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A Catalyst toward Sustainability? Exploring Social Learning and Social Differentiation Approaches with the Agricultural Poor

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Abstract: Emerging sustainability challenges, such as food security, livelihood development and climate change, require innovative and experimental ways of linking science, policy and practice at all scales. This requires the development of processes that integrate diverse knowledge to generate adaptive development strategies into the future. Social learning is emerging as a promising way to make these linkages. If and how social learning approaches are being applied in practice among smallholder farming families—the bulk of the world's food producers, requires specific attention. In this paper we use a case study approach to explore social learning among the agricultural poor. Five key evaluative factors: context assessment, inclusive design and management, facilitating learning, mobilizing knowledge and assessing outcomes, are used to analyze nine projects and programs in (or affiliated with) the Consultative Group on International Agricultural Research (CGIAR). We explore three main questions: (1) in what contexts and in what ways are socially differentiated and marginalized groups enrolled in the learning process? (2) what, if any, are the additional benefits to social learning when explicitly using strategies to include socially differentiated groups? and (3) what are the benefits and trade-offs of applying these approaches for development outcomes? The findings suggest that, in the agricultural development context, social learning projects that include socially differentiated groups and create conditions for substantive two-way learning enhance the relevance and legitimacy of knowledge and governance outcomes, increasing the potential for accelerating sustainable development outcomes.

1. Introduction

Emerging sustainability challenges, such as food security, livelihood development and climate change, require innovative and experimental ways of linking science, policy and practice at all scales [1–6]. This requires the development of processes that integrate diverse knowledge to generate adaptive development strategies into the future. Social learning is emerging as a promising way to make these linkages [7–15]. As both a research and governance approach, social learning refers to "a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks" [11]. Learning approaches are considered to be necessary to navigate complex and uncertain conditions. Cases studies in social learning have the potential to identify what types of learning environments work and how, where it is (or is not) appropriate to use learning methods and approaches for mobilizing learning and lessons learned (both successes and failures) more broadly [1,4]. In this way, social learning is emerging as a significant tool in the toolbox for transitioning toward sustainability.

Different disciplines are building upon the potential of social learning [8,10–17]. Social learning methods are being used and evaluated in diverse contexts at different scales including areas such as collaborative co-management of natural resources, livelihoods' development research and practice, global environmental change, socio-technical transitions and multi-level governance [9,10,12–14,18,19]. Often learning approaches have names taken from different disciplinary methods and techniques (e.g., participatory action research, participatory varietal selection, participatory impact pathways analysis). What these methods have in common is the importance of establishing dialogue and exchange with key and interdependent actors and fostering a learning-by-doing approach under complex conditions. It has been argued that a common framework for evaluation should be used to tease critical insights about learning and sustainability from this diversity [4].

In particular, the development community has much to offer in terms of engaging diverse actors in learning environments. Participatory approaches used at the intersection of sustainable agricultural and livelihood development and, more recently, adaptive capacity development offer critical insights for ways to address geographic and socio-economic complexity [20,21]. For instance, poor socio-economic conditions increase vulnerability to climate impacts [22] and that vulnerability is a function of the "character, magnitude and rate of climate change and variation to which the system is exposed, its sensitivity, and its adaptive capacity" [23]. In the agricultural sector in developing countries, this means rural smallholder farmers and farming communities face "double exposure" to both the fluctuations of economic globalization and climate variability and change [24]. Climate change could decrease crop production by 20%–50% [25] and rural poor agriculturalists are likely to be most affected [22]. In this type of development context, projects are beginning to emerge that address both socio-economic and climate-related vulnerabilities and stresses in integrated ways. For instance, climate-smart villages are generating learning laboratories where the socio-economic and climate

change vulnerabilities of rural agriculture are addressed at a more systemic level, turning "global food supply into more efficient multi-functional value chains" crucial for achieving sustainability [26]. Cross-scale, cross-sector linkages are being examined in order to generate or co-create relevant, legitimate and appropriate strategies for sustainable development [1,3].

Moreover, assessments of vulnerability extend into the social sphere where demographic or socially differentiated markers of communities and groups (e.g., socioeconomic status, gender, age, ethnicity) are known to increase sensitivity to climate impacts (e.g., the poor residing in hazard-prone areas) due to a compromised capacity to adapt (e.g., poverty) [25]. Among rural smallholder farmers, socio-cultural marginalization among the poor, women, the young and the elderly and the ethnic or indigenous, limits these socially differentiated groups in their ability to access knowledge, technology and power, further limiting their capacity to adapt [27]. For instance, women's limited access to resources, their restricted rights, limited mobility and reduced authority in the community are likely to be exacerbated under climate change [28–31]. We know that households and individuals hold and invest in different types of assets and that the ability to amass and maintain assets helps to manage risk and overcome shocks, yet women usually have fewer assets than men or own assets of less value [32,33]. These asymmetries lead to further exclusion and limit the adaptive capacity of women under changing conditions.

Research is beginning to highlight the potential significance of addressing such asymmetries [3,25,29,31,34]. Recent estimates suggest that: "women comprise on average 43% of the agricultural labour force in developing countries, ranging from 20% in Latin America to 50% in Eastern Asia and Sub-Saharan Africa" [35] (p. 5). This same FAO report argues that reducing gender inequalities in access to productive resources and services could produce an increase in yields on women's fields of 20%–30%, which in turn could raise agricultural output in developing countries by two and a half to four percent [35]. Whereas, further exclusion of socially differentiated groups such as women from agricultural development and innovation strategies pose significant challenges for local food security, agricultural commodities and global food supply chains. In this way, integrating socially differentiated groups and actors and their knowledge contributions into research and governance processes may have the potential to enhance overall development outcomes.

Evidence is growing to support an optimistic view of the role that social learning can play in engaging typically marginalized groups in innovative knowledge generation and governance processes [15,20]. Examples from community-based natural resource management show how learning from and responding to socially differentiated groups is a potential driver for the increased adoption of development technologies and services and to overall change in practice [36,37]. Pro-poor research and gender transformative approaches emphasize learning with and among socially differentiated groups [25,31,38]. Initial evidence suggests, for instance, that beyond empowering women, the inclusion of women in learning environments can also lead to improved and accelerated development outcomes [25,31,38]. Thus, it appears that these approaches have much to contribute when exploring questions of when and how to include the most vulnerable socially differentiated groups in social learning environments and the benefits and trade-offs of doing so.

In this study, a scan was performed of the Consultative Group on International Agricultural Research (CGIAR) to identify projects and programs that include socially differentiated groups in processes of social learning at the intersection of agricultural, livelihood and adaptive capacity development. The goal was to address the questions: (1) in what contexts and in what ways are socially

differentiated and marginalized groups involved in the learning process? (2) what, if any, are the additional benefits to social learning when explicitly using strategies to include socially differentiated groups? and (3) what are the benefits and trade-offs of applying this approach for development outcomes?

In Section 2 of this paper, we introduce five key features of social learning approaches that include socially differentiated groups. Developed from an extensive literature review, these five features include: the role of context; the management and design of science-policy/practice interfaces; the form of learning (e.g., single, double, triple loop learning); channels for knowledge mobilization; and benefits and trade-offs for outcomes. In Section 3, we describe the qualitative methods used to perform a scan of CGIAR projects and programs identifying projects that bridge social learning with socially differentiated groups and the analytical methods used to explore our research questions. In Section 4, we introduce and discuss the findings using the five-feature framework. In Section 5, we offer some concluding remarks on identifiable ways in which including socially differentiated groups has the potential to increase learning and, in a number of cases, outcomes in agricultural development and climate change contexts.

2. A Framework for Examining Social Learning and Social Differentiation

Current inquiry into social learning examines how learning occurs or can occur, the extent to which social learning is facilitated by participatory processes, how best to design processes to facilitate learning and the ways that learning may (or may not) lead to positive socio-ecological or sustainability outcomes [4,11,12,14]. Calls have been made for greater conceptual clarity both in the processes used and in ways of evaluating outputs and outcomes of learning [4,11,12,14]. Reed *et al.* [11] outline three defining characteristics of social learning: (1) a change in understanding and practice occurs; (2) the scale of change is mobilized beyond individuals and small social units; and (3) learning occurs via social networks. This meta-framework provides guidance while allowing for great diversity in types and styles of learning experimentation.

In our review of diverse literatures (*i.e.*, science-policy, adaptive capacity, development and socio-technical change), we identified five common features of social learning: (1) the role of context—relevant actors are identified; (2) the design and management among science-policy/practice interfaces—how interaction and exchange among diverse actors, including social differentiated groups, is managed; (3) the form of social learning—*i.e.*, addressing a technical problem *vs.* exploring the underlying needs, values and norms required to appropriately address the problem; (4) channels for knowledge mobilization—development of partnerships and networks; and (5) development outcomes—the need to evaluate changes in practice over time. These five features agree with the categorizations used in the literature and are outlined in detail below [39]. Particular attention is given to approaches that explicitly aim to avoid augmenting disparities by addressing socially differentiated groups such as agricultural women and the agricultural poor.

Social differentiation is a sociological term that uses common defining characteristics such as age, gender, ethnicity, socio-economic status, *etc.* to distinguish between and find commonality among groups. It is assumed that certain defining characteristics also contribute to a shared understanding of the world, how it works and particular groups' contexts and roles within it. It is therefore pertinent to

explore at a more systemic level the contexts and the ways the most vulnerable, the agricultural poor, are enrolled in and can contribute to social learning based on socially differentiated identities.

2.1. Context Assessment and Context Setting

Capacity strengthening approaches that emphasize community context in assessing and developing local livelihood and adaptive capacity are particularly relevant for examining underlying cultural and institutional drivers of particular practices. These are generally synergistic with the tenets of social learning [6]. The success of livelihood interventions aimed at improving food security, for instance, is partly dependent on quantified data on agricultural yields and their uses for income and food security; though difficult to attain due to limited household accounting (though socio-economic baselines are now regularly being undertaken) [19,40]. Even more so, success requires teasing apart the relative roles that contextual social, agro-ecological, political, cultural and institutional factors play in determining how, when and for what purposes changes in practice do or do not occur [11,31,41–43]. Contextual pressures such as access to information and marginalization from decision-making are often responsible for whether and how the most vulnerable respond to challenges.

It is therefore the role of the researcher to understand both the pressures being exerted within a community context and the most appropriate methods for elevating drivers and overcoming barriers. As Harvey *et al.* note "There is always a need to look inside the institution itself to see where the opportunities and barriers might lie, and outside into the broader context where one hopes to effect change, in order to understand the alliances that can be forged, the constraints that must be overcome, and one's own positionality as an intervening force" [16].

From a research perspective, this usually requires multiple methods (qualitative and quantitative) and sensitive and inclusive strategies to capture different perspectives (e.g., young, old, poor, rich, men, women). For instance, multiple scales of decision-making, cross-scale institutions and the perspectives of actors at even the most local and rural scales require examination in order to address drivers of and barriers to agricultural and livelihood development and adaptive capacity [43]. Both technological and practice advances and innovations *and* institutional modifications are valid adaptation strategies [44], reinforcing the need for thoughtful and targeted approaches, whereby decision-makers, researchers, practitioners, and relevant actors, such as socially differentiated groups, have knowledge and perspective to share.

2.2. Inclusive Design in Learning Experiments

A learning frame implies that conventional knowledge transfer is not sufficient for addressing complex problems with high levels of uncertainty such as livelihood and adaptive capacity development. In areas where science interfaces with society, knowledge and practices are contingent on different contextual needs, values and norms [45,46]. The relevance, legitimacy and appropriateness of knowledge are negotiated at this interface whether this interface is managed or not [46–50]. Managing and/or shaping when, why and how science moves into society, by including all relevant and interdependent actors, with their diverse knowledge and interests, in a process of exchange and deliberation has the potential to alter typical binary interpretations of science and technology as either

acceptable or unacceptable. These types of approaches may foster the conditions from which hybrid knowledge is co-created [50,51].

In livelihood and adaptive capacity approaches, bringing the most vulnerable socially differentiated groups alongside other influencers and stakeholders into these interfaces, brings new ideas, materials, and information and holds the potential to fundamentally shape or re-shape the negotiation of what is and is not relevant, legitimate and appropriate knowledge where research meets society and practice. Rist *et al.* [41] describe the ways this can create new forms of communication among internal and external actors, rebalancing relationships between social capital and other relevant competencies within a learning context. For this to occur, conventional power imbalances need to be moderated. It is understood that trustful relationships are more likely developed when interfaces are designed for less hierarchical patterns of communication [41,51]. Managing "safe interfaces" in which to exchange, deliberate and negotiate the relevance and legitimacy of diverse information is critical for generating new forms of communication, such as those that moderate any imbalances in power, and that build the trust necessary to unleash diversity and creativity toward learning, co-creation and innovation [3,4,10,52,53].

2.3. Facilitating Learning

Learning environments tend to build relational capacities and networks, contributing to more potential for broad-based adoption of relevant, legitimate and credible strategies and policies, creating the basis for joint future action [54,55]. Of critical importance in learning environments where socially differentiated groups are involved, the attitude, skills and capacities of the facilitator are crucial for moderating power imbalances and knowledge hierarchies in order to foster an environment of meaningful exchange, deliberation and, ideally, learning (for an exploration of seven key elements of strong facilitation, see [56]).

Learning has been characterized by three distinct and interacting learning loops (see Box 1) (adapted from [13]). Each of these loops describes a different form of learning, based on the extent to which actors are enabled or encouraged to interrogate the tacit assumptions and underlying values implicit in knowledge for action. Single loop learning contributes to insights and approaches for improving performance and efficiency (*i.e.*, in skills and practices) in order to meet existing goals. Double and triple loop learning, in contrast, involve the exchange of ideas, perspective, materials and knowledge among interdependent actors (including researchers). In double loop learning, reflection is encouraged that considers the tacit interests and assumptions that underlie particular goals and actions. Typically in this loop, the context, a particular problem or challenge, has been framed and interdependent actors are invited to address the challenge by asking: are these the right things to do? This form of learning aims at identifying underlying needs, values and norms that shape practice and action. It is typically associated with participatory action research and multi-stakeholder processes.

Triple loop learning, also referred to as "critical or emancipatory" in action research, encourages a more open-ended and deep-seated discussion about what the primary challenges are and ways to reshape the values, norms and social structures to address it. In triple loop learning, underlying interests, needs, values and norms are probed among interdependent actors to address the question: what are the right things to do? In this loop, exchange and deliberation about key underlying drivers and barriers help question what the critical problems are, the approaches used to address them and the

influence of the systems that govern them (enabler or barrier). Otherwise known as co-production or co-creation [46,49,50], this learning emerges through the interaction.

Box 1. Form of learning.

> **TRIPLE LOOP: Transformative Learning**
> Learning question: What is the right thing to do?
> **DOUBLE LOOP: Communicative Learning**
> Learning question: Are we doing the right things?
> **SINGLE LOOP: Instrumental Learning**
> Learning question: Are we doing things right?

Adapted from Yuen *et al.* 2013 [13].

A learning environment can be important for stabilizing knowledge for use in policy and practice [46] (p. 37.) Collaborative learning products or "boundary objects" such as ideas, maps, reports, standards or models, are a crucial way of building legitimacy for joint action. Particularly in double and triple loop learning, these products facilitate learning and knowledge that is "plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across (different interests, disciplines, and cultures)" [57] (p. 393). These objects or products are critical for mobilizing learning beyond the individual to other social contexts [5].

2.4. Mobilizing Knowledge

Diverse forms of networks and varied types of tools become channels to mobilize learning and knowledge products beyond the individual, with the aim of leading to changes in practice. Networks include (but are not limited to) partnership formation, existing professional, practice and peer networks (e.g., farmer support groups, community groups, farmer associations); boundary-spanning networks, whereby participants from diverse scales of governance mobilize differentiated learning along their respective networks, ideally collectively shaping a common praxis or goal. Technology-mediated tools can help to mobilize knowledge along virtual networks including radio, video [15] and via web-based applications such as webinars, e-dialogues or virtual conferences [58].

Identifying existing and potential networks, tools and strategies has the potential to advance the toolbox to better understand how to more effectively mobilize knowledge from the sphere of contingent innovation, identifying different learning combinations and scaling development successes more broadly in practice. Of interest, networks among socially differentiated groups, particularly women, have been identified as having great potential for mobilizing relevant and legitimate knowledge that enhances and accelerates livelihood development outcomes, increasing sustainable livelihoods and adaptive strategies [31].

2.5. Assessing Outcomes

Social learning is one of many approaches that can be considered when identifying and implementing sustainable livelihood and adaptive capacity interventions. Scholars and practitioners are

calling for a better understanding of when to apply social learning methods and the benefits and trade-offs of doing so [11]. As such, if the qualitative features of social learning are to be taken seriously as a methodology to be used under certain conditions, particularly in relation to livelihood and adaptive capacity development, then "moving beyond asset and capital impact indicators to ones measuring more intangible processes, including networks, decision-making and governance, innovation and experimentation, and institutional capacities for forward-looking features that contribute to a dynamic not static form of adaptive capacity of a system" is necessary [59] (p. 2). The influence and evaluation of social learning still requires more empirical examination but holds the promise of shaping the ways that climate change and development research and governance is done. This is particularly important when working with and including socially differentiated groups. It has been noted that a common evaluative framework can help to better understand these processes and their impact for development outcomes [4].

3. Methods

There are three particular ways CGIAR, made up of 15 research centres distributed globally, provides an opportune learning laboratory from which to investigate the role of social differentiation in social learning. First, CGIAR's recent emphasis on linking current and projected climate impacts and responses to agricultural and livelihood research and development through its cross-cutting research program on Climate Change, Agriculture and Food Security (CCAFS), provides an opportune space from which to consider and to experiment with new types and forms of research and forward-looking collaborative learning. The emphasis on improving livelihoods of the poor, enhancing food security and strengthening adaptive capacity provides the (rather daunting) space to focus on asymmetries in power affecting socially-differentiated groups (*i.e.*, women, elderly, youth, poor, indigenous).

Second, the new CGIAR Strategic Framework requires that research be relevant and applied towards achieving sustainable development outcomes. An outcome focus makes the CGIAR particularly conducive for considering innovative social learning approaches (even though they may use other terminology) aimed at linking the most vulnerable with relevant knowledge that leads to sustainable development outcomes.

Third, gender is a cross-cutting theme of high priority in the CGIAR. Gender specialists, and perhaps more transformatively, gender-focused research teams, are being hired and/or empowered by the CGIAR research centres and programs. Common among all the new CGIAR programs involving multiple research, government, private sector and development partners across the globe, is a desire to promote improved crop varieties, fish and livestock breeds, alternative sustainable agricultural, water, fisheries, land and forest management practices, and catalyse innovations that alleviate poverty, build livelihoods and address longer-term uncertainties such as climate change in southern agricultural communities.

In this context, we performed a scan of the CGIAR's 15 research centres to identify projects and programs related to social differentiation to better understand how the five features identified above contributed to social learning. Websites and documents were searched using the code words for projects and programs including socially differentiated groups. Search words were used: "gender" ("women"), "age" ("youth" and "elderly"), "ethnicity" (including "indigenous") and socioeconomic

status ("rural poor"). In addition, interim reports from the 15 research centres that were submitted to CCAFS were used to identify projects that included women, fulfilling GGIAR's new institutional requirements on gender.

Through the scan, we identified 26 participatory action research projects that included social differentiated groups who contributed to learning outcomes. To determine to what extent these projects fit or aligned with the social learning framework developed above, both document analysis and interviews were performed. Of 28 project and program managers contacted, 15 responded. Within the allotted timeframe we were able to schedule and perform interviews with nine. Seven of the projects identified were from the CGIAR; two were from non-governmental organizations, World Wildlife Fund|CARE and the Sustainable Food Lab, both of which had previous or ongoing partnerships with CGIAR research centres.

Nine semi-structured interviews were performed with project managers. These were conducted using Skype and were recorded. Interview questions related to the three overall research questions regarding the context, learning contributions and outcomes from including socially differentiated groups. Responses were coded based on the five features of the evaluative framework.

Table 1 summarizes the findings based on a synthesis of the document review and interviews. It provides the baseline analysis for addressing our three research questions regarding the context for including socially differentiated groups, including the design and management of an appropriate interface, their contribution to learning and how this learning is mobilized beyond the individual, and the benefits and/or trade-offs of their inclusion for development outcomes when using a social learning approach.

4. Results and Discussion

The nine CGIAR projects and programs are being performed at the nexus of agricultural, livelihood and (to a lesser degree) climate adaptation. The way knowledge is constructed, interpreted and mobilized in each of these projects is contingent on social, cultural, geographic, economic, institutional and governance conditions and is therefore inherently experimental and innovative. While most of the projects identified did not use the term social learning, approaches used under other names (e.g., participatory action research; participatory varietal selection; group visioning processes) were found to be the sites of dynamic learning environments.

The emphasis on agricultural research and livelihood development makes CGIAR projects and programs a living laboratory for exploring diverse and varied contexts where social learning with socially differentiated groups is occurring. The findings from the scan of the CGIAR projects and programs reviewed suggest that, in certain contexts, the inclusion of socially differentiated groups, such as women, indigenous and the rural poor, into research and service delivery contributes to important context assessment, interface design and management, facilitated learning, novel channels and tools for knowledge mobilization and important development outcomes. These key themes are outlined in Table 1 below. The detailed analysis of how these projects map onto the five-point framework are discussed in the following section.

Table 1. The five point framework for addressing context, learning and outcomes of social learning with women, the indigenous and the poor in the CGIAR.

	Social Learning with Women in Agriculture		
	Research Q's 1&2	Research Q's 1&2	Research Q's 2&3
Project	**Context assessment and interface design: Motivations for inclusion**	**Learning and mobilization: Two-way learning**	**Learning and development outcomes: Changes in practice**
AfricaRice: Rice Rural Learning Initiative [60]	**Research-driven**: Strengthens links between the informal seed sector and women's empowerment in four West African countries, linking women smallholder farmers to research, microfinance and markets.	Participatory Learning for Action Research (PLAR) uses farmer-to-farmer learning methods to encourage discussion and learning about varietal criteria and appropriate management practices. Researchers learn from farmers about preferred varieties and technologies for different ecologies; including the differentiated needs of women for faster maturing varieties (in four African countries) to address crucial periods of hunger.	Video-mediated learning via farmer-to-farmer learning videos, transferred through national extensionists and NGO's, lead to more appropriate varieties for both ecology and gender. Tested in Benin and Togo, the channel was found to be 80% more effective in changing behaviours than conventional innovation training and visit systems. Anecdotal evidence cites that the videos enhanced in-situ innovation among women's networks.
CIMMYT—International Maize and Wheat Improvement Center: Drought tolerant maize for Africa initiative [61]; Partner: IITA—International Institute for Tropical Agriculture	**Outcomes-driven**: Breeding 100 varieties of drought tolerant maize in Sub-Saharan Africa to benefit millions of men and women farmers in 13 African countries. Level of education and wealth were also identified as important social differentiations.	Using longer-term multi-season participatory varietal selection, including men and women farmers separately. Farmers compared crop varieties, becoming citizen scientists, collecting and comparing crop information ad results; researchers learned about varietal performance under moderate drought conditions over time; seed producers were able to optimize varieties for drought conditions in diverse agro-ecologies.	Personal stories were used in local media, both print and radio, to communicate farmer's learning and results. Partnerships were formed between extension specialists, seed producers, farmer organizations and NGOs contributed to extensive networks. Working with national agricultural research institutes, for instance, to train the extensionist trainers on 60 optimal varieties, helped to increase yields by 20%–30% under moderate drought. Learning is then embedded as part of a new learning cycle.

Table 1. *Cont.*

	Research Q's 1&2	Research Q's 1&2	Research Q's 2&3
	Social Learning with Women in Agriculture		
Project	**Context assessment and interface design: Motivations for inclusion**	**Learning and mobilization: Two-way learning**	**Learning and development outcomes: Changes in practice**
IRRI—International Rice Research Institute: STRASA—Stress tolerant varieties for Africa and South Asia [62]; **Partner: AfricaRice**	**Research-driven**: To reduce vulnerability of crops to abiotic stresses and increase livelihoods in unfavourable rice-growing environments. Collect aggregated baseline data in 11 rice-producing communities in Bangladesh and Nepal including female labour contributions to quantify women's participation in the rice production system.	Participatory varietal selection (PVS) used. Women have a significant role in production—selected varieties that cook faster, that have multiple uses such as household snacks and market value, and those that are easier to harvest and thresh. Women anticipate risks, such as drought and flooding, seeking ways to store surplus; men seek greater yields. Researchers and seed producers learn how to make research more relevant to livelihood needs.	Gender Protocol included in IRRI PVS research aiming to include 30% women from farming households. Inclusion provides relevant information to researchers about supply chain and seed breeders about needs and appropriate varieties. Anecdotal evidence that PVS empowers women to voice needs in Bangladesh and that the learning benefits are transmitted along robust women's networks.
WorldFish: A Gender Transformative Approach to Research in Development in Aquatic Agricultural Systems [63] **Partners: IWMI—International Water Management Institute; Bioversity International**	**Institutionally-driven**: Explores viable gender-differentiated strategies to enhance the resilience, productivity and diversity of the livelihoods of women living in highly vulnerable aquaculture systems.	Using a group-oriented visioning process, researchers train men and women farmers/fisherfolk separately to collect and interpret data so they are more independent in assessing their needs and ways to achieve gender-equitable livelihood and food security strategies and adaptive strategies to climate change.	Through farmers' networks and women's enrollment, improvements are being seen in fish circulation, homestead pond management and vertical agricultural systems. (WorldFish involves school children in learning about research and GIS mapping so they can take part in adapting to climate change in their own villages).

Table 1. *Cont.*

	Social Learning with Women in Agriculture		
Project	**Research Q's 1&2** **Context assessment and interface design: Motivations for inclusion**	**Research Q's 1&2** **Learning and mobilization: Two-way learning**	**Research Q's 2&3** **Learning and development outcomes: Changes in practice**
WWF—World Wildlife Fund & CARE International: Payment for Ecosystem Services Pilot Project in Navaisha, Kenya [64]	**Research and outcomes-driven**: Addresses siltation as a result of unsustainable land-use practices by working with Basin upstream and downstream communities and partners to identify a financial mechanism that contributes to environmental and livelihood goals. The most degraded farms were included; the rural poor and women farmers were included.	Women's inclusion lead to strategic insights into livelihood needs such as fodder crops for livestock and growing fruit trees near homesteads to curb periods of hunger. Importantly, women substantially shaped a voucher system instead of cash payment mechanism to ensure proceeds went to upgrading family agriculture, rather than cash ending up in the hands of men. Farmers were trained to track the benefits associated with changing practices, including record-keeping on crop types, yields, inputs, sales and overall water and soil management strategies. Researchers helped to identify livelihood strategies that could be funded by downstream users that would benefit the environmental conditions of the entire Basin.	Upper catchment farmers are rewarded with vouchers from downstream beneficiaries for reducing downstream river siltation by growing trees and changing practices. Vouchers are used to buy agricultural supplies, an innovative benefit-sharing arrangement that prevents discretionary spending and ensures benefits extend to the family. Anecdotal evidence suggests that households are experiencing benefits such as better fodder contributing to greater milk supply for household use and for additional income. Male and female farmers are performing on-farm accounting, making adjustments to inputs and outputs where necessary and are now supplementing water-monitoring data for researchers to monitor environmental improvements.

Table 1. *Cont.*

	Social Learning with Indigenous Farmers and Traditional Knowledge in Agriculture		
Project	**Research Q's 1&2** **Context assessment and interface design: Motivations for inclusion**	**Research Q's 1&2** **Learning and mobilization:** **Two-way learning**	**Research Q's 2&3** **Learning and development outcomes:** **Changes in practice**
CIP—International Potato Center: Impacts of climate change take a toll on Andean potato farmers [65]	**Research-driven:** This project used participatory mapping with high-resolution satellite images with potato farmers in the high Andes in order to catalogue potato diversity at elevation and to conserve a pool of varieties that may hold natural resistances to disease and pests under changing conditions.	Participatory mapping enabled farmers to identify their communal plots and contribute local knowledge on crop diversity and vulnerability, leading to two-way learning. Researchers learned that, over the past thirty years, farmers are ascending higher into the Andes to escape agricultural disease and pest problems due to increasing temperatures. They learn of traditional, undocumented varieties of potato with unique gene characteristics and natural resistances and sophisticated practices used by indigenous farmers to ensure food supply under uncertain weather conditions at altitude. The recognition of women and the elderly as traditional knowledge-holders and their inclusion in this project reshaped the research questions and overall participation in the research process.	Potato researchers and seed breeders have expanded their knowledge both in their inventory of potato genes that may have resistances to disease, pests and climate changes and traditional approaches to weather variability from which to address potential adaptive strategies to climate change. Traditional knowledge is viewed as a potential source of innovation for better understanding and using potato diversity and for adaptation information for crops and for food security. Certain women and elders are identified as key contributors to knowledge of potato diversity and uses.

Table 1. *Cont.*

Project	Social Learning with Pro-Poor Approaches in Agriculture		
	Research Q's 1&2	Research Q's 1&2	Research Q's 2&3
	Context assessment and interface design: Motivations for inclusion	**Learning and mobilization: Two-way learning**	**Learning and development outcomes: Changes in practice**
CIAT—International Center for Tropical Agriculture: Rural Agroenterprise Development Project's Linking Farmers to Markets Strategy: [66]	**Institutionally-driven:** Building learning alliances (LA) for building multi-stakeholder innovation systems [67] looks to leverage social learning in agricultural value chains, linking rural smallholder farmers with global markets and international market players. A multiplicity of stakeholders ranging from buyers, supermarkets, banks, producer associations, cooperatives are brought together in collaborative learning platforms to better understand the needs along the food value chain. Both scientific and lay knowledge are exchanged as a crucial part of rural innovation.	Global partners learn of critical vulnerabilities such as crucial periods of hunger at the smallholder scale. Rural farmers learn of the interests of global food corporations in regard to timing, quality of product, *etc.* Selection of partner agencies and individuals is crucial; a clear commitment and specific goals are necessary to streamline a "messy" process. Clear thematic, organizational or geographic focus is necessary in order for clear goals and learning to emerge in the platform.	Learning platforms ensure greater relevance and appropriateness of knowledge. Facilitated interface between researchers and multiple stakeholders allows for a level playing field built upon on needs, capacities and interests of different actors. Develops legitimacy among actors. This then develops long-term, iterative partnerships and networks that find synergies, mobilize learning and implement innovations toward improved rural livelihoods. The LA platform has lead to improved multi-organisational partnerships (e.g., between Sysco and smallholders), more effective development projects and the approval of more than $40 million of new grants in Central America to Learning Alliance partners. Need a sufficient amount of time and funding to monitor mainstreamed outcomes beyond just demonstration projects.

Table 1. *Cont.*

	Social Learning with Pro-Poor Approaches in Agriculture		
	Research Q's 1&2	Research Q's 1&2	Research Q's 2&3
Project	**Context assessment and interface design: Motivations for inclusion**	**Learning and mobilization: Two-way learning**	**Learning and development outcomes: Changes in practice**
CIAT [2]—International Center for Tropical Agriculture: Adaptation by agricultural communities to climate change through participatory and supply chain inclusive management [68,69]	**Research-driven:** Crop modelling under different climate conditions requires knowledge of who is growing, selling and involved in the supply chain, how resources change over time, who the beneficiaries of the value chain are and who will be adversely affected by changes in climate.	Strategies such as visual questionnaires, maps, and models of 20-year crop/climate projections are used to engage researchers and diverse stakeholders, such as farmers, extensionists, local and regional governments, feeding relevant information for crop/climate models. Learning that women do not get shares of revenue leads to new research questions about what varieties and practices contribute to their more visible and greater involvement. Researchers learned that young people understand issues of climate change much faster and that women and youth are more engaged in participatory workshops.	Recognition that crop modelling and adaptation strategies requires gender analysis to better understand the supply chain. A gender expert within CIAT is facilitating learning about the need for differentiated gender components in research; agronomists and other researchers are beginning to use this resource, especially now that the need has been identified within the institution. A collaboration with Oxfam helped mobilize CIAT's relevant crop/climate expertise and modelling to be disseminated across considerable networks. CIAT is making links with large development NGOs, providing relevant scientific research that get mobilized quickly along existing NGO networks of farmer associations and other organizations working on development at the local scale.

Table 1. *Cont.*

Project	Social Learning with Pro-Poor Approaches in Agriculture		
	Research Q's 1&2	Research Q's 1&2	Research Q's 2&3
	Context assessment and interface design: Motivations for inclusion	**Learning and mobilization: Two-way learning**	**Learning and development outcomes: Changes in practice**
Sustainable Food Lab: Formal value chains and the poor [70]	Working with over 60 global food organizations, including Oxfam and Unilever, members of the SFL work towards analysing food value chains and identifying areas where companies can have the biggest impact on poverty reduction. Poverty and agro-potential assessments are done to identify key intervention areas to reduce poverty and build development opportunities.	The SFL applies the multi-stakeholder engagement SFL to facilitate an interface that promotes shared reflection and learning. Learning Journey's is one method used to facilitate learning. For example, Sysco, Unilever and others engage with smallholders in Honduras. Shows for agricultural products and site visits expose corporate executives first-hand to the livelihood needs of the smallholder farmer. Questions of how to improve livelihoods while maintaining economies of scale become critical issues for iterative dialogue and deliberation over time. Smallholders learn about the needs of private sector buyers, identifying critical skills, technologies and networks to accelerate market-share and development objectives.	Unilever and Sysco purchase agricultural products from smallholder farmers, increasing livelihood opportunities in Nicaragua and Honduras while also securing suppliers in the global food supply chain. Innovative business models are used to intervene in global to local supply chains in order to distribute risks and rewards more evenly.

The five key features described in the framework above are used to discuss the key findings considered critical for including socially differentiated groups in social learning. How this learning is occurring and the influence on outcomes in the nine projects is outlined in Table 1. For reading ease, the Table emphasizes high-level features, while also serving as a glossary for the series of acronyms in the CGIAR system. In the analysis, the CGIAR research centre is used to denote the project from which the interview data was collected.

4.1. Context Assessment: Understanding Where and How Context Plays a Role in Learning

Understanding the context in which a social learning approach is being used is critical for ensuring that all interdependent actors, their cultural and institutional practices and their particular epistemologies, are included, including among marginalized socially differentiated groups. Within the agricultural and livelihood development mandate of the CGIAR, we found three different motivating factors that led to the inclusion of socially differentiated groups in our case projects and programs, addressing research question 1. These motivations are: outcomes driven, research driven and institutionally driven.

Improving the livelihoods of the most vulnerable groups is motivated in part by outcomes driven interests, including pro-poor research aimed at building capacity. In the process of examining agricultural production and processing and in identifying the most vulnerable smallholder farmers, the significant role women play in rural agriculture and livelihood development was made visible. The juxtaposition between their considerable role and their marginalization from knowledge, technology and decision-making structures, led researchers to actively include women as participants in most of the action research projects aimed at building agricultural, livelihood and adaptive capacity.

Research driven factors motivated researchers to include socially differentiated groups at the project scale. These related to *in-situ* data collection aimed at enhancing overall research objectives. For instance, the research objective of enhancing productivity and resilience in vulnerable socio-ecological systems (WWF-CARE [64]) meant that the most vulnerable residents, including women, were included in group-oriented learning environments aimed at improving water quantity and quality in a Kenyan Basin. Women were also included in participatory varietal selection research in West Africa to understand the informal seed sector and women's empowerment within it (AfricaRice [60]). Potato research aimed at understanding real world disease and pest problems due to increasing temperatures at elevation included indigenous farmers in the Andes for their perspectives on the impacts of climate variability and change on potato crops and varieties (CIP [65]).

Implicit in these motivations is the suggestion that developing a better understanding of the context and perspectives, values and norms of socially differentiated users/groups (*i.e.*, the rural poor farmer, women, indigenous farmers, *etc.*) will result in researchers being better equipped with relevant data to address agricultural and livelihood needs. In addition, in at least two of the projects, a shift in research focus from agricultural yields to market-oriented seed varieties expanded researcher's objectives. Instead of focusing on the yields of the landowner or smallholder farmers, the entire production and marketing chain became the locus of study, including the needs of processors and consumers. In the Stress Tolerant Rice Varieties for Africa and South Asia (STRASA) project, this shift meant the role that women play in the agricultural production supply chain was made visible, particularly at the

small-scale farm-level, but also in processing and marketing stages in countries such as Bangladesh, Nepal and India [62]. Recognizing the valuable roles women play in agriculture has changed the way research is being conducted at the International Rice Research Institute (IRRI)—a participatory varietal selection protocol has been established requiring that 30% of participants be women from farming households [71].

At the institutional level, these types of examples have motivated the CGIAR system to closely examine the potential of more explicit inclusion of socially differentiated groups more widely in all their research programs. In addition to IRRI's protocol noted above, CGIAR's Gender Network has developed to facilitate cross-institutional efforts in order to better understand gender roles across diverse agricultural systems. Other programs, such as the CGIAR Collaborative Research Program on Aquatic Agricultural Systems (AAS), led by WorldFish, are now explicitly including gender outcomes in order to improve both women and men farmers' and fisherfolks' livelihoods and adaptive capacity, through "transformative gender research approaches" (WorldFish [63]). Such approaches represent a new way of doing research that recognizes the role socially differentiated groups such as women can play that become important for shaping agricultural, livelihood and adaptive practices.

4.2. Inclusive Design and Management via Different Interfaces

In the projects examined, a majority of interviewees described the critical role for, and strategic management of, interfaces that link socially differentiated groups, researchers and other relevant actors. The way these groups are enrolled in the learning process depends on inclusive design and fair management of the science-policy-practice interface, addressing research question 1. In the nine projects, trust-building took different forms such as creating incentives (*i.e.*, potential livelihood benefits from participation), moderating imbalances of power (*i.e.*, through facilitated non-hierarchical exchange), attending to cultural norms (*i.e.*, gender) and to a lesser but equally important extent, attenuating knowledge hierarchies (*i.e.*, the role of the researcher is discussed below). For instance, strong facilitation was required to minimize power imbalances, building trust among interdependent actors. Moreover, researchers needed to move into "learner" roles among and amidst these interdependent actors, in effect, attenuating conventional knowledge hierarchies.

Incentives used to attract and include otherwise marginalized actors typically related to requests from researchers and other relevant actors to hear about their needs, values and knowledge and creating safe spaces to do so. In doing so, nuanced information relating to how to diversify sources of income, appropriate seed varieties for agricultural and livelihood needs, and ways of encouraging linkages between farmers and markets were developed. In the case of the International Center for Tropical Agriculture's (CIAT) "Learning Alliances", the incentive was to work with multi-scale actors from the private and non-governmental sectors to identify critical vulnerabilities in the global food supply system, including at the smallholder scale and to identify opportunities for including rural poor smallholder farmers in a more formal way [67].

Three different scales of interface were identified, structuring and managing who participated at the interface and ways of moderating power imbalances. These matched closely with Rodela's [12] individual-centric, socio-ecological systems-centric and network-centric categories. Individual-centric interfaces invited rural poor smallholders from different communities in the region to participate in

farmer-to-farmer learning processes. The goals among the projects were similar: to identify the needs and values associated with farmer's varietal preferences, to have farmers learn from one another and from researchers about preferences, practices and outcomes (AfricaRice [60]; CIMMYT [61]). The important role women play in the smallholder agriculture was clear, as were gender imbalances of power. In the International Maize and Wheat Improvement Center's (CIMMYT) multi-season varietal experimentation project, both male and female farmers were initially included in groups together to identify and discuss their varietal preferences [61]. Anecdotally, in one community, this approach had transformative affects, both validating women's agricultural and household knowledge and generating greater respect from the men regarding their perspectives and needs. However, in the majority of cases, overstepping cultural gender norms by blending male and female groups was ineffective (e.g., women were silent), making researchers adapt their methods to account for cultural norms. In the International Rice Research Institute's (IRRI) project in India, for instance, attention to cultural norms was required, separating and eliciting inputs among women of different castes (IRRI [62]). While keeping women separate did not contribute to learning across gender (or caste) lines, as it did in the case above, it provided "safe interfaces" where ideas, preferences and concerns could be shared and exchanged among women and researchers (in many cases female researchers). Most projects adapted applying a gender-oriented frame when consulting farmer/fisher women on their needs in agricultural production, post-production and livelihood development (AfricaRice [60]; IRRI [62]; CIAT [68]; WorldFish [63]; CIMMYT [61]).

Socio-ecological systems-centric interfaces were also used, identifying interdependent actors within and/or relevant to specific geographic or socio-ecological contexts (WorldFish [63]: WWF-CARE [64]). For instance, in the AAS program, participatory action research methods were used to elicit the norms, values and preferences from farmers and fishers regarding seed/stock varieties, farming practices and potential natural hazard and climate change risks in the aquatic system of Moshni in Bangladesh. In these circumstances, developing an interface and learning environment with researchers required sensitive and prolonged dialogue and incentives about the potential benefits for farmers before perspectives, preferences and opportunities were exchanged (building overall resilience was a key incentive). In the WWF-CARE case, the inclusion of upstream and downstream farmers in Kenya's Navaisha Watershed, alongside growers groups, riparian associations, a Water Resource Users Association, regional forest agencies and other interdependent stakeholders was necessary to develop an appropriate financial mechanism that could be used to build livelihoods and protect biodiversity and watershed services [64]. Building capacity and livelihoods among farmers from the most degraded areas in the upper catchment and including their voices in the creation of burden-sharing mechanism incentivized poor smallholders, including women, to participate. This goal was communicated early and frequently, before the project began, to sensitize socially differentiated groups (e.g., the poor and women) to issues of water quality and land-use practices in the upper catchment. The inclusion of other critical actors, such as downstream buyers of watershed services and representatives from forestry and other government agencies, contributed to the legitimacy of the endeavour. In this way, the management and design of the interface determined who participated, how to ensure their involvement, while implicitly building the legitimacy of the outcomes based on which interdependent actors and agencies were included. In this case, the quality of the trust and exchange developed, via strong facilitation, at the interface resulted in legitimate and appropriate learning outcomes (e.g., a gender-sensitive voucher system of payment for ecosystem services).

Network-centric interfaces included an interwoven and reinforcing network of actors that spanned diverse geographic and governance scales. In the International Centre for Tropical Agriculture's (CIAT) "Learning Alliances", including rural poor producers, farmer associations, global food corporations and other research and policy value chain providers at the interface were motivated by the need to better understand global food supply chain vulnerabilities and ways to address them [66,67]. That relevant cross-scale, cross-sector actors and agencies demanded that particular attention be paid to considerable power imbalances. Management of this interface in CIAT included building rules of engagement for equitable, less hierarchical exchange and the use of strong facilitation so that inputs from different interests, approaches and governance structures were managed equitably. In this ongoing learning environment, it was noted that trust was iteratively developed over time through regular, facilitated face-to-face workshops and virtual meetings. As the Learning Alliance develops in iterative ways and continues to demonstrate value (addressing critical supply chain issues in a collective way), these power imbalances appear to be softening (CIAT [66]).

These three types of managed interfaces were used differently to attend to cultural norms and moderate power imbalances. The goal in all cases was to generate "safe spaces" that manage the negotiation of the research at the practice interface. As noted in the WWF case, the design and management of interfaces can often determine, implicitly or explicitly, the framing of relevance and the overall legitimacy of the exchange. In addition, identification of relevant, interdependent actors, willing to collaborate, helps in the development of collaborative products and in the robustness of networks for action; both critical determinants for building strategic outcomes for sustainable development [1,5,8,14]. Thus, who is included and how the interface is managed both play critical roles in framing and shaping the learning environment.

In all of these projects, the tacit rules of engagement were defined by the researchers; including the types of actors engaged and the type and quality of engagement. This, of course, makes sense given the research-oriented mandate of the CGIAR. However, it would be remiss not to raise questions about an implicit knowledge hierarchy at the interface and its implications for overall outcomes. In many situations, having purposive research goals and methods is desirable, contributing to the credibility and usability of the information produced (e.g., participatory varietal selection for use in breeding research). In other situations, though, it may be beneficial to facilitate problem framing more broadly, allowing relevant research questions to emerge through interaction (e.g., identifying vulnerabilities in the food supply chain or finding a financial mechanism to build livelihoods and biodiversity). In these cases, the role of the scientist is one of participant rather than lead. This type of interface requires strong facilitation. As noted above, the type of interface selected determines which actors participate, how trust is fostered between them (of particular importance for socially differentiated groups) and, importantly in many cases, will influence the form and quality of learning that takes place.

4.3. Facilitating Learning: Results for Research and Governance

In this study, we were interested in finding examples of double or triple loop learning, *i.e.*, where underlying assumptions and values are exchanged and deliberated either to identify *the right things to do* (e.g., weak co-production of knowledge) or to deliberate over *which are the right things to do* (e.g., strong co-production of knowledge). This was done in order to identify any additional benefits of

a social learning approach that explicitly includes socially differentiated groups, addressing research question 2. The majority of projects examined, with the exception of two, fell within the double loop learning. All interviewees emphasized that the inclusion of socially differentiated groups helped raise the profile of differentiated needs, values and norms, making both research and service delivery more relevant and identifying potential areas for intervention specific to the goals of capacity building towards sustainable agriculture and livelihoods (e.g., CIAT [66,68]; CIMMYT [61]).

Learning about differentiated knowledge and needs in two participatory seed/varietal selection projects (IRRI [62]; AfricaRice [60]) led to insights about women's preferences for shorter and finer rice varieties that are easier to harvest and thresh; faster cooking varieties to free their time for agricultural and household duties; and the creation of faster-maturing seed varieties to address crucial periods of household hunger. In some cases, *in situ* benefits such as the need for quality fodder seed varieties for livestock contributed to food security and additional income opportunities. Based on the knowledge and insights provided by women, seed breeders are incorporating new criteria in their varietal selection processes. This is an example where efforts to develop agricultural and livelihood development was enhanced through exchange and double loop learning. In the WWF-CARE project, learning from women about their limited ability to access income for agricultural and livelihood development at the household scale contributed to the development of a voucher payment system for watershed services, not a cash payment system. In this system, vouchers are redeemable for agricultural inputs, benefiting the household not just the male head of the household, contributing to overall poverty reduction.

In Bangladesh, including the rural poor in "gher" management (a rice field that has been modified for shrimp or prawn production) helped WorldFish' Aquatic Agricultural Systems researchers understand the impacts of cyclones and increasing storm events, while also enabling smallholder farmers/fishers to communicate their needs in regard to food security and adaptive strategies [63]. In this learning environment, researchers elicited underlying interests, needs and values in order to provide relevant service delivery such as ways to improve crop management systems that reduce risk of shrimp disease and improve yields; to connect farmers to seed suppliers and local markets; and to diversify income-generating crops. Learning about the differentiated needs and values of women and men and their different approaches for coping with natural hazards, helped researchers and women participants co-create tailored adaptive strategies. These included growing vegetables on raised dykes to generate other forms of income and cultivating fast growing fish such as tilapia to sell in markets and to minimize periods of household hunger. In addition, learning about male preferences for getting the best yields and returns in the short-term (before the next storm event) helped researchers identify shorter rotation species and to create linkages between farmers, seed suppliers and markets [63]. Including the socially differentiated in learning environments contributed to greater understanding of the right or most relevant things to do to build agricultural, livelihood and adaptive capacity.

4.4. Triple-Loop Learning

Learning can be purposive and exploratory as discussed above. It can also be emergent through formal and informal interaction, at times, leading to greater insights than originally anticipated. For example, the International Potato Center's (CIP) efforts to map the biodiversity of potato crops in

Peru began as a single loop learning exercise, and through the inclusion of indigenous actors, turned into a fruitful triple loop-learning environment. CIP's participative mapping project had indigenous farmers in the Andes identify their plots and input their crop species using satellite images [65]. In the process of this documenting process, exchange between the researchers and farmers contributed to considerable learning that fundamentally changed how research is done. Farmers learned about mapping and crop management, including how to track agricultural inputs and outputs. Researchers learned of undocumented potato varieties, whose genetic potential are now being analysed for increasing potato resistance to disease and pests under the warming effects of climate change. Researchers also learned of sophisticated, traditional crop selection and rotation practices used as a way to secure household and market food supply under variable conditions at high altitude, including a 150 m farmer migration in elevation over the past 30 years to escape the warming effects of climate change. This has contributed critical insights into adaptive strategies among indigenous farmers, for possible use in other communities facing climate variability and change. In addition, researchers were directed to women and elders who were identified as those with knowledge of potato varieties and their particular uses and are now included in the research process.

All cases outlined above generated experimental and successful learning environments, which included socially differentiated actors/groups. Two caveats should be mentioned here however. First, identifying projects where learning has not occurred due to "messiness" or other unforeseen factors was desirable but would have required additional time, as these failures (or trade-offs) tend not to be reported on websites and in annual reports (likely due to the potential consequences for funding). These could not be identified because of a restricted timeframe for this study (three months). Second, social learning is iterative, dynamic and takes time. As such, each of the projects and all of the interdependent actors involved can be viewed as a part of an ongoing, iterative meta-process of social learning and therefore the full impact (benefits/outcomes) are likely to emerge over time.

4.5. Mobilizing Knowledge

The interface and learning environment in each of the projects set the stage for the trust and legitimacy built among interdependent actors. In many cases, the networks formed through the learning environment also acted as readily available channels for knowledge mobilization. Existing and new networks, including virtual networks, were critical channels for mobilizing learning beyond the individual. For instance, in CIMMYT's project a peer-to-peer interface supporting farmer-to-farmer learning led to new network formation among and between rural poor farmers, including women farmers, within and across communities, researchers and farmer associations [61]. Knowledge about the diverse criteria used to assess crops in particular conditions and ways of evaluating the benefits of specific practices (e.g., inputs *versus* outputs, rotation cycles, *etc.*) was mobilized from participants via word-of-mouth. Researchers mobilized knowledge about farmer preferences and criteria used for crop management, via reports extending along researcher and practitioner networks, influencing those working in other communities to help identify and select specific varieties and practices for similar socio-ecological contexts. In this multi-seasonal project, the interactions were iterative, contributing new insights to the research agenda. Three interviewees

mentioned that women's strong social networks acted as a significant channel for mobilizing knowledge, primarily via word-of-mouth (CIAT [68], AfricaRice [60], IRRI [62]).

In AfricaRice, inclusive processes led to social learning among women's networks. The new information and practices that emerged through these social learning processes were channeled more directly, using technology, extending to broader audiences. Farmer-to-farmer learning videos, for instance, were an important and effective channel for mobilizing knowledge in the AfricaRice project [60]. In these videos, both male and female farmers discuss particular innovation successes in their agricultural and household environments. Partners, including agricultural extensionists, shared the videos with local organizations, which then showed them to community members. Evidence in Benin suggests that women who watched the videos not only learned from the on-screen farmer (*i.e.*, 70% improvement in cleaning and drying rice properly) but, in certain instances, innovated to improve their practices (*i.e.*, parboiling techniques). AfricaRice's farmer-to-farmer learning videos, for instance, lead to an estimated 80% greater adoption rate for new technologies and practices as compared to more conventional innovation/training and visit systems in Benin (AfricaRice [60]). Translated into 30 African languages and distributed by 80 partners in 28 African countries, these videos were used by more than 300 local organizations. In addition, the videos are being broadcast on national television in four African countries and have been used to train more than 2500 trainers, likely benefiting over 100,000 rice farmers and processors across Africa. Farmer-to-farmer videos were mobilized quickly, contributing to increased learning outcomes among women and the rural poor at very low cost. The shift to technology-mediated tools occurred for two major reasons; to decentralize and democratize learning within the rice sector (AfricaRice [60]). In addition, the partners, such as National Agricultural Research System (NARS) agricultural extensionists, used to scale these learning tools played a crucial knowledge-broker role.

The majority of interviewees referred to the effectiveness of partnering with international non-governmental organisations and/or private sector partners in order to optimize channels to mobilize knowledge. For example, CIAT's [68] partnership with Catholic Relief Services (CRS) allowed CIAT to play a "niche" research role while having NGO partners, with existing cross-scale partnerships and sophisticated practices, as existing channels to mobilize relevant knowledge. In CIAT's Linking Farmers to Markets project, partnerships with private sector actors such as Costco in Guatemala and Green Mountain Coffee Roasters in Mexico, Guatemala, Nicaragua and Peru leveraged pro-poor market linkages favouring rural smallholder suppliers [66,69]. These networks have had transformative effects on rural agricultural livelihoods, addressing research question 3. They provide important new examples of how to build learning as an iterative methodology into supply chain analysis and of ways to enroll private sector actors in social learning for changing the dynamics of food supply chains.

4.6. Assessing Outcomes

Social learning requires that learning outcomes lead to a change in practice, ideally toward sustainability. The inclusion of socially differentiated actors/groups in social learning experiments by all accounts improved the relevance and legitimacy of the knowledge being generated in the CGIAR, addressing research question 3. In all case projects, it spurred the co-creation of new knowledge and innovation that likely would not have occurred otherwise, leading to three main identifiable outcomes

(though this is not exhaustive). The outcomes noted below are qualitative influencers of change that often are not easy to measure, but still have considerable merit and/or impact.

4.6.1. Empowering Vulnerable, Socially Differentiated Groups

Bringing socially differentiated groups into the sphere of knowledge and decision-making about their own needs, values and norms had an empowering effect in many projects. In Bangladesh, India, Nepal and four West African countries women are speaking about their preferences more openly and getting access to technical information and seeds that they otherwise would not have had access to (AfricaRice [60]; IRRI [62]; WorldFish [63]). It is also evident that including socially differentiated groups in the exchange of information is contributing to changes in research approaches, situating researchers in an exploratory, learning frame. These examples contribute insights into the role that the poor, women and traditional and indigenous knowledge can play, contributing to changes in cultural and research norms.

4.6.2. Increasing the Relevance and Appropriateness of Knowledge through Learning Environments

All interviewees reported that including socially differentiated groups in participatory research led to more relevant and legitimate information being generated about needs, values and norms. This in turn shifted the research towards meeting those needs, and contributed to enhanced livelihoods. Including women in participatory varietal selection (PVS), for instance, connected scientists with women's on-the-ground needs both with regard to the different ways as well as the realities of how they had to split their time between the fields and their homes. This learning influenced research approaches such as relevant trait selection among seed breeders. Related outcomes are faster maturing plants to combat periods of food scarcity (IRRI [62]), shorter varieties for easier threshing (AfricaRice [60]) and faster cooking varieties to minimize time taken for lunch breaks in the field and for household tasks (AfricaRice [60]; IRRI [62]). In the AfricaRice Rural Learning Project, farmer-to-farmer learning videos, showcasing relevant learning ranging from ways to care for plots to identifying faster maturing varieties, led to an 80% greater adoption rate of new technologies and practices when compared to more conventional training and visit systems [60]. Not to be undervalued was the role that extension agents played, due to their established trust and legitimacy in the communities. Women who watched the videos reportedly learned from on-screen farmers (female and male) and, in certain instances, creatively adapted technologies and/or practices to suit their *in-situ* environment (AfricaRice [60]).

In addition, three interviewees mentioned women's strong social networks as a significant channel for mobilizing knowledge. Certain researchers support this assertion, identifying women's groups and networks as an untapped resource or channel for engaging in and mobilizing knowledge for sustainable development [29,31].

4.6.3. Best Practices for More Equitable Service Delivery

The inclusion of the poor in AAS's Moshi project led to tangible outcomes such as the selection of faster maturing varieties with higher earning potential in the face of cyclone, storm surge and climate impacts, and greater connection of fishers/farmers to markets [63]. Additional benefits to

poor households included improved food security and additional income resulting from adopting an agricultural practice involving growing crops on raised dykes. Similarly, an outcome from WWF-CARE's Payment for Ecosystem Services project was a gender-sensitive financial mechanism to pay for ecosystem services [64]. This voucher system rewarded poor upstream residents for their conservation efforts, ensuring that all proceeds went to agricultural inputs that would enhance household livelihoods, not just male heads of the family. WWF and CARE are highlighting this case as a best practice strategy for simultaneously enhancing livelihoods and protecting biodiversity and are using their extensive research and practice channels to mobilize this innovative knowledge for use in other communities.

CIAT's Coffee Under Pressure project formed learning environments linking the private sector, such as Costco and Green Mountain Coffee Roasters, to rural poor smallholder coffee farmers [69]. A partnership with Catholic Relief Services (CRS) mobilized learning outcomes, such as strategies for reducing periods of hunger, diversifying incomes, and others, from the "niche" learning environment to over 33,000 people in Central America.

4.6.4. Catalyzing Change in Research and Institutional Approaches

Relevant research and data on the inclusion of women in learning experiments is leading to larger-scale institutional changes in the CGIAR. For instance, a participatory varietal selection protocol in IRRI includes guidance for extension agents from National Agricultural Research Systems (NARS) on ways to include women, such as seeking participation at appropriate times (e.g., during the harvest). Monitoring is now taking place to see how women are being included in learning environments and to what extent this inclusion is influencing learning in the development of varieties and uptake of seeds used by women (this type of information is increasingly required from donors).

Within the CGIAR, a common framework for assessing social learning environments is only now being developed [4]. Due to this gap, and the time-sensitive nature of this study, it proved difficult to compare CGIAR social learning projects. In particular, it was difficult to identify those projects employing a learning approach that had failed or that had experienced significant trade-offs. Information about these types of projects would, of course, be beneficial for an analysis of which contexts may not benefit from using a social learning approach, for instance. As such, the projects and programs analysed in this study are generally optimistic about social learning and the inclusivity used to encourage learning with socially differentiated groups. Future research could further scrutinize exactly when and how social learning research approaches should or should not be used, particularly among socially differentiated groups, and the costs *versus* benefits involved in these approaches for varying environments [4].

5. Conclusions

This exploratory scan contributes to a growing body of empirical literature based on case studies, considered necessary to analyse and assess when and how social learning may benefit specific research and governance practice toward sustainability goals. Particular attention was given to the inclusion of socially differentiated groups, and where and how the inclusion of the most vulnerable and marginalized contributes to social learning. Indeed these examples, taken from innovation research and

practice in the CGIAR, illustrate particular circumstances where integrating socially differentiated groups, such as women, the poor and the indigenous, can lead to substantive exchange, learning and mobilization of knowledge that extends beyond the individual.

Four critical insights emerge from this analysis. First, in the context of livelihood and adaptive capacity development, reaching the most vulnerable individuals requires inclusive strategies and approaches aimed at understanding the needs of socially differentiated groups. To include socially differentiated groups in social learning requires that particular attention be paid to minimizing power imbalances, in order to enable more equitable exchange of knowledge and ideas, and knowledge hierarchies. This is ideally done at the interface design stage, including planning how the interface will be managed among interdependent actors in order to facilitate meaningful exchange and to maintain a level playing field.

Second, in the rural agricultural context, socially differentiated groups—the poor, rural farmers, women and indigenous farmers—contribute substantive knowledge to the learning environment. This learning can be purposive (double loop learning) or emerge from the learning environment (triple loop learning). In most cases, but not always (e.g., CIP) the interaction at the interface determined the form of learning that occurred. In all of the projects, inclusion of socially differentiated groups helped to reshape the research scope, and in the case of the CIP project, helped to reframe overall research approaches. For certain, these learning environments created knowledge that would otherwise not have been generated, contributing to more nuanced and relevant research. Questions emerge about the tacit influence of the researcher in the learning process and whether, in certain cases, external facilitation would help minimize the knowledge hierarchy implicit when researchers manage and facilitate learning processes.

Third, the benefits of applying a social learning approach that includes socially differentiated groups were numerous. These benefits ranged from greater adoption of technologies, to expanded knowledge of species, to a clearer understanding of livelihood development strategies for disadvantaged smallholder farmers. The inclusion of women, for instance, may also enhance the mobilization of knowledge along strong, interwoven networks. We found novel channels for mobilizing relevant knowledge to broader communities such as new networks (cross-scale, cross-sector partnerships). In addition, the ability to convene and maintain partnerships and networks over time was viewed as a key to building trust, legitimacy and learning in an iterative manner.

Fourth, three of the projects used social learning to develop no-regrets approaches that address livelihood and adaptive capacity development to build agricultural capacity and resilience over the short and long-term (e.g., such as building dikes as gardens) (CIAT [66–69]; WorldFish [63]; WWF-CARE [64]). Identifying co-benefits among development and climate adaptation and mitigation strategies, that dovetail shorter-run livelihood-oriented development approaches with the desire to build adaptive and mitigative capacity for longer-term sustainability of food systems is a critical area for future research.

For most of the projects it is too early to discern empirically what the longer-run development outcomes of a social learning approach that explicitly includes socially differentiated actors/groups will be. While we were not able to adequately capture some of the trade-offs and transactions costs involved in dealing with more diverse and "messy" partnerships and cross-scale learning processes, funding requirements and longer timeframes than more traditional research approaches [1], the cases do

show many benefits of social learning in the agricultural, livelihoods and climate change context. It is important to recognize and further research the difficulties experienced in projects that try to equally include women, for example. As noted previously, we were not able to fully ascertain what can happen when social learning goes wrong; for example, when power relations overtake inclusion principles.

CGIAR's recent restructuring is facilitating, among other things, cross-institutional efforts to better understand gender agency, norms and roles across diverse agricultural systems and environments, and the differentiated needs of men and women as they relate to particular knowledge requirements. This broader emphasis on gender is expected to contribute further insights into ways of developing more effective research and service delivery, and in identifying strategic research and partnership opportunities for enhancing adaptive capacity of those most vulnerable. Further analysis is needed to determine when and where the benefits of social learning with socially differentiated groups outweigh the costs and when they do not. This type of analysis may result from greater definition and clarity of how to design and evaluate social learning or it may trend toward more inclusive governance models required to transition toward sustainability. Regardless, as Kristjanson *et al.* [4] argue, using a common framework for systematic evidence collection is required. This study makes a contribution to spur discussion toward this end.

In sum, we are beginning to find evidence that the inclusion of socially differentiated groups contributes to novel exchange and learning, helps to co-create relevant and legitimate knowledge and build and optimize networks, which have the potential to both improve and accelerate livelihood and adaptive capacity outcomes. In the agricultural sector in developing countries, including smallholder farmers, women and the indigenous in social learning hold the potential to identify key vulnerabilities in agricultural production and livelihoods; to identify appropriate crops and varieties for particular agro-ecosystems; and, by aligning the efforts of multi-scale actors, organizations and agencies, to mobilize relevant agricultural and food security innovations quickly shifting us toward more sustainable agricultural systems. As such, social learning with socially differentiated groups is an approach "linking knowledge with action" for those working toward catalyzing sustainable agricultural development.

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Author Contributions

Shaw performed and analyzed the research, resulting in this manuscript. Kristjanson provided relevant materials for the research and contributed in relevant ways to the development of this research paper.

Conflicts of Interest

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