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To what extent have the links between ecosystem services and human well-being been researched in Africa, Asia, and Latin America?

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1 **To what extent have the links between ecosystem services and human well-being been researched in**
2 **Africa, Asia, and Latin America?**

3
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20 **Abstract**

21
22 Most studies to date assume that there are multiple relationships between ecosystem services and human
23 well-being, but there are few studies that quantify these relationships. Our objectives were: (1) to
24 investigate the trends and understudied areas within ecosystem services and well-being research; and (2)
25 within these general trends, to analyze to what extent the linkages between ecosystem services and well-
26 being presented in empirical research in Africa, Asia, and Latin America were part of a tested hypothesis
27 and to assess which conceptual frameworks were used in understanding this interface. The results of this
28 study highlighted that most publications assumed that ecosystem services and well-being were interlinked
29 but did not analyze their relationship as part of the hypothesis to test. While different frameworks on
30 well-being were adopted by empirical research, only one out of the 29 post-Millennium Ecosystem
31 Assessment (MEA) conceptual frameworks that illustrate the linkages between ecosystem services and
32 well-being was documented, and most case studies adopted the MEA. Finally, trade-offs and synergies
33 between ecosystem services and disaggregated well-being were understudied. Considering these
34 knowledge gaps in future studies will help empirical ecosystem services research to simultaneously
35 contribute to improved well-being and environmental sustainability when applied at multiple policy or
36 institutional levels.

37
38
39 **Keywords:** Africa, Asia, conceptual framework, ecosystem services, human well-being, Latin America,
40 systematic review

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43 **1. Introduction**

44
45 Human well-being is a multidimensional concept with objective dimensions that include social and
46 material attributes, and subjective dimensions that comprise a person's assessment of their own
47 conditions (King, Renó and Novo 2014; Summers, Smith, Case *et al.* 2012). It includes different social,
48 environmental, physical, spiritual, and emotional components associated with how people function and

49 how they feel. Summers Smith Case *et al.* (2012: 328) emphasized that in order to have well-being it is
50 necessary that 'basic needs are met, that individuals have a sense of purpose, and that they feel able to
51 achieve important personal goals and participate in the society.' Although there is a substantial body of
52 literature on the indicators of human well-being (e.g. Cummins, Eckersley, Pallant *et al.* 2003; Gasper
53 2007; Prescott-Allen 2001), the benefits that humans receive from the environment are not well
54 understood within the well-being literature (Summers, Smith, Case *et al.* 2012). However, the
55 interconnectedness between well-being and the benefits provided by ecosystems to humans is
56 increasingly gaining recognition among scientists, who are progressively exploring conceptual and
57 methodological frameworks for conducting socio-ecological analysis (King, Renó and Novo 2014).

58
59 A foundational piece known as the Millennium Ecosystem Assessment (MEA, 2005) illustrates the multiple
60 links between ecosystem services and human well-being. Indeed, ecosystems, through the benefits they
61 provide, are essential for safeguarding the multiple dimensions of human well-being, such as the provision
62 of goods and services (e.g., food, timber, fuelwood, freshwater provision) that are needed for human
63 survival. Along with the rapid increase of ecosystem services literature after the publication of the MEA
64 (Gómez-Baggethun, De Groot, Lomas *et al.* 2010), numerous frameworks have emerged that attempt to
65 conceptualize the dynamics and complexity of the links between ecosystem services and human well-
66 being (e.g. Díaz, Demissew, Carabias *et al.* 2015; EPA 2012; Fisher, Patenaude, Giri *et al.* 2014; Rounsevell,
67 Dawson and Harrison 2010; TEEB 2010). For instance, Blundo Canto, Cruz-Garcia, Sachet *et al.* (in
68 preparation) found a total of 29 frameworks describing the relationship between ecosystem services and
69 human well-being that emerged after the publication of the MEA. Although these frameworks propose
70 various economic, social, political, and ecological perspectives for understanding the interactions
71 between these two concepts, it is unclear how far empirical research has advanced in demonstrating and
72 measuring these theoretical linkages, combining perspectives from different disciplines and in different
73 contexts. Exploring the connections between human well-being and ecosystem services at different scales
74 and contexts, and using a systemic analysis where different perspectives (e.g. social justice, poverty
75 eradication, environmental sustainability) and disciplines are combined, will help to identify the actions
76 required to simultaneously enhance human well-being and ecological stability, which will contribute to
77 achieving the Sustainable Development Goals (Balvanera, Siddique, Dee *et al.* 2014; Carpenter, Mooney,
78 Agard *et al.* 2009; Duraiappah 2011; Raworth 2012; Reyers, Roux, Cowling *et al.* 2010).

79
80 Although research on ecosystem services and human well-being is increasing exponentially, little is known
81 about the extent to which empirical research has studied the nature of their linkages. For instance, 81%
82 of the case studies on ecosystem services and food security (a component of human well-being)
83 conducted in Africa, Asia and Latin America assumed they are linked, while few had tested their links
84 empirically (Cruz-Garcia, Sachet, Vanegas *et al.* 2016). There is no systematic review that examines to
85 what extent the connection between ecosystem services and human well-being has been theoretically
86 assumed as part of the study justification or empirically researched by including this connection as part of
87 the study hypothesis. Such an analysis is necessary to provide useful directions for future empirical studies
88 in the way that they contribute to an understanding how trade-offs and synergies between ecosystem
89 services and well-being can simultaneously ensure environmental sustainability and improved livelihoods.
90 This is particularly important for Africa, Asia and Latin America, where improving social progress,
91 economic and human development is imperative. They include countries where social progress indices
92 range from very low to middle. Their lower social progress indices compared to North America, Europe
93 and Australia, are not clearly correlated with country income; instead, they are related to low attainments
94 in multiple dimensions of human well-being (including environmental indicators), basic need satisfaction
95 and social opportunities (Porter, Stern and Green 2016). Such a socioeconomic challenging context is
96 paired with growing environmental concerns. For instance, between 1990 and 2015, the greatest forest
97 loss occurred in sub-Saharan Africa, South-Eastern Asia and Latin America, accounting for almost 16,000

98 thousand hectares (United Nations 2016), whereas the highest threats to water security and biodiversity
99 were concentrated in Africa, Asia, South America and the Caribbean (Vörösmarty, McIntyre, Gessner *et*
100 *al.* 2010).

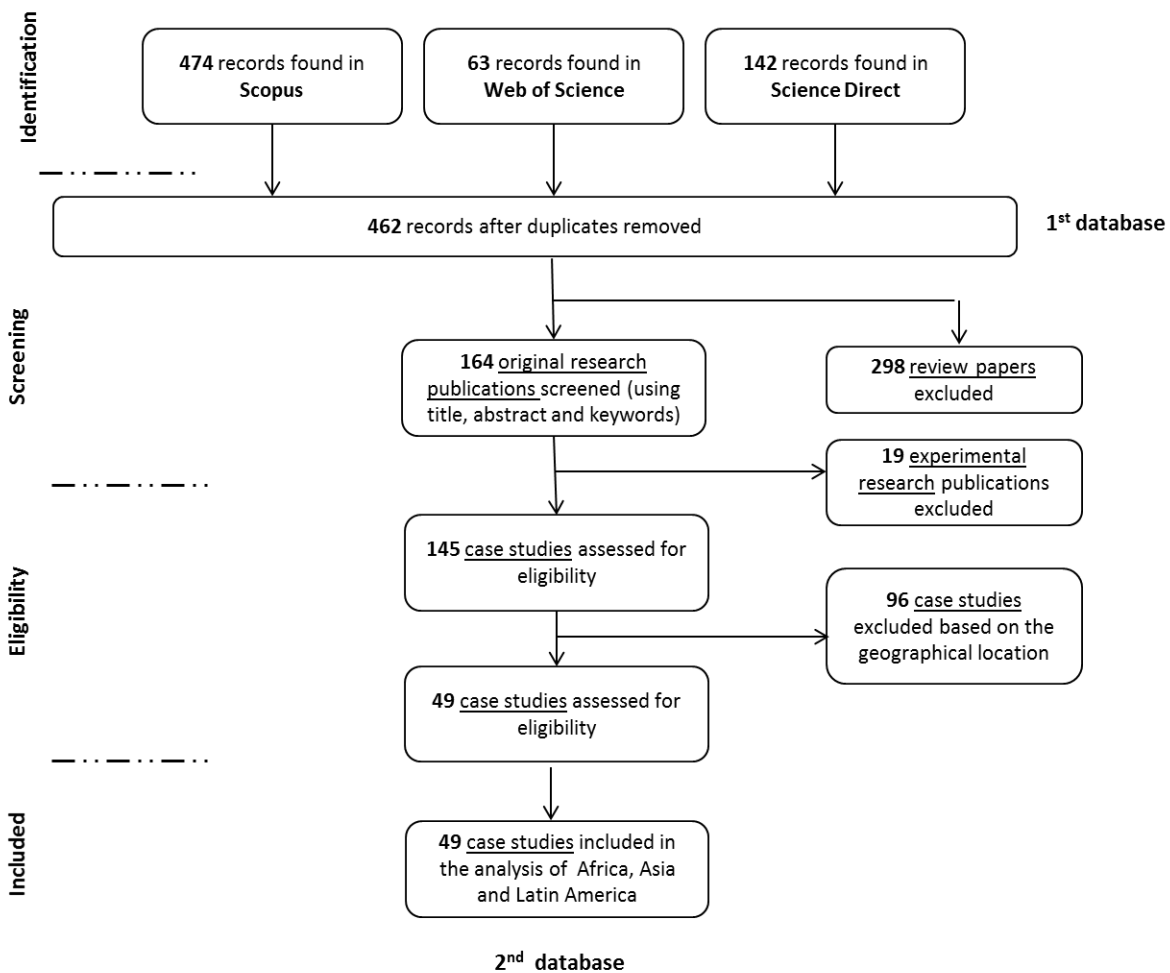
101
102 The hypothesis underlying this study is that most of the many studies on ecosystem services and human
103 well-being assume that there are multiple relationships between these two concepts, but there are few
104 research studies that examine these relationships. This paper aims to evaluate to what extent these links
105 have been empirically analyzed in scientific studies. The objectives were: (1) to investigate the trends and
106 understudied areas within ecosystem services and human well-being research (temporally, spatially and
107 by topic); and (2) within these general trends, to analyze to what extent the linkages between ecosystem
108 services and human well-being presented in empirical research in Africa, Asia, and Latin America were
109 part of a tested hypothesis or were assumed to be part of the study justification, and to assess which
110 conceptual frameworks were used to understand this interface. This empirical evidence, when applied,
111 will contribute to synergistically improve environmental sustainability and human well-being as part of
112 policies, strategies and initiatives related to the attainment of the Sustainable Development Goals.

113 114 **2. Methods**

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116 A systematic literature review was conducted using the methodological rules of the Preferred Reporting
117 Items for Systematic Reviews and Meta-Analyses (PRISMA) designed for indexed publications. According
118 to PRISMA, a systematic review is “a review of a clearly formulated question that uses systematic and
119 explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze
120 data from the studies that are included in the review” (Moher, Liberati, Tetzlaff *et al.* 2010: 336).

121
122 All indexed peer reviewed publications including ecosystem services and human well-being (or wellbeing
123 or well being) in title, abstract and keywords, published in English before 2015, were searched using the
124 Scopus®, Web of Science™ and ScienceDirect® databases. This review focused on scientific research based
125 on a peer review process, which aims to ensure the scientific rigor of publications. The choice to omit gray
126 literature was a response to the need to have a rigorous search of the established databases, systematic
127 identification of scientific publications and eligibility criteria (procedures and standards). The Booleans
128 AND, which ensures the presence of both terms, and OR, which allows the presence of either term (or
129 both), were used using the keyword combination “ecosystem services” AND (“human well-being” OR
130 “human well-being” OR “human well being”) in the search. The keywords of the query were entered in
131 Scopus’ and ScienceDirect’s ‘title-abstract-keywords’ field option, where there is no difference between
132 author and indexed keywords (Tancoigne, Richard, Barbier *et al.* 2014). The keywords of the query were
133 entered in Web of Science’s ‘topic’ field option that includes searching in: title, abstract, author keywords,
134 and indexed keywords fields. The literature search yielded a total of 474, 63, and 142 publications found
135 in Scopus®, Web of Science™, and ScienceDirect®, respectively. Duplicate articles were manually deleted.
136 Publications that were found during the search that did not include the search terms in title, keywords or
137 abstract, publications that were not written in English or were not accessible online, and non-peer
138 reviewed books, were manually excluded. This yielded a total of 462 publications establishing the first
139 database (**Fig. 1**), which was used for addressing objective 1 of the study (i.e. understanding the general
140 trends in ecosystem services and human well-being research)

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Fig. 1. Flow diagram of the selection process of publications for databases 1 and 2, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) rules and templates (Moher, Liberati, Tetzlaff *et al.* 2010).

To evaluate to what extent the linkages between ecosystem services and human well-being have been empirically analyzed as part of scientific research conducted with rural and urban communities in Africa, Asia and Latin America (objective 2), a subset of case studies was selected from database 1. A case study is defined as an empirical enquiry that requires a scientifically rigorous research design, using one or more types of research methods (qualitative and/or quantitative) for data collection and analysis (adapted from Yin 2013). The selection criteria for inclusion were based on paper coverage and the continent where the study was conducted. In addition, case studies should have been conducted with rural or urban communities. Accordingly, the first step was to select original research publications, excluding review papers from database 1. Then, experimental research publications (based on field or laboratory experiments) and case studies that did not adhere to the criteria (two articles) were excluded. This generated a total of 145 case study publications globally. Finally, case studies that were not conducted in Africa, Asia and Latin America were excluded, yielding a total of 49 case studies from Africa, Asia and Latin America, which constituted database 2.

165 The quantitative analysis of publications from database 1 was based on: type of publication (e.g. journal
 166 article, book chapter, conference paper, letter, editorial and commentary), year of publication, subject
 167 area (according to Scopus 2011), type of study area, and geographical scope (e.g. continent, country,
 168 scale). The publications from database 2 were classified into two groups: (a) case studies that analyzed
 169 the linkages between ecosystem services and human well-being as part of the hypothesis to test and
 170 designed the research methodology on this basis; and (b) case studies that assumed that these linkages
 171 existed as part of the study justification and based on this assumption, proposed a hypothesis. The final
 172 database included two variables: 'link tested' (for articles classified in group a) and 'link assumed' (for
 173 articles classified in group b). These case studies were analyzed in relation to their research methods,
 174 citation or application of a conceptual framework, dimensions or indicators of well-being used, category
 175 and type of ecosystem services included, and whether issues related to trade-offs and gender were
 176 included.

177
 178 This paper followed the ecosystem service categories and the ecosystem services types from the MEA
 179 (Millennium Ecosystem Assessment 2005), The Economics of Ecosystems and Biodiversity or TEEB
 180 (McVittie and Hussain 2013; TEEB 2015), and the Common International Classification of Ecosystem
 181 Services or CICES (Biodiversity Information System for Europe 2016; European Environment Agency 2016).
 182 Data were analyzed using Microsoft Excel®.

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185 3. Results

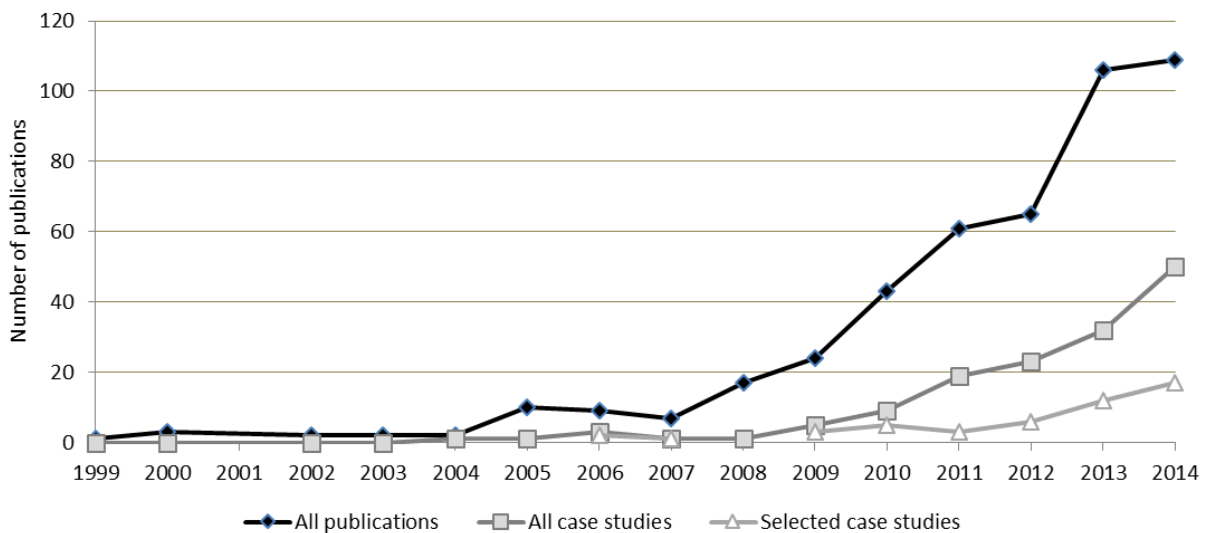
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187 3.1. Global trends in ecosystem services and human well-being research

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189 A total of 462 publications on ecosystem services and human well-being (corresponding to database 1)
 190 included journal articles (83%), book chapters (9%), conference papers (7%), editorials (1%), letters (0.2%)
 191 and commentaries (0.2%). The first article was published in 1999 and the number of publications was
 192 about 20 per year up to 2009 (Fig. 2). Since 2010, the total number of publications has exponentially
 193 increased, reaching a maximum of 109 in 2014. The first case study was published in 2004, and the total
 194 number of case studies did not show a substantial increase until 2011.

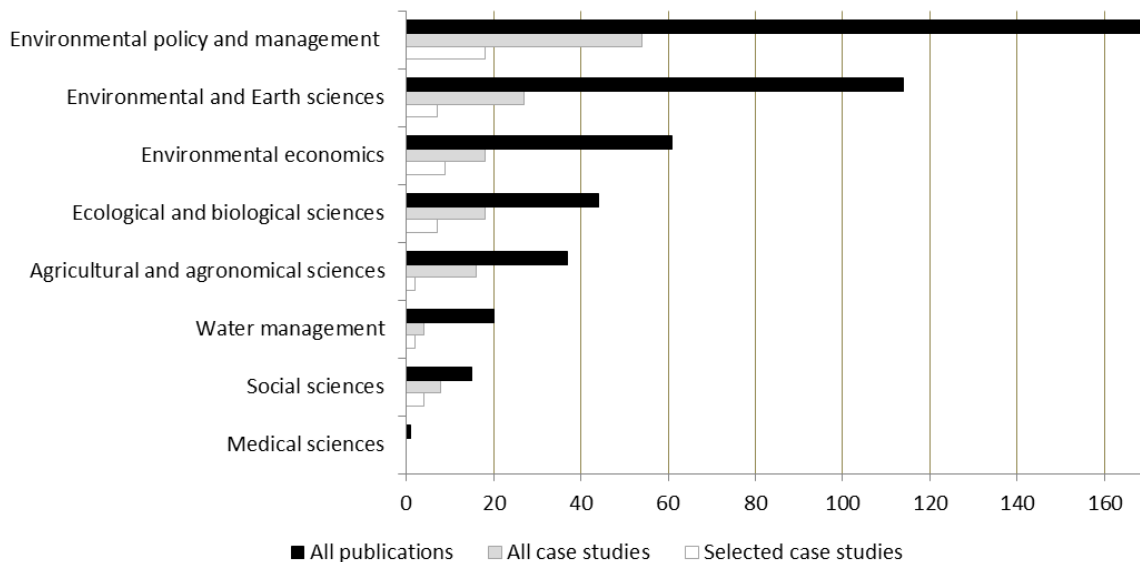
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199 **Fig. 2.** Number of publications on ecosystem services and human well-being published in English before
 200 2015, using the Scopus®, Web of Science™ and ScienceDirect® databases indicating chronological trends
 201 for all publications (n=462), all case studies (n=145), and selected case studies for communities in Africa,
 202 Asia and Latin America (n=49).
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205 The most common subject area for all publications was environmental policy and management, followed
 206 by environmental and earth sciences (**Fig. 3**). Publications on environmental policy and management
 207 mainly focused on landscape ecology (n=35), urban ecology (n=23), biodiversity (n=14), and marine
 208 environments (n=11). Similarly, publications on environmental and earth sciences mainly focused on
 209 biodiversity (n=20), followed by marine (n=13), and landscape ecology (n=12). Other key areas of research
 210 were environmental economics, and ecological and biological sciences, with a focus on biodiversity (n=9
 211 each), as well as agricultural and agronomic sciences with an emphasis on agricultural systems (n=24). The
 212 least represented subject areas were: water management, social sciences and medical sciences with 20
 213 or less publications in total, and less than 10 case studies each. Case studies (n=145) followed the same
 214 trends as all publications with respect to subject area. Similarly, most case studies were conducted on
 215 landscape ecology (n=27), marine environments (n=20), agricultural systems (n=20) and urban ecology
 216 (n=13). Biodiversity, livelihoods and forest ecosystems were the focus of eight case studies each.
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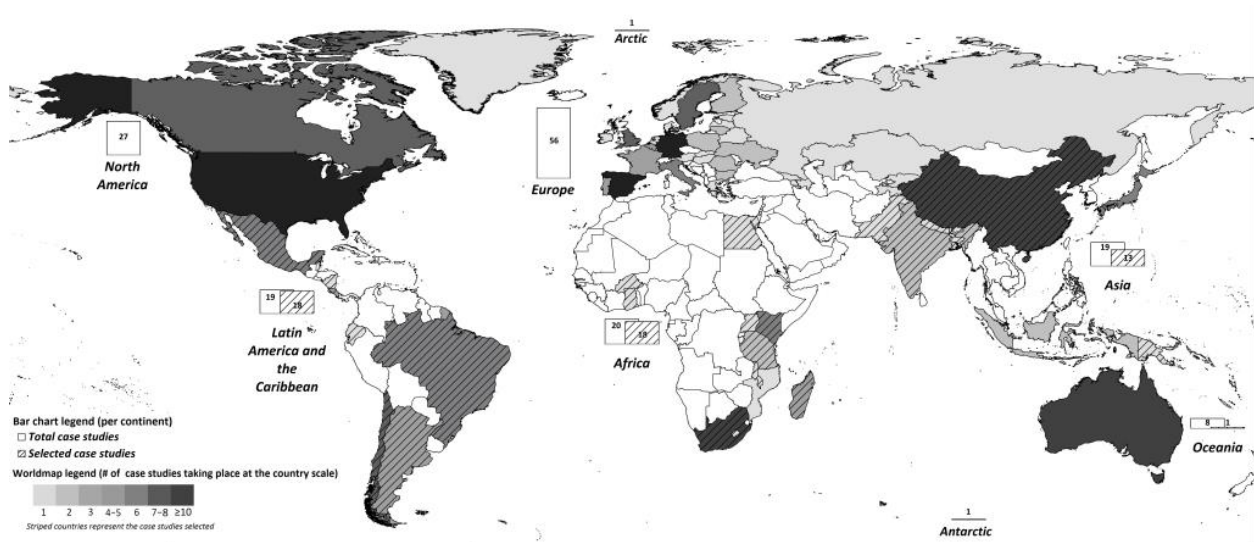
218
 219
 220 **Fig. 3.** Subject area of research on ecosystem services and human well-being for all publications (n=462),
 221 all case studies (n=145), and selected case studies for communities in Africa, Asia and Latin America
 222 (n=49).
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226 The number of publications on ecosystem services and human well-being differed in terms of their
 227 geographical scale and scope, presenting research conducted from global (5%), continental or
 228 subcontinental (9%), national or subnational (29%), to city or community scale (7%). In addition, two
 229 publications were at farm scale, and another two were at oceanic scale. Only 2% of the publications
 230 presented multiple scales, and for almost half of the papers (47%) scale was not applicable given that they
 231 were review papers. Most research took place on Europe (17% of all publications), followed by North
 232 America encompassing US and Canada (8%), Asia (8%), Africa (7%), Latin America (6%), and Oceania (3%).

233 Although 59% of all publications did not specify the country (or it was not applicable, i.e. they were at a
234 global scale or were review papers), research was conducted in a total of 92 countries, with only 7% of
235 publications taking place in multiple countries. The most researched country was the US (7%). Australia,
236 Spain and South Africa covered 3% of all publications each, and the remaining countries were included in
237 2% or less of publications.

238
239 Remarkably, more than two-thirds (68%) of all case studies (n=145) were conducted at national or
240 subnational scale, followed by city or community scale (17%), and continental or subcontinental scale
241 (11%). Most case studies were conducted in Europe (39%), whereas 19% took place in North America,
242 14% in Africa, 13% in Asia, 13% in Latin America, and 6% in Oceania. Three case studies took place in more
243 than one continent. Most case studies also took place in the US (15%), followed by Spain (9%) and
244 Germany (7%) (Fig. 4).

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249 **Fig. 4.** Geographical distribution of all articles presenting case studies on ecosystem services and human
250 well-being worldwide (n=145 articles, with 17 studies occurring in multiple countries), indicating which
251 countries included case studies with communities in Africa, Asia, and Latin America (n=49).

252 Note: The case study conducted at a global scale was not illustrated in the map. A scale of gray indicates
253 the number of case studies covered in each country, and countries from Africa, Asia, and Latin America
254 with selected case studies with stripe lines on the top of the color. Categories are nonexclusive, thus a
255 publication might be found in several countries.

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258 3.2. Ecosystem services and well-being: case studies from Africa, Asia and Latin America

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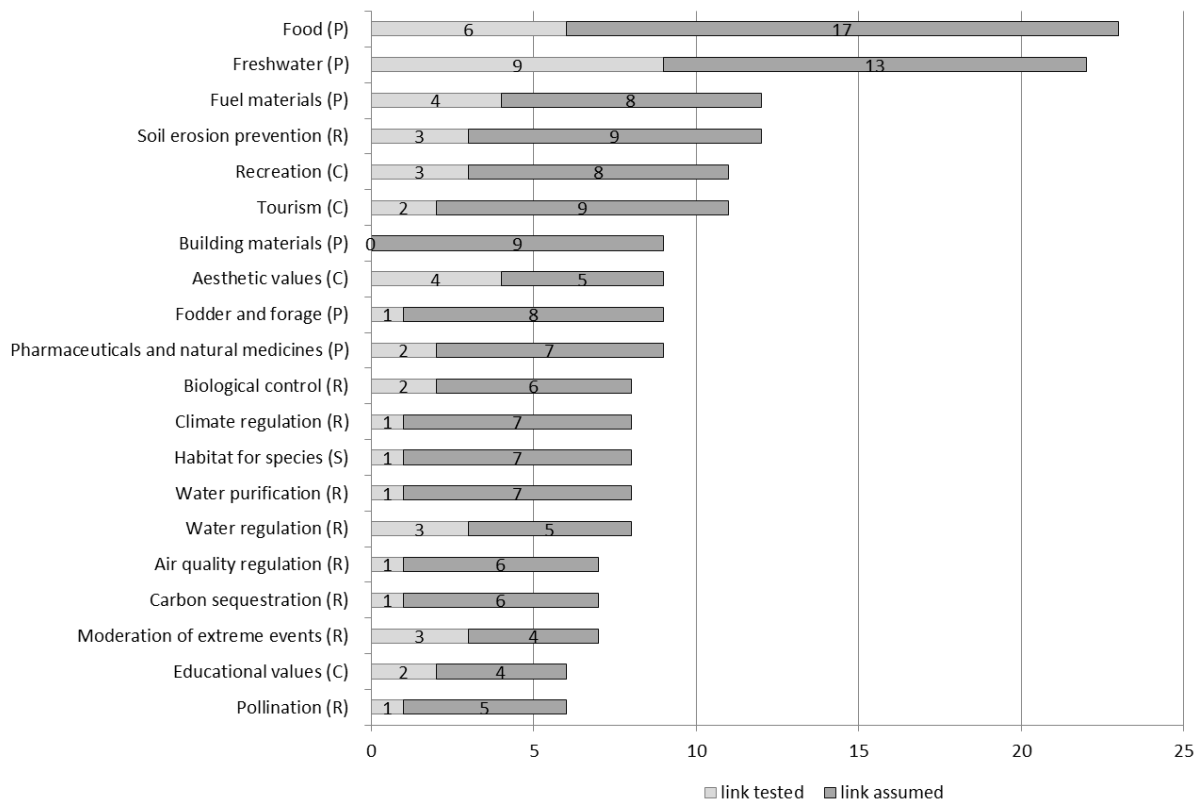
260 The presence of case studies on rural and urban communities in Africa, Asia and Latin America (n=49,
261 corresponding to database 2) is recent, with the first ones published in 2006. Their total number, however,
262 has remained below 20 up to 2014 (Fig. 2). The most important subject area was environmental policy
263 and management (n=18), followed by environmental economics (n=9), environmental and earth sciences
264 (n=7), and ecological and biological sciences (n=7) (Fig. 3). Landscapes (n=8) and livelihoods (n=7) were
265 the most common focus of study, whereas fisheries, grasslands and wetlands were the least common
266 (with one or two case studies each). All selected case studies were journal articles, with the exception of
267 two conference papers.

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Following the same trends as all case studies, 67% of selected case studies for Africa, Asia and Latin America were conducted at national or subnational level, followed by city or community level (29%), and continental or subcontinental level (4%). Some 37% of the selected case studies were conducted in Latin America, 37% in Africa and 27% in Asia. The most researched countries were China and South Africa (with 14% of all selected case studies each), followed by Chile (12%) (Fig. 4). Three case studies occurred in multiple countries.

All ecosystem service categories were covered by 18% of the publications, whereas 39% included three or two categories. Provisioning services was the most common ecosystem service category included in the articles, with almost half of the case studies (45%), followed by regulating services (39%), cultural services (20%) and supporting services (16%). There were no articles focusing only on supporting services, and the most popular study area among provisioning, regulating and cultural services was landscape ecology. Ecosystem service categories were not specified in 22% of the articles.

A total of 57 different types of ecosystem services were included. Biological control, food, freshwater and recreation were the only ecosystem services that were the focus of one publication, whereas 92% of case studies presented multiple ecosystem service types – up to 32 services in a single article. Provisioning services presented 15 different types of ecosystem services, and the most common ones were food and freshwater, which were included in almost half of the case studies. Regulating services encompassed 19 ecosystem service types in relation to soil, water, air, and organisms, among others. Cultural services included 14 types of ecosystem services, and supporting services presented nine. Fig. 5 presents the most common types of ecosystem services included in the case studies.



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295 **Fig. 5.** Number of publications for ecosystem service types assessed in more than 10% of the selected case
296 studies (n=49). The ten articles that did not specify the type of ecosystem service were not included in the
297 table.

298 Note: P = provisioning service, R = regulating service, C = cultural service and S = supporting service. The
299 bars also indicate for each type of ecosystem service the proportion of publications that analyzed the
300 linkages between ecosystem services and human well-being as part of the hypothesis to test (link tested)
301 in relation to the publications that assumed that these linkages exist as part of the study justification and,
302 based on this assumption, proposed a hypothesis (link assumed).

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305 Trade-offs were only addressed in 35% of case studies, mainly in those on environmental policy and
306 management (n=6), and at national or subnational scale (n=9). Authors, for example, evaluated the trade-
307 offs between conservation goals and improvement of livelihoods (Bremer, Farley, Lopez-Carr *et al.* 2014),
308 or between environmental and economic aspects (e.g. Brancalion, Cardozo, Camatta *et al.* 2014; Dai,
309 Ulgiati, Zhang *et al.* 2014; Jogo and Hassan 2010). The trade-offs between different types of ecosystem
310 services were also included as part of the research (e.g. Geneletti 2013; Silvestri, Zaibet, Said *et al.* 2013).
311 Most (90%) of case studies did not include gender issues as part of the research. Gender was only present
312 in case studies conducted in Costa Rica, Ghana, India, Kenya and Madagascar; and the most popular
313 subject area was environmental policy and management (60% of case studies that included gender).
314 Interestingly, most studies that included gender (four out of five) also evaluated trade-offs between social
315 and environmental issues, for instance, using participatory assessments (e.g. Abunge, Coulthard and Daw
316 2013; Berbés-Blázquez 2012).

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318
319 *3.3. Empirical analysis of the linkages between ecosystem services and well-being, in case studies from*
320 *Africa, Asia, and Latin America*

321
322 In terms of the analysis of the linkages between ecosystem services and human well-being among case
323 studies with rural and urban communities in Africa, Asia and Latin America (n=49, corresponding to
324 database 2), 71% of publications assumed that they existed as part of the study justification and, based
325 on this assumption, proposed a hypothesis (referred to as 'link assumed' from now onwards). The first
326 article that analyzed linkages between ecosystem services and human well-being as part of the hypothesis
327 to test (referred to as 'link tested' from now onwards) did not appear until 2010 when Jogo and Hassan
328 published a case study on the analysis of the linkages among economic well-being, ecological security and
329 policy. The increase in publications analyzing these linkages started in 2013 (with five articles, and six in
330 2014). For example, Delgado, Sepúlveda and Marín (2013) evaluated how much ecosystem services,
331 particularly wood from native forests and clean water, contributed to the well-being of rural populations
332 of the Aysén watershed in northern Chilean Patagonia. Celentano *et al.* (2014) proposed an
333 interdisciplinary research framework to evaluate the linkages between ecological sustainability, social
334 needs, and traditional ecological knowledge to design riparian forest restoration strategies. Abunge
335 Coulthard and Daw (2013) investigated the relations between well-being and ecosystem services from the
336 perspective of coastal fisheries stakeholders in Kenya. However, there has also been a recent increase of
337 articles that assume that these linkages exist as part of the study justification (with 11 in 2014).

338
339 Although the linkages were tested across all ecosystem service categories, it mainly occurred for
340 provisioning and regulating services. The links between ecosystem services and human well-being were
341 tested at least in one publication for 74% of the ecosystem service types, but none of the most popular
342 types of ecosystem services (i.e. these assessed in more than 10% of case studies) encompassed more
343 publications testing the links rather than assuming them in the research hypothesis (**Fig. 5**). Only six case

344 studies that tested the links analyzed the trade-offs between ecosystem services and human well-being,
345 and three incorporated a gender approach.

346
347 Sixty four percent of the case studies that tested the links between ecosystem services and human well-
348 being did it by applying one research method, whereas four used two different methods, and one used
349 three methods. The most common method was interviewing (n=5), using semi-structured and in-depth
350 interviews, followed by focus group discussions (n=2). Scientific modelling and questionnaires were
351 applied in two articles each; whereas photo-voice, transect walk, participatory well-being assessment,
352 DPSIR analysis (driving force, pressure, state, impact and response), agrarian diagnosis, secondary data
353 analysis, and trade-off analysis were only used in one case study each. For example, Berbés-Blázquez
354 (2012) used a combination of photo-voice, focus group discussions and transect walks in order to analyze
355 how a community assessed their environmental services in Costa Rica, highlighting the potential of photo-
356 voice for documenting the interactions between people and ecosystems. Jogo and Hassan (2010)
357 developed an ecological-economic model to evaluate the impacts of alternative policy regimes on
358 economic well-being and wetland functioning in Limpopo, Southern Africa. Outeiro and Villasante (2013)
359 used a combination of household surveys and scientific modelling to analyze the synergies and trade-offs
360 caused by the salmon industry on ecosystem services and their effect on human well-being in Chiloe,
361 southern Chile. In addition, Shameem Momtaz and Rauscher (2014) combined qualitative and
362 quantitative data collected through household surveys and in-depth interviews to understand how major
363 stresses and hazards shaped the vulnerability of people's livelihoods in socio-ecological coastal systems
364 in the southwest of Bangladesh.

365 366 *3.4. Conceptual frameworks used in empirical research from Africa, Asia and Latin America*

367
368 Out of ten frameworks on ecosystem services and human well-being reported by the case studies, 55% of
369 publications presented one conceptual framework, 12% presented two frameworks, and 33% did not
370 include any framework. Of the publications that presented a framework, 52% only cited it, 42% applied it
371 for the case study, and two both cited and applied frameworks. Most articles that tested the link (79%)
372 applied a conceptual framework; whereas most articles that assumed the link did not use a framework
373 (46%) or just cited it (40%). Frameworks were mainly applied in case studies that focused on provisioning
374 or regulating services (five and four articles, respectively), and six studies applied a framework but did not
375 specify the ecosystem service category. The ecosystem services that were more common in terms of
376 applying conceptual frameworks were freshwater and food, with 13 and 11 publications, respectively.

377
378 The most popular conceptual framework was the MEA, which was cited in 55% and applied in 27% of the
379 publications that presented a framework (Millennium Ecosystem Assessment 2003, 2005). The first case
380 study including the MEA was in 2006, and this number did not increase until 2013 (n=7) and 2014 (n=9).
381 The MEA was applied across the continents (**Table 1**). The Sustainable Livelihoods Framework (Scoones
382 1998) was applied in two publications and cited in one, and the Cascade Model for Ecosystem Services
383 (Haines-Young and Potschin 2010) was applied in two publications (**Table 2**). These case studies were
384 published in 2013 and 2014. Additionally, the linkages between ecosystem services and human well-being
385 were part of the hypothesis to test in 33% of the publications that used the MEA (five articles applied and
386 four cited the MEA), in all articles that used the Sustainable Livelihoods Framework, in all articles that
387 applied the Cascade Model for Ecosystem Services, and, as expected, in the two author frameworks. The
388 two publications that proposed their own frameworks for analyzing their case studies were Delgado,
389 Sepúlveda and Marín (2013), and Jogo and Hassan (2010).

390
391 The frameworks that were applied in one case study were: A multi-scale conceptual framework on nature,
392 the productive base of societies and human well-being (Duraiappah, Asah, Brondizio *et al.* 2014),

393 Maslow's Pyramid of Self-Actualization (Maslow 1954), and Multidimensional Poverty Assessment Tool
 394 (Cohen 2009); whereas the frameworks only cited in one case study were Costanza et al.'s valuation of
 395 ecosystem services and natural capital (1997), and the Gross National Happiness (Gross National
 396 Happiness Commission 2013).

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 398
 399 **Table 1.** Matrix of publications presenting case studies with communities in Africa, Asia and Latin America
 400 (n=49). The matrix compares the use of conceptual frameworks in the case studies in relation to
 401 ecosystem service categories and continent, indicating if a framework was only cited or also applied by
 402 the study. No articles were conducted in more than one continent. Some articles use different frameworks
 403 and/or assess more than one ecosystem service category.
 404

| Conceptual frameworks | Ecosystem service categories | | | | | |
|--|---|---|---|---|---|--|
| | Provisioning | Regulating | Supporting | Cultural | All categories covered | Did not specify any category |
| Author's framework | Af: 16(a) LA: 11(a) | Af: 16(a) | | | | |
| Valuation of ecosystem services and natural capital (Costanza 1997) | | As: 32(c) | As: 32(c) | As: 32(c) | | |
| A multi-scale conceptual framework on nature, the productive base of societies and human well-being (Duraiappah, Asah et al. 2014) | LA: 23(a) | LA: 23(a) | | LA: 23(a) | | |
| Cascade Model for Ecosystem Services (Haines-Young and Potschin 2010) | Af: 28(a) | | | Af: 28(a) | | As: 15(a) |
| Gross National Happiness (Gross National Happiness Commission 2013) | | | | | As: 17(c) | |
| Maslow's Pyramid of Self-Actualization (1954) | As: 9(a) | As: 9(a) | As: 9(a) | | | |
| Millennium Ecosystem Assessment (2003, 2005) | Af: 2(c); 12(c); 18(c); 24(c); 28(c) As: 9(c); 31(c); 33(c) LA: 19(c); 21(c); 23(a) | Af: 4(c); 12(c); 18(c); 24(c) As: 9(c); 31(c); 32(c); 33(c) LA: 19(c); 21(c); 23(a) | Af: 12(c); 18(c) As: 11(c); 31(c); 32(c) | Af: 8(c); 24(c); 28(c) As: 32(c); 33(c) LA: 5(c); 19(c); 21(c); 23(a) | Af: 20(a); 22(c); 29(c) As: 14(a) LA: 3(a); 13(a) | Af: 1(a) As: 27(a); 30(a) LA: 7(c); 10(a); 25(c) |
| Multidimensional Poverty Assessment Tool (Cohen 2009) | | | | | | As: 26(a) |
| Sustainable Livelihoods Framework (Scoones 1998) | Af: 18(c); LA: 6(a) | Af: 18(c) LA: 6(a) | Af: 18(c) | | | As: 27(a) |
| No conceptual framework applied | Af: 34, 45, 48 As: 38, 41 LA: 36, 37, 42, 44 | Af: 45, 48 As: 38 LA: 36, 37, 40, 44 | Af: 48 LA: 36 | LA: 49 | Af: 39, 43 | Af: 46 As: 47 LA: 35 |

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 406
 407 Geographical regions abbreviations: **Af:** Africa, **As:** Asia, **LA:** Latin America.
 408 Abbreviations about whether the framework was cited or applied: (c): cited, (a): applied
 409 References: 1. (Abunge, Coulthard and Daw 2013); 2. (Ahmed, Saleh, Abdelkadir *et al.* 2009); 3. (Berbés-Blázquez
 410 2012); 4. (Bodin, Tengö, Norman *et al.* 2006); 5. (Brancalion, Cardozo, Camatta *et al.* 2014); 6. (Bremer, Farley, Lopez-
 411 Carr *et al.* 2014); 7. (Celentano, Rousseau, Engel *et al.* 2014); 8. (Cilliers, Cilliers, Lubbe *et al.* 2013); 9. (Dai, Ulgiati,
 412 Zhang *et al.* 2014); 10. (De Freitas, Schütz and De Oliveira 2007); 11. (Delgado, Sepúlveda and Marín 2013); 12. (Egoh,
 413 Reyers, Rouget *et al.* 2011); 13. (Figuroa and Pasten 2014); 14. (Garrard, Kohler, Wiesmann *et al.* 2012); 15. (Hou,
 414 Zhou, Burkhard *et al.* 2014); 16. (Jogo and Hassan 2010); 17. (Kubiszewski, Costanza, Dorji *et al.* 2013); 18.
 415 (Leauthaud, Duvail, Hamerlynck *et al.* 2013); 19. (Marín, Gelcich and Castilla 2014); 20. (Mhango and Dick 2011); 21.
 416 (Newton, del Castillo, Echeverría *et al.* 2012); 22. (Ouédraogo, Nacoulma, Hahn *et al.* 2014); 23. (Outeiro and
 417 Villasante 2013); 24. (Reyers, O'Farrell, Cowling *et al.* 2009); 25. (Ribeiro Palacios, Huber-Sannwald, García Barrios *et al.*
 418 2013); 26. (Sandhu and Sandhu 2014); 27. (Shameem, Momtaz and Rauscher 2014); 28. (Silvestri, Zaiabet, Said *et al.*
 419 2013); 29. (Sitas, Prozesky, Esler *et al.* 2014); 30. (Su, Fu, He *et al.* 2012); 31. (Xu, Tan, Chen *et al.* 2014); 32. (Xu,
 420 Yu and Yue 2010); 33. (Yang, Dietz, Liu *et al.* 2013); 34. (Boafo, Saito and Takeuchi 2014); 35. (Bornatowski, Braga
 421 and Vitule 2014); 36. (Geneletti 2013); 37. (Hack 2010); 38. (Joshi and Negi 2011); 39. (Kari and Korhonen-Kurki
 422 2013); 40. (Karp, Judson, Daily *et al.* 2014); 41. (Khan, Page, Ahmad *et al.* 2012); 42. (Lindegren, Vigliano and Nilsson
 423 2012); 43. (Matete and Hassan 2006); 44. (Mendenhall, Archer, Brenes *et al.* 2013); 45. (Mugwiza, Yalaw, Van Der
 424 Kwast *et al.* 2014); 46. (Odada, Ochola and Olago 2009); 47. (Wang, Li and Paulussen 2010); 48. (Wendland, Honzák,
 425 Portela *et al.* 2010); 49. (Weyland and Littera 2014).
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Table 2. Description of the conceptual frameworks used by two or more case studies (n=49)

| Conceptual frameworks | General description | Number of publications that cited (c) or applied (a) the framework |
|---|--|--|
| Millennium Ecosystem Assessment (2003, 2005) | The MEA constitutes a broadly applied foundational framework that links four categories of ecosystem services (provisioning, regulating, supporting and cultural) with five components of well-being (security, basic material for good life, health, good social relations and freedom of choice and action). It has been criticized that it has limited potential for the analysis of these links, and neglects issues related to social differentiation and political economy (Fisher, Patenaude, Meir <i>et al.</i> 2013). | 18 (c), 9 (a) |
| Sustainable Livelihood Framework (Scoones 1998) | The SLF is an influential framework that conceptualizes livelihoods based on five components: contexts, conditions and trends; livelihood resources; institutional processes and organizational structures; livelihood strategies; and sustainable livelihood outcomes. Livelihood resources include natural, economic or financial, human and social capital, among others. However, the focus of the framework is on livelihoods, rather than well-being. | 1 (c), 2 (a) |
| Cascade Model for Ecosystem Services (Haines-Young and Potschin 2010) | This framework illustrates the cascade relationship between four components: biophysical structures or processes (including biodiversity), ecosystem function, services, and benefits (values) for human well-being. It differentiates intermediate products, which encompass the first three components, and final products that include the last three components. Then function and service are both intermediate and final products. | 2 (a) |

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The publications listed either indicators or dimensions of well-being (broader components of well-being encompassing one or more indicators). Only 35% of all case studies listed the indicators or dimensions of well-being used, and these belonged to different conceptual frameworks. A total of 117 different indicators or dimensions were reported, and case studies on average presented 7.3 indicators or dimensions ($SD=5$), with a maximum of 21 and a minimum of two. Most indicators or dimensions (97%) were used in one case study only. Indicators related to health, income, employment, poverty, education, security, social relations, demography, housing, food, access to resources, land and assets, inclusion and inequality, among others. Health was the most commonly used dimension of well-being (mentioned in four case studies), followed by good social relations (mentioned in three case studies), whereas education was mentioned in two publications. These dimensions, with the exception of education, were listed in the MEA framework (Millennium Ecosystem Assessment 2005). However, at least one dimension of each framework was used, and some dimensions were common to the application of more than one framework. Finally, the links between ecosystem services and human well-being were tested in at least one publication for 72% of well-being indicators or dimensions.

448 4. Discussion

449

450 4.1. General trends and understudied areas in ecosystem services and well-being research

451

452 The results of this study showed that research on ecosystem services and human well-being is growing
453 not only in general, but also in relation to empirical case studies. In addition, this growth has been very
454 recent: (a) the number of publications started to increase in 2009 with more than 20 per year (n=462); (b)
455 the number of case studies (in general for the world) did not show a major increase until 2011 (n=145);
456 (c) the number of case studies with communities from Africa, Asia and Latin America was below 20 per
457 year up to 2014 (n=50). After the publication of the Millennium Ecosystem Assessment (2005) the use of
458 the term 'ecosystem services' in research showed a substantial increase (Gómez-Baggethun, De Groot,
459 Lomas *et al.* 2010). Although the conceptualization, research and measurement of human well-being has
460 existed for more than 2,000 years (Stoll 2014), the use of the terms human development and well-being
461 became more popular following the work of Amartya Sen (e.g. 1981; 1993).

462

463 The first case study was published in 1999, but case studies were not conducted in Africa, Asia or Latin
464 America until 2006. Unquestionably, research on ecosystem services and human well-being in these
465 regions is not only very recent, but also scanty. For instance, this study showed that the most common
466 regions for research were Europe and North America (US and Canada), where 35% of all case studies were
467 conducted (n=145). In addition, only 14 case studies from indexed scientific publications conducted in
468 Africa, Asia and Latin America analyzed the linkages between ecosystem services and human well-being
469 as part of the hypothesis to test. It is necessary to increase empirical research on these continents, which
470 are characterized by a socioeconomic challenging context alongside environmental problems (Jahan 2015;
471 Porter, Stern and Green 2016; United Nations 2016; Vörösmarty, McIntyre, Gessner *et al.* 2010). For
472 instance, Balvanera, Uriarte, Almeida-Leñero *et al.* (2012) highlighted that in Latin America research is
473 needed on the links between ecological processes, ecosystem services delivery, and related values,
474 especially in understanding the vulnerabilities of different stakeholders and their cultural diversity. In
475 addition, the MEA scenarios identified hot spots of rapid decline in ecosystem services per capita in sub-
476 Saharan Africa, the Middle East and South Asia (Corvalan, Hales and McMichael 2005).

477

478 For the geographical scale of research, the most popular was national or subnational; whereas city or
479 community scale was neglected among publications in general, and continental or subcontinental scale
480 was understudied not only in general but also among case studies conducted in Africa, Asia and Latin
481 America. Both constitute a research gap in ecosystem services and human well-being research.

482

483 Urban, marine and agricultural environments were the most popular in ecosystem services and human
484 well-being research globally, whereas forest ecosystems, which is a cornerstone for well-being (Santoso,
485 Thompson and Wreford 2009), was neglected (only present in 6% of all case studies). For case studies
486 conducted in Africa, Asia and Latin America, fisheries, grasslands and wetlands were research gaps, with
487 just two or less case studies each. This is unexpected, given that these three ecosystems are crucial for
488 ensuring the well-being of rural and urban communities (see Charles, Allison, Chuenpagdee *et al.* 2012;
489 Heidenreich 2009; Horwitz and Finlayson 2011; Millennium Ecosystem Assessment 2005).

490

491 Food and freshwater were the types of ecosystem services that received most attention in the case studies
492 conducted in Africa, Asia and Latin America. Unquestionably, food, which includes agricultural and
493 livestock products, fish, fruits, bushmeat, among others, is a basic means to achieve well-being
494 (Millennium Ecosystem Assessment 2005). To achieve food and nutrition security, food availability, or a
495 sufficient supply of food, economic and physical access to food (including entitlements), the nutrients and
496 energy required for a healthy life, and stability during lean months and periods of instability (FAO 1996)

497 are required. In addition, the presence of other ecosystem services, e.g. water for food production,
498 fuelwood for cooking, soil fertility and climate regulation, which are crucial to ensuring the provision and
499 preparation of food (McMichael, Scholes, Hefny *et al.* 2005) is also required. Having access to good quality
500 freshwater throughout the year is a key determinant of well-being (Millennium Ecosystem Assessment
501 2005) but many developing countries suffer from water insecurity (Boelee, Chiramba and Khaka 2011).

502
503 Crossman, Burkhard, Nedkov *et al.* (2013) explained that supporting and cultural ecosystem services
504 remain understudied because these services are not as well understood or defined as provisioning and
505 regulating services, and, consequently, are more difficult to measure. This study showed that supporting
506 ecosystem services, such as genetic resources, nutrient cycling, soil formation and primary production,
507 constitute an understudied area of research among case studies conducted in Africa, Asia and Latin
508 America on ecosystem services and human well-being, reflecting the same trends observed in ecosystem
509 services and food security research (Cruz-Garcia, Sachet, Vanegas *et al.* 2016), and ecosystem service
510 trade-offs studies (Howe, Suich, Vira *et al.* 2014). However, these services constitute the underlying basis
511 for provisioning and regulating ecosystem services, which were well represented among the case studies.
512 In addition, the reduced presence of cultural services is aligned to what has been previously discussed in
513 the cultural ecosystem services literature (Chan, Guerry, Balvanera, Uriarte, Almeida-Leñero *et al.* 2012;
514 Chan, Satterfield and Goldstein 2012; Daniel, Muhar, Arnberger *et al.* 2012). For instance, it has been
515 argued that ecosystem service research gives less attention to nonmaterial values, including cultural
516 services, given that they are not suitable for monetization and cannot be easily linked to certain socio-
517 ecological changes. Cultural benefits are related to cultural services and to different types of ecosystem
518 services (Chan, Guerry, Balvanera *et al.* 2012). Different authors have proposed frameworks that may
519 facilitate the integration of cultural services into the ecosystem services approach (e.g. Chan, Guerry,
520 Balvanera *et al.* 2012; Daniel, Muhar, Arnberger *et al.* 2012). However, this has not been free of criticism;
521 for instance it has been claimed that it is not possible to incorporate pivotal cultural values of nature,
522 including symbolic meanings, into the ecosystem services framework. For instance, Kirchhoff (2012: 1)
523 explained that although “ecosystems produce the plants and animals that we perceive as parts of
524 landscapes, the object ‘cultural landscape’ is a product of a specific way of seeing within the cultural
525 framework of symbolic experience”.

526
527 *4.2. To what extent have the links between ecosystem services and human well-being been empirically*
528 *researched?*

529
530 The analysis of the linkages between ecosystem services and human well-being is necessary to help us to
531 understand how human well-being is affected by ecosystem composition and functioning, and how
532 ecosystems are transformed by humans’ choices about the ways ecosystem services should be managed
533 in order to increase their benefits in terms of human well-being (McMichael, Scholes, Hefny *et al.* 2005).
534 The research findings, however, show that the majority of case studies presented in indexed scientific
535 publications from Africa, Asia and Latin America assumed the existence of linkages between ecosystem
536 services and well-being as part of the study justification and, based on this assumption, proposed a
537 hypothesis. Only 29% of case studies analyzed the linkages between ecosystem services and human well-
538 being as part of the hypothesis to test and, on this basis designed the research methodology and selected
539 the variables that were investigated. Furthermore, the focus of analysis on these linkages from an
540 empirical perspective only started in 2010.

541
542 Recently published conceptual frameworks could be useful for disaggregating well-being and ecosystem
543 services to analyze their multiple interactions, i.e. Daw, Brown, Rosendo *et al.* (2011), and to consider
544 equity (Pascual, Phelps, Garmendia *et al.* 2014). While their disaggregation is a priority for understanding
545 the synergies and trade-offs between ecosystem services and human well-being for different groups in a

546 society, it has been largely under-researched in the ecosystem services arena (Daw, Brown, Rosendo *et al.* 2011; Duraiappah 2011). Understanding who benefits or is disadvantaged in terms of the use and
547 access to ecosystem services, and how this affects their well-being is imperative given that different
548 segments might derive different benefits from ecosystem services according to their contexts and needs
549 (Butler and Oluoch-Kosura 2006; Daw, Brown, Rosendo *et al.* 2011; Nelson 2011; TEEB 2010). Although it
550 has been widely reported that gender influences natural resource knowledge, management, use and
551 access (Meinzen-Dick, Brown, Feldstein *et al.* 1997; Rocheleau and Edmunds 1997; Sunderland,
552 Achdiawan, Angelsen *et al.* 2014; Westermann, Ashby and Pretty 2005), and that men and women differ
553 in their preferences for environmental conservation (e.g. Rao, Nautiyal, Maikhuri *et al.* 2003), gender
554 constitutes a major research gap in the empirical study of the interface between ecosystem services and
555 well-being. Only five case studies incorporated a gender perspective, and of the ones that did, only three
556 used a gender lens to analyze the links between ecosystem services and human well-being. Undoubtedly,
557 an ecosystem service might have a different value for different groups of people, and effective ecosystem
558 service assessments and valuation studies must not undermine the poorest segments of society (Díaz,
559 Demissew, Carabias *et al.* 2015).

561
562 The analysis of case studies that tested the linkages between ecosystem services and human well-being
563 mainly focused on provisioning and regulating services. Certainly, as mentioned before, these ecosystem
564 service categories are more tangible and amenable to quantification, whereas cultural and supporting
565 services are more difficult to measure (Crossman, Burkhard, Nedkov *et al.* 2013). Additionally, these
566 results reflect what has been reported for the interface of ecosystem services and food security research,
567 where provisioning and regulating services have been mainly studied (Cruz-Garcia, Sachet, Vanegas *et al.*
568 2016).

569
570 Trade-offs not only occur between different types of ecosystem services, but also between ecosystem
571 services and human well-being (McMichael, Scholes, Hefny *et al.* 2005). The well-being of ecosystem
572 service users affects their management choices, leading to trade-offs or synergies; such choices might
573 affect the sustainability of the ecosystem service, and, in turn, affect the well-being of ecosystem service
574 beneficiaries. Therefore, the study of trade-offs and synergies plays a key role in understanding the
575 interface between ecosystem services and human well-being. However, the research findings showed that
576 the study of trade-offs in the intersection between ecosystem services and human well-being has been
577 neglected in scientific publications conducted with rural and urban communities from Africa, Asia and
578 Latin America: Only 43% of the case studies that analyzed the links between ecosystem services and
579 human well-being evaluated their trade-offs. Certainly, it has been highlighted that the trade-offs
580 between ecosystem services and human well-being are understudied in ecosystem services research
581 (Howe, Suich, Vira *et al.* 2014).

582 583 *4.3. Empirical use of conceptual frameworks in the interface of ecosystem services and human well-being*

584
585 Most case studies reported a conceptual framework as the basis of the research conducted with rural and
586 urban communities in Africa, Asia and Latin America. These frameworks were cited but not applied in
587 more than half of the case studies, while their application was mainly reported in publications that
588 analyzed the linkages between ecosystem services and human well-being as part of the hypothesis to test.
589 Conceptual frameworks contribute to interdisciplinary analysis in ecosystem services research and assist
590 the assessment of complex and dynamic situations (Fisher, Patenaude, Meir *et al.* 2013). According to the
591 Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), frameworks are a 'concise
592 summary in words or pictures of relationships between people and nature' (Díaz, Demissew, Carabias *et al.*
593 2015: 3), not only representing social and ecological components, but also the relations between them,

594 providing a common structure and terminology to the variables that are central to the socio-ecological
595 system.

596
597 Nonetheless, the analysis of frameworks among case studies showed that: (a) only ten different
598 frameworks were reported (cited or applied) by the case studies; (b) 80% of the frameworks were applied
599 (the other 20% were only cited); and (c) 70% of the frameworks were applied only once. Comparing these
600 results with the review of post-MEA frameworks (Blundo Canto, Cruz-Garcia, Sachet *et al.* in preparation),
601 we were surprised to see that although 29 frameworks on ecosystem services and well-being were
602 published up to December 2014, only one (Duraiappah, Asah, Brondizio *et al.* 2014) was applied in a case
603 study. This shows that the diversity of frameworks used for the study of the interface between ecosystem
604 services and human well-being was very low – 82% of the articles including a framework used the one
605 proposed by the MEA (2003, 2005) and the remaining frameworks were not applied. In addition, whereas
606 frameworks such as the Sustainable Livelihoods Framework (Scoones 1998), Maslow’s Pyramid of Self-
607 Actualization (Maslow 1954), the Multidimensional Poverty Assessment Tool (Cohen 2009), and the
608 “Gross National Happiness (Gross National Happiness Commission 2013), which have not been framed
609 within an ecosystem services and well-being approach, were used in case studies, ecosystem services
610 frameworks such as The framework for ecosystem service provision (Rounsevell, Dawson and Harrison
611 2010) and The Economics of Ecosystems and Biodiversity (TEEB) framework (TEEB 2010) were not cited
612 or applied in any of the case studies. Most frameworks that were developed to aid the understanding of
613 the interface between ecosystem services and human well-being have not been applied in empirical
614 research conducted in Africa, Asia and Latin America. This reflects a lack of application of theory in practice
615 within ecosystem services research, and that there might be too many frameworks emerging faster than
616 are potentially applicable, and are not necessarily innovative compared to the ones that are already
617 available.

618
619 The MEA framework (2003, 2005), which was used in most case studies has been criticized not only for
620 oversimplifying the relationships between nature and well-being (Lele, Springate-Baginski, Lakerveld *et al.*
621 *et al.* 2013), but for overlooking issues related to social differentiation and the political economy (Daw,
622 Brown, Rosendo *et al.* 2011; Fisher, Patenaude, Meir *et al.* 2013). Fisher Patenaude, Meir *et al.* (2013) also
623 argued that it neglects social trade-offs in ecosystem management strategies. On one hand, social
624 differentiation and inequality (related to rights, access and entitlements) are underlying causes of poverty
625 (Sen 1981). Poverty is related to environmental degradation (Raworth 2012) and its eradication is part of
626 the Sustainable Development Goals. On the other hand, the role of institutions in the governance of the
627 relationships between people and ecosystem services, and among different social groups, should become
628 a crucial component of ecosystem services and human well-being research (Butler and Oluoch-Kosura
629 2006; Díaz, Demissew, Carabias *et al.* 2015).

630
631 *4.4. Recommendations for future systematic literature reviews on ecosystem services and human well-*
632 *being*

633
634 While this review mainly focused on empirical research on ecosystem services and human well-being in
635 Africa, Asia and Latin America, future reviews could expand the geographical scope. Future studies could
636 also incorporate environmental services as part of the search in order to capture articles published before
637 the 1990s. Likewise, the search could be expanded beyond human well-being, including e.g. poverty,
638 quality of life, livelihoods, among others. Additionally, future reviews could also consider gray literature.

639
640 **5. Conclusions**
641

642 The outcomes of this study based on the review of scientific indexed publications of research conducted
643 with rural and urban communities in Africa, Asia and Latin America demonstrated that the analysis of the
644 linkages between ecosystem services and human well-being as part of a hypothesis to test remained
645 largely neglected. This analysis mainly focused on provisioning and regulating services, but addressing
646 cultural and supporting services is increasingly important. The study showed that there are various
647 understudied areas in the empirical literature on the relationships between ecosystem services and
648 human well-being, which constitute future research opportunities for further empirical research in these
649 continents; for example, in relation to fisheries, grasslands and wetlands.

650
651 The application of conceptual frameworks is a useful tool in helping us to understand the links between
652 ecosystem services and human well-being, but most existing frameworks have not yet been applied in
653 empirical research as most case studies that presented a framework used the one proposed by the MEA.
654 Moreover, important issues, such as those related to social inequality, disaggregated needs and
655 outcomes, and governance, are often overlooked within such frameworks. It is also imperative to have a
656 better understanding of trade-offs and synergies, not only between different types of ecosystem services,
657 but also between ecosystem services and disaggregated human well-being. Social differentiation,
658 including gender approaches, should be considered as part of the analysis of the interface between
659 ecosystem services and well-being. Considering these recommendations will certainly help empirical
660 ecosystem services research to synergistically contribute to improved well-being and environmental
661 sustainability when applied at multiple policy or institutional levels, thereby advancing the achievement
662 of the Sustainable Development Goals.

663
664

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670
671

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973 Tables

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975 **Table 1.** Matrix of publications presenting case studies with communities in Africa, Asia and Latin America
976 (n=49). The matrix compares the use of conceptual frameworks in the case studies in relation to
977 ecosystem service categories and continent, indicating if a framework was only cited or also applied by
978 the study. No articles were conducted in more than one continent. Some articles use different frameworks
979 and/or assess more than one ecosystem service category.

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981 **Table 2.** Description of the conceptual frameworks used by two or more case studies (n=49).

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Figures

Fig. 1. Flow diagram of the selection process of publications for databases 1 and 2, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) rules and templates (Moher, Liberati, Tetzlaff *et al.* 2010).

Fig. 2. Number of publications on ecosystem services and human well-being published in English before 2015, using the Scopus®, Web of Science™ and ScienceDirect® databases indicating chronological trends for all publications (n=462), all case studies (n=145), and selected case studies for communities in Africa, Asia and Latin America (n=49).

Fig. 3. Subject area of research on ecosystem services and human well-being for all publications (n=462), all case studies (n=145), and selected case studies for communities in Africa, Asia and Latin America (n=49).

Fig. 4. Geographical distribution of all articles presenting case studies on ecosystem services and human well-being worldwide (n=145 articles, with 17 studies occurring in multiple countries), indicating which countries include case studies with communities in Africa, Asia, and Latin America (n=49). The case study conducted at global scale was not illustrated in the map. A scale of gray indicates the number of case studies covered in each country, and countries from Africa, Asia, and Latin America with selected case studies have stripe lines on the top of the color. Categories are nonexclusive, thus a publication might be found in various countries.

Fig. 5. Number of publications for ecosystem service types assessed in more than 10% of the selected case studies (n=49). The ten articles that did not specify the type of ecosystem service were not included in the table. The letters between parentheses mean: P = provisioning service, R = regulating service, C = cultural service and S = supporting service. The bars also indicate for each type of ecosystem service the proportion of publications that analyzed the linkages between ecosystem services and human well-being as part of the hypothesis to test (link tested) in relation to the publications that assumed that these linkages exist as part of the study justification and, based on this assumption, proposed a hypothesis (link assumed).