Assessment of the Growth in Social Groups for Sustainable Agriculture and Land Management

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Abstract

For agriculture and land management to improve natural capital over whole landscapes, social cooperation has long been required. The political economy of the later 20th and early 21st centuries prioritised unfettered individual action over the collective, and many rural institutions were harmed or destroyed. Since then, a wide range of social movements, networks and federations have emerged to support transitions toward sustainability and equity. Here we focus on social capital manifested as intentionally-formed collaborative groups within specific geographic territories. These groups focus on 1) integrated pest management; 2) forests; 3) land; 4) water; 5) pastures; 6) support services; 7) innovation platforms; 8) small-scale systems. We show across 122 initiatives in 55 countries that the number of groups has grown from 0.5M (at 2000) to 8.54M (2020). The area of land transformed by the 170-255M group members is 300 Mha, mostly in less-developed countries (98% groups; 94% area). Farmers and land managers working with scientists and extensionists in these groups have improved both environmental outcomes and agricultural productivity. In some cases, changes to national or regional policy supported this growth in groups. Together with other movements, these social groups could now support further transitions towards policies and behaviours for global sustainability.

Collective Management of Natural Resources and Agriculture

For as long as people and cultures have managed natural resources, collective action has produced systems of efficient and effective offtake as well as offering potential for sustaining natural capital and valued flows of ecosystem services (King, 1911; Kelly, 1995; Li Wenhua, 2001; Folke et al, 2010; FAO, 2016a). A wide range of different types of more sustainable agriculture and land management have recently been developed and implemented, most centring on the notion that making more of existing land by sustainable intensification and collective action can result in greater and synergistic co-production of food and ecosystem services (Foresight, 2011; Benton, 2015; FAO, 2016b; Maréchal et al, 2018; Pretty et al., 2018). Yet at the same time, agriculture and land management has also contributed to biodiversity loss, nutrient loading of the biosphere, climate forcing, depletion of aquifers and surface water, and pollution of air, soil and water (Rockstrom et al., 2011; 2017; IPBES, 2019).

Humans have a long history of developing regimes and rules in both hunter-gatherer-forager and agricultural communities to protect and preserve natural resources in a steady state (Denevan, 2001; Kelly, 2007; Cummings et al., 2014; Berkes et al, 2020). These diverse and location-specific rule systems form informal institutional frameworks within communities, legitimated by shared values. These social frameworks have regulated the use of private and common property throughout history, for instance by defining access rights and appropriate behaviours (Ostrom, 1990). Where these systems are robust, they can maintain productivity and diversity without the need for external legal enforcement: compliance derives from shared values and internal rules and obligations (Bagadion and Lorten, 1991; Gunderson and Holling, 2002; Agarwal, 2018). In some agricultural systems, there is evidence that social structures have sustainably governed resource use over millennia, for example subak irrigation groups in Bali (Yekti et al., 2017) and irrigation tank groups in Tamil Nadu (Mosse, 1992). Elsewhere, the structure of farms in landscapes has been shown to shape wider social and political participation, such as in the classic study of small and large farmed communities in California (Goldschmidt, 1946, 1978; Lobao, 1990): social connectedness, trust and participation in community life was greater when farm size was smaller.

However, many of these inherited and legacy institutions have been undermined by choices made by the modern agricultural political economy: social institutions have been ignored, coopted, undermined and deliberately broken (Wade, 1989; Cernea, 1991). The emergence of neo-liberal forms of economic development prioritised the competitive choices and actions of individuals rather than cooperation (Uphoff, 1992; Dorling, 2020), and framed the approaches to technology adopted during the green revolution (Conway and Barbier, 1990). In some cases, state institutions were imposed on farmers as the price for obtaining modern varieties, fertilizers and pesticides, such as in Malaysia and the Philippines (Palmer, 1976); in others local institutions lost power and withered, such *kokwet* water systems in Kenya (Huxley, 1960), *warabandi* in Pakistan (Bandaragoda, 2008), common property resources in India (Jodha, 1990). The collapse of institutions allowed over-extraction by the unfettered actions of individuals (e.g. of groundwater in Gujarat: Shah, 1990). Empty and paper institutions were also formed by states without local participation, such as for grazing in China (Ho, 2016) or irrigation in Thailand (Ricks, 2015).

Further changes to social structures of communities were fostered by the conditional policies of structural adjustment adopted by international finance institutions from the 1970s and 1980s resulting in the destruction of public institutions (Crisp and Kelly, 1999; Forster et al., 2019), and by the adoption of the Training and Visit (T&V) system of agricultural extension (Benor et al., 1984). The T&V system was built on a linear diffusion model (or transfer of technology), first implemented on recommendation of the World Bank in 1967, and resulting in disbursement to 512 projects valued at US$3 billion over 1977-1992. Structural adjustment brought free-market policies to 135 countries between 1980-2014, causing severe impacts on inequality (Forster et al., 2019). At the same time, forestry management had also become centralised into state and private enterprises that took little account of existing cultural institutions and norms of co-management (FAO, 2016a). This era has been called the height of the “capitalocene” (Haraway, 2015; Moore, 2017).

Concerns over the cost of ignoring local institutions and group approaches emerged, with project evaluations showing that the creation of farmer and rural institutions led both to sustained performance after project completion and to more efficient and fair use of natural resources (Cernea, 1987; Ostrom, 1990; Uphoff, 1992). New forms of participatory inquiry and systems of collective learning and action were field-tested, putting farmer knowledge and capacity to experiment at the centre of practices for improvement (Chambers, 1989; Pretty, 1995; FAO, 2019). By the mid-1990s, the linear diffusion model was increasingly seen as ineffective: non-adopters had been termed laggards, extension staff had become poorly motivated, and research systems had been prevented from becoming learning systems (Antholt, 1994).

Since then, a wide range of new forms of social organisation have been intentionally formed to support transformations in agricultural landscapes. These have sought to build political strength for land rights, to protect against resource extraction, to increase market strength and power (such as through formal cooperatives), to link farmers and consumers through food chains, and to re-establish forms of co-management for natural resources (Ostrom, 1990; Berkes, 2020). All these structures are forms of social capital (Coleman, 1990), in which it is recognised that personal relations of trust, reciprocity and mutual obligation can result in actions and change that benefit larger numbers of people and farmers, particularly those ignored or disadvantaged by past forms of development. In some cases, these have been supported by novel public policies that reversed decades of state control by devolving decisions to local communities (Bawden, 2011; FAO, 2016c; Rahman, 2019); in others they have been organised to prevent the actions of the state (Veltmeyer, 2018).

Here we assess the emergence of social groups within particular geographic territories, with a focus on group-based learning and co-management for integrated pest management, forest, watershed and irrigation, and groups and platforms for microfinance, innovation and direct connections with consumers. We seek to address one key research question: to what extent have efforts to form social groups for agriculture and land management within defined territories resulted in the formation of persistent collective groups, and do the worldwide numbers indicate improved possibilities for transitions toward sustainable agricultural development that will lead to improved outcomes for farmers and the environment?

The Emergence of Social Groups in Support of Sustainability

A wide range of advances in agricultural and land sustainability have been made in the past two decades, with a range of terminologies and priorities. These include calls for a doubly green revolution (Conway, 1997), for alternative agriculture (NRC, 1989), for an evergreen revolution (Swaminathan, 2000), for agroecological intensification (Garbach et al., 2016) and for agroecological movements (Giraldo and Rosset, 2017), for evergreen agriculture (Garrity *et al*., 2010), for save and grow agriculture (FAO, 2011, 2016), and for sustainable intensification (Godfray et al., 2010; Smith, 2013). All of these have in common a desire to optimise the use of natural, social, human and financial capital while also being vigilant about the direct effects of agricultural and land management practices on these assets. Sustainable forms of management thus seek to use and enhance these capitals and reduce the costs of externalities on ecosystems and human health. Most of these also emphasise outcomes applying to any size of enterprise, and not predetermining technologies, production type, or particular design components (Weltin et al., 2018).

A recent global assessment of sustainable intensification (Pretty et al., 2018) indicated that systems of agricultural management undergoing fundamental redesign produce beneficial outcomes over sustained periods of time across differing ecological, economic, social and political landscapes. Redesign is, however, as much a social and institutional challenge as it is a technical one (Gliessman and Rosemeyer, 2009), as there is a need to create and make productive use of human capital in the form of knowledge and capacity to adapt and innovate, and social capital to promote landscape-scale change, such as for positive contributions to biodiversity, water quantity and quality, pest management and climate change mitigation. As ecological, climatic, and economic conditions change, and as knowledge evolves, so must the capacity of farmers and communities improve to allow them to drive transitions through processes of collective social learning (Hill, 1985).

Social capital has become a term used to describe the importance of social bonds, trust and reciprocity, and collective action through institutions (Putnam, 1995). It was defined by Coleman as "the structure of relations between actors and among actors" that encourages productive activities (Coleman, 1990); by Bourdieu (1986) as "a durable network of institutional relationships of mutual acquaintance and recognition…, to membership of a group, which provides each of its members with the backing of collectively-owned capital"; and by Bhandari and Yasunobu (2009) as a "multifunctional phenomenon comprising stocks of social norms, values, beliefs, trusts, obligations, relationships, friends, memberships, civic engagement, information flows and institutions that further cooperation and collective action for mutual benefits."

These aspects of social infrastructure act as resources for individuals to realise personal and community interests. As social capital lowers the costs of working together, it should facilitate cooperation. Individuals have the confidence and the means to invest in collective activities, knowing that others will do so too. They are also less likely to engage in unfettered private actions that result in resource degradation, though this is no guarantee that tragedies of the commons will not occur (Wade, 1989). Social capital can also have a "dark side", with exclusion and elite capture resulting in non-democratic outcomes for some (Putzel, 1997; Reddy and Reddy, 2005; Verma et al., 2019). It may also be deployed deliberately to offset the existing structures of states and international institutions (Forssell and Lankowski, 2015). The literature emphasises the importance of building relations of trust, reciprocity and exchange,, agreeing common rules and sanctions, and developing connectedness through groups (Pretty, 2003; Veltmeyer, 2019).

Social capital is thus generally seen as a prerequisite for the sustainable management of resources, and for the development of approaches and methods across all geographic territories (Waddington et al., 2014; Leisher et al., 2016; Agarwal, 2018). It does not, though, guarantee sustainable outcomes. It is common for fishing communities to want to believe that fish stocks are not being eroded, even though the evidence might indicate otherwise. Not all farmers know that the application of insecticides harms populations of beneficial natural enemies. In the Netherlands, farmers recently organised a backlash to demonstrate against environmental objectives and the addressing of climate change by farm policy (van der Ploeg, 2020). It is also true that not all transformation towards sustainability requires the formation of local social capital: a simple intervention heuristic in Vietnam ("no-spray in first 40-days of rice cultivation") resulted in farmers cutting pesticide use by 50% (Escalada and Heong, 2004); and the aerial releases of parasitoid wasps (*Anagyrus lopezi)* in Africa to control cassava mealybug did not require active farmer involvement (Wyckhuys et al., 2018).

Many forms of social capital have emerged in support of transitions towards greater sustainability and equity. These include transnational farmer movements, such as La Vía Campesina with 200M families represented worldwide (Martínez-Torres and Rosset, 2014), national land rights and anti-land grab movements, such as MST and the resettlement of 0.37M families on 7.5 Mha over ten years (Movimento dos Trabalhadores Rurais Sen Terra: Veltmeyer, 2018), national rural unions (Welch and Sauer, 2015) and agroecology and social movements (Veltmeyer, 2019). In some cases, these have led to active conflict and "peasant wars" (Giraldo and Rosset, 2017; Levien et al., 2018). At the same time, organisation around food has advanced in the form of food sovereignty and justice movements (McMichael, 2013; Edelman et al., 2014) and alternative food networks (AFNs) and alternative food movements (AFMs), particularly from urban food production landscapes and many involving consumers as well as growers/farmers (Desmarais and Wittman, 2014; Forssell and Lankowski, 2015; Si et al., 2015; Hoey and Sponseller, 2018; Plieninger et al., 2018; Saulters et al., 2018).

Our focus here is on a subset of this social capital, specifically social groups within defined geographic territories (Ostrom, 1990; Flora and Delaney, 2012). We use numbers of established groups as a proxy for social capital within communities, as each provides the context for innovation, negotiation and experimentation, bringing together individuals with different skills and knowledges. Such groups also require forms of engagement by professionals (researchers, extensionists, advisers) largely different from those dominant in the previous era of transfer of technology.

The concept of system redesign implies the establishment of new knowledge economies for agriculture and land (MacMillan and Benton, 2014). It is clear that the technologies and practices increasingly exist to provide both positive food and ecosystem outcomes: new knowledge needs to be co-created and deployed in an interconnected fashion, with an emphasis on ecological and technological innovation (Willyard et al, 2018). There have been many adaptations in terminology for these systems of co-learning: farmer field school, learning lab, science and technology backyard platform, science field shops, junior life schools, innovation platform, farmer-led council, agro-ecosystem network, farmer cluster network, joint liability group, landcare group and epistemic community. What is common to these social innovations has been an understanding that individual farmers, scientists, advisors and extensionists also undertake a transformative journey. Their worldviews are challenged and change, resulting in the formation of broader epistemic communities of common interest (Norgaard, 2004), that utilise, synthesise and apply knowledge and skills from many sources. For sustainable outcomes, cognitive social capital in the form of beliefs and worldviews also changes.

Assessment Methods

For this assessment of territory-based social groups, we have analysed agriculture and natural resource systems worldwide, drawing upon both published literature and the knowledge and networks of the co-authors. We searched online research platforms for published literature in Agricola (USDA National Library), Agris (UN FAO), CAB Abstracts, Google Scholar and Google, Scopus, and Web of Science for published records over the past ten years (web links listed in references), and drew on the collective knowledge of the assessment team and their personal contacts regarding further unpublished material from government and non-government initiatives. Projects and programmes in all countries were eligible. We selected terms for searches drawn from our knowledge of programmes in the field: social + capital; sustainable + agriculture; sustainable + intensification; joint/participatory + forest + management; agroforestry + groups; integrated + pest + management; farmer + field + schools; watershed + management; conservation + agriculture; irrigation + management; water + user + groups; pasture/grazing + management; microcredit/microfinance + groups; innovation + platforms; participatory + methods/approaches; farmer + organisations/institutions. A number of international analyses were drawn upon (e.g. of farmer fields schools: FAO, 2019; van den Berg et al., 2020a; of community forestry: FAO, 2016a).

We organised the findings into eight functional categories of redesign, each with different types of enabling social intervention (Table 1). We report on data gathered from 122 initiatives in 55 countries across six continental regions, and have applied no lower limit to the number of groups reported per initiative. Of the 55 countries, 13 were in industrialised and 42 in less-developed countries (see endnote on terminology).

Table 1. Eight categories of social group interventions for sustainable agriculture and land management

Category	Social intervention types
1. Integrated pest management	Farmer field school (FFS), push-pull systems of IPM, IPM clubs and FFS alumni groups
2. Forest management	Joint forest management (JFM), community based forestry (CBF), participatory forest management (PFM), agroforestry
3. Land management	Watershed and catchment management, conservation agriculture (CA), integrated biodiversity, farmer clusters
4. Water management	Participatory irrigation management (PIM), water user groups (WUGs), farmer water schools, farmer-led watersheds
5. Pasture and range management	Management intensive rotational grazing groups, veterinary groups, dairy groups, agropastoralist field schools
6. Supporting services	Microfinance groups, multifunctional farmer and non-farmer groups

7.	Innovation platforms	Research platforms, co-production groups, science and technology backyard platforms, field science labs, joint liability groups
8.	Intensive integrated systems	Community supported agriculture groups, biogas-pig-vegetable groups, aquaculture

Note: previous assessments of social capital used 5 categories (mapping here onto 1-4, 6): Pretty and Ward (2001). A global assessment of sustainable intensification used 7 categories (mapping here onto 1-5, 7-8: Pretty et al., 2018).

We gathered data on numbers of social groups, numbers of farmer members, and numbers of hectares under interventions for co-management. We have excluded data on groups where there is evidence of misreporting or the phenomenon of paper or empty groups, those reported to meet political targets, but which do not exist on the ground (Ravindranath and Sudha, 2004; Ricks and Arif, 2012; Ho, 2016; Ricks, 2016). An unintended outcome of positive policy support for group formation has led to some inaccurate reporting to meet targets in some locations, such as for participatory irrigation management and forest co-management. We have also not made assumptions about intended adoption: for example, an EU Directive (2019) now requires all farms to use integrated pest management, but preparations for implementation have not yet led to significant uptake of agricultural practices that significantly benefit ecosystem services (Buckwell et al., 2014). We have not included reporting of area of land under co-management where group data does not exist, such as for large tracts of forest now under community-based forestry (FAO, 2016a).

As indicated above, we also did not include here analysis of non-territorial social capital in the form of cooperatives, farmer organisations, federations and movements. Many rural and agricultural cooperatives (focusing on milk processing, input supply, collective marketing and sales) are not geographically-based. In the USA, there are 2047 rural cooperatives (though down from 10,040 in 1950) (USDA, 2018), in Brazil 1620 (with 1M members) (Dias and Teles, 2018), in China 2.2M (MARA, 2019), and in the UK 420 co-ops (6% of UK farm market share by value; market shares by farm co-ops are higher in the Netherlands (68%), France (55%) and Spain (45%)) (Cooperatives UK, 2018). In a number of countries, dispersed clusters of farmers collaborate on common research interests, but may not result in natural capital improvements within whole territories. In India, there are >3000 Farmer Producer Organisations with 0.3M members, but these too tend not to be geographically based (SOIL, 2017; Verma et al., 2019). Federations, food networks and movements that can be effective at transforming agriculture and food systems across and within countries, often at national and international levels, such as in Canada (Leykoe, 2014; Desmarais and Wittman, 2014), the EU and Japan (Plieninger et al., 2018), across 81 countries (182 member groups) for La Vía Campesina (La Vía Campesina, 2019), and 71 countries (258 member groups) for the International Partnership for the Satoyama Initiative (Kozar et al., 2019). These forms of social capital are not included in this assessment, but comprise a rich field of study for further work on transitions towards sustainability in agriculture and land management.

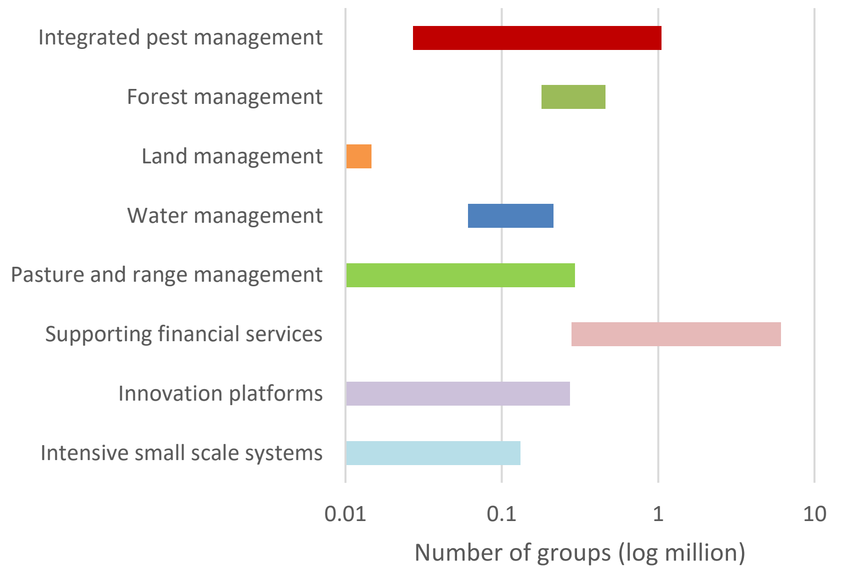
Layers of federations can be important in ensuring local priorities reach upwards to influence policy and practice. In Andhra Pradesh, for example, the 830,000 women's self-help groups (SHGs) are organised into village level federations (of 15-30 SHGs) each, and these into distinct federations of 40-60 village organisations (Kumar, 2017; Bharucha et al., 2020). In Japan, 1000 teikei purchasing groups are linked to organic and natural farming and have organised into federations, with some leaders coming to be elected as members of parliament (Kondoh, 2015; iPES-Food, 2016).

This assessment of social group formation also does not imply that numbers of farms and hectares are fixed: on the ground, there will be a flux in numbers resulting from both adoption and dis-adoption. This may arise from farmer choice and agency, but equally from the actions of vested interests, input companies, consolidation of small farms into larger operations, changes in agricultural policy or shifts in market demand, and discrepancies between on-paper claims and what farmers have implemented. We have excluded data on groups formed during the assessment period, but since abandoned by changes in development assistance funding and/or national priorities. In the 1990s, for example, 4500 catchment groups were formed in Kenya by the Ministry of Agriculture; the catchment approach ended in 2000, evolved into a National Agriculture and Livestock Extension Programme with common interest groups, but since then the focus has changed away from these groups (Pretty et al., 2011). In South East Asia, some recorded participatory irrigation groups later also become ineffective (Ricks, 2015, 2016).

Outcomes: Group Numbers

We organised the findings into eight categories of agricultural and land management intervention that are contributing to the emergence of new knowledge economies (Table 1). Across the eight categories and 122 distinct initiatives, we recorded 8.54M intentionally-formed social groups worldwide. These comprise groups collectively managing 299Mha of agricultural and non-agricultural land. This represents a growth in these types of groups from 0.005M at the end of the 1980s (primarily in participatory irrigation management) to 0.48M in 2001 (Pretty and Ward, 2001; Pretty, 2003), and now to 8.54M by 2020 (exponential fit: R=0.982). Figure 1 shows the marginal increase between 2000-2020 in groups in each of the eight categories.

Figure 1. Increase in numbers of groups in eight categories of sustainabe agriculture and land management (2000-2020)



Most social groups surveyed contain 20-25 members (range 15-30), with occasional numbers progressing toward 100 (e.g. for microfinance groups). Group sizes have remained constant over time. Small groups provide for more effective communicative interactions and permit the agreement of common goals and practices, the sharing of planning and evaluation, and the agreement with norms and rules that work for all. As groups progress to larger size, they are generally more effective if divided and then federated. Small groups of approximately 25 members are generally able to survive with the presence of small numbers of free-riders (those that do not actively contribute to collective outcomes, but benefit from these outcomes) (Dannenberg et al., 2015). Using the mean membership of 20-30 people per group, this assessment suggests that there are 170-255M members of social capital groups providing both private and public benefits. Though not all of these are farmers (e.g. non-land owners with rights to jointly managed forests), a midpoint (assuming membership of 25 per group) represents 39% of all 570M farms worldwide (Lowder et al, 2016). The distribution of groups and areas is shown in Table 2 and Figures 2-3. The majority of groups have been formed in less-developed countries (98.2%), as is the area (93.6%). The distribution of groups across six continental regions is shown in Figure 2.

Table 2. Social groups and land area across eight categories of agriculture and land management (2020)

Categories	Social groups (M)	Area (Mha)
Integrated pest management	1.045	24.98
Forest management	0.459	150.39
Land management	0.015	38.03
Water management	0.214	50.16
Pasture and range management	0.294	2.08
Supporting services	6.105	23.41
Innovation platforms	0.273	8.51
Intensive small-scale systems	0.131	2.08
Totals	8.536	299.63

Figure 2: Social groups formed in categories of agricultural and landscape redesign (122 initiatives, 55 countries): disc area (Mha)

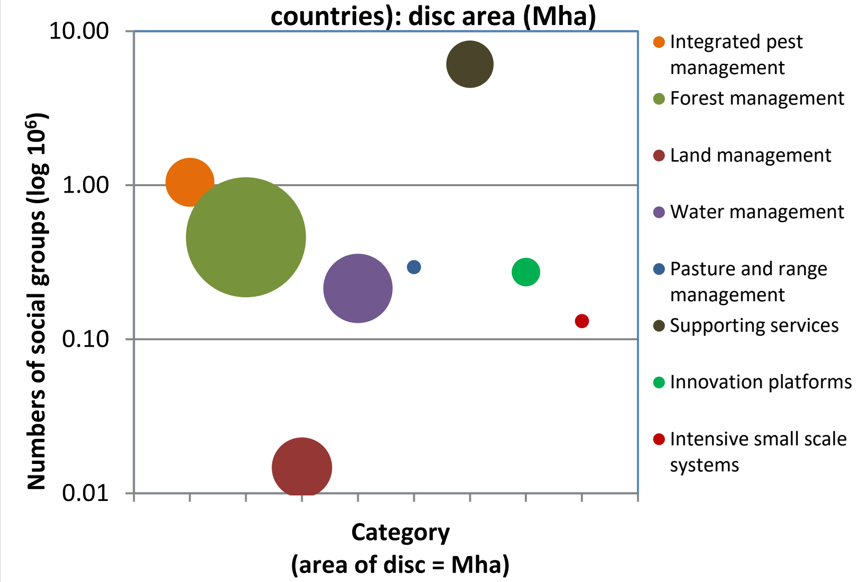
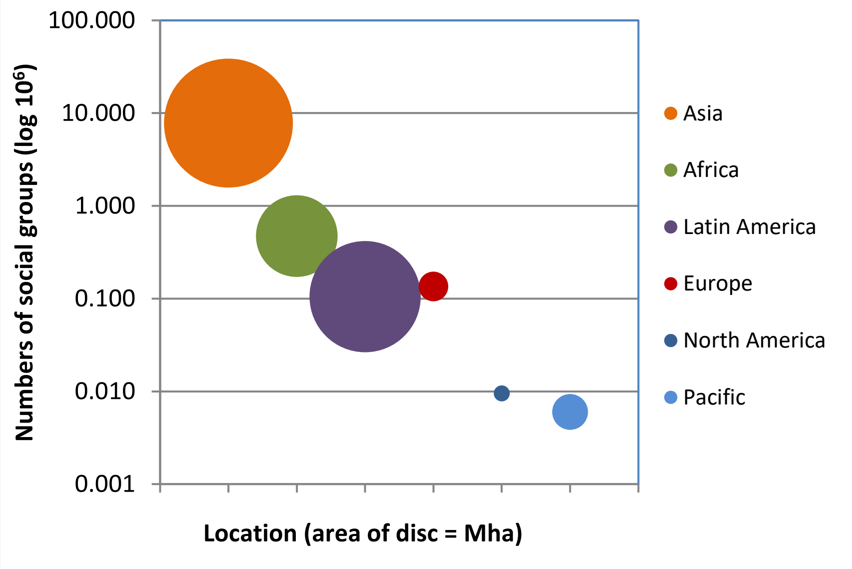


Figure 3: Social groups formed across six continental regions (122 initiatives, 55 countries): disc area (Mha)



Outcomes: Documented Impacts

Across all literature, there is considerable evidence of improvements within agroecosystems, landscapes and farm household economies as a result of the formation of intentional social capital within geographic areas (Ostrom, 1990; Cernea, 1991; Uphoff, 1992; Waddington et al., 2014; Leisher et al., 2016; Agarwal, 2018). Comparisons have been made between projects/programmes working with groups compared with individuals, with prior degraded natural systems (e.g. forest or eroded landscapes), with prior agroecosystems harmed by compounds used in agriculture (e.g. harmful pesticides), and with agroecosystems with legacies of low productivity (e.g. that have not seen productivity improvements in recent decades).

The overwhelming evidence from the field and reported in the published literature is that collective management of resources can lead to redesign and also result in net increases in system productivity. There have been few counterfactual examples, such as where groups could have been formed to increase resource exploitation or extraction (e.g. water or forest capture). In Malawi, for example, where village management committees were imposed without taking account of existing institutional arrangements for resource management, it resulted in clearance of trees, heightened conflict within communities, and destruction of existing institutions (Kamato et al, 2013). There are also other institutions, corporations and groups of individuals engaged in resource depletion to serve private and generally short-term interests.

It is also clear that any social capital established in the form of groups can lead to sub-optimal outcomes for certain population sub-groups. By definition, groups comprise members, and those outside groups may be excluded from the benefits of membership. This phenomenon of "the dark-side of social capital" (Coleman, 1990; Putzel, 1997) has seen both elite capture (the already wealthy or more powerful individuals using groups to strengthen personal benefit at the expense of others), exclusion (group membership restricted to only some members of a population or location), and negative selection (where individuals are actively excluded). Nonetheless, the majority of the literature points to the benefits of social capital to i) individuals, groups/communities, ii) agricultural systems, and iii) wider landscapes and ecosystem services.

i) To individuals, groups/communities: evidence of changes to personal capabilities and growth, to worldviews, and locally-generated resource availability:

- Emergence of new leaders of groups, especially by women (Agarwal, 2018), and changes in the relationships between women and men (Westerman et al., 2005);
- Positive role of women leaders in group effectiveness and conflict resolution over common resources (Coleman and Mwangi, 2013);
- Changes in the worldviews of farmers (Campbell et al., 2017; van den Berg et al., 2020a), and of scientists and extensionists working with farmers in novel innovation platforms (Zhang et al., 2016);
- Increases in the savings and repayment rates of members of microfinance groups (BRAC, 2019; Rahman, 2019).

ii) To agricultural system net farm productivity: evidence of increased system outputs and reduced input needs:

- Increases in crop productivity, such as by farmer field schools on all crops (Chhay et al, 2017; FAO, 2019), and in grazing and pasture productivity (NRC, 2010);
- Increases in tree and agroforestry cover on farms (Reij et al., 2008; Garrity et al., 2010; Bunch, 2018);

- Reductions in the use of pesticides in integrated pest management (Yang et al., 2014; Pretty and Bharucha, 2015);
- Adoption of organic and zero-budget systems (Reganold and Wachter, 2016; Bharucha et al, 2020).

iii) To natural capital and key ecosystem services: evidence of increased productivity and reductions in use of harmful or potentially-harmful compounds and releases:

- Increases in irrigation water availability and efficiency of use (Zhou et al., 2017; Ricks, 2016);
- Improvements in forest productivity of wood, forage and secondary products (Ravindranath and Sudha, 2004; FAO, 2016a);
- Increases in carbon sequestration in soils by conservation agriculture (FAO, 2011; Lal, 2014);
- Reductions in surface water flows and soil erosion (Reij et al., 2008).

Key Findings for the Eight Functional Categories

Category 1: Integrated pest management (IPM)

There are 1.045M farmer field school and IPM groups covering 25 Mha (FAO, 2016c, 2019; van den Berg et al, 2020a, b). Notable country leads include Indonesia, Burkina Faso, Kenya, Sri Lanka, China and Vietnam. Integrated Pest Management (IPM) is the integrated use of a range of pest (insect, weed or disease) control strategies in a way that reduces pest populations to non-economically important levels, minimizes risks to human and animal health, and can be sustainable and non-polluting. Inevitably, sound application of IPM is a more complex and knowledge-intensive process than relying on spraying of pesticides: it requires a high level of human capital in the form of field observation, analytical and ecosystem literacy skills and understanding of agro-ecological principles; it also benefits from cooperation between farmers.

Farmer-field schools (FFS) (also "schools without walls") centre on groups of up to 25 farmers meeting weekly during the entire crop season to engage in experiential learning (Braun and Duveskog, 2009). The roots of FFS are in adult education using discovery-based learning, particularly drawing on the work of Freire (1970): the aims are thus co-learning and experiential learning so that farmers' innovative capacity is improved. FFS are not only an extension method but also increase knowledge of agroecology, problem-solving skills, group building and political strength. Over the years, the FFS has evolved to include crops, livestock, agroforestry and fisheries. Meta-analyses and in-country level analyses have shown increases in farm productivity, reductions in pesticide use, and improvements in ecological literacy (Settle and Hama Garba, 2011; Waddington et al., 2014; Yang et al., 2014; Pretty and Bharucha, 2015; van den Berg et al., 2020b). Other innovations in IPM using close farmer engagement in groups include push-pull redesign in East Africa, with 130,000 farmer adopters (Khan et al., 2016; FAO, 2016b). Elsewhere, e.g. in Cambodia, 270 farmer field schools produced a range of innovations to increase both wet and dry season rice yields (Chhay et al, 2017). Nonetheless, it is difficult to overcome the fears many farmers have: that insects always cause harm, and compounds banned are sprayed at night (Palis et al., 2006; Hoi et al., 2016).

Category 2. Forest management

There are 4000 Mha of forests globally, with 28% now reported under various forms of community management (FAO, 2016a), variously termed participatory conservation, joint forest management, community forestry, forest user cooperatives, forest user groups, forest farmer co-ops and forest protection councils (Nightingale and Sharma, 2014). All are designed to increase the role of local people in governing and managing forest resources, including inherited indigenous practices as well as government-led. Only those locations where numbers of groups can be identified have been included here: this category contains 0.41M groups covering 150 Mha, and includes a number of initiatives involving redesign of agro-ecosystems with trees and shrubs (Garrity et al, 2010). Significant country innovations include the establishment of forest protection committees in India and Nepal, following key policy changes in 1990 and 1993 respectively (Paudel, 2016; Fox, 2018). In both China and Vietnam, forest farmer cooperatives (FFCs) have issued land use certificates to 250,000 FFCs, and are now managing 73 Mha of local forest. Some 30,000 forest user groups have been formed in Mexico. Other countries with significant uptake of community-based forestry include Tanzania, Niger, Burkina Faso, DR Congo and Ethiopia, and together with fertiliser tree groups in Malawi and Zambia.

Where successful, positive outcomes include increased forest cover on landslide-risk slopes, fewer patches and greater margins of forest cover, reduced incidence of fire and use of slash and burn, more wood value, better incomes for households (Pagdee et al., 2006; Sundar, 2017), and improved health and wider social benefits (Tirivayi et al, 2018). Increased tree cover in the Sahel has amended local climate, increased wood and tree fodder availability, and better water harvesting (Sendzimir et al, 2011; Bunch, 2018). Elsewhere, there is evidence of forest departments, such as in some Indian states, seeking to maintain control over local groups, including examples of rent-seeking (Behera and Engel, 2006). Nonetheless, despite difficulties, old attitudes have changed, as foresters came to appreciate the regeneration potential of degraded lands, and the growing satisfaction of working with, rather than against, local people (Ravindranath and Sudha, 2004).

Category 3. Land management

This category has seen the establishment of 0.015M groups on 37.2 Mha, and includes the largest national initiative in industrialised countries (Landcare in Australia: Campbell et al., 2017) and the mobilisation of social capital in watersheds above New York City to ensure the production of clean drinking water, resulting in savings of foregone engineering costs (Pfeffer and Wagenet, 2011). Following decades of limited success at often enforced soil and water conservation technologies, governments and NGOs from the late 1980s came to realize that the protection of whole watersheds or catchments could not be achieved without the engagement of local people. This led to an expansion in programmes focused on micro-catchments, areas of usually no more than several hundred hectares, in which people can trust each other. Where successful, programmes report public benefits in the form of groundwater recharge, reappearance of springs, increased tree cover and microclimate change, increased common land revegetation, and benefits for local economies. A number of integrated watershed development programmes did, however, turn to enforcement or payment for participation, or led to the greater extraction of groundwater (Blomquist and Schlager, 2005; Bharucha et al., 2014).

Conservation agriculture (CA), using zero-tillage to improve soil health, has grown to cover over 180 Mha worldwide (Pretty et al., 2018), and covers >50% of cropland in Australia and southern Latin America, and 15% in North America. A number of countries have built territory-based social capital (e.g. in the maize mixed farming system of East and Southern Africa, and in the rice-wheat farming systems of South Asia), though more often regional and national networks have been the vehicle for engagement and spread. In the UK, 452 catchment-based projects have delivered collaboration across farms, citizen scientists, wildlife experts and water companies, resulting in the engagement of 28,000 people, the reduction of pollution, riverbank restoration and habitat creation, and removal of fish barriers (CaBA, 2018). In the USA, a number of farmer-led watershed councils are advancing redesign, each usually with small numbers of farmers (FLWC, 2015), and in the UK, 120 Farmer Clusters have been formed to address landscape scale transformations to improve biodiversity (GWCT, 2019).

Category 4: Water management

This category has seen the establishment of 0.213M water users' associations, participatory irrigation management groups, water user schools and farmer managed irrigation systems on 48.7 Mha worldwide. Notable country examples include the Philippines (3100 groups managing 82% of irrigated area (Bandyopadhyay et al, 2009), Sri Lanka, India, Nepal, Mexico, Turkey, China and Vietnam (Uphoff, 1992; Rap, 2006; Yildiz, 2007). Once again, experiments in participatory irrigation management and the establishment of water user groups and associations began in the 1980s, with many building upon existing legacy systems (De los Reyes and Jopillo, 1986). Without regulation or collective control, water tends to be overused by those who have access to it first, resulting in shortages for tail-enders, conflicts over water allocation, and waterlogging, drainage and salinity problems. The same challenge exists for watersheds crossing national boundaries (e.g. the Mekong). Where social capital is well-developed, then groups with locally-developed rules and sanctions are able to make more of existing resources than individuals working alone or in competition.

Where effective groups operate, there emerged good evidence of increases in rice yields, higher farmer contributions to design and maintenance of systems, changes in the efficiency and equity of water use, decreased breakdown of systems and fewer complaints to government departments. In China, a quarter of all villages have Water User Associations (WUAs), and these have reduced maintenance expenditure whilst improving the timeliness of water delivery and fee collection. Farm incomes have improved whilst water use has fallen by 15-20% (Zhang et al, 2013; Zhou et al, 2017). Water user associations have become the primary vehicle for local water management in Mexico, where 2M of the 3.2 Mha of government-managed systems have been transformed by WUAs; half the systems in Turkey have been turned over to local groups, increasing cropping intensity and yields by 53% (Groenfeldt, 2000; Uysal and Atış , 2010). In India, WUAs cover 15 Mha, but still only 12% of the irrigated area, even though they lead to increases in area under irrigation, greater equity (improved benefits for tail-enders), and greater recovery of water charges (a measure of improved yields) (Sinha, 2004). Some are thought to exist only on paper, and in some areas have been subject to variable performance, elite capture and irrigation department control (Reddy and Reddy, 2005). In some contexts, rights' transfers to landowners and tenant farmers have led to landless and fisher families losing access to wild foods.

Water user groups have been subject to direct political interference, such as in Indonesia, or have seen low implementation successes where irrigation departments have been unable to devolve decision-making to farmers: in Thailand, official records indicate the presence of 13,000 water groups, but most exist only on paper (Ricks, 2015). Elsewhere, elite capture and continued irrigation department control continue to restrict success, such as in India, and lack of involvement of women, and selection bias in the tendency to research groups that work (Meinzen-Dick, 2007). WUAs and groups have been taken up in central Asia, such as in Azerbaijan, Tajikistan and Uzbekistan, but farmer numbers tend to be large per social group (>2000 and 76 respectively), and thus the large coverage (1.5 Mha) may not be matched by effective social capital at local level (Balasubramanya et al, 2018).

Category 5. Pasture and range management

Notable pasture examples of social capital include the establishment and spread of management intensive rotational grazing groups (MIRGs), which require new thinking and methods for grazing practices, diversification of cropping, including organic agriculture, and new approaches for agropastoralism. In Brazil, redesigned *Brachiaria* forages in maize-rice and millet-sorghum systems have increased net productivity led to large increases in all-year forage, used both for livestock and as a green manure (FAO, 2016b). MIRGs use pasture redesign, centred on short-duration grazing episodes on small paddocks or temporarily fenced areas, with longer rest periods that allow grassland plants to regrow before grazing returns (NRC, 2010). Well-managed grazing systems have been associated with greater temporal and spatial diversity of plant species, increased carbon sequestration, reduced soil erosion, improved wildlife habitat and decreased input use (Sprague et al, 2016).

Group innovations have occurred in Uganda with the development of Agro-Pastoral Field Schools (APFS) with the training of a large pool of facilitators and trainers (FAO, 2016c). The primary aim has been to build resilience for communities subject to recurrent hazards such as drought, flood and animal disease, some accentuated by climate change. Some 4400 APFS have been deployed, with the training of 850 facilitators and master trainers. Agropastoralists build their livelihood resilience by increasing the number of intervention options, including pest and disease management, tree nurseries, watershed management, group marketing, vegetable production, improved seeds and livestock nutrition. In Kenya and Uganda, volunteer farmer trainers have helped facilitate >300 diary producer groups (Kiptot and Franzel, 2019). As in all categories, there are examples of empty social groups having been formed by states (Ho, 2016).

Category 6. Supporting services

A significant social innovation has been the emergence of informal microfinance systems emerging from local collective action, particularly for groups of poor families without access to formal capital and collateral. These have been enablers for agricultural and land transformations, such as for index-based insurance for livestock herders in the face of climate change (Amare et al., 2019). The largest numbers of groups have been formed in Bangladesh (1.8M groups), India (4.16M groups) and Pakistan (0.12M groups). Many groups or programmes begin with microfinance, and evolve to become multifunctional, representing the specific needs of members at their locations. A major change in thinking and practice occurred when professionals began to realise that it was possible to provide micro-finance to poor groups, and still ensure high repayment rates. When local groups, in particular of women, are trusted to manage financial resources, they can be more effective than banks. The systems work on trust, and payback rates typically reach 98% (Rahman, 2019). In Cambodia, forming IPM Farmers' Clubs have become Self-help Groups with members putting in their own money in savings funds to help members access financial assistance instead of borrowing from other sources that charge high interest rates (FAO, 2018). The microcredit and microloan programmes in industrialised countries, such as in the USA, are not included in this analysis.

Three leading innovative institutions are from Bangladesh: the Grameen Bank, the Bangladesh Rural Advancement Committee (BRAC), and Proshika (BRAC, 2019; Grameen, 2019; Proshika, 2019). All groups work primarily with women, and members of groups save every week in order to create the capital for re-lending. Grameen has 8.9M members in 1.38M groups spread over 81,000 villages: 97% of its members are women. BRAC has 5.4M members in 108,000 groups, and takes a deliberately integrated approach to poverty pockets, especially in wetlands, on riverine islands and for indigenous populations. Through a single platform they provide agricultural and skills support, education, legal services, health care, and loans. More than 130 of its women members have been elected into government structures. BRAC has also diversified into social enterprises: for artisans, livestock insemination services, cold storage for potato farmers, milk processing, services for fish farmers, tree seedlings, iodised salt, and sericulture.

Category 7. Innovation platforms

This category centres on the co-production of technologies to advance the sustainable management of agriculture and land. There are a growing number of successful platforms for such engagement, including in West Africa, China, Bangladesh, Cuba, India and Indonesia (Winarto et al., 2017; Agarwal, 2018). Most, though, remain at small scale. Innovation platforms in West Africa have resulted in increased yields and income for both maize and cassava systems (Jatoe et al., 2015). Farmer collectives have put agroecological and cultural objectives higher than just productivity in China (Zhou et al., 2017) and, in Bangladesh, similar platforms have led to adoption of direct seeded rice and early maturing varieties that have changed patterns of both wet and dry season farming, increasing incomes by US$600 per hectare, and substantially reducing labour costs (Malabayabas et al., 2014). In all successful cases, there have been facilitators curating the redesign.

The concept of the Science and Technology Backyard Platforms (STB) was established in China's Quzhou County (Zhang et al., 2016), an innovation deployed to increase the sharing of knowledge and skills between scientists and farmers. STBs bring agricultural scientists to live in villages, and use field demonstrations, farming schools, and yield contests to engage farmers in externally- and locally-developed innovations. Reflections on success centre more on in-person communications, socio-cultural bonding, and the trust developed amongst farmer groups of 30-40 individuals. In Cuba, the Campesino-a-Campesino movement has developed an approach to agroecological integration that is redesigning systems (Rosset et al., 2011). It is also centred on Freirian social communication, in which farmers spread knowledge and technologies to each other through peer-to-peer exchanges, teaching and cooperatives. There are 100,000 peasant farmer members of Campesino-a-Campesino in Cuba.

Social groups have been formed in industrialised countries to develop cooperative approaches towards sustainable practices, and include Concept Oriented Research Clusters and Groupement Agricole d'Exploitation en Common in France (Caron et al, 2008; Agarwal and Dorin, 2019), Practical Farmers of Iowa (PFI, 2019), No-Till on the Plains (Kansas) (NTP, 2019), and the Ecological Farmers Association of Ontario (EFAO, 2019). Across all of the EU, 900 EIP Agri-Operational groups have been formed to aid farmer innovation (EC, 2019); and with ten countries, 34 projects investigated as part of the PEGASUS project have been engaged in rehabilitating orchards, wilding headwaters, improving groundwater quality, creating biosphere reserves, developing IPM, and creating new haymilk systems for upland farmers, with the aim to achieve persistent improvements in natural capital by engaging in social action within defined geographic areas (Maréchal et al., 2018).

Category 8. Intensive small-scale systems

Social capital has been formed to aid the intensive use of small patches of land and water, particularly for the cultivation of vegetables and rearing fish, poultry and small livestock. It has also been developed to link farmers directly to consumers, particularly through Community Supported Agriculture (CSA) farms and Japanese teikei in industrialised countries (Urgenci, 2016). Across the EU, there are 2800 CSAs directly linked to consumer members. Further examples include allotments, community gardens and urban farms, and vertical and hydroponic farms. In less developed countries, small patches are often located in gardens, at field boundaries, and in urban and rural landscapes. Patch intensification for aquaculture ponds and tanks has been shown to raise protein production, reduce nitrogen requirements for crops, and positively impact agricultural productivity (Brummett and Jamu, 2011). Raised beds for vegetables in East Africa have been beneficial for large numbers of women, homestead garden production has spread in Bangladesh, and in China redesign has been exemplified by the development of integrated vegetable and fruit, pig and poultry farms with biogas digesters: farm plots are small (0.14 ha), yet farmers recycle wastes, produce methane for cooking, and reduce burning of wood and crop residues, with implementation on 50M household plots (Gu et al., 2016). In Brazil, the government's food purchase program (PAA) and *Fome Zero* project supports 364,000 family farmers in groups through direct purchase for schools, religious projects, hospitals, municipal departments and jails (Wittman and Blesh, 2017), and in Cuba urban organopónicos have contributed substantially to the effectiveness of food systems (Cederlöf, 2016).

Securing Sustainability

We have shown that over the past two decades a variety of novel social infrastructure has created platforms for collective transitions toward greater sustainability of agriculture and land management amongst rural communities across the world. These have increased greater flows of knowledge and technologies, and built trust amongst individuals and agencies. The cumulative increase in numbers of social groups from 0.5M to 8.5M over two decades implies there have been transformations in capacity and personal benefit combined with improved environmental outcomes for agricultural landscapes.

The marked difference in implementation and uptake of social capital between industrialised and less-developed countries is striking. In industrialised countries, farmers have tended also to be self-organised into value-chain based groups of common interest rather than in groups within specific geographic territories, though this could change with growing interest in policy support for landscape scale change to deliver public goods, such as in the UK's 25 Year Environmental Plan (Defra, 2019). The latter needs facilitation and support, a particular challenge where investments in extension are small, or where public extension systems no longer exist. Nonetheless, where geographically-based groups are formed, both productivity and natural capital outcomes can be substantial (Maréchal et al, 2018).

This shift towards sustainable redesign in agriculture and land management has been successful where individual worldviews have changed, emerging from the processes of co-production embedded in groups. Many programmes have built on the principles of adult learning, social ecology, liberation education and epistemic change. Social capital can provide a supportive context for transformations, both in practices (behaviours and choices) and personally (the inner journey) (Norgaard, 2004; Bawden, 2011). Through experiences in the world, each person comes to see and know it from a particular epistemic position that reflects a set of assumptions about reality. These assumptions and worldviews shape the way each person chooses to act and behave. Such epistemic change is called for in turbulent times, as there is an inseparable interconnection between cognition and action (Fear et al, 2006). It has previously been argued that social groups, movements and campaigns comprise an "immune system" for the planet (Hawken, 2007), in that they offer platforms for collective action and larger scale actions towards greater sustainability and equity.

Social media and mobile platforms for information will play a complementary role in information access and exchanges, as well as helping to keep people connected (FAO, 2019). The term sustainable suggests an incorporation of the need for improvement (e.g., to well-being, food production, natural capital), and thus requires the need to change the way individuals think about and come to know about the world (Norgaard, 2004). To date, epistemic communities and networks of social capital have been established in many locations, and could build distributed expertise and trust over time (Granjou and Arpin, 2015; de Bruijn and Gerrits, 2018), particularly where there is a greater number and diversity of engaged actors (Hazard et al, 2018; Grêt-Regamany et al., 2019). Social capital in a variety of forms could help to open up science to innovation, particularly where problems are complex and solutions unknown, and where the values of all actors are salient (Richardson et al., 2018).

Nonetheless, there will be constraints and countervailing pressures. Land tenure and secure rights are preconditions to local people making long-term investments in natural and social assets. When Burkina Faso and Niger granted rights to individuals to use their own trees as they wished (mid-1980s), this resulted in an increase in tree cover as there were now incentives for the long-term rather immediate resource extraction (Godfray et al., 2010; Sendzimir et al., 2011).

Though state and international organisations have contributed to the advance in numbers of social groups, the evidence for positive actions from the private sector is weak, with many not matching up to their own statements on corporate social responsibility (Elder and Dauvergen, 2015). There is evidence (from the field) that pesticide companies have promoted and run farmer field schools precisely to sell more product, and thus not to develop forms of integrated pest management that reduce negative impacts on the environment and human health. It has been argued that big retail power will not be interested in social groups in rural areas unless they serve their own purposes, and thus that the "dance of the supply chain" (Friedberg, 2020) cannot produce progressive outcomes. At the same time, apparent inflows of foreign direct investment into poorer countries may continue to lead to outflows of capital in profits and returns on investments (Veltmeyer, 2018).

We have found that social groups have emerged from both government and non-government contexts. Some have required critical changes to policy or regulation, often more effective at state or district level. Changes to water rights allowed the emergence and spread of participatory irrigation; changes to forest and tree use rights were essential platforms for joint and participatory forest management programmes to be established and devolve decision-making to local people; changes to lending assumptions allowed banks to lend to NGOs and social groups, which then provided security rather than individuals. Further policy changes and support will be important to help these projects spread. Extension systems , for example, will need to adopt more cooperative models rather than seeking only to work with compliant individuals (Clark et al., 2017).

It will be important to be mindful of the past failures of state organisations that have undermined, ignored or suffocated local resource-based institutions (Palmer, 1976; Jodha, 1990; Levien et al., 2018), or who have created paper or empty institutions (Ho, 2016). Many members and activists in social and agroecological movements would also argue that it's the structures of the world economy (and its capitalism) that prevent effective transformations towards sustainability and equity (Giraldo and Rosset, 2017; Moore, 2017). Nonetheless, as social groups federate into higher-level structures, they too are able to act to deliver greater agricultural and natural capital benefits, as well as returns to farmers (Kondoh, 2015). Thought we were unable to gather data on the gender mix between and within social groups, it is clear that mixed groups of women and men are more effective (in terms of farm and/or forest productivity) than single gender groups, and groups of women are more effective than groups just consisting of men (Westerman et al., 2005; Leisher et al., 2016; Agarwal, 2018). Programmes seeking to form social groups will thus need to be aware of how to ensure full and proper participation by women.

A separate but important evidence base points towards the health and well-being effects of the greater trust and reciprocity that inheres when social capital is high. Social capital is known to have positive effects on well-being (Holt-Lunstad et al., 2017), and on life satisfaction and longevity (Graton and Scott, 2016; Layard, 2020). Though not part of the recorded benefits of these social groups, it can reasonably be assured that members will be receiving personal benefits over and above the functional improvements to farm productivity and income. The socially-connected live longer and are happier (Holt-Lunstad et al., 2017), and countries with higher levels of trust in other people are happier (WHR, 2019, 2020). Volunteers who contribute to the well-being of others and to the quality of lived environments tend to have healthier lifestyles, lower incidence of mental ill-health, and live longer (Borgonovi et al., 2008, 2010; Anderson et al., 2014; Layard, 2020). On the other hand, net well-being across populations is reduced by growth in inequity (Wilkinson and Pickett, 2009, 2018), breakdown of social structures and support (Picketty and Saez, 2014), and lack of access to natural and green spaces (Mitchell and Popham, 2008; Mitchell et al., 2015).

This platform of 8.5M social groups distributed across 55 countries, but comprising 3% of the world population, could comprise an opportunity to consider greater challenges, such as advances towards meeting the Sustainable Development Goals and addressing climate change. If different worlds are to brought forth as a function of a quest to transform the way we live and consume, we will need to modify the epistemes that have come to dominate modern consumption cultures (Bawden, 2011). Some social capital is already influencing global systems, resulting for example in mitigations of climate change, biodiversity loss and air pollution, as well as increases in net food production. Platforms of groups, for example, could engage in co-production of new patterns of material consumption and ways of living within global boundaries and limits (Jackson, 2009; Pretty, 2013; Dorling, 2020). Some argue that large scale advances in sustainability and equity are impossible if capitalism and class are ignored (Levien et al, 2018).

It is clear that considerable changes will be required worldwide to limit the advance of the climate crisis, both in individual choices and behaviours and in the policies developed by all countries. An era of "degrowth" may be needed (Gerber, 2020), and certainly of green restructuring of economies directly to reduce material consumption and substitute with sustainable or green alternatives (Ivanova et al., 2020). There may be, in short, possibilities of the good life within planetary boundaries (O'Neill et al., 2018; Dorling, 2020; Layard, 2020). We have not analysed the political philosophies or aims of these social groups. Clearly individuals will have many reasons for organising and taking collective action, and given the context for these changes it is likely that many individuals will continue to support sustainability and equity outcomes. But there is no guarantee that such values will remain unchanged.

Can these groups survive and flourish? Threats to these groups will come from external and internal sources. External could include major social and economic disruption (e.g. following the Covid pandemic); climate-driven forced abandonment of farms and territory; policy changes in support of land grabs and large commercial monoculture operations (e.g. for oil palm); and state support for only empty or non-credible groups. Internal disruptors could include stresses arising from benefit capture by individuals; gender imbalances in benefits; and farm abandonment in favour of employment in urban areas. Nonetheless, many advantages have been found in the sharing economies of connected food systems where goods and services are pooled (Miralles et al., 2017): more even distribution of power, increased collaborative consumption, higher trust, and more efficient use of resources. Agricultural transformations will be critical in the coming years both for contributing to reducing climate forcing and to mitigate negative effects. Some have called for adventurous food futures (Carolan, 2015). It would appear that social groups and movements have already created opportunities for individual and collective transformations.

Concluding Comments

This assessment has shown growth in numbers of groups engaged in platforms of innovative and sustainable management within geographic territories of engagement over the past two decades. These groups deliver individual and public benefits, improve well-being and natural capital, and provide platforms for wider progress towards sustainability. These groups provide the basis for further progressive change towards sustainable policies and behaviours, with opportunities to help mitigate the advance of some global environmental challenges. We further note this social infrastructure has already changed worldviews, capacities to redesign towards sustainability, and increased net productivity of agricultural and land systems.

Attention will need to be paid to ensuring access to groups is equitable, and to ensure there is further research on the causative links between all forms of social capital and the emergence of more sustainable practices. In a number of contexts, social groups exist only on paper to meet policy objectives, and any increase of this phenomenon will undermine the wider goals of seeking further social capital formation. At the same time, some wider political and economic structures will make formation of social groups harder to sustain. Nonetheless, the redesign of all agricultural and land management remains a critical global challenge, and though growth in numbers of groups has been substantial, in many cases supported by novel policies and regulations within countries, more support is needed to ensure best practice is spread to aid the transitions towards more sustainable and equitable forms of farmed and managed landscapes worldwide.

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A Note on Terminology

There is no completely acceptable terminology for grouping of types of countries. Terms relate to past stages of development (developed, developing, less-developed), state of economy or wealth (industrialised, affluent, G8, G20), geographic location (global south or north), or membership (OECD, non-OECD). None are perfect: China has the second largest economy measured by GDP (which does not accurately measure all aspects of economies, environments and societies), yet might be considered still developing or less-developed; the USA has the largest economy by GDP, yet has nearly 50M hungry people. Here we have simply used *industrialised* and *less-developed*, and acknowledge the shortcomings. We use the term *pesticide* to cover all forms of insect, weed and disease control compounds; similarly integrated pest management is taken to cover insect, weed, disease, mammal and bird management. We use *extensionist* to describe agricultural extension workers or service providers, as it is in common use in the sector; here we suggest that the role has greater effectiveness when centred on engagement and co-production of knowledge, rather than simply transfer.

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Competing Interests

The authors declare there are no competing interests in this paper, as defined as financial and non-financial interests that could directly undermine, or be perceived to undermine, the objectivity, integrity and value of a publication, through a potential influence on the judgements and actions of authors with regard to objective data presentation, analysis and interpretation.