *20*, 220–225. [CrossRef]
118. Vernooy, R.; Ruiz, M. Access to and benefit sharing of plant genetic resources: Novel field experiences to inform policy. *Resources* **2013**, *2*, 96–113. [CrossRef]
119. Hilali, M.; Rischkowsky, B.A. *Simple Smokers to Improve Traditional Dairy Products*; SmaRT Ethiopia Intervention factsheet 6; ICARDA: Addis Ababa, Ethiopia, 2017.
120. Heinz, G. *Preservation and Processing Technologies to Improve Availability and Safety of Meat and Meat Products in Developing Countries*; FAO: Rome, Italy, 1995.
121. Ruiz, M.; Vernooy, R. *The Custodians of Biodiversity*; Ruiz, M., Vernooy, R., Eds.; Routledge: London, UK, 2012.
122. Gauchan, D.; Joshi, B.K.; Bhandari, B. Farmers' rights and access and benefit sharing mechanisms in community seed banks in Nepal. In Proceedings of the Community Seed Banks in Nepal, 2nd National Workshop Proceedings, Kathmandu, Nepal, 3–5 May 2018; Joshi, B.K., Shrestha, P., Gauchan, D., Vernooy, R., Eds.; NAGRC: Entebbe, Uganda; LI-BIRD: Pokhara, Nepal; Alliance of Bioversity International and CIAT: Rome, Italy, 2018.
123. Herrero, M.; Thornton, P.K.; Gerber, P.; Reid, R.S. Livestock, livelihoods and the environment: Understanding the trade-offs. *Curr. Opin. Environ. Sustain.* **2009**, *1*, 111–120. [CrossRef]
124. Joshi, B.K. *Good Practices for Agrobiodiversity Management*; NAGRC: Entebbe, Uganda; LI-BIRD: Pokhara, Nepal; Alliance of Bioversity International and CIAT: Rome, Italy, 2020.
125. FAO. *LinKS Project—Gender, Biodiversity and Local Knowledge Systems for Food Security*; FAO: Rome, Italy, 2006.
126. ECHO. *Farmers' Seed Fairs*; Techincal Note #67; ECHO: North Fort Myers, FL, USA, 2014.
127. Cardinaletti, L.; Thüngen, J.V.; Lanari, M. Marketing of wool for traditional handicraft with Linca sheep from Patagonia. In Proceedings of the Paper presented during writeshop on Marketing Niche Products from Indigenous Livestock, Kalk Bay, South Africa, 4–6 December 2008.
128. Sthapit, B.; Rana, R.; Eyzaguirre, P.; Jarvis, D. The value of plant genetic diversity to resource-poor farmers in Nepal and Vietnam. *Int. J. Agric. Sustain.* **2008**, *6*, 148–166. [CrossRef]
129. McGuire, S.J. Securing access to seed: Social relations and sorghum seed exchange in eastern Ethiopia. *Hum. Ecol.* **2008**, *36*, 217–229. [CrossRef]
130. Meinzen-Dick, R.; Eyzaguirre, P. Non-market institutions for agro-biodiversity conservation. In *Agrobiodiversity, Conservation and Economic Development*; Kontoleon, A., Pascual, W., Smale, M., Eds.; Routledge: London, UK, 2009; pp. 82–91.
131. Grazioli, F.; Turdieva, M.; Kettle, C.J. The role of school gardens as conservation networks for tree genetic resources. In *Agrobiodiversity, School Gardens and Healthy Diets*; Bioversity International: Maccarese, Italy, 2020; Volume 105.
132. Drucker, A.G.; Ramirez, M. Payments for agrobiodiversity conservation services: An overview of Latin American experiences, lessons learned and upscaling challenges. *Land Use Policy* **2020**, *99*, 104810. [CrossRef]
133. Montagnini, F.; Finney, C. Payments for environmental services in Latin America as a tool for restoration and rural development. *Ambio* **2011**, *40*, 285–297. [CrossRef]
134. Chambers, R. Poverty and livelihoods: Whose reality counts? *Environ. Urban.* **1995**, *7*, 173–204. [CrossRef]
135. Igoe, J. Scaling up civil society: Donor money, NGOs and the pastoralist land rights movement in Tanzania. *Dev. Chang.* **2003**, *34*, 863–885. [CrossRef]
136. Sanginga, P.; Best, R.; Chitsike, C.; Delve, R.; Kaaria, S.; Kirkby, R. Enabling rural innovation in Africa: An approach for integrating farmer participatory research and market orientation for building the assets of rural poor. *Uganda J. Agric. Sci.* **2004**, *9*, 934–949.
137. Malerba, F. Sectoral systems of innovation and production. *Res. Policy* **2002**, *31*, 247–264. [CrossRef]
138. Leeuwis, C.; Aarts, N. Rethinking communication in innovation processes: Creating space for change in complex systems. *J. Agric. Educ. Ext.* **2011**, *17*, 21–36. [CrossRef]
139. World Bank. *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems*; World Bank: Washington, DC, USA, 2007.
140. Powell, W.W.; Grodal, S. *Networks of Innovators—The Oxford Handbook of Innovation*; Oxford University Press: Oxford, UK, 2006.