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How does gendered vulnerability shape the adoption and impact of sustainable livelihood interventions in an era of global climate change?

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Abstract

Background. Though many studies have long considered the broad social implications of climate change, researchers have only recently started to consider the gendered unevenness of the global landscape of vulnerability, exposure, and adaptive capacity to environmental stressors and shocks. Historically, policies and interventions addressing natural resource-based livelihoods have rarely considered underlying gender dynamics despite the global pervasiveness of gendered disparities in both economic opportunities and welfare outcomes. **Methods/Design.** Using two electronic databases, Web of Science and Scopus, we conducted a systematic review of peer-reviewed academic literature describing livelihoods policies or interventions that included documentation of gendered impacts. We focused on natural resource-based livelihoods most likely to be affected by climate change, centering on interventions targeting agriculture, fisheries and aquaculture, and forestry. **Review Results/Synthesis.** We identified 131 relevant articles, most of which focus on adoption or participation in interventions rather than outcomes. In general, women are less likely than men to engage with sustainable livelihoods interventions. When women do engage, some researchers have documented income and food security gains as well as improvements in environmental indicators in the short-term. However, these initiatives have also been found to increase women's labor burden without corresponding gains in income. Few studies measure longer-term effects of women's engagement on welfare and environmental outcomes, a key gap in the literature. Additionally, relatively few studies explore the intersectional impacts of initiatives, such as the added burdens of ethnicity, class, education, or other differences that modify gender disparities. **Discussion.** Climate change has gendered impacts on natural resource-based livelihoods. In general, existing initiatives designed to increase livelihood resilience fail to reduce gender disparities and improve women's livelihoods. Greater attention should be paid to gender when designing sustainable livelihoods policies and interventions in order to increase adoption and participation, negotiate trade-offs, improve environmental conditions, and promote broadly beneficial welfare outcomes.

1. Introduction

Though the long-term effects of global climate change, such as extreme temperatures and sea level rise, will have widespread impacts, climate change will disproportionately affect those who depend on natural

resources for their livelihoods (Olsson *et al* 2014). Currently, researchers estimate that rural households in low and middle-income countries earn nearly 70% of their income through a combination of agriculture, the collection of forest products, timber harvesting, and capture fishing or aquaculture (Angelsen *et al*

2014). In the near term, climate change is projected to reduce agricultural productivity (Fischer *et al* 2005), reduce the capacity of forests to support livelihood diversification through timber harvesting and the collection of non-timber forest products (Wunder *et al* 2018), and influence both the quantity and distribution of fish and other marine resources (Cheung *et al* 2016). As such, over the last several decades many government agencies and NGOs have begun to explore potential policies and interventions for improving environmental sustainability, or the capacity of the environment to cope with and fully recover from stressors and shocks while maintaining well-being and the natural resource base of those who are dependent on natural resource-based livelihoods (Chambers and Conway 1992).

Numerous intersecting economic, cultural, and social factors shape the capacity of individuals to engage in sustainable natural resource-based livelihoods. Within the past two decades, as the empirical research has developed, it has become clear that gender is one of the most universal and important stratifying elements affecting natural resource use and vulnerability to the effects of climate change, as illustrated by numerous systematic literature reviews on the topic (Bunce and Ford 2015, Sellers 2016, Pearse 2017, Yadav and Lal 2018). Additionally, a variety of publications have drawn on this empirical literature to highlight specific gendered vulnerabilities associated with climate change and to suggest new pathways forward for further developing the evidence base (Carr and Thompson 2014, Bradshaw and Fordham 2015, Rao *et al* 2017, Jerneck 2018). In particular, many of these pieces have highlighted the importance of intersectional approaches to examining gender issues, noting that the effect of gender can be modified by power structures, discrimination, poverty, geographical, political, and historical legacies, among other factors (Nagel 2012, Moosa and Tuana 2014).

As a result of cultural gender roles, rules, and norms, women and girls may be exposed or vulnerable to environmental stressors or shocks in ways that differ from the challenges faced by men and boys (Ellis 1998, Gladwin *et al* 2001, Cleaver 2005). Likewise, women and men may differ in their access to the resources and skills necessary for adaptation, or adjustments that improve an individual's capacity to cope with external stressors (Smit and Wandel 2006). Though women and girls are often portrayed as being especially vulnerable, men and boys often face significant, though sometimes distinct, challenges as a result of environmental stressors and shocks (Omolo 2010, Alston and Whittenbury 2013, Keshavarz *et al* 2013). Thus, in order to ensure equitable outcomes for all individuals, policies to facilitate sustainable natural resource-based livelihoods in an era of global climate change need to take into account gender differences in vulnerability, exposure, and adaptive capacity.

Resulting from this dialogue, a growing advocacy movement has developed to further discourse around

gender issues at international environmental policy forums. In addition, many environmental organizations have developed gender programs designed to advance research on the gendered effects of climate change and to provide information to policymakers (International Union for the Conservation of Nature 2013). Partly as a consequence of these activities, large climate financing regimes, such as the Green Climate Fund, have adopted progressive gender policies, including requirements for funded projects to produce Gender Action Plans and Gender Assessments as a means of ensuring gender remains a lens through which projects examine their activities and impacts (Green Climate Fund 2015).

Despite this growing global gender discourse, many natural resource-based livelihoods policies and initiatives that promote climate change adaptation have struggled to develop goals, indicators, budgeting practices, or other mechanisms through which to comprehensively understand gendered impacts and ensure that program benefits are enjoyed by both women and men (Anderson *et al* 2015, Eggerts 2015). To help inform decision-makers, a handful of recent reviews have discussed gendered impacts of natural resource-based livelihoods interventions in specific resource sectors (Weeratunge *et al* 2010, Peterman *et al* 2014, Baynes *et al* 2015, Leisher *et al* 2015). We expand upon these earlier reviews by assessing, synthesizing, and analyzing the uneven gendered landscape of adoption or participation as well as the social and environmental impacts of sustainable livelihood policies and interventions. The interventions we discuss are typically framed as improving the resilience of individuals to the effects of climate change, and for purposes of this review, we accept the plausibility of these hypotheses. In practice, however, interventions may not always function as designed. Barriers or limits to adaptation may prevent individuals from increasing their adaptive capacity, which can result in adverse outcomes for vulnerable populations (Barnett *et al* 2015). Our aim is to provide a current understanding of research concerning the gendered adoption and impact of these policies and interventions for policymakers and practitioners.

2. Methodology

We employ a systematic literature review methodology to assess the literature on gender and sustainable natural resource-based livelihood initiatives, searching English-language peer-reviewed articles on the Web of Science and Scopus databases for literature published from January 2005 through September 2018. Though we found that the majority of articles were published after 2009, we decided to include articles back to 2005 in our assessment for the sake of comprehensiveness. To locate articles, we performed Boolean queries using a set of compound keyword search terms that incorporated a set of both

gender-related terms (e.g. women, men), as well as terms designed to capture particular interventions focusing on natural resource-based livelihoods (e.g. REDD+, aquaculture) (supplementary tables 1, 2 and supplementary figure 1 are available online at stacks.iop.org/ERL/14/083005/mmedia). Our choice of intervention keywords was based on our expert knowledge of the topic and our focus on three key sectors of natural resource-based livelihoods: agriculture, capture fisheries and aquaculture, and forestry. The interventions and policies included in our search were all implemented to improve the sustainability of natural resource-based livelihoods, though not all of these programs were specifically in response to the effects of climate change. Some, as in the case of many of the agricultural interventions, were in response to land degradation while others were developed under the broad objective of improving social and environmental resilience to shocks, including, but not limited to, those associated with climate change.

In assessing articles for inclusion, we drew from both the quantitative and qualitative literature, as well as both cross-sectional and longitudinal studies. Further, we include articles if they addressed either differences in intervention adoption or participation between men and women or gender differences in outcomes (e.g. income, empowerment, well-being, resource use) as a result of an intervention. However, we restrict our review to empirical literature where there is documented evidence of gender differences in adoption or outcomes that can be attributed to a policy or intervention. We exclude literature that merely describes patterns of vulnerability or differential adaptive capacity between women and men, but which does not attribute differences (or lack thereof) to either a policy or intervention. We also only include peer reviewed articles in our review, though we acknowledge that gray literature also exists on this topic.

Although we are aware that it is an oversimplification, we have chosen to consider gender as binary (i.e. men, women) in this systematic literature review, as that is how it is considered in much of the existing natural resources literature, particularly in quantitative studies. While our decision to draw upon this literature limits the extent to which we can address the role of intersectionality in our discussion and analysis, we believe our review allows for a summary of the range of outcomes and disparities experienced by women and men in natural resource management initiatives as found in current literature. However, as noted above, the vulnerability of individuals to environmental shocks and the ability of individuals to benefit from natural resource policies or interventions is affected by gender as well as its intersection with other characteristics including race, social class, educational attainment, and health status (Arora-Jonsson). Since we are unable to delve further into intersectionality in most of the studies we analyze for our systematic literature review, we acknowledge that we may be

missing crucial components of the ways in which intersectional vulnerability shapes gendered adoption patterns and the outcomes of natural resource-based livelihoods policies and interventions.

3. Results

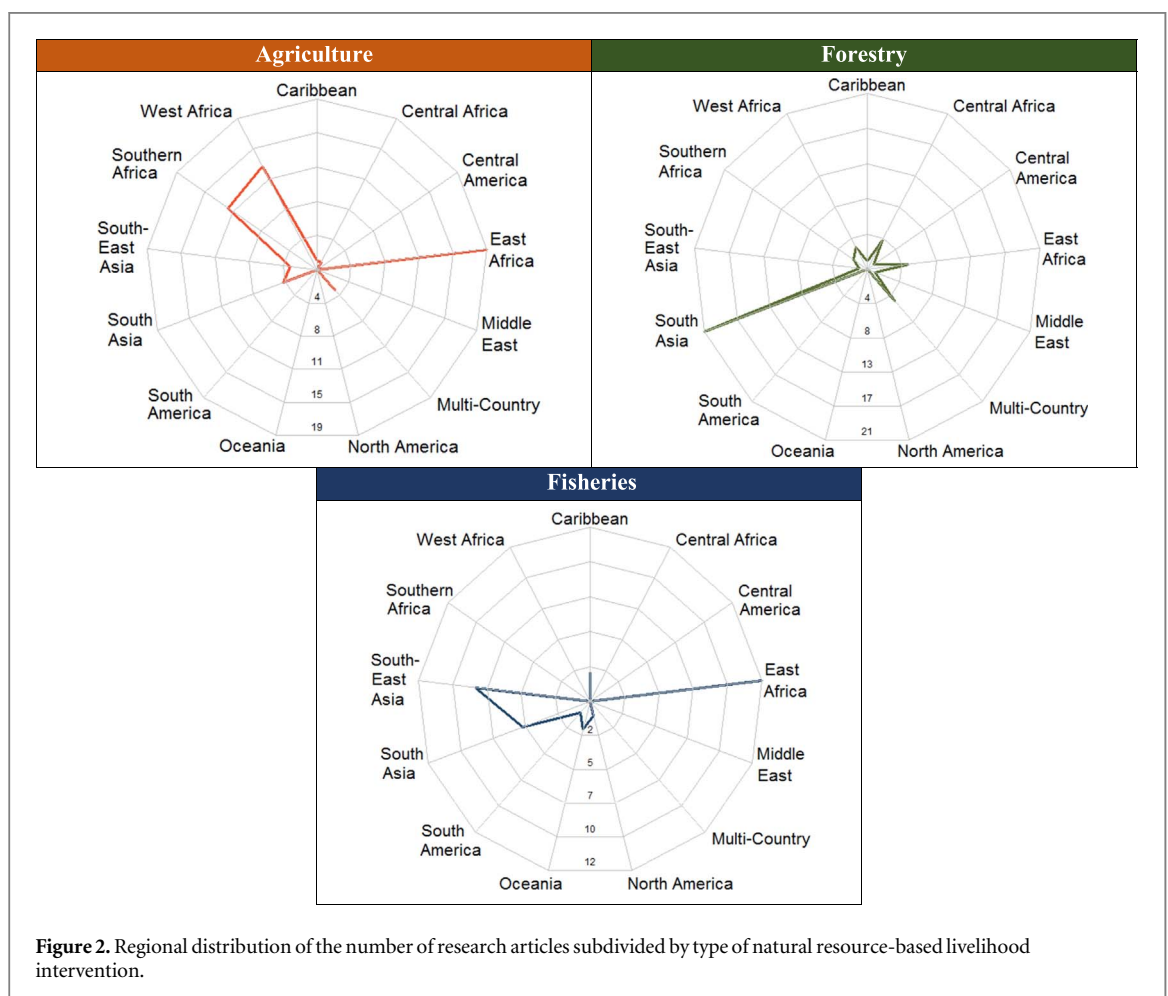
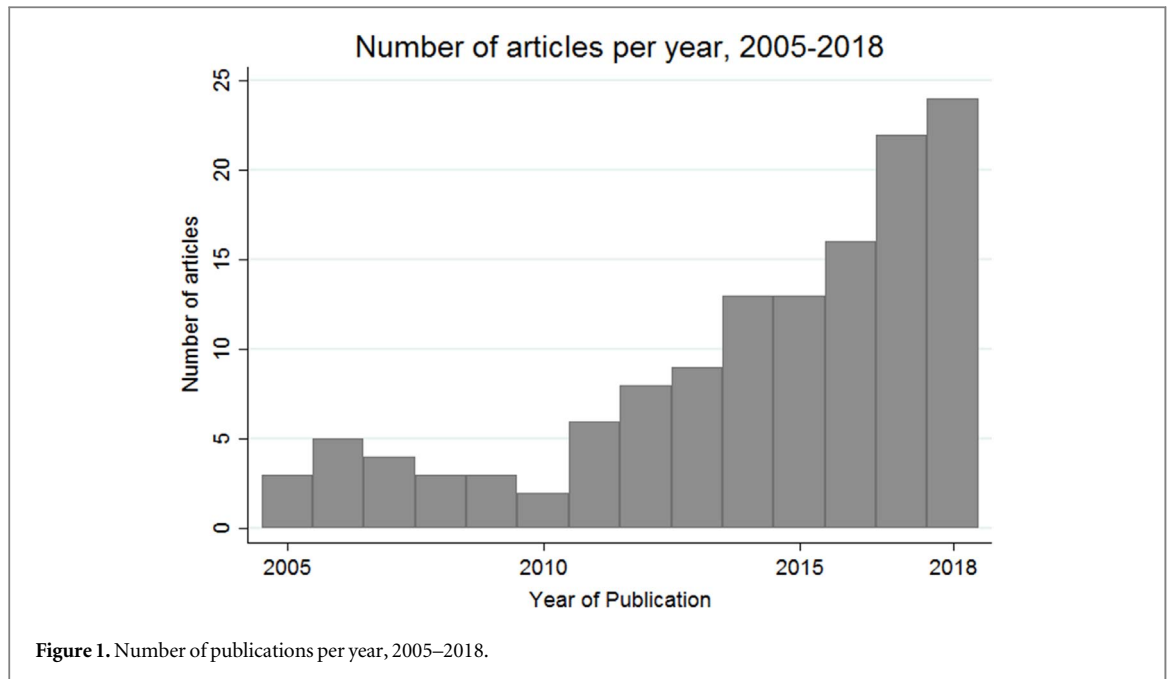
3.1. Overview

Our initial search located 1508 articles from Web of Science and 2137 articles from Scopus. From this list, we eliminated articles because they either lacked gender-specific information on adoption or outcomes or did not examine a specific policy or intervention to which gender-specific outcomes can be attributed. We also reviewed the reference lists of relevant articles located on the electronic databases, identifying additional articles for inclusion and yielding a final total of 131 relevant articles based on the criteria outlined above (supplementary table 2). The majority of the articles we analyzed were published after 2010, indicative of a recent increase in research interest in understanding the gender dimensions of natural resource-related climate adaptation policies (figure 1). To assess and synthesize the findings from these articles, we grouped them into categories based on broad natural resource-based livelihood approaches: agriculture, capture fisheries and aquaculture, and forestry. While we group articles by topic, we emphasize that there is considerable heterogeneity within each category in terms of the types of policies and interventions explored and their quality of implementation, which in turn affects their gendered impacts.

We located 56 articles focused on agricultural interventions, the majority of which addressed interventions in Africa (see figure 2) and employed quantitative analyses techniques (table 1). Considering capture fisheries and aquaculture, we found 31 relevant articles, two thirds of which examined marine protected areas (MPAs) while the other third explored aquaculture. These articles were largely focused on interventions in East Africa, South-East Asia, and South Asia (figure 2), and employed a range of methodological approaches (table 1). In regard to forestry interventions, we identified 44 articles that addressed the gender dimensions of either forest decentralization schemes or payments for ecosystems services programs. These empirical studies were primarily quantitative analyses (table 1) and had a strong geographic bias toward South Asia (figure 2). The following sections provide a synthesis of these articles, grouped by these three broad natural resource-based livelihood approaches.

3.2. Agriculture

Across low- and middle-income countries, smallholder agriculture remains an important livelihood strategy for over 2.5 billion people (UNEP 2013). Rainfed agriculture is the most common agricultural approach among smallholders, and in many regions,



the use of fertilizer, mechanization, and improved/hybrid seeds remains low (Sheahan and Barrett 2017). As a result, agricultural productivity—and therefore the livelihoods of many rural smallholders—is highly vulnerable to the effects of climate change (Knox *et al* 2012),

especially when coupled with the widespread soil degradation that some researchers argue is currently occurring in these settings (Sanchez 2002).

Smallholder farms are particularly vulnerable to the effects of climate change (Morton 2007). Thus, a

Table 1. Methodological approaches used in empirical analyses.

Livelihoods category	Methodological approach		
	Quantitative	Qualitative	Mixed methods
Agriculture	35	12	9
Fisheries	13	7	11
Forestry	26	13	5

variety of interventions have been developed to improve their sustainability, including those centered on promoting agricultural technologies as well as agricultural extension to improve the knowledge base of smallholder farmers. However, one potential barrier to the success of these interventions is that they are rarely gender-sensitive, though it is well-established that men and women typically play different roles in the smallholder agricultural production process. These culturally established roles may involve men and women cultivating different crops (e.g. women cultivating legumes while men grow maize) or taking responsibility for specific parts of the planting and harvesting cycle (e.g. women weed, men till) (Carr 2008). Further, women generally have reduced access to land use and ownership, financial capital, and information in comparison with men, and women are also often faced with the additional burden of household maintenance and childcare alongside agricultural responsibilities (Jost *et al* 2016).

Though it is now well-established that men and women are unlikely to engage in or benefit from agricultural interventions and policies in the same ways, understanding how gender affects adoption and outcomes is an ongoing research topic. To improve livelihood outcomes for women and men, a growing body of research centers on the gender dimensions of agricultural interventions intended to increase household resilience to economic or environmental shocks and/or improve environmental conditions. These agricultural interventions typically involve either promoting specific agricultural technologies or improving the accessibility of, or engagement with, agricultural extension services.

3.2.1. Agricultural technology promotion

The majority of research on gendered adoption of agricultural policies and interventions has focused on the promotion of agricultural technology. These technological initiatives are generally intended to either directly increase crop yield through inputs (such as fertilizers or improved seeds) or to improve local environmental conditions for the dual purpose of achieving ecological goals while maintaining or increasing agricultural productivity. The former programs are primarily focused on near-term welfare gains (Sunding and Zilberman 2001) while the latter

category of interventions may not yield immediate social or environmental benefits but has the potential to improve long-term environmental and food security outcomes (Knowler and Bradshaw 2007). While these two strategies both fit under the category of agricultural technology interventions, sometimes tradeoffs exist in achieving both economic and environmental goals. For example, input-driven improvements in crop yield may ultimately lead to increased greenhouse gas emissions and local environmental degradation from agricultural intensification (Sapkota *et al* 2018). Agricultural inputs can increase crop yield but they are often prohibitively expensive for smallholders, especially for women and female-headed households. Input-oriented interventions generally seek to reduce barriers to access for inorganic fertilizer or improved (genetically modified or hybrid) seeds (Sunding and Zilberman 2001).

Numerous studies from East and West Africa have found that men, male-headed households, and households with a higher proportion of men were more likely than women, female-headed households, and households with a higher proportion of women to participate in programs that promote the use of fertilizer (Chen *et al* 2011, Fisher and Kandiwa 2014, Karamba and Winters 2015, Theriault *et al* 2017, Lambrecht *et al* 2018). Particular barriers to women's use of fertilizer include lack of capital, credit, and equipment, as fertilizer is typically expensive. Research from Malawi suggests that access to an input subsidy may reduce these barriers for women, if they are able to access the subsidy (Fisher and Kandiwa 2014). Likewise, research from Africa and South Asia has demonstrated that women are typically less likely than men to participate in initiatives promoting the use of improved seeds as a result of physical and cultural barriers to access as well as a lack of targeted extension services (Uduji and Okolo-Obasi 2018, Fisher and Kandiwa 2014, O'Brien *et al* 2016, Theriault *et al* 2017, Lambrecht *et al* 2018). One study from the Democratic Republic of the Congo did find, however, that women were much more likely to engage in the use of improved seeds when they were promoted by an extension service, as their cultivation was labor-intensive but not as capital-intensive as fertilizer (Lambrecht *et al* 2018).

In contrast to agricultural input interventions, natural resource management interventions seek to improve local environmental conditions through the use of improved land and water management practices (e.g. land terracing, no-till cultivation) for the dual purpose of achieving ecological goals while maintaining or increasing agricultural productivity despite changing hydrometeorological conditions (Shiferaw *et al* 2009). Climate-smart agriculture (CSA) initiatives, for example, are designed to simultaneously reduce carbon emissions, enhance smallholder

resilience, and increase crop productivity through agricultural strategies such as intercropping and no-till agriculture (Lipper *et al* 2014). Soil and water conservation interventions, on the other hand, seek to mitigate soil degradation and water shortages through strategies including grass strips, soil bunds, and land contouring. While these approaches may reduce runoff and erosion, they also require major upfront, and ongoing, investments of time, labor, and resources (Blanco and Lal 2010).

Research examining CSA and soil and water conservation approaches in Ethiopia, Malawi, Rwanda, Kenya, and Uganda found that women and female-headed households were less likely than men and male-headed households to adopt these practices (Mugonola *et al* 2013, Ndiritu *et al* 2014, Murray *et al* 2016, Asfaw and Neka 2017, Nahayo *et al* 2017). This disparity was attributed to the greater challenges women face in securing financial capital, labor, and time to invest in these initiatives, as well as the existence of insecure land tenure regimes that discourage investment (Kinkingninhoun-Médagbé *et al* 2008, Pircher *et al* 2013, Asfaw and Neka 2017, Hove and Gweme 2018). Several studies from Malawi highlight another barrier to adoption of sustainable agricultural practices—gender-differentiated agricultural labor responsibilities. This means, for instance, that interventions seeking to improve soil nitrogen through the intercropping of legumes and maize may be ineffective when aimed at male agricultural decision-makers who view legumes as ‘women’s crops’ (Pircher *et al* 2013, Mutenje *et al* 2016).

Despite the numerous cultural factors that can limit the adoption of agricultural innovations, there are also cases from Kenya and Benin where gender did not significantly affect the adoption of management strategies or inputs (Yokouchi and Saito 2016, Muriithi *et al* 2018). However, in both of these cases, farmers’ groups and organizations were heavily involved in promoting these agricultural technologies to both women and men. Further, studies from Nigeria, Malawi, Haiti, and Benin offer examples of cases where women were actually more likely than men to adopt new agricultural technologies (Bayard *et al* 2007, Fisher and Kandiwa 2014, Sodjinou *et al* 2015, Onyeneke *et al* 2018). In these instances, however, the interventions were related to farming activities primarily carried out by women. Finally, though women may be more likely to adopt a new agricultural technology, this does not necessarily mean that they will be able to continue using it over the long run. As an example, though Haitian women were more interested than Haitian men in adopting the land management strategy of alley cropping, researchers found that men were more likely to manage alley cropping structures than women, as women’s time was constrained by other household duties (Bayard *et al* 2007).

Considering social welfare outcomes, research from Nepal and Ethiopia found that women who

adopted CSA technologies such as minimum till cultivation often faced an increase in their labor burden, at least in the short term (Halbrendt *et al* 2014, Vandercaesteelen *et al* 2018). Further, some studies have found that women’s adoption of improved seeds or irrigation schemes does not always result in the longer-term benefit of an increase in crop yield or income, due to limited access to land, equipment, and markets (Kinkingninhoun-Médagbé *et al* 2008, Yokouchi and Saito 2016). By contrast, adoption of new agricultural technologies in Bangladesh and Malawi has been observed to increase women’s household decision-making power, women’s income, provide more time for girls’ education, and improve children’s nutritional outcomes (Rahman *et al* 2012, Snapp *et al* 2018).

Uneven environmental, as well as social, outcomes result from gendered engagement with agricultural technology interventions. However, the literature on these ecological outcomes is very limited. Research from Malawi found that women are more likely than men to adopt the pigeon pea-maize intercropping approach. The researchers demonstrated that this intercropping approach improved soil organic matter retention and may contribute to soil accrual (Snapp *et al* 2018). Further, research from India indicated that women were more likely to adopt zero tillage strategies and less likely than men to apply manure to their crops following an intervention designed to promote the reduction of greenhouse gas emissions from agriculture (Sapkota *et al* 2018). As such, these studies suggest that it may be environmentally beneficial to increase women’s capacity to adopt, and maintain, sustainable agricultural technologies.

3.2.2. Agricultural extension initiatives

Concerning the effects of agricultural extension initiatives and farmers’ groups on men and women, the observations from this primarily qualitative literature are somewhat more straightforward. Cases from Ethiopia, Malawi, and Ghana suggest that extension and farmers’ organizations have typically provided a greater benefit to men than women, in large part because a combination of socio-cultural barriers (e.g. stereotypes of women’s ignorance) and limited mobility for women have often prevented women from accessing them (Mogues 2013, Ragasa *et al* 2013, Mudege *et al* 2015, Mudege *et al* 2017, Quaye *et al* 2017). As a result, these organizations have increased gender inequity in some agricultural communities (Kinkingninhoun-Médagbé *et al* 2008). However, research from Mozambique, Malawi, and Ghana found that when the participation of women is facilitated through strategies such as gender equity training for men and the use of female extension officers to target women farmers (Mudege *et al* 2015, Kondylis *et al* 2016, Quaye *et al* 2017), extension services have the potential to increase the adoption of both agricultural inputs and natural resource management strategies by women (Najjar *et al* 2013,

Lambrecht *et al* 2016, Achandi *et al* 2018). In the long run, although research from Zambia and Uganda found that women's engagement in extension services may result in a long term increase in income and market access, there is no evidence of an increase in women's empowerment (Meier zu Selhausen 2016, Mudege *et al* 2017, Carney and Carney 2018). Finally, while it is likely that gender differences in involvement with agricultural extension initiatives can also affect environmental outcomes, the literature on these outcomes is underdeveloped.

3.3. Capture fisheries and aquaculture

Capture fisheries provide a vital resource to poor communities in low- and middle-income countries. They are a source of protein and micronutrients and can provide much-needed economic opportunities, making their sustainable use extremely important (Béné *et al* 2010, Kawarazuka and Béné 2010). Globally, women are crucial actors in fisheries, particularly in harvesting invertebrates and for processing and selling fish (Harper *et al* 2013, Kleiber *et al* 2015). Climate change is affecting fish populations in much of the world, with adverse economic and nutritional consequences (Allison *et al* 2009, Golden *et al* 2016). As a common pool resource, fisheries may be prone to overexploitation without schemes to regulate their use (Ostrom 2008). The challenges that fisheries face from social and ecological drivers, including climate change, as well as their importance to the livelihoods and health of poor people around the globe, have spurred the development of initiatives designed to protect these resources. Governments or NGOs often establish marine protected areas (MPAs) in order to regulate marine resource harvesting and other activities that can affect ecosystem health. MPAs vary widely in their effectiveness in achieving conservation outcomes, but well-designed MPAs can significantly improve ecosystem resilience to climate change while also benefitting human welfare (McClanahan 2010, Selig and Bruno 2010, Edgar *et al* 2014).

Despite the global proliferation of MPAs and the importance of women in fisheries worldwide, relatively little research has explored whether MPAs allow women and men to equally benefit from fisheries. In general, existing MPAs appear to perpetuate, rather than transform, gender disparities in terms of leadership and power, which often results in men's resource needs being prioritized at the expense of women's. Studies exploring MPAs in Brazil (Di Ciommo and Schiavetti 2012), the Caribbean (Dalton *et al* 2012, Smith 2012), Kenya (Mahajan and Daw 2016), Tanzania (Gustavsson *et al* 2014, de la Torre-Castro *et al* 2017, Kamat 2018), Madagascar (Baker-Médard 2017), Indonesia (Gurney *et al* 2015), and the Philippines (Kleiber *et al* 2018, Twitchell *et al* 2018) found that women were less likely than men to participate in MPA governance or activities. In contrast, a handful of

studies have found roughly equal participation between women and men in MPA governance (Pollnac and Pomeroy 2005, Tobey and Torell 2006). Because women sometimes view MPAs as less relevant due to MPA structures that do not emphasize the importance of women as resource users, there is also some evidence to suggest that women may be less likely than men to follow MPA rules (Rohe *et al* 2018).

Fewer studies look at gendered aspects of MPAs beyond participation, and in particular, little literature exists on whether the gendered engagement gap in management leads to disparate welfare outcomes for women and men. The current literature has touched on a handful of the gendered impacts of MPAs including well-being and food insecurity. In Indonesia, no significant gender differences were found in well-being in a 15 year impact evaluation of MPAs (Gurney *et al* 2015). By restricting fishing, MPAs may reduce household food security, which has the potential to disproportionately and adversely affect women as they are forced to take on additional responsibilities to provide for their families (Kamat 2014, Moshy *et al* 2015). In other instances, however, the extent to which households depend on fishing or other factors, appears to matter more than gender in influencing household food insecurity outcomes (Darling 2014). Initiatives that combine MPAs with other development activities targeted at women, such as family planning programs, have been found to improve household food security outcomes as well as natural resource conditions (D'Agnes *et al* 2010).

Aquaculture, the farming of aquatic organisms, is often promoted as a more reliable income source than capture fisheries, particularly in places where fisheries are under threat from overexploitation and environmental changes, including climate change (Belton and Little 2011). Moreover, aquaculture ponds can be placed near homes, allowing women to more easily engage in this activity while fulfilling other household responsibilities (Weeratunge *et al* 2010). However, the peer-reviewed literature on gender and aquaculture is quite limited, predominately consisting of small-scale case studies providing accounts of gendered experiences with aquaculture development initiatives promoted by governments or NGOs.

In general, aquaculture appears to provide an opportunity for both women and men to diversify their income. When women and men participate in aquaculture activities, they are roughly equally productive, illustrating the attractiveness of this activity for women (Lebel *et al* 2009, Karim *et al* 2016). However, the high capital costs of establishing aquaculture ponds can make it particularly challenging for women to adopt, necessitating interventions to provide credit as well as training and technical support. Interventions to subsidize the adoption of aquaculture and provide training have produced income and employment gains for women in India (Panda *et al* 2012) and Nepal

(Bhujel *et al* 2008, Rai *et al* 2014, Farquhar *et al* 2018). However, the growth of larger-scale, commercial forms of aquaculture in some locales, where capital constraints disproportionately affect women, have resulted in increased inequality and welfare losses for women (Gurung *et al* 2016). In addition to pond aquaculture, studies on seaweed farming have found this activity helps women supplement income, albeit with a high labor burden (Fröcklin *et al* 2012, Periyasamy *et al* 2014).

3.4. Forestry

Forests are immensely valuable for sustaining rural livelihoods in low- and middle-income settings. Around the world, roughly 1–1.5 billion people rely on forests for cash or in-kind income (Agrawal *et al* 2013). In addition, forests are a key resource when households experience income shocks, providing relatively reliable, albeit often modest, sources of income (Angelsen *et al* 2014). Forests are likely to play an especially important role in promoting household resilience in the coming decades, as climate change increases the risk of crop failure and other household income shocks. Recent empirical evidence suggests that income from forest product collection often increases when temperatures are at extremes, helping to substitute for decreases in crop income associated with non-optimal temperatures (Wunder *et al* 2018).

As with the agriculture and fisheries sectors, forests are gendered spaces, where women tend to collect fuelwood and edible plants while men generally harvest timber and engage in hunting (Sunderland *et al* 2014). The two groups of policies we discuss below, decentralized forest governance and payments for forest ecosystem services, both have the potential to generate economic benefits for women and men as well as to reduce the pace of rapid deforestation that is contributing to climate change. However, as the literature indicates, in order for these benefits to be realized, initiatives must be carefully designed with gendered needs in mind.

3.4.1. Decentralized management

Decentralization, a process through which decision-making responsibilities are transferred from higher-level bodies to lower-level ones, has been a key trend in forest governance over the past several decades in many low- and middle-income settings (Larson and Soto 2008). Research suggests that forest decentralization may result in more responsive local institutions that can adaptively manage forest resources under changing environmental pressures, ultimately improving economic and sustainability outcomes (Ribot *et al* 2006, Tacconi 2007). However, critics note that poor institutional design and corruption can lead to decentralization generating inequitable outcomes for users (Persha and Andersson 2014). Often,

decentralization results in forests being managed by local forest users through committees, which are responsible for setting and enforcing rules for forest use. A variety of studies have explored the process of decentralization to local user groups to understand its effects on both women and men.

In many settings where decentralization has taken place, women are underrepresented in forest user committees. Cases from Burkina Faso (Coulibaly-Lingani *et al* 2011), Ethiopia (Tadesse *et al* 2017), Nepal (Chhetri *et al* 2013, Oli and Treue 2015, Subedi and Timilsina 2016), Nicaragua (Evans *et al* 2017), and Tanzania (Khatun *et al* 2015) illustrate that men disproportionately engage in decision-making in decentralized forest governance systems, which often has ramifications on the types of rules adopted and their enforcement, both of which typically benefit men and their forest use activities, which often center on timber harvesting

However, these disparities are starting to change in some locations, and various authors have identified factors that can improve women's engagement with forest governance. In Nepal, interventions designed to make decision-making processes more inclusive have increased women's participation in local forest governance (Maskey *et al* 2006, McDougall *et al* 2013b). In India, creating forest management groups exclusively for women significantly increased participation (Das 2011). Additionally, a 'critical mass,' at least 1/4 to 1/3 of a forest user committee comprised of women, can increase the probability that female committee members actively participate as resource decisions are made (Agarwal 2010). Cross-national research suggests that lower levels of wealth and income inequality in communities are strongly associated with whether women are in leadership positions and the number of women in forest user groups (Coleman and Mwangi 2013).

Examining the environmental outcomes from forest governance interventions, various cases illustrate that involving women in forest management can impact ecological conditions and in turn, the ability of forests to store carbon and generate livelihood benefits. Agarwal (2009) found that a greater share of women in forest user committees resulted in improved forest growth, while Das (2012) notes slight increases in the value of non-timber forest products in forests managed by all-female user groups versus those managed by male-dominated groups. However, while there are substantial benefits that accrue when more women participate in institutions where they have been largely absent, a lack of gender balance may also result in adverse outcomes. For instance, while female-dominated user groups tend to have stronger property rights, they are less effective at monitoring forests and sanctioning rule-breakers than gender-balanced groups. Researchers hypothesize this may be

a result of women's inability to adopt necessary technologies, insufficient extension services targeted at women, and competing demands on women's time, reducing their ability to engage with forest management (Mwangi *et al* 2011, Sun *et al* 2011).

Women's participation in forest management groups can also facilitate welfare gains. When women participated more in forest management groups in India, forest incomes were significantly higher (Ray *et al* 2017). Setting up separate forest management groups for women, as was done in parts of India, resulted in increases in forest incomes and resources collected (Das 2012). Greater involvement of women in Nepali forest user groups resulted in women and landless households more likely to collect fuelwood in local forests, as opposed to making long treks elsewhere (St. Clair 2016). Also in Nepal, women received employment and credit at substantially higher rates after the adoption of an adaptive model of local forest governance that increased women's participation (McDougall *et al* 2013a).

3.4.2. Payments for ecosystem services (PES)

In addition to decentralization, another type of forest livelihoods initiative involves PES. PES programs compensate individuals or communities in exchange for preserving a resource, and can take many forms (Muradian *et al* 2010). In the forestry sector, such initiatives are often focused on carbon storage through reducing emissions from deforestation and forest degradation (REDD+) projects, which compensate individuals and communities that own forests for preserving the quality and quantity of existing forests. However, PES efforts in forestry have not been without controversy for many of the same reasons that other conservation initiatives have been challenged—namely that REDD+ projects are typically not designed with women in mind, nor are women's voices often considered during REDD+ consultations with communities (Larson *et al* 2015, Westholm and Arora-Jonsson 2015). This contention has been somewhat supported by the existing literature, although the growing awareness concerning the need to incorporate women in all parts of REDD+ processes appears to have resulted in improving outcomes for women in some settings.

A variety of cases from sub-Saharan Africa and South and Southeast Asia have largely affirmed the critique that women are substantially less likely to participate in REDD+ decision-making activities than men (Khadka *et al* 2014, Stiem and Krause 2016, Westholm 2016, Corbera *et al* 2017, Howson 2017, Samndong and Kjosavik 2017), although a handful of contrasting examples exist from Nepal, where women's participation in forest governance has increased with REDD+ interventions (Maraseni *et al* 2014, Sharma *et al* 2017). Women's general lack of participation is often attributed to cultural norms about women's gender roles, lack of effective

communication to women about REDD+, and time devoted to other household activities (Coleman and Mwangi 2013, Larson *et al* 2015).

Women's lack of participation in REDD+ forest governance extends even to communities where women tend to use forests more than men, and so have a greater stake in management decisions (Larson *et al* 2015). All too often, elite capture occurs in forest user groups that manage REDD+ projects in communities, with (predominately male) elites making most of the key decisions to the detriment of women and other generally disadvantaged groups (Devkota and Mustalahti 2018).

Concerning REDD+ welfare outcomes, the literature is still developing, although to date results have been mixed as to whether REDD+ improves outcomes for women. Some studies have found that benefits associated with REDD+, such as project-affiliated jobs or microcredit opportunities, have been given to women less often than men (Howson 2017, Samndong and Kjosavik 2017). Further, a global study found that individuals in REDD+ communities saw decreased well-being compared to control communities, with women in REDD+ communities experiencing greater declines than men in the same communities (Larson *et al* 2018). Once again, Nepal stands out as having somewhat bucked this trend, as several studies of REDD+ pilot projects have found the country's policies around REDD+ implementation have been more successful at ensuring benefits are targeted to women (Maraseni *et al* 2014, Poudel *et al* 2015, Sharma *et al* 2017). One reason for this may be because the formula used in Nepal to calculate carbon payments provides extra benefits to communities with higher shares of traditionally marginalized populations, including women, on their forest management committees, illustrating the importance of incentive structures in shaping local governance systems and benefit distribution (Shrestha *et al* 2014).

4. Discussion and conclusions

This systematic literature review study examines natural resource-based livelihoods policies and interventions, with the goal of providing an up-to-date understanding of women's and men's engagement with, and outcomes from, these interventions. Overall, natural resource management interventions and policies designed to help buffer individuals in rural areas from shocks associated with climate change have uneven implications for women and men. Researchers continue to document examples of initiatives emphasizing men's activities and preferences over those of women, resulting in suboptimal social, economic, and environmental outcomes. As the effects of climate change are likely to worsen in the coming decades, greater attention must be paid to gender equity in order to ensure that the most vulnerable individuals,

particularly women and girls, are effectively served by interventions focused on natural resource-based livelihoods. The rapid growth of literature in this field suggests that the research community is increasingly interested in these challenges, but additional work is necessary to find and scale solutions that can result in greater gender equity and resilience.

In summarizing the current empirical literature, we emphasize three themes that cut across the different subject areas, highlighting important commonalities between geographies and natural resource types. These are: the implications of gender for climate change adaptation; the association of gender with other disparities that can impede the adoption or effectiveness of interventions; and the dearth of literature examining the role of gender in shaping the environmental outcomes of interventions.

4.1. Gender has significant impacts on the adoption of natural resource-based livelihoods interventions, affecting the ability of households to adapt to the effects of climate change

In all three sectors explored, women or female-headed households generally have lower rates of adoption or participation in natural resource-based livelihoods initiatives than men. As such, these interventions can inadvertently propagate vulnerability and inequity in adaptive capacity rather than reduce it. For example, in the case of agricultural interventions, men or male-headed households are much more likely to adopt improved seeds, which are largely promoted to both increase household crop productivity as well as to help households cultivate climate-resilient crops (Uduji and Okolo-Obasi 2018, Fisher and Kandiwa 2014, O'Brien *et al* 2016, Theriault *et al* 2017, Lambrecht *et al* 2018). Women and men also often engage in different forest harvesting activities, and when men are often the main voices in forest management programs like REDD+ this can impact women's vulnerability by reducing their capacity to benefit from forest resources (Devkota and Mustalahti 2018). The most successful interventions and policies are those which are based on a sound understanding of how individuals use natural resources, and if gender differences do exist, are tailored to accommodate gendered practices.

4.2. Gender often correlates with disparities in resources and information, and effective natural resource-based livelihoods programs recognize and adapt to these disparities to yield beneficial social outcomes for both women and men

When natural resource-based livelihoods interventions are sensitive to the power dynamics shaping gender relations in communities, they have the potential to yield broadly beneficial social outcomes. For example, research from Mozambique, Malawi, and Ghana found that when the participation of women in extension groups was promoted through

the use of female extension officers (Mudege *et al* 2015, Kondylis *et al* 2016, Quaye *et al* 2017), these services have the potential to increase both the adoption of agricultural inputs as well as improve the natural resource management strategies of participating women (Najjar *et al* 2013, Lambrecht *et al* 2016, Achandi *et al* 2018). While in the case of agriculture, the limitation for many women may be access to information, for aquaculture, the barrier to entry is often the cost of establishing an aquaculture pond. As such, research from India and Nepal has demonstrated that interventions that subsidize adoption of aquaculture improve income and employment gains for women, reducing inequity (Bhujel *et al* 2008, Panda *et al* 2012, Rai *et al* 2014, Farquhar *et al* 2018). As gender is often correlated with other disparities, successful interventions and policies often use creative strategies for identifying and addressing multiple deficits, including gaps in knowledge and resources. When these disparities are adequately addressed, women and men are able and interested in adopting new natural resource management practices, and these practices are more likely to yield gender-equitable outcomes.

4.3. Gender may affect environmental outcomes of natural resource-based livelihoods interventions, but the literature is scant

Across agriculture, forests, and fisheries, natural resource-based livelihoods interventions infrequently evaluate the environmental outcomes of policies that are ostensibly designed to improve both environmental and social conditions. Regarding forests, studies from India suggest female forest user committees can improve ecological outcomes (Agarwal 2009, Das 2012), but this may not be a universal phenomenon. More evidence is needed to understand the mechanisms through which some women's user groups have successfully improved forest quality outcomes (Mwangi *et al* 2011, Sun *et al* 2011). Similarly, scant evidence exists in the agriculture and fisheries/aquaculture sectors. As such, although there is a small body of evidence suggesting that women's engagement in natural resource-based livelihoods interventions has the potential to be environmentally beneficial, we caution against broad generalizations or assumptions regarding more sustainable environmental outcomes associated with greater involvement of women in these activities. Additional, tailored research is needed to analyze the gendered environmental, as well as social, implications of natural resource management interventions and policies.

4.4. Limitations and conclusions

As a result of our foci, our review has important limitations. First, our review does not include articles that descriptively examine differences in engagement with agricultural, fisheries, or forestry practices unless

this engagement is related to a policy or intervention. As a result of our approach, many studies examining observed gender differences in the usage of agricultural inputs, for instance, are excluded from our study. Second, our review only includes English-language articles, which may account for the dearth of evidence from certain parts of the world. Third, our focus on the livelihoods impacts associated with policy interventions excludes literature focused on risk perception or attitudinal differences between women and men (Willox *et al* 2012, Boissiere *et al* 2013, Cullen *et al* 2018) or variation in vulnerability to the effects of climate change (Djouidi *et al* 2013, Bunce *et al* 2016), though both are critical components of effective intervention design. Fourth, it is challenging to draw broad substantive conclusions as a result of the strong regional bias in the studies of each natural resource-based livelihood. The majority of studies on agricultural interventions focus on sub-Saharan Africa, whereas much of the forestry literature centers on South Asia, and the fisheries literature examines East Africa, South Asia, and Southeast Asia. In particular, we note that Latin America and the Caribbean are broadly absent from the literature we identified in our review. Fifth, due to the limitations of the methodology contained in much of the empirical literature, we are unable to comprehensively examine the important role that intersectionality plays in shaping gendered outcomes. Sixth and finally, climate change has significant effects on human health outcomes, which can also be gendered (Sellers 2016). While health status can affect livelihoods outcomes, and vice versa, the linkages between livelihoods and health are complex and multifaceted, and often difficult to attribute to a livelihoods intervention. We thus opted to exclude such effects (other than impacts on household food security) from our review.

In sum, we systematically explore literature on the gender dimensions of natural resource-based sustainable livelihoods policies and interventions, in order to provide an up-to-date assessment of our knowledge of their gendered adoption and implications for climate change adaptation. In addition to an increased quantity of research, greater diversity in research methods and design, study locations, as well as research that adopts an intersectional approach to gender to better understand differences among each gender (for instance, stratifying women's and men's outcomes by social class) are needed to inform how to better design and implement effective livelihoods interventions and policies, particularly for the most marginalized and vulnerable individuals. Given the recent growth of literature in this field, we look forward to seeing gender examined with greater regularity and with new and innovative methodological approaches in the coming years.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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