

The relevance of political ecology perspectives for smallholder Climate-Smart Agriculture: a review

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Abstract

Climate-smart agriculture has emerged as a way of increasing food productivity, building resiliency to climate change and reducing carbon emissions. Despite rapid technical advances, research on climate-smart agriculture has arguably under-theorized the socio-political processes that continue to marginalize vulnerable groups such as smallholder farmers. This review discusses the potential usefulness of political ecology perspectives for improving climate-smart agriculture. Political ecology theory elucidates how three inter-related socio-political processes that perpetuate smallholder farmer vulnerability significantly influence climate-smart responses: inequality, unequal power relations and social injustice. The article discusses these three inter-connected political ecology factors using a number of examples from the Green Revolution, smallholder farming communities, and indigenous farmers. In comparison to conventional technical approaches, our article argues that Climate-Smart Agriculture needs to consider political ecology perspectives at different levels to explore the vulnerability of smallholder farmers to current and future climate change impacts. Interventions to support climate-smart agriculture should examine local risks, specificities and priorities of smallholder farmers. The article concludes with a renewed call for concepts of inequality, unequal power relations and social injustice to be embedded into both the policy and practice of climate smart agriculture.

Keywords: climate-smart agriculture, equality, political ecology, power, smallholder, social justice

Résumé

L'agriculture intelligente face au climat (Climate-Smart Agriculture) est apparue comme un moyen d'accroître la productivité alimentaire, de renforcer la résilience aux changements climatiques et de réduire les émissions de carbone. Malgré les progrès techniques rapides, la recherche sur l'agriculture intelligente au climat a sans doute sous-théorisé les processus sociopolitiques qui continuent à marginaliser les groupes vulnérables tels que les petits agriculteurs. Cet examen traite de l'utilité potentielle des perspectives de «l'écologie politique» pour améliorer l'agriculture intelligente au climat. La théorie de l'écologie politique élucide comment trois processus socio-politiques interdépendants, qui perpétuent la vulnérabilité des petits agriculteurs, influent sur les réponses intelligentes au climat: inégalités, rapports de pouvoir inégaux et injustice sociale. Cet article traite de ces trois facteurs interconnectés en utilisant un certain nombre d'exemples de la «Révolution verte», des petites communautés agricoles et des agriculteurs indigènes. Par rapport aux approches techniques conventionnelles, notre article soutient que l'agriculture intelligente face au climat doit considérer les perspectives d'écologie politique à différents niveaux pour explorer la vulnérabilité des petits exploitants aux impacts actuels et futurs des changements climatiques. Les interventions pour soutenir l'agriculture intelligente au climat devraient examiner les risques, les spécificités et les priorités locaux des petits agriculteurs. L'article se termine par un appel renouvelé pour que les concepts d'inégalité, les relations de pouvoir inégales et l'injustice sociale soient intégrés dans la politique et la pratique de l'agriculture intelligente au climat.

Mots-clés: agriculture intelligente au climat, égalité, écologie politique, pouvoir, petits exploitants, justice sociale

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Resumen

La agricultura inteligente para el clima ha surgido como una manera de maximizar la producción de alimentos, creando resiliencia a el cambio climático y la reducción de gases de carbono. A pesar de los rápidos avances técnicos, es posible que la investigación sobre la agricultura inteligente para el clima haya subestimado los procesos sociopolíticos que siguen marginando a grupos vulnerables como los pequeños agricultores. Este artículo discute la utilidad de las perspectivas de la ecología política para mejorar la agricultura inteligente para el clima. La teoría de la ecología política dilucida cómo tres procesos sociopolíticos interrelacionados perpetúan la vulnerabilidad de los pequeños agricultores e influyen significativamente en las respuestas inteligentes al clima: desigualdad, relaciones de poder desiguales e injusticia social. Este artículo discute estos tres procesos interconectados de ecología política usando una serie de ejemplos de la revolución verde, las pequeñas comunidades agrícolas y los agricultores indígenas. En comparación con los enfoques técnicos convencionales, este artículo argumenta que la agricultura inteligente para el clima necesita considerar las perspectivas de la ecología política en diferentes niveles para explorar la vulnerabilidad de los pequeños agricultores a los impactos actuales y futuros del cambio climático. Las intervenciones para apoyar la agricultura inteligente en relación con el clima deben examinar los riesgos, especificidades y prioridades locales de los pequeños agricultores. El artículo concluye con un nuevo llamado a que los conceptos de desigualdad, relaciones de poder desiguales e injusticia social se integren tanto en la política como en la práctica de la agricultura inteligente para el clima.

Palabras claves: Agricultura inteligente para el clima, igualdad, ecología política, poder, pequeños agricultores, justicia social

1. Introduction

More than 500 million smallholder farmers across the world manage less than ten hectares of land each, and yet they produce as much as 80 percent of the food consumed in Africa and Asia (IFAD 2013). Climate-Smart Agriculture (CSA) is a revived approach to managing climate impacts and reducing greenhouse gas emissions while simultaneously increasing agricultural productivity (Lipper *et al.* 2014). A common definition of CSA was offered by the Food and Agriculture Organization (FAO): "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals."² CSA can contribute to future food security and the sustainability of smallholder agriculture in developing countries. The approach is being trialed around the world, informing contemporary agriculture research and development, and it is emerging as a climate financing option for developing countries through mechanisms such as the Green Climate Fund. For example, climate-smart villages have been constructed in India and Vietnam, while Ghana and Myanmar have developed climate-smart pathways to reach their country's agriculture goals (CCAFS 2016). Similarly, community-based adaptation projects are targeting vulnerable rural farms in Philippines and Timor-Leste. But how is CSA linked to socio-political factors confronting smallholder farmers? In other words, what do these different interventions have to do with political ecology? The answer to this question lies in how (global/national) institutions that fund, oversee and manage policies construct the identities, challenges and vulnerabilities of communities through aid and development interventions.

This article reviews how political ecology perspectives can offer insights into resolving many of the challenges and criticisms leveled at CSA. The CSA discourse, developed predominately by the FAO and the World Bank, has gained considerable political importance since 2007 and is overseen by a peak body, the Global Alliance for Climate Smart Agriculture (GACSA) (Lipper *et al.* 2014). The UN Secretary General established the GACSA at the high level Climate Summit in 2014. The GACSA governs the CSA and coordinates the science, strategy and partnerships under the alliance. Supported by a multitude of research organizations (the majority originating in the global North), the Climate Change Agriculture and Food Security (CCAFS) research program, international agencies and donors are establishing the scientific knowledge and credibility of CSA by launching projects on agricultural resilience to climate change targeting rural communities in the global south. However the CSA discourse and its governance have met criticism

² <https://csa.guide/csa/what-is-climate-smart-agriculture>

especially from grassroots farmers, civil society and non-governmental organizations.³ Some have argued that CSA is a vehicle for transnational corporations to exploit peasant farming systems, a twenty-first century Green Revolution (GR) agenda that will permit the capitalist expansion of agricultural markets (e.g. Anderson 2014; Delvaux *et al.* 2014; Sugden 2015). There are serious concerns from NGOs and other actors about how policy and practical outcomes are constructed in CSA, in part due to the weak scientific consensus about what it involves, a lack of attention to existing climate-adapted practices, and the dominance of institutions from the global North (CIDSE 2015).

While many scholars have focused on the scientific and technical dimensions of CSA practices, few have sought to examine the political influences on how and what smallholder issues are integrated into climate change and agriculture policies (see Harvey *et al.* 2013; Jost *et al.* 2016; Smith and Olesen 2010). Ongoing work at CCAFS has also shown that there is a fundamental lack of evidence about how CSA programs should address the myriad socio-economic challenges faced by farmers across different scales (Campbell *et al.* 2016). Although the social dimensions of CSA, including its effects on gender relations, are now being addressed (see e.g. CCAFS 2016), research into the political determinants of food security is lacking (Davidson 2016). Inequality, unequal power relations and social injustice are largely absent from CSA policy and the literature. There are even fewer studies on how socio-economic factors challenge the implementation of CSA programs. We lack a more nuanced understanding of context-specific socio-political challenges that operate across scales, and their consequences for addressing the vulnerability of smallholder farmers.

We offer review of the CSA literature via a political ecology lens, with the aim of contributing conceptually to CSA. It will do so in three steps. First, we begin by providing a rationale for why research and policy on CSA must focus on the marginalization of smallholder farming systems. Second, we discuss theoretical perspectives from political ecology focusing on inequality, unequal power relations and social injustice and illustrate with examples how these are the key determinants of vulnerability for smallholder farming communities and indigenous farmers. Third, we evaluate the arguments for embedding these factors in CSA, and we conclude that CSA initiatives need to address the underlying socio-political issues confronting farming communities. Socio-economic and political analysis is an important step to accompany scientific and technological solutions for green growth, increasing food security and responding to climate change. This needs to take the form of designing participatory and inclusive strategies using a rights-based approach within CSA interventions.

2. Why focus on the marginalization of smallholder farmers?

Theoretically this article draws extensively on Paul Robbins' conception of marginalization. Robbins (2012) articulated the degradation and marginalization thesis that described how the power structures of state and market institutions in the First World influence socio-environmental vulnerability of the least powerful farmer groups in the Third World. He uses empirical cases from the Amazon and Caribbean to show that multi-scale politics operating across levels of governance contribute to the vulnerability of rural agricultural communities. Marginalization of smallholder farmers is amplified by monopolistic political representations of elite institutions, or by the discriminatory policies of hegemonic groups *vis-à-vis* inequitable resource allocation decisions (Yates 2014). It results from periods of uneven development patterns, agrarian reform measures and land distribution that create social division and conflict (based on class, gender and race imaginaries). Ecological injustice is prevalent in rural agrarian dependent communities. In the face of climate change, social divisions translate into acute vulnerability: differentiated risks to men and women, migration, national security concerns, geo-political rivalries and exclusion of people from development interventions (Newell and Bumpus 2012). Research also shows that marginalized groups may experience decreased access to basic social services like healthcare, education, and food security, and are often overlooked in government statistics on household vulnerability (Adger *et al.* 2006).

The marginalization thesis (Robbins 2012) is applicable to understanding socio-economic relations in particular localities, but its link to broader techno-political processes are more complex and multifaceted. In

³ See <http://www.climatesmartagconcerns.info>

his seminal study on political ecology of climate change adaptation, Taylor (2014) argues that the origins of smallholder marginalization are that political power, capital accumulation, and economic hegemony exist elsewhere, with institutions in the global North and South. Differential vulnerability of farmers to climate impacts is co-produced. It is important to note from Taylor's work that rural agricultural systems in developing countries have undergone radical reforms resulting from historic and existing patterns of resource exploitation, governance, land tenure and organizational structures (e.g. colonial land reforms, and the impacts of Green Revolution technologies). Taylor suggests land and water rights, power relations and social injustice are (re)framed apolitically or they are absent from the agendas of contemporary international food security, land reform and climate change. Climate change and agricultural policies understate issues related to human rights, power imbalances and social injustices due to the often normative visions of donors, and their economic interests - credit policies, loans and subsidies. International climate solutions like CSA, and Certified Emissions Reductions, result in exclusion of minority communities, negative externalities for indigenous groups and elite capture of development benefits.

Scholars contributing to the adaptation and mitigation literature have begun thinking about how unequal scalar relations of power, political structure and economies of scale undermine the ability of poor and marginalized farmers to respond to climate change (Eriksen *et al.* 2015; Yates 2014). In poor agrarian households, customary roles and societal values mean a lack of freedom, and disadvantage for some individuals, especially women and children (Ribot 2009, 2014). Accessing new climate information, farming skills and resources is difficult. Similarly physical remoteness, power relations, and participation affect the access to resources needed for successful scaling-up of adaptation, mitigation and agricultural programs (Niles *et al.* 2016; Wood *et al.* 2014). CSA poorly acknowledges the intimate relationship between technical responses and the socio-political processes leading to marginalization, climate injustices and their consequences for vulnerable smallholder farmers (Lipper *et al.* 2014). An understanding of how marginalized farming groups are actually affected by socio-political processes may help policymakers to target these populations more appropriately.

3. Political ecology theory: conceptualizing inequality, unequal power relations and social injustice

We view CSA as largely prescriptive and see political ecology as largely critical. This is a simplification, since both use some interrelated concepts. Political ecology explicitly considers relations of power in smallholder farming communities, building on various empirical studies of local on-farm and off-farm processes that operate at discursive, micro and structural levels - wider factors beyond the farming landscape. The focus is commonly on the participation of, and action by, marginalized, disadvantaged and vulnerable populations. We acknowledge that CSA is a relatively new approach, and its application at the grassroots is fairly limited. Paradoxically, although the vulnerability of smallholder farmers to climate change dominates the GACSA agenda, CSA policies only weakly conceptualizes the local challenges and lived realities of smallholder farmer communities (GACSA 2015). This is made worse by CSA's weak articulation of historical and contemporary cases of injustice, unequal power relations, inequality and the techno-politics of international aid and development agencies. This disconnects the analysis of power from techno-scientific solutions, prompting rather rigid approaches to mitigation and adaptation. The result is that fundamental livelihood challenges are continuously disconnected from mainstream decision-making processes, engendering persistent vulnerability to environmental change and political economic problems (Yates 2012).

When the political ecology lens is applied to CSA in smallholder farmer settings, it enables us to understand:

- (1) global-local institutions and actors that influence smallholder property rights, knowledge, livelihoods and safeguards;
- (2) how socio-political factors structure specific vulnerabilities of smallholder farmers, women and men;

- (3) opportunities and barriers to adaptation and mitigation responses to boost agriculture productivity and livelihoods; and
- (4) the relevance of CSA actions to those most vulnerable to climate change.

Within the adaptation discourse, political ecology factors like inequality, power and social injustice have been used commonly as separate social categories in empirical case studies to examine localized ideologies (Adger *et al.* 2013; Alston 2015; Eriksen *et al.* 2015). In contrast, in the mitigation (and climate finance) discourse, the debates on inequality, power relations and social injustice have been framed at the global level, focusing on policy principles such as market mechanisms, polluter payers and differential equity (Olawuyi 2016). Both strands of climate change discourses emphasize that for the most vulnerable communities, the relationship between the three factors are diverse, complex and multi-scaled. This requires attention to dynamics across different scales (Adger 2001).

Furthermore, political ecology can help explain how inequality, power structures and social injustice emerge within the CSA discourse by critically evaluating the ethical dimension of issues relevant to smallholder farming communities (e.g. climate justice, land and resource tenure and the distribution of rights). Applying political ecology theory to CSA opens up a deeper set of questions about the discursive nature of smallholder identity, its co-production, and the nature of hegemonic land and agrarian institutions. Therefore, as a theory, political ecology provides an important means by which we can understand the origins, root causes and characteristics of marginalization within smallholder communities. In recognition of this, we propose that inequality, unequal power relations and social injustice are three composite interacting factors, amplifying marginalization in rural agrarian societies. While there are likely many gaps in CSA, we focus on three key socio-political dimensions of marginalization: inequality, unequal power relations and social injustice (Anderson 2014; Aubert *et al.* 2015). These issues have been raised in the 2015 Paris Agreement of the United Nations Frameworks Convention on Climate Change (UNFCCC) and Sustainable Development Goals (Chandra *et al.* 2016; Verschuuren 2016). Yet there are few conceptual tools to understand how inequality, unequal power relations and social injustice operate in smallholder farming landscapes vulnerable to climate change (Eriksen *et al.* 2015).

Figure 1 frames the complex interactions between these three factors. For example, power is relational, while social justice is normative and ideal - a goal to aspire to. Power and its dimensions or scales, from powerful to powerless, are unevenly distributed (Yates 2014). Similarly, the consequences of social justice are positive and aspirational, whereas inequality is largely negative for groups of people (though it may have a positive effect on some groups).

Based on Figure 1, the interactions between these composite factors produce the characteristics, conditions and processes that marginalize smallholder farmers. Their examination reveals the processes that contribute to vulnerability, faced with climate impacts. They reflect the broader on-farm and off-farm social-political-economic factors which enable some, but not others, to benefit from CSA practices. We contend that the relationships and dynamics between the three factors are mutually reinforcing, inter-linked, heterogeneous or spatially diverse (i.e. operate at multi-levels), and change over time due to socio-economic and environmental change. By seeing marginalization as an interactional and mutually reinforcing concept, we can understand differential vulnerabilities within smallholder farming communities. We now review the theoretical origins of inequality, distribution of power and social injustice in the context of climate change.

Inequality

Climate change impacts on local farming communities are heterogeneous and tightly coupled with persistent poverty and inequalities (Adger and Jordan 2009). Inequality has become a useful entry point in vulnerability studies to analyze the uneven social distribution of impacts on rural and natural resource-dependent communities (Adger *et al.* 2006). Inequality is a significant barrier to producing sufficient food sustainably. Inequality prevents poor and marginalized people from managing daily risk and coping with climatic and non-climatic shocks (Tschakert *et al.* 2013). Scholars have examined the distribution of risks and

impacts on crop yields, assets, food insecurity and rural livelihoods across different analytical categories such as age, class, race, ethnicity and disability (Bolin *et al.* 2005; Leiserowitz and Akerlof 2010; Lindsay and Yantzi 2014; Newell 2005; Wolf *et al.* 2010). These categories help to explain the unequal social consequences of environmental change. They also help characterize marginalized groups, understand in-depth vulnerability factors affecting farming communities and identify the differential responses needed at a particular location (Kelly and Adger 1999).

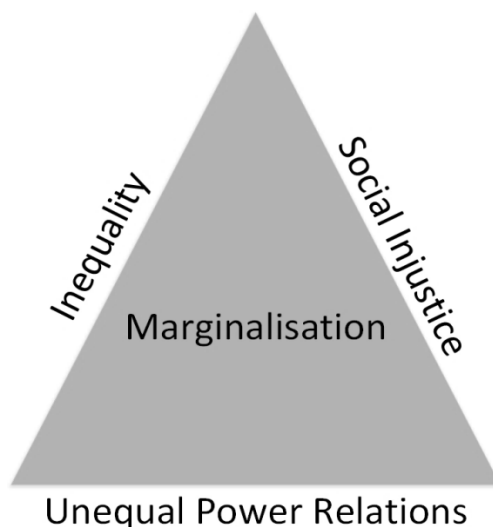


Figure 1: The three composite factors influencing marginalization in smallholder farming communities. The interactions between inequality, unequal power relations and social injustice produce different patterns of vulnerability to climate change experienced by smallholder farmers.

A gender lens is commonly used by feminist political ecology scholars to study marginalization and vulnerability. Literature that has applied a gender perspective considers knowledge, participation, womens' rights and responsibilities, and feminist political movements and activism as units of analysis (Alston 2015; Carlsson-Kanyama *et al.* 2010; Salleh 2006). Eco-feminist researchers like Alston (2015) emphasize that gender perspectives should be conceptualized beyond households. Transversal structures of gender difference exist within climate policies, and women are active agents in bringing about equitable climate change solutions (beyond the stereotype of women as 'vulnerable'). Scaling up gender-sensitive CSA practices is central (e.g. GCF 2015), but understanding of what makes agriculture practices gender-responsive remains weak (Jost *et al.* 2016).

Post-structuralist political ecology has studied the underlying causes of inequality stemming from historical, political, economic, demographic, and environmental contexts (Escobar 1996). Analysis of inequality leading to persistent marginalization needs to pay attention to changes in regimes of governance, colonial norms of land administration, agrarian reforms and green transformations (Batterbury and Fernando 2006; Scoones *et al.* 2015; Taylor 2014). Historical injustices - in conjunction with poverty - perpetuate the inequality witnessed in many smallholder communities. Critiques have also related the CSA discourse to corporate deception, suggesting the approach could repeat the injustices that resulted from earlier GR agricultural policies (CIDSE 2015). When left unaddressed by current development interventions, the underlying causes of inequality and injustice push the vulnerable deeper into poverty, accelerate ecological degradation and co-produce disproportionate vulnerability to climate change (IPCC 2014). In section 4 of this article, we delve further into how inequality has been historically produced by GR in rural smallholder farming structures.

Unequal power relations

Governing for CSA is not straightforward as a range of institutions influences the discourse and its operation. Technical choices made at the farm level are inspired by national regulatory choices and international policies made in favor of politics behind climate change, food production, water distribution and trade outcomes. In addition to this, transboundary institutions at different levels of authority mediate how vulnerability is addressed and external assistance channeled to smallholder farming communities (Adger 2001). For example NGOs have an influence on the implementation of climate-smart practices, government may control the distribution of livelihood assets (e.g. land, water rights) and donors determine the amount of climate finance through aid policies. These complex socio-ecological relations reframe CSA debate from a purely technical debate to one that fundamentally seeks to address how power at different levels influences the vulnerability of marginalized groups and distribution of agricultural resources.

A growing body of scholarly work, much of which has been synthesized in recent iterations of Intergovernmental Panel on Climate Change (IPCC) reports (Adger *et al.* 2014; Olsson *et al.* 2014), is paying attention to the ways in which power relations are unequally distributed and politically motivated. We use power here, quoting Puente-Rodriguez (2014, 431), to refer to the broader political and economic responses to climate change that "...control or influence capacities of actors within decision-making process". The theoretical and philosophical foundations of studying unequal power relations within political ecology are broad. For instance, researchers (Adger *et al.*, 2006; Taylor 2014; Yates 2014) have built on the work of poststructuralist scholars such as Luke (1974), Mann (1984) and Cox (1987) to critically evaluate how risk and vulnerability is shaped by institutional decision-making (i.e. how political processes facilitate climate change responses in the agriculture sector). Here, the literature establishes that actions of powerful agriculture, environment and rural development institutions at different scales impact decisions related to climate change (e.g. (re)-structuring of farmer-farm-environment relationships, resource rights of socially less powerful groups (see Biersack 2006; Robbins 2012).

Eriksen and others (2015) call on deeper analyses of unequal distribution of power that clearly situate climate change responses of disadvantaged groups within political processes, negotiations, state relations and cooperation at multiple scales. The principal argument within the literature is that institutionalized power relations condition how different farming groups experience vulnerability and in structuring their capacity to adapt/mitigate using climate-smart options. Food insecurity and political relations is also underlined as a primary source of conflict (Gemenne *et al.* 2014). We therefore need to think about power relations broadly – how interests of different vulnerable smallholder farmers are represented, distributed within and across communities and who has the authority to promote climate-smart responses.

The climate change and agriculture literature have only narrowly considered power analysis. The concept of power relations has been understood from the position of authorities, i.e. which social groups make decisions and control resources of another (Eriksen *et al.* 2015). To appreciate the role of power relations and structures in current CSA policies, a more nuanced understanding of power encompassing the influence of historical social justice issues, decisions of trans-national political networks and social groups is needed. Moreover, the popularization of scalar arrangements and institutions that structure mitigation and adaptation responses is a relevant concept for evaluating governance of climate change programs (Adger 2001; Ikeme 2003). The distribution of institutional power relations and scalar arrangements beyond farming communities have a profound influence on how scientific knowledge on CSA is formulated, how global politics around climate change is shaped, and how local realities on vulnerability represented (or excluded) by northern institutions (Hulme 2010).

Social injustice

Climate change is a moral, ethical and social justice issue. The IPCC (2014) affirms that climate change will exacerbate impacts on the welfare of poor smallholder farmers and socially disadvantaged groups in developing countries. Recognizing the unique vulnerabilities of specific groups, many scholars and social advocates have pointed out cases of social injustice, particularly human rights violations induced by climate

change and disasters (Finley-Brook and Thomas 2011; Olawuyi 2016). Many of the arguments relating to social injustice draw on alternative political ecology research grounded in neo-Marxist and post-Marxist theories of the late 1980s (see Parks and Roberts 2010). These theories emphasize the importance of climate justice and equity in addressing vulnerability of marginalized communities, minority groups, indigenous people and geographically remote communities that are weakly represented politically and economically (Agrawal 2002).

Political ecologists have researched different elements of social injustice. These elements include fairness, equity, entitlement, identity and participation, as well as the production of climate knowledge and value, conflicts, and paradoxes in the politics of climate justice (Adger *et al.* 2006; MacLennan and Perch 2012). Scholars conclude that vulnerability of minority groups and their political struggles are characterized by unequal distribution of resources, unjust socio-environmental conditions and inequity. Climate injustice is also born out of socially disparate development, the infringement of basic rights to livelihoods, weak environmental protection and resource use dynamics that elite social institutions mediate strongly (Collins 2010; Shiva 2005).

An emerging theme in the literature is social justice from the perspective of disproportionate exposure of minority, ethnically diverse groups and indigenous people from geographically remote locations of Latin America, North America, Africa and Pacific Islands (Tsosie 2007). Indigenous people manage many of the world's most valuable agrarian and biodiverse areas, under a range of property rights structures. They are important stewards of agricultural resources and biodiversity, and inhabit each of the Earth's biomes. While climate change impacts on indigenous agrarian societies have increased, business opportunities for development ventures have emerged (e.g. carbon credits, clean energy, reducing deforestation projects). Research into the benefits of such climate ventures is growing, but more attention is needed on the impacts for indigenous communities.

4. How inequality, unequal power relations and social injustice influence smallholder communities

This section discusses how inequality, unequal power relations and social injustice are manifested within and across smallholder communities. Given the underlying historical nature of inequality, we first undertake an analysis of the GR given its role in pre-existing inequalities and vulnerabilities for smallholder farmers. Second, we offer a deeper analysis of the unequal power relations within smallholder communities, vital to understand the social and spatial differentiation of CSA interventions. Finally, we examine how social justice and the rights of minority groups like indigenous farmers are challenged despite climate change interventions. We focus on these three examples to illustrate our point that both historical and current political ecologies influence smallholder agricultural landscapes. Again, by narrowly focusing upon technical and scientific solutions to climate change and food production the wider socio-political processes affecting local farming systems are downplayed, entrenching vulnerability and structural problems faced by smallholder farmers.

The residual effects of the first Green Revolution

One of the concerns shared by grassroots NGOs is that CSA could result in another GR, supporting industrialized agriculture in rural peasant and smallholder farming communities (IPM 2014). Agrarian technology and development changes promoted by the first GR in the 1960s resulted in a range of ecological and social impacts on smallholder farmers and the agriculture sector. The historical legacies of the GR led to hierarchical control of livelihood assets, contributing to the present unequal distribution of resources and climate risks in smallholder communities in a number of ways. Specifically, three key issues in the GR literature resonate with inequality and power relations in smallholder communities: (1) technology and scientific approaches deepened uneven power relations between the global north and south; (2) income inequalities amongst smallholders widened and polarized traditional social farming structures; and (3) environmental degradation endangered the livelihood assets of the grassroots setting a deterministic approach to future agricultural strategies.

GR institutions used, or permitted, an approach to agricultural technology that can easily benefit richer households, as we explain in the next paragraph, rather than being a land and social reform agenda. Kerr (2012) notes that although the intention of globalizing the benefits of technologies, science and the industrial model was used to maintain stable power relations between the North and South, it instead resulted in increasing concentration of commercial power of large agribusinesses in the North. This is of particular relevance to agro-ecologists who note that smallholder farmers therefore became more dependent on fertilizer, pesticides and other inputs (Holt-Giménez and Altieri 2013). For example, GR supported the rise of many agrochemical, pharmaceutical and food multinationals in the United States and Europe, which many farms across Asia and Africa heavily depended on for farm inputs (Patel 2013).

A longstanding academic debate is whether income distribution from GR technologies has contributed to social exclusion and inequality amongst the poorest farmers. Drawing on decades of research, scholars like Griffin (1979) note that the benefits of the GR were unequal, and accrued to more affluent regions, wealthy landowners and the socio-economic elite and their industries. During the GR, higher yield variety technologies targeted capital intensive inputs and investments to the best endowed farmers in the most productive regions, which directed away farming opportunities for poor/smaller scale farmers (Patel 2013). Furthermore, science and technology excluded the poor in resource-scarce regions, thus concentrating wealth and income in larger scale rich farms. There is now contextual evidence to suggest that following the GR some versions of this techno-political strategy, including rural development policies, worsened income and asset distribution (Freebairn 1995). For example in Punjab, India, Shiva (1991) observed that quick technological fixes (e.g. high yielding varieties of seeds, pesticides, packages) were counterproductive, unsustainable and less accessible to poor farmers across poor regions.

Another interesting observation is that corporate capitalism fueled by GR knowledge and technology transformed subsistence agriculture to commercial ventures. High costs of technology, fertilizers and other inputs were unaffordable to many poor farmers, thus shifting the commercial profit margins of agricultural produce to richer individuals. These disrupted social structures and political relationships are evident in changes such as purchase of inputs and arable land, increased debt and landlessness, widening equality gaps between big and small farmers, polarized peasant cultural movements, community and ethnic conflicts and new arrangements between land owners and laborers (Pilipinas *et al.* 2007; Shiva 1989). Shiva (1991), in her book *The violence of the Green Revolution*, claims that:

...since all the externally supplied inputs were scarce, it [the Green Revolution] set up conflict and competition over scarce resources, between classes, and between regions...this generated on the one hand, an erosion of cultural norms and practices and on the other hand, it sowed the seeds of violence and conflict. (Shiva 1991: 171)

Agarwal (1997) similarly argues that the GR increased and entrenched social inequities amongst small and marginal farmers in India, particularly along the lines of caste, ethnicity and gender, by explicitly focusing on technical approaches to reduce hunger and poverty. In many ways we continue to see poor farmers experience hardship due to ongoing agricultural reform initiatives, especially when corporate economic interests are prioritized above the welfare of poor communities. The overall winners of the first GR were large-scale farmers and multinational corporations, who reaped commercial benefits at the expense of the small-scale farmers.

Marginalized smallholder and resource-poor farmers dependent on rain-fed agriculture, particularly in marginal production systems across Africa and Southeast Asia, still do not have equal access to adequate information, technology and economic opportunities resulting from the historical and social disadvantages created or exacerbated by agricultural policies (Hazell 2010). In addition to their increasing vulnerability to climate impacts, inequality in the agriculture sector has a cumulative effect on farmer income and livelihoods, even after decades of the first GR. Additionally, poverty amongst rural smallholder farmers remains high globally, and the industrial model of agriculture and the deterministic influences of GR, continues to push millions of peasant farmers deeper into crisis and poverty, contributing to widening interregional income and

power disparities (Fan and Hazell 2001). Technical and scientific fixes, such as new crop varieties, pest management, and scaling up of best practices, will not address inequality and other social problems. How will resource-poor farmers of the developing world gain equitable benefits and access to 'climate-smart' knowledge and opportunities? Can this be factored into contemporary agricultural science, technology and research policies?

Finally, to address climate change and food security, a number of governments and development agencies have called for a 'second' GR through their foreign political and trade agendas (Meena *et al.* 2013; Wollenweber *et al.* 2005). Given the agricultural growth and poverty challenges in Sub-Saharan Africa, new investment is flowing into research and development to launch an African Green Revolution (Hertel *et al.* 2014). The calls for a second GR obfuscate the long-term problems in agriculture production and distribution, which has left vulnerable countries weak in their responses to inequality, land grabs, patents on life, and nutritional and food shortages resulting from climate events. The second and new wave of GR is justified by governments and development institutions to reduce poverty, foster agricultural modernization, keep improving agricultural productivity, and to lead pro-poor and sustainable development in rural areas (Dawson *et al.* 2015). The CSA discourse is supporting the second GR by presenting CSA as a transformative development solution for the agriculture sector, addressing climate change impacts and reducing CO₂ and other emissions from agriculture (Lipper *et al.* 2014). Yet our review of the first GR reveals that centrally designed CSA policies and technical fixes may be insufficient to deal with historic inequalities in income, land ownership, technology access and healthy ecosystem services further exacerbated by climate change. In light of future climate variability and extremes, the GR model is less likely to be successful and implies significant use of natural resources and inputs. CSA could differentiate from the contemporary GR model by prioritizing smallholder needs, local participation, and adaptation of global policies to local context (Dawson *et al.* 2015).

Dynamic power relations shaping elite institutions and farmers

A review of empirical literature on unequal power in smallholder farming communities emphasizes four broad narratives applicable to the multi-scalar nature of agrarian governance. **First**, within the different market chains and policy spaces, small-scale farmers are weakly represented and poorly linked to local, urban, regional and international markets. Trade policies, relationships, processing and retailing in the agriculture sector control food security and smallholder farming systems. There are different, competing agendas and stakeholders in climate change, agriculture and trade policy spaces.

We illustrate these in Figure 2, which shows multiple, competing and highly contested regulatory and political agendas operating at different scales. They are influenced by different stakeholder groups operating across local, (sub) national, regional and international market chains. For example institutionalized routines allow for the involvement of specific interest groups, party delegations or observers in the UNFCCC, WTO, IPCC and G20 discussions (Patel 2012). Similarly, decisions on adaptation and mitigation in the agriculture sector are usually made in the context of the implications for food production, fuel and income policy requirements. Technical experts and policy makers 'mutually construct' policies that back CSA initiatives but embedded within complex diplomatic circles, networks (complex interplay of social actors), and institutional relationships.

Second, an overarching narrative in food security dialogues is the concentration of market power and influence in the hands of a few industries operating from developed countries. The current concentration of agricultural industries, trade policies and economic incentives are less favorable for small-scale farmers and rural livelihoods. For example, the world's top ten food retailers operate out of Europe, USA and Japan while the top six agrochemical companies and their seed businesses are situated in the USA and Europe (IAASTD 2009; Wield *et al.* 2010). The ten leading seed companies in Europe and the USA accounted for US\$14,785 million or two-thirds (67%) of the global proprietary seed market (ETC group 2008). The world's largest seed company, Monsanto, accounted for almost one-quarter (23%) of the global proprietary seed market, and in 2017 is soon likely to merge with Bayer (ETC group 2008). These North-South power imbalances in trade relationships have significant implications. The concentrated corporate power in northern countries drives up

costs of production, and further undermines their rights to save and exchange knowledge and seeds (Leach *et al.* 2010).

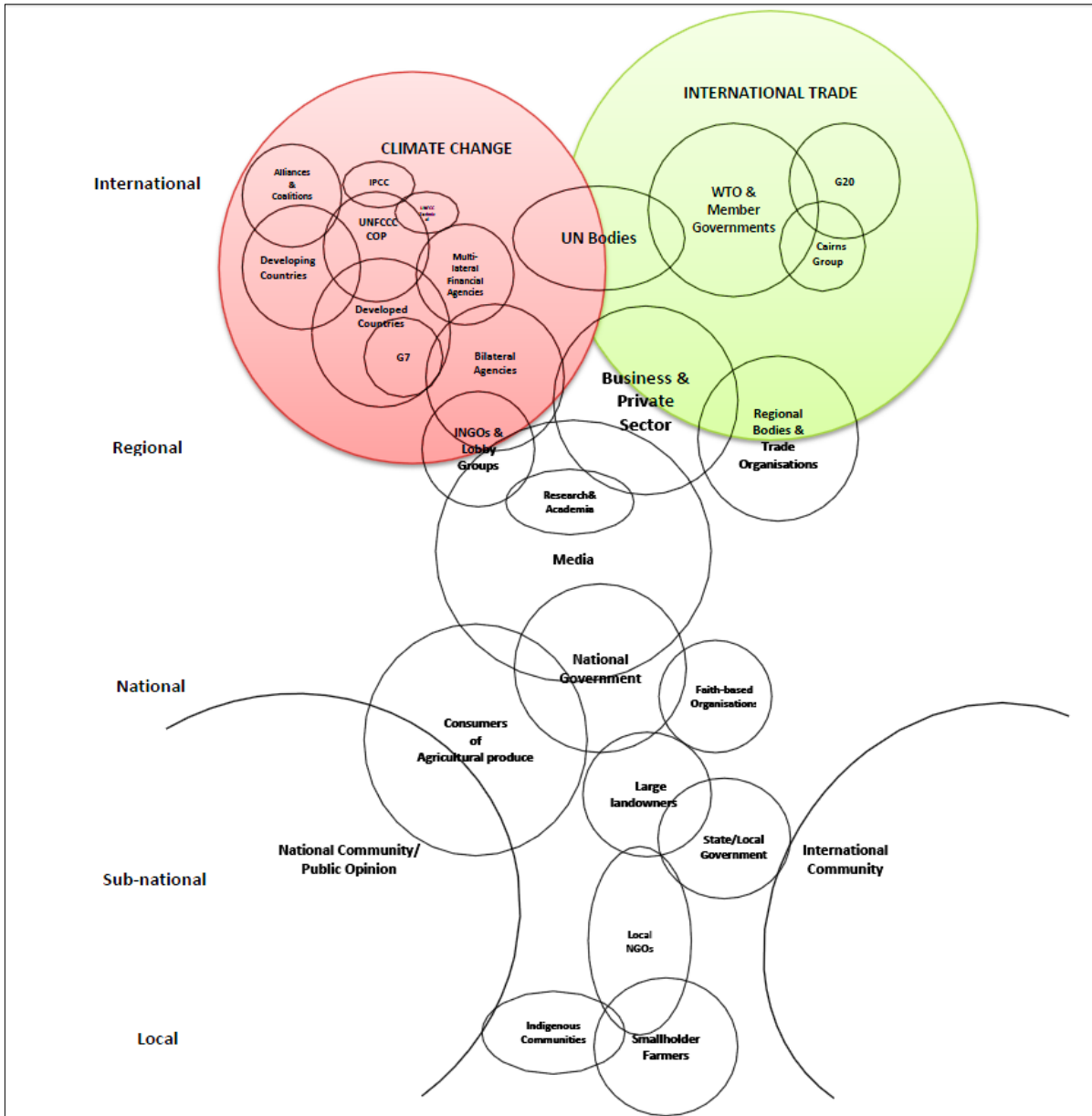


Figure 2: The globalization and scalar engagement of different institutions in the climate change and agriculture policy space across different governance levels. The red circle depicts the climate change processes, the green represents the agriculture processes while the whole circles are common to both. The size of the circle represents the degree of influence, determined on the basis of participation and representation of stakeholder groups within and across the networks of policy spaces.

Third, recent studies provide clear evidence of smallholder communities operating as their own networks. Their community structures are complex, diverse, divided and have multiple perspectives that are rarely identified by climate change institutions due to social conflicts, available resources, prejudice, culture, ethnicity and/or gender (Jost *et al.* 2016). As Yates (2014) argues, these factors co-determine vulnerability and adaptive capacity, which then influences flows of development assistance, knowledge and technical support. Added to this complexity are the political alliances and power relationships interacting with traditional forms of governance and community-based interventions. In this way, power relations direct us to question equity in the processes and the outcomes of CSA programs: who decides what is climate-smart, which farms should be targeted for demonstrations, and whose resilience should be managed and for what purpose?

Finally, the benefits of 'climate-smart' practices and technology may assist some elite (economic or otherwise) farmers yet exclude others. Most political ecology scholars agree that technical interventions are shaped by power imbalances that affect how benefits trickle down to the most marginalized communities (e.g. Bryant 1998; Taylor 2014). Elite control of livelihood assets, farmlands and materials has political ramifications and unintended consequences for community-based projects. For example, in community forestry projects in Nepal, decision-making on resource use was found to be dominated by elite and wealthy households, and the resulting benefits excluded women, lower caste groups or poor households (Thoms 2008). In this context, interventions through development programs that attempt to build adaptive capacity may be maladaptive if the benefits are accrued by some segments of a community at the expense of others.

Agricultural technology interventions may be initiated by institutions with philanthropic or commercial interests. For example, Glover (2007) describes the Monsanto Smallholder Program, in which the US-based transnational biotechnology company implemented a package of agricultural extension support to smallholders in selected developing countries in 1999, but appeared to exploit their vulnerability. Other Bt cotton impact studies in India have found that the higher prices charged for GM seeds, monopoly over technology acquisition and complex patent rights had elevated farming and socio-economic risks for the poorest farmers (Flachs 2016; Glover 2010; Ramasundaram *et al.* 2007). While the dominance of multinational companies has created new commercial markets for seeds, technology and agrichemicals, the benefits have gone to a small group of farmers, in a few developed countries (Wield *et al.* 2010). For the poorest smallholder farmers, or where agrarian institutional policies are weak, benefits arising from CSA technology will remain a formidable challenge. Integration of smallholders and rural farmers into the wider market is difficult when institutional policies continue to favor monopolistic elite interests and hegemonic partnerships. Improving access to technical services, improved crop varieties, public sector investments and public-private partnerships need to pay greater attention to socio-economic differences, especially the capacity of poorer farmers to exploit agriculture technologies aimed at reducing climate risks.

Lack of justice for indigenous farming communities

There is a need to better research the effects of climate change on indigenous people, who globally account for 370 million inhabitants and a third of the world's poor (UN 2009). Climate change is an existential threat to the future of many indigenous communities, undermining their right to food, health, life and an adequate standard of living (Kothari 2001). In addition to climate change, research has identified a range of factors at play contributing to the economic and social marginalization of indigenous people. They include geographical isolation, small populations, a lack of political representation, outmigration and conflict (Reed 2011).

In regions including the Arctic and the Pacific, there have been laudable advances in the participation of indigenous people in climate change programs. Indigenous agrobiodiversity conservation practices and traditional knowledge for monitoring climate variability have been documented. Indigenous agencies have advocated for stronger climate action (Vlassova 2006). In parallel, development agencies such as the World Bank, UN and other donors have established policies to stimulate provision of climate finance to indigenous people (Olawuyi 2016). Not all the initiatives are linked to agricultural societies, since farming is not part of the culture of all indigenous peoples.

Protecting the rights of indigenous people has been challenging for three reasons. **Firstly** there is weak recognition and protection of tenure and resource rights in climate policies, programs and interventions. Rights to land, water and indigenous knowledge entitlements have been prompted by first-generation environmental justice movements (Taylor 2000). But protecting indigenous rights to resources is variable (Carlson 2009). Tsosie (2007) argues that the governance of climate change programs focusing on indigenous farming communities poses a set of unique challenges, influenced by a multitude of formal and informal institutions: national reform agendas, customary laws, entitlements, intellectual property accords and multiple indigenous agencies. The International Indigenous Peoples' Forum on Climate Change (IPFCC) identifies unique vulnerabilities and has advocated within the UNFCCC to fully "integrate and operationalize human rights based approach in climate change policies and actions, including the rights of indigenous peoples" (IPFCC 2015: 1). A human rights-based approach to CSA could include recognizing the positive contributions of indigenous people in: agriculture adaptation and mitigation, traditional knowledge and technology transfer, and participation in the design, implementation, monitoring, and evaluation of CSA programs. Interestingly – and in contrast – where climate change programs have adequately targeted indigenous livelihood rights, the absence of legal entitlements and rights have resulted in limited benefits to marginalized indigenous farmers.

A **second** issue is how existing and planned CSA projects and policies will integrate safeguards for indigenous people. National climate change and agriculture policies target indigenous populations in research, as leaders of community action plans, or as beneficiaries of projects. Climate change interventions are failing to meet minimum national or international safeguard standards (Arhin 2014; Olawuyi 2016). There have been land acquisitions by governments and companies, physical violence and greater livelihood insecurities. Cases in India, Panama and Honduras suggest the violation of indigenous rights through the construction of hydropower dams and clean coal technology under Clean Development Mechanism projects (Finley-Brook and Thomas 2011; Grieg-Gran 2005). Similarly REDD+ initiatives in Indonesia, Mexico and Uganda have resulted in land grabs, land conflicts and violation of customary land rights, with benefits accruing to external agencies (Grainger and Geary 2011; Raftopoulos 2016). Reed (2011) points out that many indigenous groups express skepticism of climate change projects linked to international markets (e.g. CDM and REDD+) and multinational companies, because in practice they have been avenues to exploit indigenous land sovereignty and self-determination. The implementation and monitoring of safeguards is underdeveloped, and this is a warning for CSA (Larson 2011). As a result, some organizations are developing their own safeguards in the context of climate change mitigation and adaptation activities.

A **third** challenge is how social movements and influential actors shape and transform new climate justice policies of indigenous people. Politically, the participation of indigenous people in international climate policies and regimes has been contentious and sensitive. This has created opportunities and imperatives for new transnational movements to proliferate, representing a political symbol of grassroots indigeneity. Institutions and events such as the IPFCC and the the World People's Conference on Climate Change and the Rights of Mother Earth (2010) have emerged. Powerful indigenous social movements now sanction and contest the mainstreaming of indigeneity in national and international climate change policies. They are new social networks, forms of identify and political action, connecting different national indigenous agendas and priorities within the international climate regimes. For example, the IPFCC, since 2008, has lobbied the UNFCCC to develop modalities to fully integrate and operationalize a human rights-based approach in climate change policies and actions, including the rights of indigenous people taking into account commitments under the United Nations Declaration on the Rights of Indigenous Peoples (Khan 2014).

Recognition of Indigenous rights appeared in the text of the Paris Agreement at COP-21 only as aspirational goals, but they are not legally binding and enforceable due to pressure exerted by the US, Norway and EU.⁴ While transnational movements such as the IPFCC have advocated for indigenous rights and amplified their social struggles, they continue to be challenged and shaped by hegemonic powers and political and economic forces. Transnational networks and movements have revitalized new arguments that are beyond 'entitlement', climate justice and safeguard issues. They include an emphasis on the importance of indigenous

⁴ The USA later committed to leave the Paris Agreement in June 2017.

practices and knowledge in effecting successful adaptation and mitigation responses in agri-food systems (UNFCCC 2014).

5. Discussion: embedding equality, fair power relations and social justice into CSA policy and practice

We have asked how political ecology can inform CSA policy and practice that better reflects the realities of smallholder agrarian communities. In particular we reflected systematically on the notion of marginalization, and argued that three inter-related socio-political processes perpetuate the marginalization of smallholder farmers: inequality, unequal power relations and social injustice. Mainstream approaches to CSA acknowledge social factors, yet weakly address these intertwined socio-political factors in smallholder farming systems. While CSA is beginning to feature in national plans (e.g. Intended Nationally Determined Contributions, national science and food security strategies) and international climate change policies, they deplore the socio-political aspects of vulnerability while over-emphasizing technical and scientific approaches. We believe that the emerging CSA discourse can better embed social and political factors for scaling-up practices in smallholder farming communities. Political ecology is a useful lens, or framework, to guide the development of policies that better address the needs and priorities of the vulnerable.

A political ecology perspective to CSA via the marginalization lens unveils the socio-political concerns of smallholder farmers. Our review of scholarly work highlights the specific vulnerability of smallholder farmers (men, women, indigenous people, and farmer organizations). Their unique vulnerabilities are increasingly being highlighted and targeted within climate and agriculture policies to attract resources or to be used within community-based interventions to justify the same. While there is no universally agreed definition of 'vulnerable', nor an agreed criteria or methodology for assessing vulnerability, some form of targeting is required to ensure 'climate-smart' interventions are assisting marginalized farmers most in need. Smallholder farmer concerns and priorities often come from their unique daily experiences, concerns about livelihoods, indigenous entitlements, gender differences and human rights. Institutions concerned with formulating and implementing climate and agriculture policies therefore need to engage directly with smallholder farmers in planning and decision-making related to smart approaches.

The vulnerabilities in agrarian production systems to the adverse impacts of climate change are created through the interplay between our three concerns: inequality, unequal power relations and social injustice. Each factor or combination of them produces differential implications on livelihoods and the outcomes expected to be achieved under CSA interventions. Food insecurity in vulnerable farming landscapes is not only about climatic variability or population growth, as often expressed in CSA narratives. There are multiple concerns around inequality, power imbalances and injustice in the agriculture sector (interacting in complex ways), a legacy that emerged in the first GR and one that remains unresolved at grassroots levels today. To highlight the discursive unequal power relations generated by GR policies is not to argue that the benefits have largely been negative (GR impacts continue to be researched). On the contrary we stress that early agricultural policies arguably paid relatively little attention to the inequalities within smallholder farming communities, which continue to pervade and perpetuate today. The science and technology of the GR and agrarian reforms is a key feature of historical political ecologies of smallholder farming systems and play a crucial role in structuring and differentiating vulnerabilities. Effective CSA approaches should recognize these socio-political risk factors.

The critique of GR inequalities point to structures of unequal power and privilege as critical battlegrounds of new policy paradigms encouraging food security and 'smart' technology. Addressing the historical causes of injustices and inequality must play a fundamental role in scientific knowledge and technological solutions offered by climate change strategies and agricultural reform policies. Investments in climate-smart options such as new crop varieties, extension services, early warning systems, agronomic practices, and alternative livelihoods need to be sensitive to, and cognizant of, the everyday lives of poor groups and marginalized individuals. This might make CSA interventions more locally relevant, equitable and therefore sustainable.

Our analysis further indicates that 'scalar power relations' and hegemonic institutions structure differential vulnerability, the distribution of benefits from projects, and arguably subject indigenous farming communities to unequal power and contestation. At the same time, a wide-ranging articulation of climate impacts on smallholder farmers in aid policies has propelled transnational climate justice movements, 'scaling up' to work at international levels to promote urgent climate action (Hulme 2010). Analysis of social justice through multi- and cross-scale networks in emergent political ecology research recognizes increasing social and political complexity in climate governance. New global and regional platforms such as the GACSA, CCAFS and the West Africa Climate-smart Alliance recognize agriculture as a driver of climate change (CCAFS 2015). While these alliances are opening new spaces for (high-level) political engagement, representation, recognition and participation of grassroots communities and organizations in CSA platforms and dialogues is oddly weak (Sugden 2015). In part, this means that the complexity, diversity, incongruity and reality of day-to-day farmer experiences can be overlooked in research and policies.

What we need in the governance of CSA is democratization, with a deeper engagement with a range of organizations, especially local community groups and civil society organizations. We need partnerships reflecting diverse interests of groups and networks from smallholder farming communities. Organizations concerned with the governance of CSA should include perspectives from social scientists, including political analysts and cultural anthropologists. CSA policies must rethink traditional technical approaches to science, innovation, capacity development, policy and communication. They need to address future challenges of the agriculture sector but pay equal attention to the realities and diversity of solutions, particularly at the local level. While decision-makers require projections of climate conditions, scientists must support the creation of policies that harness political ecology perspectives dealing critically with gender, indigenous rights, power relations and justice.

Participatory mechanisms are also needed to capture a variety of voices at the bottom of the hierarchy of power, and to articulate farmer needs and priorities to make the best use of resources invested in climate-smart approaches. Despite the increasing attention of research to climate impacts on smallholder farming, there is limited information on differential risks (both climate and non-climate related), and the mitigation and adaptation needs of smallholder farmers (Harvey *et al.* 2014). Community-based risk assessments of agrarian communities, and agendas for reform, need to integrate the analysis of equality, power relations and justice within existing and new climate change interventions.

The challenge for finance in the agriculture sector is to ensure that there is sustainable access to credit, land deals are made in a transparent manner, and investment in infrastructure development that ensures equitable benefits for local people. Currently, national and international climate policies fail to attend to issues of injustice, the protection of traditional knowledge, and safeguarding the rights of local farmers. Funding opportunities should be available to local community groups, civil society organizations and sub-national stakeholders. Finance for adaptation and mitigation in the agriculture sector should direct attention to tackling elite interests and unequal networks of power. In particular funding decisions need to carefully analyze the links between unequal power, agency, structure, and the practices and actions of different social actors (Leach *et al.* 2010).

These factors establish direct links between local agricultural practices and the corresponding food security and livelihood benefits to marginalized farmers. We propose a rights-based approach to climate-smart policies and practice for participatory work with vulnerable smallholder farming communities. Some commentators have argued that a human rights-based approach can be useful in building resilience to climate change, attaining food security and sustainable intensification of agriculture (Ensor *et al.* 2015; Tanner *et al.* 2015). Extending a rights-based approach in climate-smart interventions will expose the mechanisms of marginalization that operate alongside farmer adaptation to climate change.

Going forward, we recommend revival of research on marginalization and vulnerability in CSA research and policies targeting smallholder-farming systems. We suggest that CSA research should be context-specific and locally driven, but could benefit from a more explicit focus on analyzing climate change concerns beyond purely technical measures, with a more explicit focus on the interactions between inequality, power relations and social injustice. Analysis leading to the integration of social, cultural and political aspects

could enable projects and program tied to agrarian communities to address roots causes and complex factors related to vulnerability to climate hazards.

6. Conclusion

The review has argued that CSA falls short of promoting the socio-political concerns of smallholder farmers, and many of the vulnerabilities that they face. The scientific, institutional, policy and funding landscape has focused on generating scientific practices, technology innovation, low emissions agriculture and mainstreaming of these practices into national and international policies. CSA focusing on technical and scientific fixes at the farm level, will be insufficient to meet increasing climate and social impacts, especially in vulnerable regions of Sub-Saharan Africa and Asia and Pacific. This is because distinctive types of political ecologies are being produced in smallholder farming communities through inequality, unequal power relations and social injustice. We conclude that vulnerabilities among the most marginalized at local and global levels will amplify if 'climate-smart' policies sidestep issues related to smallholder farmer rights, equitable distribution of agricultural resources and hegemonic power relations. CSA interventions need to move beyond the farm level and target inequality, unequal power relations and injustice beyond the farm to address socio-political processes influencing livelihoods, food production, and vulnerability.

As advocated by the IPCC in the Paris Agreement on Climate Change (2015), rights-based approaches that recognize the critical importance of good governance, climate justice and the agency of smallholder farmers could distinguish the CSA movement. This will require addressing the knowledge gaps on socio-political dimensions, to increase the effectiveness of responses to the root causes of agrarian challenges. Rather than emphasizing scientific rigor, we should begin by asking which mix of climate-smart approaches help to address these causes.

We remain optimistic about research, planning and policy on CSA. There is a unique opportunity to promote the concerns of the millions of the most marginalized smallholder farmers, men and women, who are deprived of justice and equality – the poor, women, indigenous communities and the resource-poor living in high-risk areas. Rather than perpetuating a repetitive cycle of marginalization (Robbins 2012), a rights-based perspective is a prerequisite to new research, planning and policy agendas. For this, CSA institutions need to create inclusive structures that foster the direct participation of farmers and grassroots social movements. In this way 'smart' agricultural practices and science investments will be directed to make more radical changes and optimize economic, social and environmental co-benefits.

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