



# Gendered perspectives of ecosystem services: A systematic review

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## ABSTRACT

Women and men often have differential access to and derive different benefits from ecosystem services; therefore, their perception and knowledge of ecosystem services also differ. Understanding these differences is critical to ensuring that policies aimed at enhancing access to and use of ecosystem services can provide benefits to all genders. We conducted a systematic review of studies that aim to understand the relationship between gender and ecosystem service perceptions to summarize research from this emerging topic and to identify patterns between gender and ecosystem service perceptions from different case studies. The results show that highly gendered ecosystem services include medicinal products from forest or mangrove ecosystems and freshwater supply. Women have a stronger perception of water quality and erosion control, soil formation, habitat conservation and sustaining biodiversity. Men, on the other hand, had more knowledge of fuel and timber and extreme event mitigation services. Our review also identifies the limitations of sample size for this interdisciplinary topic, calls for more case studies and comparative studies to identify relationships between gender and ecosystem service perceptions, and calls for the development of models on ecosystem services that incorporate gender. Finally, we discuss how our review can augment existing gender frameworks for policymaking.

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## 1. Introduction

The Millennium Ecosystem Assessment defines ecosystem services (ES) as the benefits that humans derive from their surrounding ecosystems (Reid et al., 2005). These services are often difficult to measure and quantify. Many researchers have argued that an in-depth understanding of how people value ecosystem services is crucial for policymakers to conceptualize the contribution of ecosystems to human society, for undertaking tradeoff analyses of development and conservation (Costanza et al., 1998), for understanding the size of economic activity in relation to its ecological life support capacity (Daly, 1992), and for providing financial compensation to preserve these services.

While the need to protect ecosystem services is critical, it is also extremely relevant to acknowledge the extensive and balanced involvement of women and men as important parts of the use, conservation and management of ecosystem services (Kariuki and Birner, 2016; Rajvanshi and Arora, 2010). In this article, we define gender as the differential experiences of men and women. We further define an approach to be gender-sensitive if it pays specific and sustained attention to gender needs, interests, and culturally specific dynamics and recognizes the disparities in opportunities, resources, and power that are organized by gender and that are pervasive, as described by Brisolará (2014). As a social construct, gender is both relational and culturally embedded (Butler, 2011), making generalizations about how men and women utilize ecosystem services across countries or regions difficult. Kelemen et al. (2016) argue that a gendered understanding of ecosystem services can create just, legitimate and effective policies, institutional arrangements and management interventions for ecosystems and biodiversity. The Millennium Development Goals (MDGs) explicitly stated that the goal to “promote gender equality and empower women” was considered only partially achieved through advances in gender parity in education and government (UN, 2015a). The three indicators used to measure gender parity under the MDGs (parity in education at all levels, in employment in non-agricultural jobs, and proportion of seats held by women in national parliaments) did not acknowledge gendered relationships with the environment. Moreover, none of the indicators used to measure “MDG 7: Ensure Environmental Sustainability” were gender-sensitive or gender-disaggregated.

The Sustainable Development Goals (SDGs) developed by the United Nations, with contributions from governments, businesses, and civil society, aim to mobilize efforts to end all forms of poverty, fight inequalities, and tackle climate change while ensuring that no one is left behind (UN, 2015b). The SDGs have not only generated stronger linkages between environmental and developmental outcomes but have also integrated gendered considerations for achieving the targets and goals. Unfortunately, comprehensive insights on gender–ecosystem service linkages in important goals, such as SDG2 on food, SDG6 on water or SDG15 on life on land have yet to be developed. Cruz-García et al. (2016) argue that it is imperative for research on ecosystem services to incorporate a gender lens in order to achieve the SDGs. Similar studies that discuss the relationship between gender and environmental science have focused on specific aspects, such as water resources management (Rathgeber, 2003), land-use decision making (Villamor et al., 2014), and vulnerability and adaptation to climate change (Denton, 2002).

Gender research has a long history of developing gender analysis frameworks, with evolving philosophies regarding the role of women—and then gender—in development processes since the 1970s. Gender analysis frameworks are methods of research and planning for assessing and promoting gender issues in institutions (March et al., 1999). In chronological order, some examples of com-

mon gender analysis frameworks include the “Harvard Analytical Framework,” one of the earliest frameworks that maps the work and resources of women and men in a community and highlights the main differences; and its modified version: “People-Oriented Planning” (POP, Overholt et al., 1985) that aims to reduce disparities between genders. The “Moser Gender Planning Framework” (Moser, 1993) aims to design programs that emancipate women from their subordination; the “Gender Analysis Matrix” (GAM, Parker, 1993) tries to determine the differential impacts development interventions have on women and men; the “Longwe Framework” (Longwe, 1995) seeks to enable women to take an equal place as men and participate equally in development projects; and the “Social Relations Framework” (Kabeer, 1994) analyzes existing gender inequalities and aims to enable women to be agents of their own development.

These frameworks concentrate on certain factors in women’s and men’s lives. The chosen focus reflects a set of values and assumptions on the part of the framework’s designers. “Motives/Means and Opportunities” is a more recent framework aimed at capturing aspects of access to, control of, and motivations for exploiting resources; particularly as they pertain to women (Meinzen-Dick et al., 2014). The framework scope ranges from the intangible aspects contained in the ecofeminist literature, such as closeness to nature, to the tangible aspects discussed in the political ecology and natural resource management literature, such as access to financial resources and knowledge. With the exception of more recent frameworks, most of these frameworks were developed before the concept of ecosystem services was firmly established in the early 2000s. Thus, no explicit linkages between gender and ecosystem services are documented. However, several frameworks do consider “uses and management of natural resources” as one of their focus, or “means and opportunity to exploit resources (Meinzen-Dick et al., 2014).”

Recently, a growing number of scientific studies have used systems-based approaches to evaluate the relationship between gender and ecosystem services. These studies aim to bridge the research gap in understanding how women and men perceive ecosystem services in different cases. This paper provides a systematic review of how these studies have defined, operationalized and assessed gender differences in relation to ecosystem services. Based on the review, we have tentatively proposed a concept of an “ecosystem services-gender nexus” that attempts to describe gender differences in the perceived value, knowledge and importance of different ecosystem services. We also discuss how results of this review can complement existing gender analysis frameworks. This summary can frame further discussions on gender and ecosystem services, help craft gender-sensitive investments, and deepen practitioners’ capability to better design conservation plans with financial and/or cultural incentives. The structure of this review paper is organized as follows: the methodology section introduces the materials and methodology used for this paper, the results’ section presents the literature review, and the subsequent sections present our discussion and conclusions.

## 2. Methodology

Our review is based on articles published in the Institution for Scientific Information (ISI) Web of Knowledge database. First, we searched publications from 1900 until March of 2017 in the “TOPIC” section with the term “ecosystem service,” which yielded 14,992 articles. Then, we searched publications with the same criteria, but using specifically gendered terms including {“ecosystem services” and gender}, {“ecosystem service” and gender}, {“ecosystem valuation” and gender}, {ecosystem services and gender},

{ecosystem service and gender} and {ecosystem valuation and gender}. This second search resulted in 113 articles in total. This means that less than 1% (i.e. 0.7%) of the state-of-the-art research on ecosystem services had examined gender aspects. This small percentage is comparable with findings from Ravnborg et al. (2007), who show that less than 5% of the “Payment for Ecosystem Services” literature addresses gender issues.

We conducted a detailed review of these 113 papers and removed irrelevant studies (e.g. studies about non-human gender, studies about the business ecosystem, studies focused on ecology but not ecosystem services). The final sample from the systematic review consisted of 51 ES-Gender papers that highlighted women and men’s attitudes, perceptions, knowledge, preferences, willingness to pay (WTP) and awareness of different ecosystem services. A comprehensive list of these core papers is provided in the [Supplemental Material \(Table S1\)](#).

We acknowledge that this methodology has several limitations, including the focus on English language publications (e.g. we only identified one non-English paper among all 113 papers which was included in the 51 final papers), publication bias in the literature towards findings that are deemed relevant, and a lack of recognition of publications not included in the ISI Web of Knowledge database, including grey literature like unpublished reports by NGOs or government agencies. However, this methodology allows us to focus on the emergence of this research direction in the academic field (Seppelt et al., 2011). An alternative method would be to use the Google Scholar database (e.g. Villamor et al., 2014). However, since the scientific definition of ES is still under debate and the term “ecosystem services” is considered a “buzzword” by some (Boyd and Banzhaf, 2005), using the Google Scholar database would have resulted in an overwhelmingly large amount of publications that are not focused on actual ecosystem service studies. Therefore, we chose to focus our review on papers included in the ISI Web of Knowledge database.

### 3. Results

#### 3.1. Ecosystem services and gender: Temporal and spatial distribution

[Fig. 1\(a\)](#) shows the temporal distribution of the 51 core papers. Most studies were published after 2007. This finding is consistent with the popularization of the term “ecosystem services,” which was established in 2005 as part of the Millennium Ecosystem Assessment. However, Juma (1998) already explicitly discussed the relationship between gender and perception of mangrove forests in the late 1990s, making this paper the earliest among the 51 papers reviewed. The number of papers confirms that an increasing number of scientists are paying attention to the relationship between gender and ecosystem services. Note that this figure only shows results from 1998 to 2016 (46 papers in total) since our review was concluded in March of 2017. To our knowledge, five additional studies have been published between January to March, 2017.

[Fig. 1\(b\)](#) and [\(c\)](#) show the spatial distribution (geographic focus) of these ES-Gender studies. [Fig. 1\(b\)](#) indicates that more than 80% (42 in total) of these studies were located in Africa, Asia and Europe, five in America and only two in Oceania. We also found that most studies focused on one geographic area—only two of the 51 studies reviewed spanned two continents. [Fig. 1\(c\)](#) further disaggregates these studies to the country level. China, Spain and Kenya were the countries with the most studies. Note that the majority of previous studies that examine broad relations between gender and natural resources are focused on developing countries (see, for example, Crow and Sultana, 2002; Mwangi et al., 2011). However, among the 51 papers reviewed in this study, a relatively high

number focused on developed countries (about 27%). Given the relatively complexity of the ecosystem service terminology, focused on benefits of ecosystems to humans, as compared to natural resources management, which focuses on how humans manage natural resources, this is unsurprising.

#### 3.2. Ecosystem services and gender: Contextual issues

Second, we examined details regarding the types of ecosystems studied, the number of ecosystem services analyzed, and the methods used. [Fig. 2\(a\)](#) shows that more than half of the papers reviewed focused on forest or agroforestry ecosystems (29 in total). Ecosystem services related to freshwater bodies (rivers, lakes and wetlands) were the second most common. Six papers considered several ecosystems, for example, a watershed, a natural reserve or a protected area that includes both terrestrial and aquatic ecosystems. [Fig. 2\(b\)](#) shows the number of ecosystem services analyzed in each paper. Of the 51 papers, 64% focused on a single ecosystem service. The majority of papers (14 in total) examined provisioning ecosystem services (e.g. freshwater, food, fuel and timber, etc.) followed by supporting ecosystem services (e.g. habitat conservation and maintaining biodiversity) and regulating ecosystem services (e.g. extreme events mitigation and water quality control). Only five studies focus on cultural ecosystem services (e.g. recreation and tourism). About one-third of the papers (16 in total) analyzed two ecosystem services in their studies. Only three studies analyzed more than three ecosystem services in their paper, possibly due to the complexity of the methodological design.

[Fig. 2\(c\)](#) shows the primary methods used in these studies. Surveys (including online, postal or face-to-face) and in-depth interviews were the two most common methods. About half of reviewed papers used surveys (23 in total) and one-third used in-depth interviews (16 in total). Other methods used included analysis of existing data with regression, choice experiments, and focus group discussions. Only one study (Villamor and van Noordwijk, 2016) applied a modeling approach (agent-based modeling, ABM) to study the relationship.

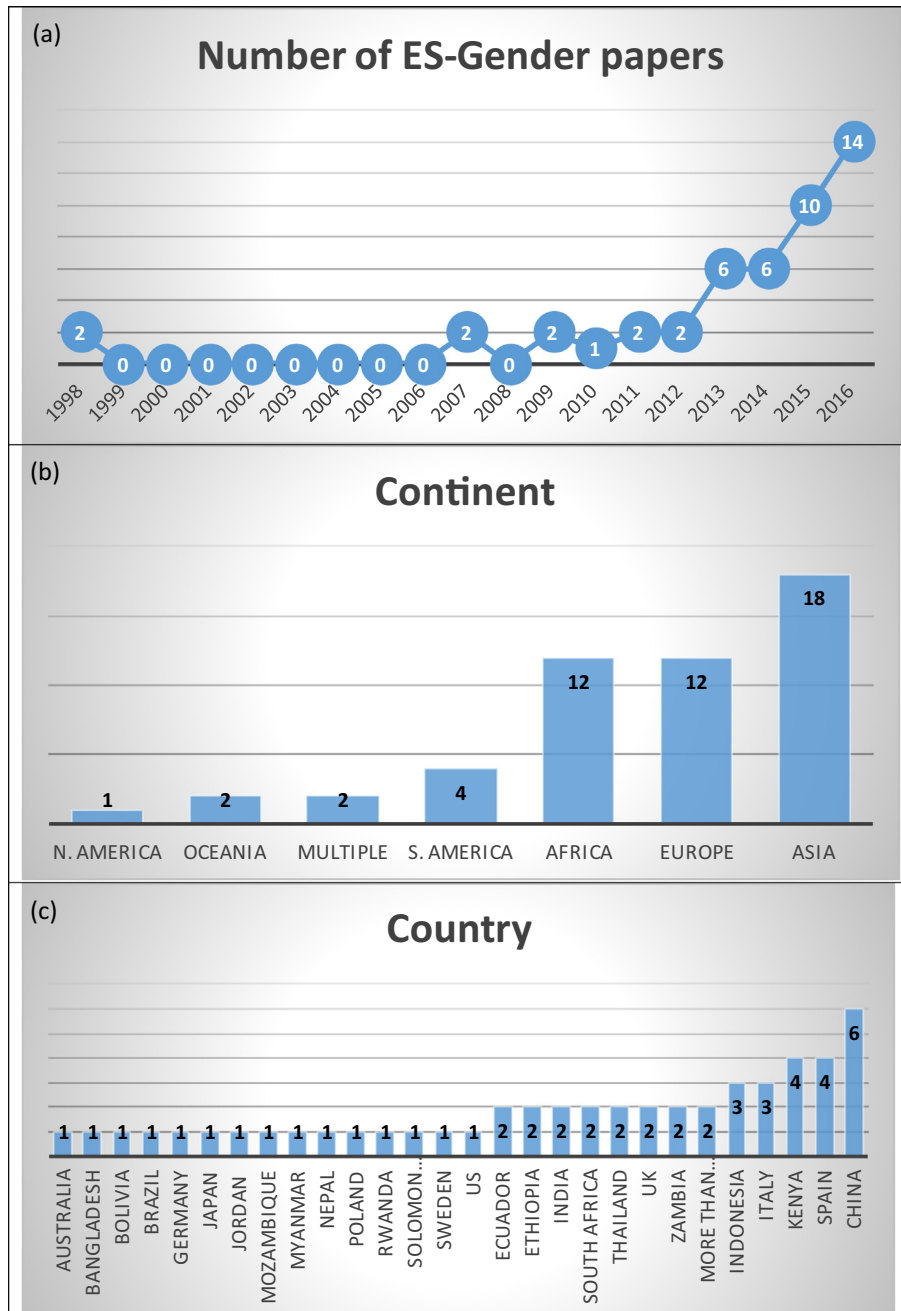
#### 3.3. Ecosystem services and gender: Substantive issues

We summarize the contents of the 51 ES-Gender papers and categorize the relationship between gender and ecosystem services based on different types of ecosystem services. [Table 1](#) lists the four main categories of ecosystem services in the first column and the different types of services studied in the second column. The third column summarizes briefly how different genders perceive the specific ecosystem service. In the last column, we propose the concept of an “ecosystem services-gender nexus,” which uses gender symbols to represent if in the published studies, the authors specifically highlighted that women (♀) or men (♂) in their study valued, knew more about, or gave more importance to the specific ecosystem service. The purpose of the table is to provide an overview of how gender intersects with ecosystem services and to offer a guide for practitioners to recognize the potential degree of gender sensitivity (Brisolara, 2014) surrounding certain ecosystem services when designing policies.

The following section provides a detailed description of each reviewed ecosystem service type and its relationship with gender.

##### 3.3.1. Provisioning

Provisioning ecosystem services consist of all “the products obtained from ecosystems”. We summarize several of the most common ES from the 51 ES-Gender papers: Fuel and timber, food, medicine, fresh water and other provisioning services.

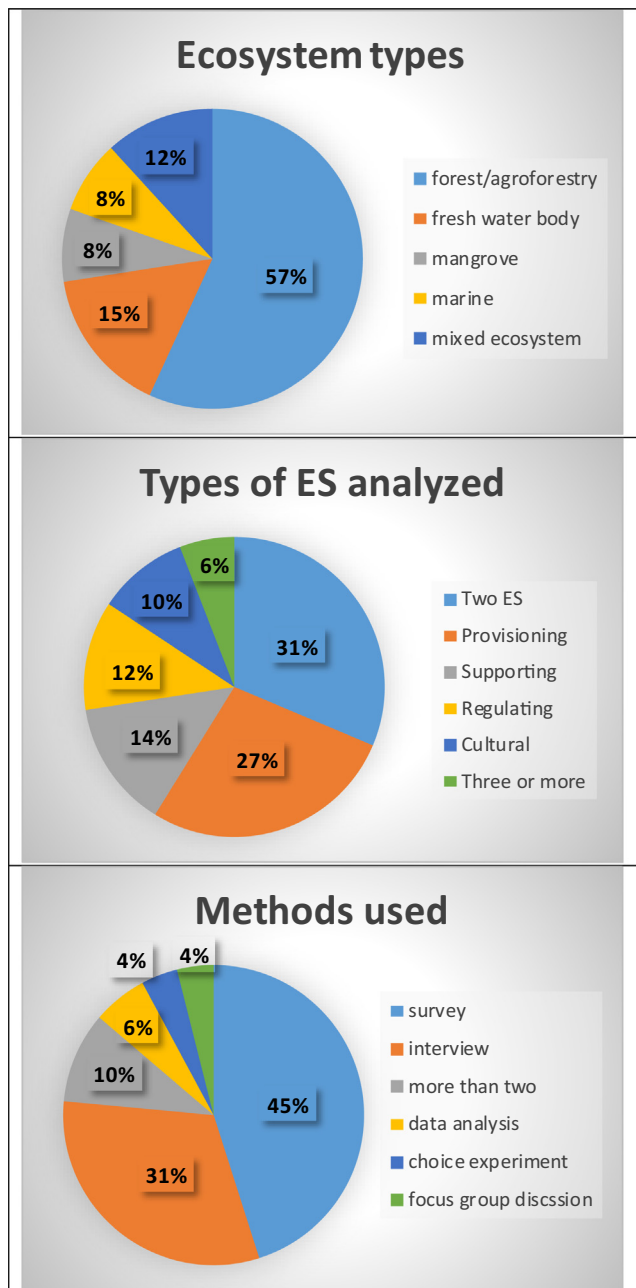


**Fig. 1.** (a) Number of ES-Gender papers from 1998 to 2016; (b) Geographic focus of ES-Gender papers by continent; (c) Geographic focus of ES-Gender papers by country.

**3.3.1.1. Fuel and timber.** In general, women and men focus on different aspects of fuel and timber services (Paudyal et al., 2015). Men were more likely to have a higher awareness or perceived a higher value for firewood, charcoal and timber for profit-earning purposes (Martin-Lopez et al., 2012; Mensah et al., 2017). However, women demonstrated a higher knowledge of and more direct use of domestic fuel supply (Hamann et al., 2015; Juma, 1998; Tadesse et al., 2014). Women usually have a higher dependency on this ecosystem service (Mutandwa and Kanyarukiga, 2016), but under stress and shock conditions (e.g. crop failure, livestock loss), men were more likely to use fuel and timber to cope with these shocks compared to women (Kalaba et al., 2013a,b). Only one study explicitly concluded that gender has no association with fuel and timber (Grilli et al., 2016).

**3.3.1.2. Food.** When considered as a provisioning service, the provision of food was generally not viewed as gendered (Potts et al., 2015; Villamor and van Noordwijk, 2016). But some studies concluded that men considered fisheries and seafood as more important compared to how women viewed them (Jefferson et al., 2014; Juma 1998; Martin-Lopez et al., 2012; Ronnback et al., 2007), while other studies showed the opposite result—that women had a higher willingness-to-pay for the same ecosystem services (fisheries and seafood) compared to men (Shen et al., 2015). Women tended to have greater knowledge of and gave more importance to domestic food supply items, such as wild vegetables and coastal seafood (Juma, 1998; Singh et al., 2015; Tadesse et al., 2014; Veuthey and Gerber, 2012).





**Fig. 2.** (a) Types of ecosystems studied in ES-Gender papers; (b) Types of ES analyzed in ES-Gender papers; (c) Methods used in ES-Gender papers.

These findings differ from non-ecosystem service-focused studies on food and agriculture that often show how, while women work together with men for food production and security, women play dual roles of agricultural producers and household caregivers. Men generally own most agricultural assets and make decisions regarding food production, while women are key to securing household food security and nutrition (SOFA and Doss, 2011). Some studies associate specific crops with men and others with women, but gendered crop disaggregation is not always feasible (Doss 2002). The Sustainable Development Goal 2 (ending world hunger) explicitly mentions addressing the constraints of women small-scale food producers and the nutritional needs of women and adolescent girls (UN, 2015b).

**3.3.1.3. Medicinal products.** Women were predominant in the valuation of medicinal products. All papers reviewed that focus on this ecosystem service show that women usually know more species with medicinal properties as well as more medicinal uses per species, especially species associated with childbirth and childhood ailments as compared to men (Al-assaf et al., 2014; Deb and Haque, 2011; deSantana et al., 2016; Diaz-Reviriego et al., 2016).

**3.3.1.4. Water supply.** Similar to medicinal products, in most cases women value water supply services more than men or had a higher WTP for this service (Hamann et al., 2015; Kisaka and Obi, 2015; McKay et al., 2013; Paudyal et al., 2015). This may be due to the fact that women and young girls are the main collectors and users of domestic water.

**3.3.1.5. Other provisioning services.** Several studies identified differences in gender perceptions of miscellaneous provisioning services, but without similar studies to further support their conclusions. For example, Narjes and Lippert (2016) suggest that men had higher WTP for policies that preserve pollination services by bees (for agricultural production) compared to women; and Buechler et al. (2016) conclude that women's workload regarding water collection had been significantly affected by hydropower development.

### 3.3.2. Regulating

Regulating ecosystem services are the “benefits obtained from the regulation of ecosystem processes.” We focus on extreme events, water quality and erosion control regulating services described in the ES-Gender papers reviewed.

**3.3.2.1. Extreme event mitigation.** In most cases men had more knowledge about or considered this ecosystem service to be more important (Allendorf and Yang, 2013,2017; Ronnback et al., 2007; Warren-Rhodes et al., 2011). Women, on the other hand, were less likely to perceive this ecosystem service partly due to restricted access to information. However, two case studies concluded that women assigned a higher value or WTP to this ecosystem service (Calvet-Mir et al., 2016; Vivithkeyoonvong and Jourdain, 2017).

Boissiere et al. (2013) showed that women and men might focus on different types of regulatory services. Men had a greater perception of the potential benefits that tropical forests can have on mitigating drought frequency, while women were more perceptive of their benefits for the mitigation of flood frequency.

**3.3.2.2. Water quality control.** Women generally had more knowledge of water quality control, accorded it a higher importance or had a higher WTP for this service in most of the studies that we reviewed (Kisaka and Obi, 2015; Martin-Lopez et al., 2012; McKay et al., 2013; Shen et al., 2015). One study drew the opposite conclusion—that women usually have less (or even negative) WTP for this ecosystem service, possibly because women generally have a lower socioeconomic status than men do in this study area in China (He et al., 2015). Specifically, women were more sensitive to costs other than living expenses and were not willing to pay for wetland restoration efforts that would improve water quality.

**3.3.2.3. Erosion control and soil formation.** Most studies reviewed suggest that women had more knowledge of, or accorded more importance to, or had a higher WTP for this type of ecosystem service (Calvet-Mir et al., 2016; Martin-Lopez et al., 2012; Oteros-Rozas et al., 2014; Villamor and van Noordwijk, 2016). In contrast, two other studies found that men acknowledged more of these ecosystem services than women (Briceno and Ravera, 2016; Ronnback et al., 2007).

**Table 1**  
Summary of findings for ES-Gender papers.

ES category	ES type	Link with gender issue via literature	ESG Nexus <sup>*</sup>
Provisioning	Fuel and timber	In general, men had more knowledge on/perceived stronger importance about/use more of this ES type (Kalaba et al., 2013a,b; Martin-Lopez et al., 2012; Mensah et al., 2017; Mutandwa and Kanyarukiga, 2016) But in some cases (Hamann et al., 2015; Juma 1998; Tadesse et al., 2014; Paudyal et al., 2015), women had more knowledge on domestic fuel supply	♀♂♂
	Food	No specific studies can identify significant gender differences on knowledge/perception of this ES type. In some cases, men perceived stronger importance about fisheries/seafood (Jefferson et al., 2014; Juma 1998; Martin-Lopez et al., 2012; Ronnback et al., 2007) but women had higher WTP in other cases (Shen et al., 2015) Women usually had greater knowledge on/perceived more importance about domestic food supply (Juma 1998; Singh et al., 2015; Veuthey and Gerber, 2012)	♀♂
	Medicinal products	Women were predominantly active in this ES type. They usually know more medicinal plant species and also more medicinal uses per species (Al-assaf et al., 2014; Deb and Haque, 2011; deSantana et al., 2016; Diaz-Reviriego et al., 2016), especially species associated with childbirth and childhood ailments.	♀♀♀
	Water supply	In most cases, women perceived stronger importance about/had higher WTP for this ES type (Hamann et al., 2015; Kisaka and Obi, 2015; McKay et al., 2013; Paudyal et al., 2015). This is mostly due to women and young girls acting as the primary stewards of domestic water supply	♀♀♀
	Others	Men had higher WTP for the policies that can preserve pollination services by bees (Narjes and Lippert (2016)) Women's workload regarding water collection had been affected by hydropower development (Buechler et al., 2016)	Insufficient data
	Regulating	Extreme events mitigation	In most cases, men had more knowledge of/perceived more importance about this ES type (Allendorf and Yang, 2013; Allendorf and Yang, 2017; Ronnback et al., 2007; Warren-Rhodes et al., 2011) Two cases show that women gave higher WTP to this ES type (Calvet-Mir et al., 2016; Vivithkeyoonvong and Jourdain, 2017)
Water quality control		In general, women had more knowledge of/perceived more importance about/ had higher WTP of this ES type (Kisaka and Obi, 2015; Martin-Lopez et al., 2012; McKay et al., 2013; Shen et al., 2015) One case shows that women had lower WTP for this ES type than men (He et al., 2015)	♀♀♂
Erosion control and soil formation		In most cases, women had more knowledge of/perceived more importance about/had higher WTP of this ES type (Calvet-Mir et al., 2016; Martin-Lopez et al., 2012; Oteros-Rozas et al., 2014; Villamor and van Noordwijk, 2016) Only two case shows that men acknowledge more of this ES type than women (Briceno and Ravera, 2016; Ronnback et al., 2007)	♀♀♂
Others		Women had higher awareness of reducing waste and odor and use of chemicals from forest than men (Zoderer et al., 2016a,b)	Insufficient data
Cultural	Recreation and tourism	Most studies concluded that there is no gender difference in this ES type (Dallimer et al., 2014; Martin-Lopez et al., 2012; Mensah et al., 2017; Petrosillo et al., 2007; Pinto and Maheshwari, 2016) However, a few studies do show some gender differences (Garcia-Llorence et al., 2016; Swapan et al., 2017)	♀♂
	Aesthetic	Although only two studies focus on this topic, women appreciated more about this ES type (Jefferson et al., 2014; Sang et al., 2016)	Insufficient data
	Spiritual	One case study shows that women had higher awareness of this ES type (Baker et al., 2015)	Insufficient data
	Others	Some studies show that women had more positive attitudes towards cultural connections to ecosystems (Mathooko et al., 2009; Singh et al., 2015)	Insufficient data
Supporting	Habitat conservation and maintaining biodiversity	In general, women perceived more importance about /had greater awareness of/ were more willing to contribute their time to this ES type (Briceno and Ravera, 2016; Gao et al., 2014; Mensah et al., 2017; Mudaca et al., 2015; Palliwoda et al., 2017; Swapan et al., 2017; Yang et al., 2010; Zoderer et al., 2016a,b) Some studies do show that men tended to have higher awareness of this ES type (Allendorf and Allendorf 2013; Oteros-Rozas et al., 2014; Warren-Rhodes et al., 2011; Yang et al., 2015).	♀♀♂

\* Ecosystem Services-Gender Nexus: Gender symbols represent if women (♀) or men (♂) had perceived higher value/knowledge/importance of this ES type. Numbers of gender symbols (usually three) represents the degree of nexus to the gender(s) specified. "♀♀♀" represents no significant gender difference can be found.

3.3.2.4. *Other regulating services.* Two papers from the same research group discussed that women had a higher awareness of the services forests provided for reducing waste and odors than men (Zoderer et al., 2016a,b), but no general conclusions can be drawn due to the small number of studies.

### 3.3.3. Cultural

Cultural ecosystem services include cultural services, life-filling functions, information functions, cultural and amenity services, and socio-cultural fulfillment. We highlight several common foci identified from the 51 ES-Gender papers.

3.3.3.1. *Recreation and tourism.* Most studies we reviewed conclude that there is no significant gender difference in this type of ecosystem service (Dallimer et al., 2014; Martin-Lopez et al., 2012;

Mensah et al., 2017; Petrosillo et al., 2007; Pinto and Maheshwari, 2016), regardless of the type of ecosystem that was providing the services. Only two studies showed differing results. Swapan et al. (2017) showed that urban park forests are more important to men than women in terms of their recreational function, whereas Garcia-Llorence et al. (2016) show that women are more willing to spend their free time on ecosystem services of river viewing and tourism.

3.3.3.2. *Aesthetic.* Only two papers that we reviewed discussed this type of ecosystem service; therefore, we do not have sufficient data to draw any general conclusions. Nevertheless, both of these studies concluded that women saw greater value or appreciated this type of ecosystem service more than men (Jefferson et al., 2014; Sang et al., 2016).

**3.3.3.3. Spiritual.** Only one study reviewed examines the relationship between gender and spiritual ecosystem services. Baker et al. (2015) interviewed local stakeholders to highlight key ecosystem services in a three-dimensional watershed of Ethiopia. The authors found that only women identified some holy water sites, suggesting women had a greater awareness or accorded greater importance to this type of ecosystem services.

**3.3.3.4. Other cultural services.** Although no specific definition had been given, some studies show that women had a more positive attitude towards the term “cultural connection” to specific tree species (Singh et al., 2015) and might have higher perceived values of the “cultural functions” provided by rivers (Mathooko et al., 2009) due to their key responsibility and decision-making roles for domestic water supply.

### 3.3.4. Supporting

Supporting ecosystem services are the services that allow the other ecosystem services to be present. The most common of these services from the 51 ES-Gender papers are habitat conservation and maintenance of biodiversity.

**3.3.4.1. Habitat conservation and biodiversity maintenance.** Generally speaking, most studies reviewed conclude that women had greater awareness of, were more willing to contribute their time to, or considered habitat conservation and biodiversity maintenance more importantly compared to men (Briceno and Ravera, 2016; Gao et al., 2014; Mensah et al., 2017; Mudaca et al., 2015; Palliwoda et al., 2017; Swapan et al., 2017; Yang et al., 2010; Zoderer et al., 2016a,b). This conclusion was true for all ecosystem types: forest/agroforestry, waterbodies, mangroves and marine areas. A few studies had different findings, suggesting that men had a higher awareness of this ES type (Oteros-Rozas et al., 2014; Warren-Rhodes et al., 2011). In some of these cases, the authors describe how other social factors might be driving these gender differences. For example, women often had limited access to information (Allendorf and Allendorf, 2013) or women had a lower rate of literacy (Yang et al., 2015). One study showed that no specific gender differences in the WTP of this ecosystem service type were observed (Zhang and Tu, 2009).

### 3.3.5. Ecosystem services and gender nexus

In Table 1, we used gender symbols (usually three) to represent the ecosystem service and gender nexus (ESG nexus). The symbols attempt to describe degree of gender differences in the perceived value, knowledge and importance of a particular ecosystem service type. For example, “♀♀♀” means that women had a substantially higher awareness of or assigned a greater importance to this service relative to men, “♂♂♂” means that, in general, men accorded a higher importance to the selected ecosystem service and “♀♂” represents that no significant gender difference was found or that differences varied across cases.

As Table 1 indicates, gender differences can be found in different types of provisioning, regulating and supporting ecosystem services, while cultural ecosystem services do not exhibit significant gender differences, or the available literature was insufficient to identify differences. Based on the studies reviewed, ecosystem services that were mostly perceived by women are medicinal products from forests or mangrove ecosystems (provisioning) and freshwater supply (provisioning). Women also accorded a higher importance to water quality, erosion control, and soil formation (regulating), habitat conservation and sustaining biodiversity (supporting). Men, in general, had more knowledge of fuel and timber (provisioning) and the mitigation of extreme events (regulating).

These results are not intended to imply that specific ecosystem services are always perceived by a given gender in this way. We

acknowledge that gender perceptions are highly variable based on the context and ES being studied. We also acknowledge that these results will be highly biased based on the studies that have been undertaken and published on each topic, so they are not intended to describe an overall societal phenomenon. Rather, this table is meant to summarize the findings from the 51 papers included in our systematic review.

## 4. Discussion

### 4.1. Ecosystem services and gender: Pointers for future research

In this section, we summarize the limitations and concerns related to studying ES-Gender relationships that arose in the studies we reviewed. Note that suggestions regarding the specific study areas' conservation policy and research are not the focus of this section. The most common limitation observed by authors of these studies was the need to focus on other social factors in addition to gender. Many studies mentioned that gender differences in ecosystem service perceptions might arise due to the intersection of a number of factors, including educational backgrounds, culture, socioeconomic status, age, religious beliefs and access to information (Allendorf and Allendorf, 2013; Allendorf and Yang, 2013; Calvet-Mir et al., 2016; Grilli et al., 2016; Shen et al., 2015). Another commonly cited limitation was whether the indicators or metrics these studies used to qualify responses truly reflect the relationship between gender and the specific ecosystem service in question (Dallimer et al., 2014; Hamann et al., 2015; He et al., 2015; Mensah et al., 2017; Vivithkeyoonvong and Jourdain, 2017; Yang et al., 2015).

In addition, while the studies used a variety of methods to understand gender and ecosystem services linkage, many of the studies were qualitative and relied on small samples. Sample representativeness and participant diversity were common concerns among these studies (Baker et al., 2015; Calvet-Mir et al., 2016; Mensah et al., 2017; Swapan et al., 2017; Vivithkeyoonvong and Jourdain, 2017). Usually, the sample sizes in the qualitative studies were less than 50. Quantitative studies included sample sizes ranging from more than 3000 (Martin-Lopez et al., 2012) to less than 100 interviewees (He et al., 2015). This means that the conclusions drawn in some studies could suffer from scalability and context-specificity of the research areas. To overcome this limitation, most of these 51 papers suggest that additional similar studies should be conducted to broaden the scope of the research.

One research direction suggested as a result of this review is to better reflect gendered differences through modeling. Only a few studies among the 51 ES-Gender papers mentioned the use of models (Hamann et al., 2015; He et al., 2015). In fields where quantitative research methods dominate—including modeling of ecosystems, water, and climate—gender most often remains absent from discussions and methods with a few exceptions (Baker et al., 2015; Villamor and van Noordwijk, 2016). Without an improved understanding of interactions between gender and the environment, models may suffer from reduced accuracy, inadequate specificity or inappropriate recommendations. Agent-based modeling (Villamor and van Noordwijk, 2016) can potentially be a suitable tool to address this issue. Gender can be categorized as one attribute to represent agents' heterogeneity. Agents can be defined at different scales—from country/watershed to individual/household—with different purposes (Yang et al., 2009, 2012), and the functions of ecosystem services within the ESG nexus can be one of the objectives that local-scale agents (such as individuals or households) optimize. However, solid qualitative and quantitative research to identify gender agents' behaviors and preferences—and the intersection of gender with other social and cultural factors in a given context—is an essential prerequisite.

Moreover, gaps in the full understanding of gender and ecosystem services may just reflect a lack of research in a particular area. Too often, gendered research focuses only on women and does not aim to understand men's roles. This is also a criticism of some existing gender analysis frameworks (March, 1999). Gaps in understanding are also likely due to information asymmetry, fueled by differences in education, norms, and social status. Finally, for some services, the language of ecosystem services is often not used by gender researchers working on the topic. An example would be the provision of food. Many papers have been written on the gendered nature of food production, preparation and consumption, but few have made it into the realm of ecosystem service assessment due to differences in the terminology used and the scope of awareness of other academic disciplines.

Based on Fig. 2, we can offer a suggestion on where research gaps are greatest. More research should be undertaken in North and South America and the Oceania region. Freshwater bodies, mangrove and marine areas are ecosystem where studies are particularly lacking. In addition, these future studies should also focus more on supporting, regulating and cultural ecosystem services. Finally, only two of the 51 papers compared more than two study sites. Comparative studies are important to understanding how ecosystem services differ across gender and other factors and can help identify patterns of similarities and differences.

#### 4.2. Ecosystem services and gender: Complementing existing gender frameworks

As mentioned in the Introduction, several existing gender analysis frameworks can help practitioners evaluate gender issues in a systematic way. Here, we discuss how review results (ESG nexus, Table 1) from this paper could complement existing frameworks for policymaking purposes, in order to create more gender-sensitive development initiatives. Hunt (2004) summarize critical steps for applying these frameworks; we go through these steps to illustrate how to apply our Table 1.

- *Step 1-Collect sex-disaggregated data/information:* If an initiative is strongly related to an ES (e.g. water quality control investment, environmental timber policy or setup a natural preserve areas), our ESG nexus results in Table 1 can provide background information to researchers, especially non-gender specialists, about whether the collection of gender-disaggregated data would be of particular importance for a project.
- *Step 2-Assess the gender division of labor and patterns of decision making:* Table 1 provides a comparison of case studies in different regions of the world; this can help researchers understand the common ESG nexus of “who does what” issues (i.e. Tool 1 in Harvard and Moser Framework and Tool 2 in POP) in different geographies. Table 1 also partly provides the information for GAM Tool 1 about the “level” of society that researchers need to consider. The essence of the targeted ES should provide information on whether the “work” is productive or reproductive, especially for provisioning ecosystem services.
- *Step 3-Assess access to and control over productive resources, assets and benefits & Step 4-Understand differences in needs and strengths:* Table 1 is a summary of what has been observed in different areas regarding women's and men's perceptions of different ecosystem services, which can be seen as resources, assets and benefits. Therefore, Table 1 highlights the potential needs of ES that should be addressed and can fit into Tool 2 in the Harvard and Moser Framework, Tool 3 in the POP and Tool 2 in the Longwe Framework. For example, say a government is planning a natural reserve, which is considered as a supporting ES. According to the ESG nexus, women tend to have a stronger perceptions of supporting ES. But if the purpose of

this natural reserve is for timber, then men's needs should be highlighted. On the other hand, if the purpose of this natural reserve is for timber, medicinal plants, and vegetable production, then women's needs may need to be weighed more heavily.

Table 1 on its own cannot provide a full understanding of the gender relations described in steps 5 to 9 in Hunt (2004), such as reducing the barriers to access for women and men, promoting gender equality, and assessing program objectives to empower women. However, since the results of this review can reduce the burden for researchers from Step 1 to Step 4, this leaves more project resources for these later steps.

Finally, to develop gender-sensitive indicators, as described in Step 10 in Hunt (2004), we believe the ESG nexus can contribute to the development of a semi-quantitative, gender-sensitive indicator. In summary, a future framework that incorporates ecosystem services-gender nexus results could be used to provide guidelines for collecting gender-disaggregated data, craft gender-sensitive investments to enhance ecosystem services, and deepen practitioners' capacity to better design conservation plans with financial and/or cultural incentives.

## 5. Conclusion

To ensure that progress on the Sustainable Development Goals on environmental sustainability and gender equity are achieved, an increasing number of studies have applied systems-based approaches to evaluate the relationship between gender and ecosystem services. We conduct a systematic review of these previous studies to confirm this as an emerging research topic, to analyze the research methods used and ecosystem services targeted, to summarize the relative ‘genderedness’ of ecosystem services from different case studies, and to highlight common limitations identified in these studies. The summarized results show that, in the literature reviewed, collecting medicinal products from forest or mangrove ecosystems (provisioning) and freshwater supply (provisioning) were services more strongly perceived by women relative to men. Women also had a relatively higher valuation of water quality, control of erosion, soil formation (regulating), habitat conservation and sustain biodiversity (supporting). Men, on the other hand, had more knowledge of fuel and timber (provisioning) and the mitigation of extreme events (regulating).

Our review also summarized the concerns and limitations from previous studies about the need to consider the intersection of gender with other social factors, the inadequacy of indicators used for assessing ES-Gender relationships, and unrepresentative samples. We call for more case studies and comparative studies to identify relationships between gender and ecosystem service perceptions within and across populations, and call for more research on modeling development that integrates gender. We also provide a path to incorporate our review results regarding the ecosystem service-gender nexus into existing gender analysis frameworks for policymaking purposes. We believe that these efforts can help scientists and practitioners to better understand the interaction between gender and ecosystem services, and that projects can better integrate gender-sensitive approaches to maximize the benefits for both people and the environment.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.ecoser.2018.03.015>.

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