Journal of Coastal Research	SI	77	116-126	Coconut Creek, Florida	2017

Ecosystem Services to Enhance Coastal Resilience in Mexico: The Gap between the Perceptions of Decision-Makers and Academics

Debora Lithgow[†‡*], M. Luisa Martínez[††], Rodolfo Silva[†], Davide Geneletti[†††], Juan B. Gallego-Fernández[‡], Carlos R. Cerdán[§], Edgar Mendoza[†], and Allison Jermain[††]

[†]Instituto de Ingeniería
Universidad Nacional Autónoma de México
Mexico City, Mexico

[††]Instituto de Ecología, A.C.
Xalapa, Mexico

[‡]University of Seville
Seville, Spain

[†††]University of Trento
Trento, Italy

[§]University of Veracruz
Veracruz, Mexico

www.cerf-jcr.org

www.JCRonline.org

ABSTRACT

Lithgow, D.; Martínez, M.L.; Silva, R.; Geneletti, D.; Gallego-Fernández, J.B.; Cerdán, C.R.; Mendoza, E., and Jermain, A., 2017. Ecosystem services to enhance coastal resilience in Mexico: The gap between the perceptions of decision-makers and academics. *In:* Martinez, M.L.; Taramelli, A., and Silva, R. (eds.), *Coastal Resilience: Exploring the Many Challenges from Different Viewpoints*. *Journal of Coastal Research*, Special Issue No. 77, pp. 116-126. Coconut Creek (Florida), ISSN 0749-0208.

In this study, we assessed the respective perceptions of academics and decision-makers concerning the relationships (dependence and impact) between economic activities and ecosystem services in coastal environments. Our goal was to explore the potential for achieving informed decisions that are based on an effective and appropriate use of the concept of ecosystem services. A set of questionnaires was e-mailed to a selected group of academics and decision-makers and the responses analysed. The perceived degree of negative impact caused by economic productive activities on ecosystem services differed, probably because of the different parameters used by each group: biophysical by academics and socioeconomic by decision makers. The academics commonly perceived that the negative impact and dependence of economic activities upon ecosystem services was much greater than that perceived by the decision-makers. This may indicate that decision-makers underestimate the impact of economic activities on ecosystem services during the decision-making process, or conversely, that academics potentially overestimate the impact. This dynamic could account for current discrepancies in the inadequacy of public policies related to resource management. Such differences of opinion, whether scientifically based or not, affect the decisions that are made and the conservation status of natural ecosystems, the ecosystem services they provide and their resilience to extreme disturbance events.

ADDITIONAL INDEX WORDS: *Academics, decision-makers, ecosystem services, resilience.*

INTRODUCTION

Human encroachment, sectoral management and poor planning of potentially conflicting activities have led to the degradation or loss of the health, integrity and resilience of coastal ecosystems (Böhnke-Henrichs *et al*., 2013). In consequence, the provision of ecosystem services has been modified and human wellbeing affected (Braat and de Groot, 2012; Cullen-Unsworth *et al*., 2013). The consideration of loss of resilience is important given scenarios of climate change and an increased human encroachment on the coast. Thus, the vulnerability of coastal areas is likely to be exacerbated by the combination of all these phenomena, affecting both natural and human systems (Hills, Carruthers, and Chape, 2013; Mycoo and Gobin, 2013).

Ensuring that ecosystem services continue to benefit both people and ecosystems requires effective conservation and management of ecosystem processes (Su *et al*., 2012; van Jaarsveld *et al*., 2005). Furthermore, boosting coastal resilience to the impacts of climate change requires the implementation of approaches that address diverse socioeconomic activities and at the same time help preserve natural ecosystems. The importance of ecosystem services to society has been increasingly acknowledged, which is evident in the relatively large amount of literature recently published on the topic (*e.g.*, Costanza and Kubiszewski, 2012). The relevance of ecosystem services is now increasingly implemented in holistic management approaches such as ecosystem-based coastal management, maritime spatial planning and strategic environmental assessment. Ecosystem based approaches have also been applied in national conservation schemes (*e.g.*, schemes of payment for ecosystem services) and supranational policies (*e.g.*, Hassan, Scholes, and Ash, 2005; Ruckelshaus *et al*., 2013; UNEP, 2014).

In spite of the above, many ecosystem services are still overlooked by decision-makers because many of these benefits they provide are either intangible or unmeasurable (Daily *et al*., 2009). Examples are services with cultural or intrinsic value (Plieninger *et al*., 2013) or services such as pollination (Schulp, Lautenbach, and Verburg, 2014), flood protection and climate regulation (Baral *et al*., 2014). Thus, oftentimes these services are not considered in the decision-making process (Daily and

DOI: 10.2112/SI77-012.1 received 5 July 2016; accepted in revision 8 October 2016.
*Corresponding author: debora.lithgow@gmail.com

Matson, 2008; Laurans *et al*., 2013), since the focus is often singularly placed on socio-economic development or the management of natural resources (Karrasch, Klenke, and Woltjer, 2014; Mace, Norris, and Fitter, 2012). Furthermore, trade-offs between ecosystem services and economic activities are frequently acknowledged only after severe degradation or loss of ecosystem services has occurred (Cárcamo, Garay-Flühmann, Gaymer, 2014; Euliss *et al*., 2010; Rodríguez *et al*., 2006).

The reasons for the delayed recognition of the importance of ecosystem services are manifold, and include: (a) gaps in the current understanding of the flow of ecosystem services, and how they change over time (Bommarco, Kleijn, and Potts, 2013; Serna-Chavez *et al*., 2014); (b) unknown trade-offs between economic activities and the supply of ecosystem services (Burkhard *et al*., 2012; DeFries, Foley, and Asner, 2004) and; (c) a lack of effective communication between scientists, managers and policy makers (Laurans *et al*., 2013; Paavola and Hubacek, 2013).

Considering the above, we decided to analyse the perceptions of the impact of economic activities on ecosystem services in coastal environments, particularly the similarities and/or differences in the perceptions of government decision-makers and scientists who study ecosystem services. Our starting point was the assumption that the perceptions of these two groups would reflect their level of knowledge of ecosystem services and their perceived relevance. Ultimately, this perception is dependent upon communication between those who generate scientific information (scientists) and those who use such information (decision-makers). In this paper, the results and their implications are discussed in terms of the potential for establishing an integrated approach by which ecosystem services would be contemplated in decision-making processes in order to improve the resilience of coastal ecosystems by better recognizing their value and minimizing their degradation by human activities.

STUDY AREA

Mexico is located within tropical and subtropical latitudes, extending from 14° 32′ 27” to 32° 43′ 06” N and 118° 22′00” to 86° 42′36” W. The continental territory covers 1,960,000 km^2 (14th in size, worldwide), the maritime surface (territorial seas and exclusive economic zone) 3,150,000 km (Farfán, Alfaro, and Cavazos, 2013) and the coastline 20,180 km (Ortíz-Pérez and de la Lanza-Espino, 2006).

From 1950 to 2015, the population has increased from 26 to 120 million (INEGI 2015). Nearly 47% of the population live in the seventeen coastal states (Figure 1), and almost 30% of the national population live on the coast (Martinez *et al*., 2014).

Mexico is a megadiverse nation, and it is estimated that it contains approximately 10% of all living organisms on earth (Dirzo and Sarukhan, 1992). Such a high richness of species and concentration of endemic and endangered species (Ceballos *et al*., 1998) prioritizes conservation at both national and global levels. The biological richness of Mexico is matched by its cultural diversity, the result of a long history of human occupation throughout the territory (Lindig-Cisneros, 2010).

According to Silva *et al*. (2017), the land use and settlement patterns in the coastal areas of Mexico are similar to that of the rest of Latin America. From 1492 to early 17th century (pre-Columbian era and the first stage of Colonialism) there was little coastal impact. A shift in population dynamics from the late 17th to early 19th centuries, due to the establishment of strategic ports, coastal cities and fortresses, induced land use changes in coastal areas, where natural vegetation was replaced with agriculture or urbanization. In the 20th century, development moved from rural to urban and industrial, accompanied by disordered growth and lack of planning, which caused more coastal degradation. In this century, the growth of coastal areas continues rapidly and in a disorganized way, mostly owing to urban and tourism development and environmental degradation is an increasing concern.

In economic terms, Mexico is the 11th most productive country in the world and ranks 2nd in Latin America (World Bank, 2015). The most important activities include agriculture, livestock, fisheries, energy, petrochemical industries and tourism (OECD, 2010; Sistema de Cuentas Nacionales de México, 2011). While these productive activities are of great economic importance, they have also led to a rapid and expansive transformation of land use in recent years. The coastal plain has particularly been transformed by deforestation. In the coastal states, 31,700 km^2 (9.3%) of original coastal vegetation cover was lost between 1976 and 2000 (Seingier, Espejel, and Ferman, 2009). In particular, municipalities on the Gulf of Mexico and southern Pacific coast have lost most of their natural ecosystems, 28% and 18%, respectively.

Mexico presents both challenges and opportunities in the management of natural resources, in which the coordination of multiple actors and economic interests is required. In spite of intensive and extensive productive activities, economic development in Mexico has been unequal and has not brought an increased standard of living for all its inhabitants. For instance, in 2014, around half of the population of Mexico lived in poverty, with 55 million people categorized as moderately poor and over 11 million as extremely poor (50% and 64% living in coastal states, respectively; CONEVAL 2015). Thus, the intense degradation of the natural ecosystems of coastal states, brought about by economic and land transformations, has not generated an improvement of the wellbeing of the majority of the inhabitants (Seingier, Espejel, and Ferman, 2009).

The socio-environmental problem described above was addressed in the 2013–2018 National Development Plan (Plan Nacional de Desarrollo 2013). However, but it only focused on socioeconomic goals, such as the increment in national productivity, including the agriculture and tourism sectors. In apparent contrast with the above, one of the objectives of the NDP also includes a transition from the current economic model of growth to a green and inclusive development, which preserves natural capital and generates wealth, competitiveness and employment (Gobierno de México, 2013-2018). In this document, the terms “resilience,” “vulnerability,” “sustainable management,” “costs and benefits of development” and “ecosystem services” appear repeatedly. In terms of coastal ecosystems, emphasis is placed on the importance of ecosystem services. There is a corresponding interest in developing a national strategy to achieve sustainable management of coastal and marine ecosystems in order to promote economic development, competitiveness and climate change adaptation. We can therefore assume that the management of the trade-offs between ecosystem services and economic activities are being

considered in regional planning practices to promote economic development, resilience and climate change adaptation.

METHODS

A structured e-mail survey was carried out. There were three waves of mailings to 80 decision-makers and 132 scientists. The recipients were selected from a wide range of expertise areas in different productive economic activities and coastal ecosystem services.

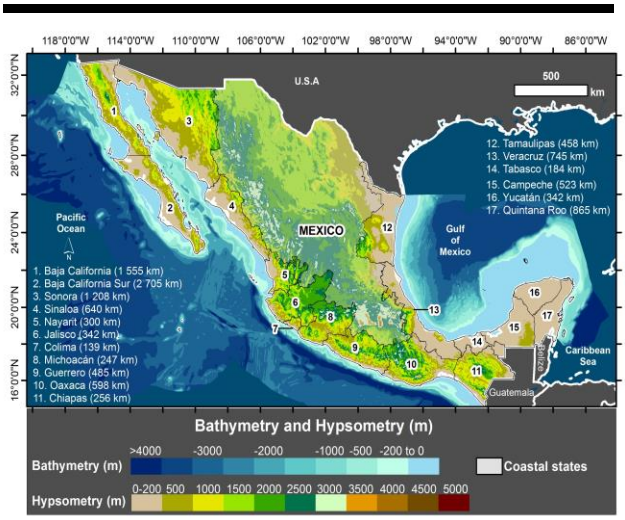

Figure 1. Mexico: coastal states, bathymetry and hypsometry (Atlas Nacional de México, 1990).

Active scientists were identified through research institutions, following a review of their professional curricula and respective research areas. All the scientists selected were involved in research projects and/or scientific publications addressing the ecosystem services and/or economic activities that take place in coastal ecosystems.

Decision-makers were chosen from government and non-profit organizations (NGOs) as the latter commonly advice the government. All of them had previous experience in environmental decision-making linked with one or more of the principal productive economic activities that take place along the coast of Mexico: agriculture, livestock and tourism. The survey had three sections (Figure 2), with an introduction to explain the aim of the questionnaire and provide its basic concepts. The first and second sections inquired about personal information and area of expertise (subjects and ecosystems). The third focused on the perceived degree of relationship between productive activities and ecosystem services.

RESULTS

Profile of Respondents

Of the 212 surveys that were e-mailed, 79 (37%) were completed and returned. Of these, 52% of the respondents were academics and 48% decision-makers. The scientists surveyed worked in 27 research centres or universities (70% and 30%, respectively) as full-time researchers and professors.

Decision-makers belonged to 24 government departments or Secretaries (national and state level) which deal with environmental protection (33%), disaster management (23%), agriculture, livestock and fisheries (21%), water management (15%) and knowledge and use of biodiversity (8%). Approximately half of the decision-makers were the head of their department, more than a third were assistant department managers and those remaining were technicians.

More than half of the scientists attested to having experience in identification and measurement of ecosystem services (ID and measure ES), although very few had participated in decision-making processes directly related to the regulation or protection of ecosystem services (Figure 3). In turn, the majority of decision-makers had a wide range of experience in Payments for Ecosystem Services (PES) and used the concept of ecosystem services in their decision-making processes (Figure 3). However, few decision-makers expressed having sufficient knowledge to identify and measure ecosystem services or having used these concepts in restoration efforts.

Section 1: Personal information

Professional affiliation and official position

Section 2: Level of expertise

Areas
Decision-making
Ecological Restoration
Identification of ES
Economic valuation of ES

***Economic activity:**
Agriculture
Livestock production
Tourism

Ecosystems
Beach and Dunes
Wetlands
Agroforestry ecosystems
Temperate forests
Tropical forests
Water bodies
Riparian ecosystems
Marine ecosystems

Section 3:
Intensity of the relationship between activities and ES

How much does (one of the activities: A, B or C) impact on (one of the Ecosystem Services*)?
1: None or Low 2: Medium 3: High

How much does (one of the activities: A, B or C) rely on (one of the Ecosystem Services*)?
1: None or Low 2: Medium 3: High

***Ecosystem Services (ES):**
1: Disturbance regulation; 2: Water purification;
3: Pollination and pest control; 4: Cultural services (aesthetic value and recreational opportunities)

Figure 2. Survey design and structure.

Among the existing coastal ecosystems both groups admitted to having more experience in wetlands, agroforestry systems, and temperate forests and more than half acknowledged a lack of experience in riparian ecosystems, beaches, dunes, and coastal ecosystems (Figure 4).

Perceived Impact and Dependence of Ecosystem Services on Different Productive Activities

In general, academics tend to perceive a higher impact and dependence of economic activities on the evaluated ecosystem services.

Perceived Impact and Dependence of Agriculture on Ecosystem Services

Impact

Figure 5 shows that academics perceived agriculture to have a greater negative impact on the evaluated ecosystem services than decision-makers. A large difference in perception was found for the effect of agriculture on cultural services (*e.g.*, aesthetic value and recreational opportunities); twice as many academics as decision-makers perceived agriculture to have a high impact.

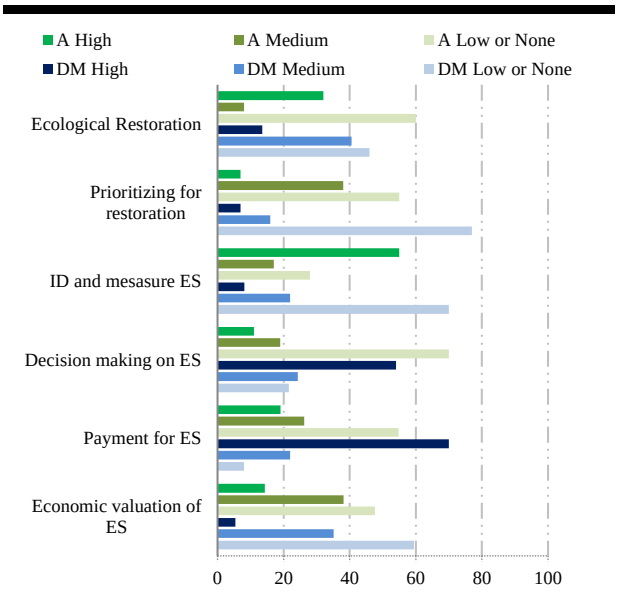

Figure 3. Level of experience of academics (A) and decision-makers (DM) with respect to areas of knowledge.

Around half of academics and decision-makers answered that agriculture has a medium impact on disturbance regulation services (focused on floods). In contrast, almost a third of decision-makers perceived no impact, while nearly the same proportion of academics perceived a high impact. Similarly, around half of both groups perceived a medium impact on pollination and pest control services. However, three times more decision-makers than academics evaluated agriculture not to have an impact on these ecosystem services.

In general, both groups followed similar trends regarding the negative impact of agriculture on the provision of water purification services. A slightly greater proportion of academics than decision makers perceived a high impact. However, no respondents considered the impact to be none.

The greatest difference between the groups was found for the impact of agriculture on weather regulation. In this case, five times more academics than decision-makers perceived a high impact. At the same time, an important proportion of both groups perceived low or no impact.

Dependence

Academics generally perceived that agriculture was more dependent on ecosystem services in comparison to decision-makers (Figure 6). Nearly half of the respondents considered that agriculture does not depend on cultural services. However, a third of academics and a quarter of decision-makers perceived a high dependence. Furthermore, academics perceived a greater dependence between agriculture and disturbance regulation services. In this case, half of the academics perceived that agriculture was highly dependent on this service; a similar proportion of decision-makers perceived that the dependence was moderate. Finally, almost a quarter of this group of respondents considered dependence to be low or none.

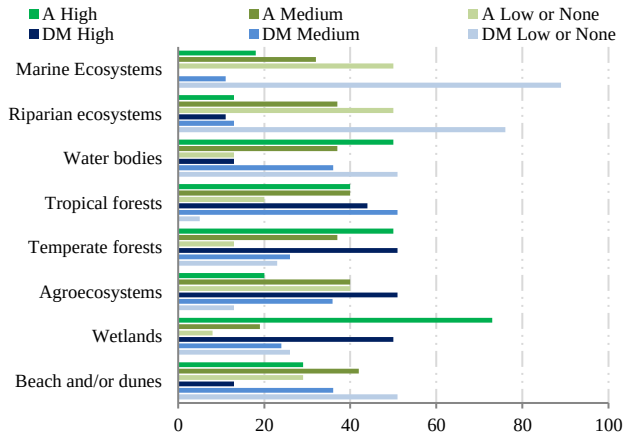

Figure 4. Level of experience of academics (A) and decision-makers (DM) with respect to ecosystems.

All of the respondents perceived a high or medium dependence of agriculture on water purification services. Similar to the general trend, a higher proportion of academics than decision-makers perceived the dependence to be high.

Finally, the majority of the respondents perceived that agriculture had a medium or high dependence on weather regulation. Around a quarter of both groups perceived a high dependence. However, in general, academics perceived a smaller dependence and more than a quarter of them considered that the dependence is low or non-existent (Figure 6).

Perceived Impact and Dependence of Livestock Production on Ecosystem Services

Impact

Similar to the responses for agriculture, academics generally perceived that livestock production affected ecosystem services to a greater extent than decision-makers (Figure 7). No academics perceived livestock production to have low or no impact on water quality, pollination and pest control services. In contrast, no decision-makers perceived livestock production to have a high impact on cultural, water purification and pollination services.

Around half of each group perceived a null or minimum impact of livestock production on the provision of cultural services, including aesthetic values and recreation opportunities. A small portion of academics perceived a high impact.

Similar to the general trend, more academics than decision-makers perceived livestock production to highly impact disturbance regulation. Meanwhile, half of academics and a third of decision-makers perceived a moderate impact. A lower proportion of academics than decision-makers perceived a null or minimum impact.

A similar proportion of academics perceived that livestock production had a moderate or high impact on pollination and pest control. Decision-makers also perceived a high impact, although nearly half answered that the impact is null or minimum. Likewise, all of the academic respondents perceived a moderate or high negative impact of livestock production on weather regulation services. In contrast, none of the decision-makers perceived a high impact, and half perceived the impact to be null or minimum (Figure 7).

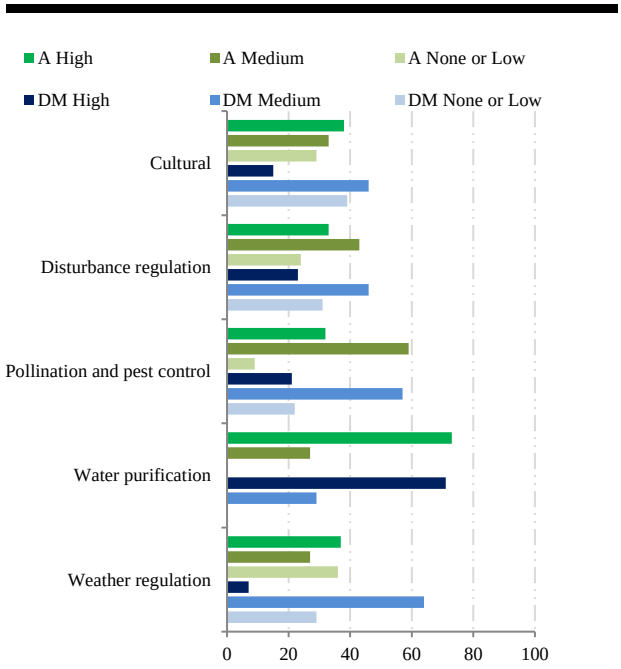

Figure 5. Perceived impact of agriculture on ecosystem services (A: academics; DM: decision-makers).

Dependence

Similar to trends in agriculture, academics perceived a higher dependence of livestock production on the evaluated ecosystem services (Figure 8). Likewise, all academics perceived no dependence on pollination and pest control, water quality and weather regulation. In contrast, decision-makers perceived a stronger dependence of livestock production on weather regulation. Almost all of the respondents perceived livestock production to have no or low dependence on cultural services.

Perceived Impact and Dependence of Livestock Production on Ecosystem Services

Impact

Similar to the responses for agriculture, academics generally perceived that livestock production affected ecosystem services to a greater extent than decision-makers (Figure 7). No academics perceived livestock production to have low or no impact on water quality, pollination and pest control services. In contrast, no decision-makers perceived livestock production to have a high impact on cultural, water purification and pollination services.

Around half of each group perceived a null or minimum impact of livestock production on the provision of cultural services, including aesthetic values and recreation opportunities. A small portion of academics perceived a high impact. Similar to the general trend, more academics than decision-makers perceived livestock production to highly impact disturbance regulation. Meanwhile, half of academics and a third of decision-makers perceived a moderate impact. A lower proportion of academics than decision-makers perceived a null or minimum impact.

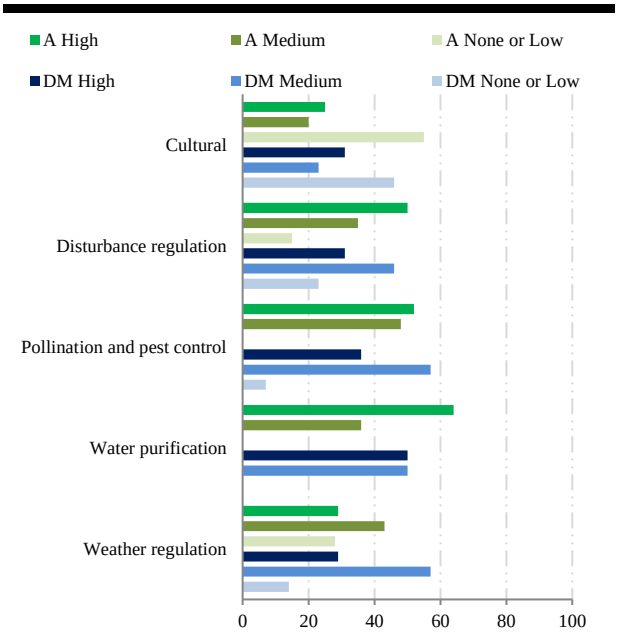

Figure 6. Perceived dependence of agriculture on ecosystem services (A: academics; DM: decision-makers).

A similar proportion of academics perceived that livestock production had a moderate or high impact on pollination and pest control. Decision-makers also perceived a high impact, although nearly half answered that the impact is null or minimum. Likewise, all of the academic respondents perceived a moderate or high negative impact of livestock production on weather regulation services. In contrast, none of the decision-makers perceived a high impact, and half perceived the impact to be null or minimum (Figure 7).

Dependence

Similar to trends in agriculture, academics perceived a higher dependence of livestock production on the evaluated ecosystem services (Figure 8). Likewise, all academics perceived no dependence on pollination and pest control, water quality and weather regulation. In contrast, decision-makers perceived a

stronger dependence of livestock production on weather regulation. Almost all of the respondents perceived livestock production to have no or low dependence on cultural services.

Perceived Impact and Dependence of Tourism on Ecosystem Services

Impact

Differences in the perception of the impact of tourism on the ecosystem services evaluated followed the same tendency as described in previous sections, although the differences were subtler.

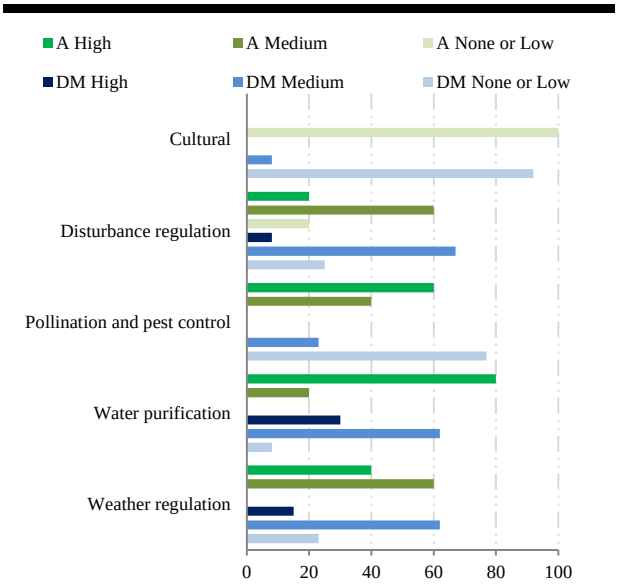

Figure 7. Perceived impact of livestock production on ecosystem services (A: academics; DM: decision-makers).

Figure 9 shows that the majority of both groups assigned moderate values for impact on ecosystem services. In contrast to the findings for the other sectors, a larger number of decision-makers perceived higher values of dependence. Almost all of the respondents perceived tourism activities to have a medium or high impact on cultural services. Half of the academics perceived a high impact and the remainder perceived a moderate impact. However, more decision-makers than academics perceived a high impact. This difference may be compensated by the fact that no academics perceived no impact, although a small proportion of decision-makers did (Figure 9).

The majority of both groups perceived tourism to have a high or medium impact on disturbance regulation services. Slightly more academics than decision-makers perceived a high impact. Respondents from both groups perceived a null impact, although the proportion of academics was smaller (Figure 9).

Most of the respondents perceived tourism to have a medium or null impact on pollination and pest control services. Following previous trends, academics perceived a higher impact than decision-makers. Three-quarters of the latter perceived no impact, while half of academics perceived a medium impact. No respondent perceived tourism to have a null impact on water purification services. In contrast with the general trend, academics perceived a lower impact than decision-makers. Approximately half of the academics perceived a medium impact, while three-quarters of decision-makers perceived a high impact.

Academics perceived tourism to have a lower impact on weather regulation services than decision-makers. In fact, half of the academics perceived that tourism has a medium impact in comparison to three-quarters of decision-makers; a quarter of both groups perceived no impact. However, a small proportion of academics perceived a high impact, although no decision-makers gave a high rating (Figure 9).

Dependence

All of the respondents perceived tourism to have a high or medium dependence on cultural services, including aesthetic values and recreational opportunities (Figure 10). In contrast with the general trend, academics perceived a lower dependence than decision-makers. In fact, a quarter of the academics perceived that tourism had a medium dependence on cultural services, while all the decision-makers considered that the dependence is high (Figure 10).

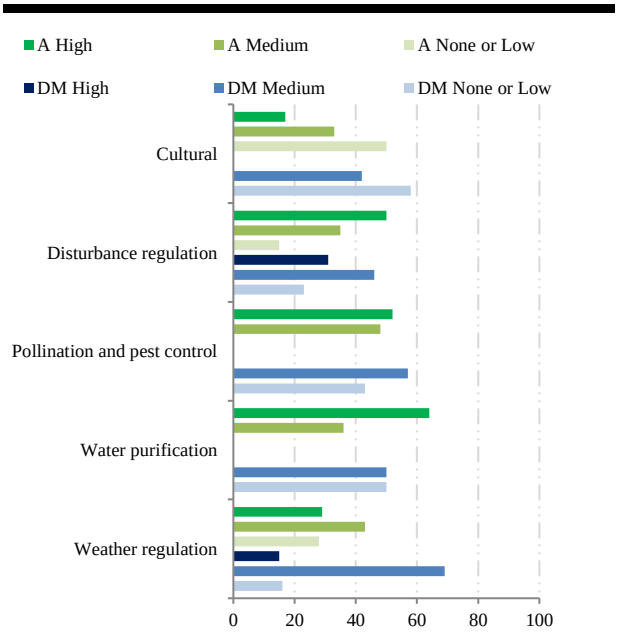

Figure 8. Perceived dependence of livestock production on ecosystem services (A: academics; DM: decision-makers).

Most of the respondents perceived that tourism has a high or medium dependence on disturbance regulation services. A slightly greater proportion of academics than decision-makers perceived a high dependence. However, a small proportion of the former perceived no dependence.

Half of the academics perceived that tourism has a medium dependence on pollination and pest control, while all of the decision-makers perceived that such dependence was null or minimum (Figure 10). Nevertheless, the majority of respondents perceived that tourism has a high or medium dependency on water purification services. In contrast with the general trends, the

proportion of academics that perceived a high dependence was lower than the proportion of decision-makers, and a small proportion of the former perceived no dependence.

More than a half of the respondents in both groups perceived that tourism has a medium dependence on weather regulation services. A quarter of the academics perceived that such dependence is high, and a similar proportion of decision-makers perceived a null dependence.

DISCUSSION

The perceived degree to which economic productive activities and ecosystem services were related differed between academics and decision-makers. More frequently than not, academics perceived the impact and dependence of economic activities on ecosystem services to be much greater than did the decision-makers. This may indicate that, during the decision-making process, decision-makers tend to underestimate the impact of economic activities on ecosystem services, or that academics potentially overestimate their impact. Such differences of opinion, whether scientifically informed or not, affect the decisions that are made and, consequently, the conservation status and resilience of natural ecosystems.

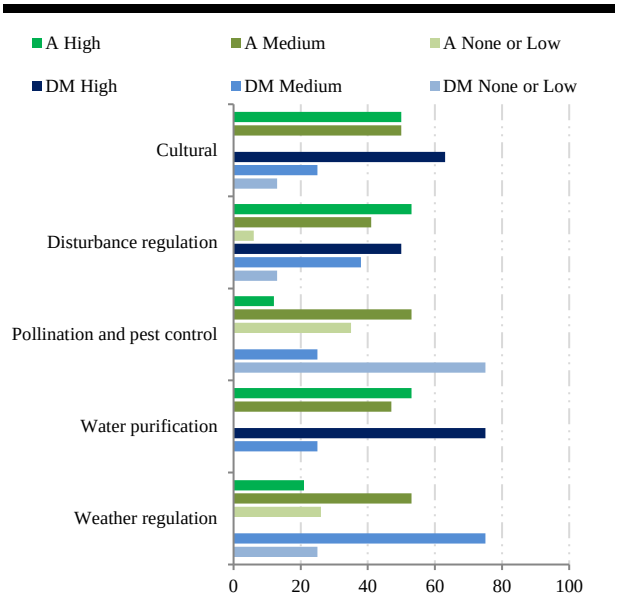

Figure 9. Perceived impact of tourism on ecosystem services (A: academics; DM: decision-makers).

The main strength of this approach is the identification of differences in perception that we found between academics and decision-makers which show a communication gap that, in the end, obstruct the transition towards an integrated coastal management where resilience is the cornerstone. This shows the need to strengthen efforts and strategies that promote multi- and interdisciplinary interactions and the exchange of advances in knowledge, on one hand, and needs, on the other. It is worth noting that not only the individual or guild perceptions but also the language used to communicate between society groups may difficult the understanding of the message. An example is the difficulty of communicate complex environmental issues including the information on associated uncertainty (Wardekker *et al.*, 2008). Simultaneously, the communication of scientific assessments limits is important because it can influence the policy strategy selected and it has been considered as an option to improve the science-policy and science-society interfaces. When public users of natural resources and key decision makers do not have an easy access to scientific research, then there is a systemic problem that is generated the lack of comprehension of the critical links between environmental degradation and human well-being. This communication gap will very likely have consequences in both, conservation and development (Shanley and López, 2009).

In countries such as Mexico, the impact and dependence of economic activities on ecosystem services has often been minimized or not fully acknowledged. As a result, natural ecosystems have been degraded, and their integrity, health and resilience have not been considered a priority (Davenport and Davenport, 2006; Hutchinson *et al.*, 2013). The responses of the decision-makers demonstrated certain awareness, yet knowledge of specific scenarios may be lacking. For example, decision-makers did not link ecosystem restoration with provision of ecosystem services. In coastal communities, the restoration and maintenance of natural ecosystems and services is important given that a resilient natural system can help mitigating the effects of natural disturbances, such as hurricanes and storms. Thus, this loss of resilience has been directly linked to the lack of prioritizing ecosystem services in decision-making processes, which in turn may have a negative impact on human wellbeing (Christie *et al.*, 2012; Díaz *et al.*, 2006; Gray *et al.*, 2013).

The minimization of ecosystem services in decision-making may derive from the limited information available on the subject matter, deficient communication between academics and decision-makers or the relative "invisibility" of some ecosystem services (Doyle *et al.*, 2014). This aspect is central and can also be linked to how uncertainty is dealt with during the decision-making process, which may not consider the seriousness of a threat (Doyle *et al.*, 2014).

Independently of the reasons that lie beneath the communication gap, one of the side effects is that it can reduce the disposition to implement resource management, conservation, or restoration initiatives (Bateman *et al.*, 2013; Lithgow *et al.*, 2013) focused on the maximization of multiple ecosystem services and the maintenance or recovery of their resilience (Geneletti, 2013; Granek *et al.*, 2010). For example, we found 10,509 studies in the Scopus database (June 21, 2016), that mention ecosystem services in the title, abstract or keywords. From these studies, ecosystem services associated with weather regulation received most attention (38% of the total). Meanwhile, studies on the provision and purification of water (8%) and the protection and regulation of disturbances are less frequent (12%); pollination and pest control (4%) as well as cultural (1.3%) services received the least attention. None was related with the decision making process. This clearly evidences the communication gap between academics and policy makers.

This literature review highlights the strength of some subjects and shows that interdisciplinary research is still incipient. Few studies on ecosystem services involve decision-making and almost none develop end-user tools to help the decision processes.

Thus, this study can be considered as a starting point in which it is explored the differences in perception of the relevance of ecosystem services from different viewpoints. Certainly, more work is needed to identify the role played by different sectors of society and the responsibility in the decision-making process associated with ecosystem services. The most common governing themes were environmental sciences and agricultural and biological sciences (37% and 28%, respectively). Studies grounded in the social sciences and decision-making processes are less common (10% and 2%, respectively). Several studies did focus on the relationship between ecosystem services and economic activities. In this case, the relationship between ecosystem services and agriculture has been more frequently studied (14%) in comparison to ecosystem services as related to tourism and livestock production (4% and 3%, respectively). Finally, studies on ecosystem services in coastal areas represent only 2% (246 articles) of the total. It is important to note that a Mexican research institution, The Institute of Ecology (Instituto de Ecología, A.C.), ranks third worldwide in this area, after Stanford and James Cook University. Despite the examination of ecosystem services in academic circles, it is a concept has not fully permeated public policies.

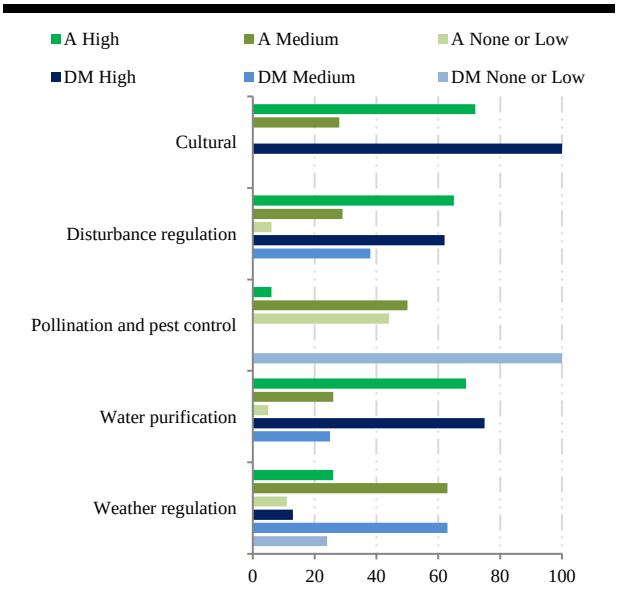

Figure 10. Perceived dependence of tourism on ecosystem services (A: academics; DM: decision-makers).

While the development plans of national and coastal states include the terms ecosystem services, resilience and vulnerability, the definition of these terms is often unclear and it are rarely provided in a useful context. In the National Development Plan of Mexico (Plan Nacional de Desarrollo, 2013), the relationships between ecosystem services, economic activities and human wellbeing is seldom recognized; the need for a better design of management strategies in coastal areas is highlighted. In turn, 80% of the development plans of coastal states mention the term ecosystem services. However, only a third of these plans recognize the importance of coastal ecosystem services, and the rest focus on services provided by forests.

Interestingly, in the National Development Plan of Mexico, the term resilience only refers to the economic term, in the context of a global economic crisis. Ecological resilience is not often included in the development plans of coastal states; less than a third mentioned it.

Previous management mistakes and poor decision-making have provoked social and economic marginalization and increased pressure on natural systems (Chapin *et al*., 2010; Yang *et al*., 2013). For example, the establishment of agricultural and cattle production in floodplains, or the authorization of tourist developments on coastal dunes make coastal communities less resilient to natural disturbances (Ghaley, Vesterdal, and Porter, 2014; Hanley *et al*., 2014). These scenarios are common in the coastal states of Mexico. The immediate income derived from such economic activities is more highly valued than resilience, although in the long-term, this may affect the integrity of natural ecosystems, the viability of coastal economic activities and, consequently, human wellbeing (Martínez *et al*., 2007; Patterson and Glavovic, 2013).

Human society is dependent on the maintenance of ecosystem services (Lopes and Videira, 2013; Spalding *et al.*, 2014). Therefore, it is necessary to use ecosystem resilience as a guiding principle that helps to integrate the concept of ecosystem services in decision-making processes at all levels (Geneletti, 2011). We propose that coastal resilience be a guiding theme for decision-making at all levels (local, state and federal).

Furthermore, when there are long-term guarantees for ecosystems, the resilience of the coast is enhanced. In addition, it is important that the costs and benefits associated with maintaining ecosystem services is weighed against the assumed advantages associated with the development of different economic or productive activities. Sustainable coastal management needs improved communication between academics and decision-makers, at both the national and local level, in order for them to understand the concept of ecosystem services and be aware of relevant research. In addition, we believe that the perceptions of farmers regarding ecosystem services should be included in decision-making processes, due to their increasingly recognized role as ecosystem managers (Cerdán *et al*., 2012).

CONCLUSION

Even though the importance of ecosystem services to human society has been widely acknowledged, the concept has not fully permeated public policies, such as those directly related with economic activities. This has highlighted the perceived difference of the impact and dependence of economic activities on ecosystem services between academics and decision-makers; which poses the challenge in designing an effective science-policy interaction (Cash *et al.*, 2003, Daniel *et al*., 2012).

Understanding these differences is crucial if we are to change the current trajectory of economic development, which has brought about environmental degradation and ultimately decreased ecosystem resilience and human wellbeing in the coastal states of Mexico and elsewhere.

Research is necessary to understand how different economic activities impact on the integrity, health and resilience of the natural ecosystems upon which they depend. These studies should

be multi- and trans- disciplinary and address the different interacting elements of complex socio-ecological systems. In parallel, it should be acknowledged that decision-makers and the public oftentimes challenge the status of scientific knowledge as a neutral ground in the decision-making process. Hence, better understanding of the role of science in policy-making will enhance the possibility of better decision making for policies designed to improve human wellbeing and the conservation and recovery of natural ecosystems.

Long-term resilience of ecosystems and the services they provide should become the guiding criterion in decision-making. Nevertheless, on top of scientific knowledge, decisions cannot be legitimized without consideration of pubic values and preferences, which only highlights the complexities of the decision-making process.

ACKNOWLEDGMENTS

DL sincerely thanks the UNAM-DGAPA program for her Postdoctoral fellowship. We thank our respective institutions for support. We also thank the comments and suggestions made by two anonymous reviewers. No decision makers or academics were harmed in the creation of this paper.

LITERATURE CITED

Atlas Nacional de México, 1990. *Batimetría-hipsometría*. http://www.igeograf.unam.mx/sigg/publicaciones/atlas/anm-1990-1992/muestra_mapa.php?cual_mapa=TI-I-1-1.jpg

Baral, H.; Keenan, R.J.; Sharma, S.K.; Stork, N.E., and Kasel, S., 2014. Economic evaluation of ecosystem goods and services under different landscape management scenarios. *Land Use Policy*, 39, 54–64.

Bateman, I.J.; Harwood, A.R.; Mace, G.M.; Watson, R.T.; Abson, D.J.; Andrews, B.; Binner, A.; Crowe, A.; Day, B.; Dugdale, S.; Fezzi, C.; Fonden, J.; Hadley, D.; Haines-Young R.; Hulme, M.; Kontoleon, A.; Lovett, A.A.; Munday, P.; Pascual, U.; Paterson, J.; Perino, G.; Sen, A.; Siriwardena, G.; van Soest, D., and Termansen, M., 2013. Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. *Science*, 341, 45-50.

Böhnke-Henrichs, A.; Baulcomb, C.; Koss, R.; Hussain, S.S., and de Groot, R.S., 2013. Typology and indicators of ecosystem services for marine spatial planning and management. *Journal of Environmental Management*, 130, 135-145.

Bommarco, R.; Kleijn, D., and Potts, S.G., 2013. Ecological intensification: Harnessing ecosystem services for food security. *Trends in Ecology and Evolution*, 28, 230–238.

Braat, L.C. and de Groot, R., 2012. The ecosystem services agenda: Bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem Services*, 1, 4–15.

Burkhard, B.; Kroll, F.; Nedkov, S., and Müller, F., 2012. Mapping ecosystem service supply, demand and budget. *Ecological Indicators*, 21, 17–29.

Cárcamo, P.F.; Garay-Flühmann, R., and Gaymer, C.F., 2014. Opportunities and constrains of the institutional framework for the implementation of ecosystem-based management: The case of the Chilean coast. *Ocean and Coastal Management*, 84, 193-203.

Cash, D.W.; Clark, W.C.; Alcock, F.; Dickson, N.M.; Eckley, N.; Guston, D.H.; Jäger, J, and Mitchell, R.B., 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences*, 100(14), 8086-8091.

Ceballos, G.; Díaz-Pardo, E.; Espinosa, H.; Flores-Villela, O.; García, A.; Martínez. L.; Martínez-Meyer, E.; Navarro, A.; Ochoa, L.; Salazar, I., and Santos-Barrera G., 1998. Zonas críticas y de alto riesgo para la conservación de la biodiversidad de México. *In:* Dirzo, R.; González, R., and March, I.J. (eds.), *Capital Natural de México vol II: Estado de Conservación y Tendencias de Cambio*. Mexico City: CONABIO, pp. 575-600.

Cerdán, C.R.; Rebolledo, M.C.; Soto, G.; Rapidel, B., and Sinclair, F.L., 2012. Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems. *Agricultural Systems*, 110, 119-130.

Chapin, F.S.; Carpenter, S.R.; Kofinas, G.P.; Folke, C.; Abel, N.; Clark, W.C.; Olsson, P.; Smith, D.M.; Walker, B.; Young, O.R.; Berkes, F.; Biggs, R.; Grove, J.M.; Naylor, R.L.; Pinkerton, E.; Steffen, W., and Swanson, F.J., 2010. Ecosystem stewardship: Sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution*, 25, 241–249.

Christie, M.; Fazey, I.; Cooper, R.; Hyde, T., and Kenter, J.O., 2012. An evaluation of monetary and non-monetary techniques for assessing the importance of biodiversity and ecosystem services to people in countries with developing economies. *Ecological Economics*, 83, 67–78.

CONEVAL (Consejo Nacional de Evaluación de la Política de Desarrollo Social), 2015. *Resultados de Pobreza en México 2014 a Nivel Nacional y por Entidades Federativas*. Mexico City, México: CONEVAL, 30p.

Costanza, R. and Kubiszewski, I., 2012. The authorship structure of "ecosystem services" as a transdisciplinary field of scholarship. *Ecosystem Services*, 1, 16–25.

Cullen-Unsworth, L.C.; Nordlund, L.M.; Paddock, J.; Baker, S.; McKenzie, L.J., and Unsorth, R.K.F., 2013. Seagrass meadows globally as a coupled social-ecological system: Implications for human wellbeing. *Marine Pollution Bulletin*, 83, 387-397.

Daily, G.C. and Matson, P.A., 2008. Ecosystem services: From theory to implementation. *Proceedings of the National Academy of Sciences* 105, 9455–9456.

Daily, G.D.; Polasky, S.; Goldstein J.; Kareiva P.M.; Mooney, H.A.; Pejchar, L.; Ricketts T. H.; Salzman, J., and Shallenberger, R., 2009. Ecosystem services in decision making: Time to deliver. *Frontiers in Ecology and the Environment*, 7, 21-28.

Daniel, T.C.; Muhar, A.; Arnberger, A.; Aznar, O.; Boyd, J.W.; Chan, K.M., and Grêt-Regamey, A., 2012. Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences*, 109(23), 8812-8819.

Davenport, J. and Davenport, J.L., 2006. The impact of tourism and personal leisure transport on coastal environments: A review. *Estuarine and Coastal Shelf Science*, 67, 280–292.

DeFries, R.S.; Foley, J.A., and Asner, G.P., 2004. Land-use choices: Balancing human needs and ecosystem function. *Frontiers in Ecology and the Environment*, 2, 249–257.

Díaz, S.; Fargione, J.; Chapin, F.S., and Tilman, D., 2006. Biodiversity loss threatens human well-being. *Public Library of Science Biology*, 4, e277.

Dirzo, R. and Saruhkan, J., 1992. *México Ante los Retos de la Biodiversidad*. Mexico City, Mexico: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, 343p.

Doyle, E.E.; McClure, J.; Paton, D., and Johnston, D.M., 2014. Uncertainty and decision making: Volcanic crisis scenarios. *International Journal of Disaster Risk Reduction*, 10, 75–101.

Euliss, N.H.; Smith, L.M.; Liu, S.; Feng, M.; Mushet, D.M.; Auch,, R.F., and Loveland, T.R., 2010. The need for simultaneous evaluation of ecosystem services and land use change. *Environmental Science and Technology*, 44, 7761–7763.

Farfán, L.M.; Alfaro, E.J., and Cavazos, T., 2013. Characteristics of tropical cyclones making landfall on the Pacific coast of Mexico: 1970-2010. *Atmósfera*, 26(2), 163–182.

Geneletti, D., 2011. Reasons and options for integrating ecosystem services in strategic environmental assessment of spatial planning. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 7, 143–149.

Geneletti, D., 2013. Assessing the impact of alternative land-use zoning policies on future ecosystem services. *Environmental Impact Assessment Review*, 40, 25–35.

Ghaley, B.B.; Vesterdal, L., and Porter, J.R., 2014. Quantification and valuation of ecosystem services in diverse production systems for informed decision-making. *Environmental Science and Policy*, 39, 139–149.

Plan Nacional de Desarrollo, 2013. Gobierno de México. *Plan Nacional de Desarrollo: 2013-1018.* http://pnd.gob.mx/

Granek, E.F.; Polasky, S.; Kappel, C.V.; Reed, D.J.; Stoms, D. M., Koch, Kennedy, C.J., Cramer, L.A.; Hacker, S.D.; Barbier, E.B.; Aswani, S.; Ruckelshaus, M.; Perillo, G.M.E.; Silliman, B.R.; Muthiga, N.; Bael, D., and Wolanski, E., 2010. Ecosystem services as a common language for coastal ecosystem-based management. *Conservation Biology*, 24, 207–216.

Gray, S.R.J.; Gagnon, A.S.; Gray, S.A.; O´Dwyer, B.; O´Mahony, C.; Muir, D.; Devoy, R.J.N.; Falaleeva, M., and Gault, J., 2013. Are coastal managers detecting the problem? Assessing stakeholder perception of climate vulnerability using Fuzzy Cognitive Mapping. *Ocean and Coastal Management*, 94, 74-89.

Hanley, N.; Hynes, S.; Jobstvogt, N., and Paterson, D.M., 2014. *Economic Valuation of Marine and Coastal Ecosystems: Is It Currently Fit for Purpose?* St Andrews: University of St Andrews Press, 38p.

Hassan, R.; Scholes, R., and Ash, N., 2005. *Ecosystems and Human Well-Being: Current State and Trends*. *Millennium Ecosystem Assessment (MEA).* Washington, D.C.: Island Press, 47p.

Hills, T.; Carruthers, T.J.B., and Chape, S., 2013. A social and ecological imperative for ecosystem-based adaptation to climate change in the Pacific Islands. *Sustainability Science*, 8, 455–467.

Hutchinson, L., Montagna, P., Yoskowitz, D., Scholz, D., and Tunnell, J., 2013. Stakeholder perception of coastal habitat ecosystem services. *Estuaries and Coasts*, 38, 67-80.

INEGI (Instituto Nacional de Estadística y Geografía), 2015. *Censo de Población y Vivienda. Mexico*: INEGI. http://www.inegi.org.mx/est/contenidos/proyectos/ccpv/cpv2015/

Karrasch, L.; Klenke, T., and Woltjer, J., 2014. Linking the ecosystem services approach to social preferences and needs in integrated coastal land use management: A planning approach. *Land Use Policy*, 38, 522–532.

Laurans, Y.; Rankovic, A.; Mermet, L.; Billé, R., and Pirard, R., 2013. Actual use of ecosystem services valuation for decision-making: Questioning a literature blindspot. *Journal of Environmental Management*, 119, 208–219.

Lindig-Cisneros, R., 2010. Ecological restoration in Mexico: The challenges of a multicultural megadiverse country. *Ecological Restoration*, 28, 232–233.

Lithgow, D.; Martínez, M.L.; Gallego-Fernández, J.B.; Hesp, P.A.; Flores, P.; Gachuz, S.; Rodríguez-Revelo, N.; Jiménez-Orocio, O.; Mendoza-González, G., and Álvarez-Molina, L.L., 2013. Linking restoration ecology with coastal dune restoration. *Geomorphology*, 199, 214-224.

Lopes, R. and Videira, N., 2013. Valuing marine and coastal ecosystem services: An integrated participatory framework. *Ocean and Coastal Management*, 84,153-163.

Mace, G.M.; Norris, K., and Fitter, A.H., 2012. Biodiversity and ecosystem services: A multilayered relationship. *Trends in Ecology and Evolution*, 27, 19–26.

Martínez, M.L.; Intralawan, A.; Vazquez, G.; Pérez-Maqueo, O.; Sutton, P., and Landgrave, R., 2007. The coasts of our world: Ecological, economic and social importance. *Ecological Economics*, 63, 254–272.

Martínez, M.L.; Moreno-Casasola, P.; Espejel, I.; Jiménez-Orocio, O.; Infante-Mata D., and Rodríguez-Revelo, N., 2014. *Diagnóstico de las dunas costeras de México*. Guadalajara, Jalisco: CONAFOR, 350p.

Mycoo, M.A. and Gobin, J.F., 2013. Coastal management, climate change adaptation and sustainability in small coastal communities: Leatherback turtles and beach loss. *Sustainability Science*, 8, 441-453.

OECD (Organization for the Economic Cooperation and Development), 2010. *Higher Education in Regional and City Development: State of Veracruz, Mexico*. Paris, France: OECD Publishing, 147p.

Ortíz-Pérez, M.A. and de la Lanza-Espino, G., 2006. *Diferenciación del Espacio Costero de México: Un inventario Regional.* Mexico City*:* Instituto de Geografía, UNAM, 138p.

Paavola, J. and Hubacek, K., 2013. Ecosystem services, governance, and stakeholder participation: An introduction. *Ecology and Society*, 18, 42.

Patterson, M. and Glavovic, B., 2013. From frontier economics to an ecological economics of the oceans and coasts. *Sustainability Science*, 8(1), 11-24.

Plieninger, T.; Bieling, C.; Ohnesorge, B.; Schaich, H.; Schleyer, C., and Wolff, F., 2013. Exploring future of ecosystem services in cultural landscapes through participatory scenario development in the Swabian Alb, Germany. *Ecology and Society*, 18, 39.

Rodríguez, J.P.; Beard, T.D.; Bennett, E.M.; Cumming, G.S.; Cork, S.J.; Agard, J.; Dobson, A.P., and Peterson, G.D., 2006. Trade-offs across space, time, and ecosystem services. *Ecology and Society*, 11, 28.

Ruckelshaus, M.; McKenzie, E.; Tallis, H.; Guerry, A.; Daily, G.; Kareiva, P.; Polasky S.; Ricketts, T.; Bhagabati, N.; Wood, S. A., and Bernhardt, J., 2013. Notes from the field: Lessons

learned from using ecosystem service approaches to inform real-world decisions. *Ecological Economics*, 115, 11-21.

Schulp, C.J.E.; Lautenbach, S., and Verburg, P.H., 2014. Quantifying and mapping ecosystem services: Demand and supply of pollination in the European Union. *Ecological Indicators*, 36, 131–141.

Seingier, G.; Espejel, I., and Ferman, J.L., 2009. Cobertura vegetal y marginación en la costa mexicana. *Investigación Ambiental*, 1, 54-69.

Serna-Chavez, H.M.; Schulp, C.J.E.; van Bodegom, P.M.; Bouten, W.; Verburg, P.H., and Davidson, M.D., 2014. A quantitative framework for assessing spatial flows of ecosystem services. *Ecological Indicators*, 39, 24–33.

Shanley, P. and López, C., 2009. Out of the loop: Why research rarely reaches policy makers and the public and what can be done. *Biotropica*, 41, 5, 535–544.

Silva, R.; Lithgow D.; Esteves, L.; Martínez, M.L.; Moreno-Casasola, P.; Martell, R.; Pereira, P.; Mendoza, E.; Campos-Cascaredo, A.; Winckler Grez, P.; Osorio, A.F.; Osorio-Cano, J.D., and Rivillas, J.D., 2017. Mitigation of coastal risk by green infrastructure in Latin America. *Maritime Engineering*. (*in press*)

Sistema de Cuentas Nacionales de México, 2011. *Producto Interno Bruto por Entidad Federativa 2005-2009: Año base 2003.* Mexico City: Instituto Nacional de estadística y Geografía, 357p.

Spalding, M.D.; Ruffo, S.; Lacambra, C., and Beck, M.W., 2014. The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. *Ocean and Coastal Management*, 90, 50–57.

Su, S.; Xiao, R.; Jiang, Z., and Zhang, Y., 2012. Characterizing landscape patterns and ecosystem service value change for urbanization impacts at an eco-regional scale. *Applied Geography*, 34, 295–305.

UNEP (United Nations Environment Programme), 2014. *Integrating Ecosystem Services in Strategic Environmental Assessment: A guide for Practitioners*. Nairobi: United Nations Environment Programme Publication, 66p.

van Jaarsveld, .S.; Biggs, R.; Scholes R.J.; Bohensky, E.; Reyers, B.; Lynam, T. Musvoto, C., and Fabricius, C., 2005. Measuring conditions and trends in ecosystem services at multiple scales: The Southern African Millennium Ecosystem Assessment. *Philosophical Transactions of the Royal Society*, 360, 425-441.

Wardekker, J.A.; van der Sluijs, J.P.; Janssen, P.H.; Kloprogge, P., and Petersen, A.C., 2008. Uncertainty communication in environmental assessments: Views from the Dutch science-policy interface. *Environmental Science and Policy*, 11, 627–641

World Bank, 2015. *Mexico overview of 2015*. http://www.worldbank.org/en/country/mexico/overview.

Yang, W.; Diez,T.; Liu, W.; Luo, J., and Liu, J., 2013. Going beyond the millennium ecosystem assessment: An index system of human dependence on ecosystem services. *Public Library of Science ONE*, 8, e64581.