The capacities of institutions for the integration of ecosystem services in coastal strategic planning: The case of Jiaozhou Bay

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1. Introduction

Coastal areas are difficult to manage because they involve dynamic natural systems that are increasingly under pressure from expanding socio-economic systems (Turner, 2000). One central challenge for coastal management and planning in practice is to develop innovative approaches for managing diverse human uses of ecosystems through a range of activities (Lester et al., 2010). To meet this challenge, an ES approach has been increasingly adopted in ecosystem-based coastal management, marine spatial planning and strategic environmental assessment (e.g., Partidario & Gomes, 2013; Böhnke-Henrichs et al., 2013). The concept of ES provides a lens through which we can understand the relationships between humans and natural systems. Specifically, this notion helps us assess how these services benefit humanity and how human actions generally impact ecosystems and the delivered ESs (MA, 2005; Carpenter et al., 2009). The Millennium Ecosystem Assessment (2005) developed four broadly employed ES categories to help understand the above question: provisioning, regulating, cultural and supporting services.

A key difficulty in integrating these services into natural resource management and planning is their complex and dynamic interrelationships in terms of trade-offs and synergies. Trade-offs arise when the attempt to optimize a single service leads to reductions or losses of other services (Holling & Meffe, 1996). A typical example would be a situation where offshore wind farm development enhances energy production but simultaneously has negative impacts on biodiversity (Busch et al., 2011). ES synergies often arise when multiple services are enhanced simultaneously (Raudsepp-Hearne et al., 2010). For instance, marine protection areas maintain habitats while also producing important benefits for certain fish (Shen et al., 2011). These interrelationships usually emerge when several services respond to a driver modified by human management or due to the interplay between ESs (Bennett et al., 2009). It has been argued that making these interrelationships explicit is a key informational need for policy-making. More clarity on these interrelationships may reduce the risk of negative trade-offs and enhance potential win-win scenarios (Bennett et al., 2009; Lester et al., 2013; Kelble et al., 2013).

Consequently, there has been increasing interest in developing decision-making approaches based on analyzing ES interrelationships (Butler et al., 2013). Scholars typically use economic valuation, geospatial information and multiple stakeholders' objectives to quantify

ES values or geographical clusters across landscapes and seascapes. Current approaches for measuring ES trade-offs and/or synergies can be broadly grouped into four main approaches: mapping (e.g. Costanza et al., 1998; Martínez-Harms & Balvanera, 2012; Crossman et al., 2013), modeling (e.g. Swallow et al., 2009; Chisholm, 2010), social-survey analysis (e.g. Hauck et al., 2013; Potts et al., 2014), and content analysis (Piwowarczyk et al., 2013; Wilkinson et al., 2013). A large number of recent studies have used hybrid methods of mapping and modeling (e.g. InVEST and ARIES; Nelson et al., 2009; Villa et al., 2009), or mapping and social-survey analysis (e.g. SolVES; Sherrouse et al., 2011). Such approaches have also been employed in the field of coastal and marine management to ascertain the influence of diverse activities on key ESs. Examples involve reclamation, fisheries, aquaculture, offshore wind farming, special marine protected areas, and wetland developments that impact varying ESs (e.g., Brown et al., 2001; Martinet & Blanchard, 2009; Busch et al., 2011).

The studies mentioned earlier mainly show people's general preferences for different service categories: people tend to be less appreciative of regulating services and supporting services that create high-value provisioning and cultural services (Carpenter et al., 2006; Rodríguez et al., 2006). In fact, scientists have emphasized the critical and vulnerable roles of regulating and supporting services (e.g., water purification, climate and flooding regulation, wetland habitat and biodiversity) in various ES interrelationships. However, both these ES categories are easily threatened by investment primarily in provisioning services (Bennett et al., 2009). In addition, the studies mentioned earlier also suggest that close interrelationships among ES are not well-articulated or handled in current coastal policy-making or planning (Halpern et al., 2008). It is particularly true in coastal strategic planning, which generally refers to a framework for arranging coastal and marine spatial use and organizing human activities to achieve economic and social benefits while sustaining ecosystem health, function and services. Current coastal strategic planning has been unable to make ES trade-offs and synergies explicit, especially when indirect effects make the identification and assessment of the interplay of ESs more complex than simple cause-effect mechanisms (Halpern et al., 2008). Moreover, when either the spatial scale (in-site or off-site effects of interrelationships) or the temporal scale (short-term or long-term effects) increases, ES interlinks could become more uncertain and difficult to manage (Rodríguez et al., 2006). This would restrict the ability of policy and planning to be more sustainable and adaptive.

New approaches to coastal strategic planning are increasingly important to addressing the issues of sustainable and adaptive coastal and sea use. Although current research on approaches for assessing ES interrelationships has contributed to decision-making in a variety of ways, there are two main limitations. First, no attempt has been made to systematically clarify the integration of ES interplay from coastal strategic plans in practice. There has been a lack of attention to understand causal ES interrelationships embedded in actual coastal policies. The second limitation is that most approaches do not handle a wide scope of drivers and related ESs, and often lack an understanding of institutional contexts that determine which specific driving forces, ESs and their interrelationships may be taken into account.

Therefore, the specific objective of this research is to propose a four-step method to assess a broad range of drivers and ES interrelationships included in coastal strategic planning, based on a more causal analyzing mechanism. In this way, this paper aims to clarify ES interrelationships formulated in policy language, and it aims to provide insights into complex aspects of the coastal environment, from non-academic and strategic-policy points of view. Such views may enable strategic planning to be more adaptive and sustainable in coastal areas where the integration of ESs for realizing ecosystem-based coastal management and planning is in an early stage of development. Jiaozhou Bay in China is used as an illustrative case. The following section will introduce the background of this case. Next, we will explain our four-step method. After reporting the findings by applying the method, we will analyze the results, discuss institutional implications for the consideration of the drivers and ES interrelationships and, finally, reflect on our method's strengths and its implications.

2. The case study: Jiaozhou Bay in China

Jiaozhou Bay is a semi-enclosed and fan-shaped natural bay located on the southern coast of Shandong Peninsula in East China (Fig. 1). In 2012, it covered an area of 343.5 km^2 and its coastline measured 206.8 km. Several rivers feed into this bay, of which the largest is the Dagu River. Seven districts and five county-level cities (all belonging to Qingdao City) surround the bay, with a total population of 8.71 million.

We chose Jiaozhou Bay as a case study for several reasons. First, the development of the whole urban area around the bay essentially depends on a large range of ESs provided by the bay, such as aquaculture, fisheries, transportation, sea sports, tourism and large wetland maintenance (Zhao et al., 2005). A great deal of research on the ecological, physical, chemical environment of Jiaozhou Bay has been extensively conducted (e.g. Shen 2001; Liu et al., 2004; Gao et al., 2014). The rich diversity in coastal and marine services and understandings of the ecosystem yield useful ES information for strategic planning. The second consideration concerns the importance of identifying how coastal activities may be considered as drivers in the formation of ES interrelationships in strategic planning. Coastal areas where fast-paced and long-term development takes place are more likely to provide answers, since intensive anthropogenic pressures result in different conflicts about ESs. This is particularly the case in Qingdao – a leading coastal city in China and an economic center in Shandong Province – whose extractive, industrial, commercial, recreational and emerging ocean uses have shrunk the area of Jiaozhou Bay by 173 km^2 (nearly one-third) over the past 45 years as a result of extremely rapid resource development (Ge & Zhang, 2011). The third reason for choosing the case was its institutional environment. One of Qingdao's planning goals is to manage resources for the benefit of citizens and the ecosystems on which the city depends. Qingdao and the Jiaozhou Bay play a key role in the first national-level marine economy development strategy, paving the way for Shandong Province to be in the forefront of coastal planning and management in China. As such, there are comprehensive rules about coastal ecological protection in Jiaozhou Bay area, giving rise to a promising institutional context for many related strategic plans (e.g. Qingdao Provisions of Marine Environment Protection). These existing strategic plans attempt to address ES conflict issues by redefining spatial use and managing activities to ensure local sustainable development.

3. A four-step method to analyze ES interrelationships

In general, coastal strategic planning for Jiaozhou Bay features activities for exploiting, utilizing and protecting coastal and marine resources. However, the impacts and extent of these activities on a set of ESs vary considerably since ESs are inevitably interconnected. We used a four-step method to investigate how activities, trade-offs and synergies among ESs were portrayed in coastal strategic plans. Meanwhile, reading the plans systematically enabled us to understand how plans are organized under a broad institutional environment, and to understand institutional implications to improve the inclusion of ES interrelationships.

Step 1: Selecting strategic plans

We focused on strategic spatial plans formulated during the last five years and collected four strategic plans for Jiaozhou Bay from official websites and the responsible authorities (Table 1). The "Conservation and Development around Jiaozhou Bay" Strategy of Qingdao (Plan 1) in 2008 was the first of these plans to promote the concept of integrating ecological protection with industrial development for Qingdao City. It was an important urban space development strategy that enabled Qingdao to be part of The Development Plan of Shandong Peninsula Blue Economic Zone (Plan 2). This plan is the first national sustainable development strategy with a marine economy theme that highlights optimizing both seascape and landscape, producing modern marine industrial systems and enhancing marine ecological civilization. Two statutory urban strategic plans – The Twelfth Five-Year National Economic and Social Development Plans of Qingdao (Plan 3) and The Overall Urban Plan of Qingdao (2011-2020) (Plan 4) – also reflect the role of coastal and marine resources in Jiaozhou Bay in improving citizens' well-being and the urban economy. Gaining insight into which and how activities and ES interrelationships may be integrated into these strategic plans can enhance the adaptivity and sustainability in urban, regional and even national development.

Overall, given the emphasis these strategic plans place on interrelationships between ESs delivered by Jiaozhou Bay and regional/local development, we assumed that these plans have to address issues such as the organization, protection and development of activities that impact multiple ESs. Furthermore, as these are all strategic-level plans, they include a whole range of coastal activities. This could be useful for identifying more ES interrelationships caused by all these activities that are commonly found in coastal areas.

Step 2: Identifying ESs

Our previous study already identified the coastal ESs included in the four strategic plans' efforts (Li et al., 2015). We used a content analysis method accompanied by text interpretation. To ensure coding consistency, a ES coding system was established based on the four standard classification system put forward in the Millennium Ecosystem Assessment (MA, 2005), which was complemented with other research particularly focused on coastal and marine ESs. There were several reasons for choosing the MA classification. First, the four categories play a fundamental role because other modified classification schemes have widely employed them as a foundation (e.g. Haines-Young & Potschin, 2010; Atkins et al., 2011). Second, in order to qualitatively identify how activities and ES interrelationships may be portrayed in strategic planning, it is appropriate to adopt the MA typology which has been used as a basis for prompting the discussion of social preference and values towards the environment (Bryan et al., 2010). This classification would thus serve our research goals better than others, which aim at valuing ESs (Haines-Young & Potschin, 2010; Atkins et al., 2011), uncovering the processes of delivering benefits (De Groot et al., 2002; Wallace, 2007), analyzing spatial characteristics (Costanza, 2008), and distinguishing between ES excludability and rivalness (Fisher et al., 2009). A third reason concerns the supporting services. Current studies usually exclude supporting services or subsume them in the group of regulating services to avoid double counting of ES values. However, in our case, double counting should not be an issue since no values would be aggregated. In our method, it is important to consider supporting services and their institutional environment because some supporting services (e.g. habitat protection, biodiversity and resilience maintenance) have become popular in political discourses across the world. Fourth, to gain a broad view of how coastal and marine resources are used and affected by human activities through strategic planning, some important and traditional abiotic services (regardless of ecological production processes), such as space for navigation, industrial development and infrastructure and offshore wind, were added to the provisioning group as some authors have done, for example, Atkins et al. (2011).

Subsequently, we examined each selected strategic plan sentence by sentence in order to identify each coastal ES listed in the coding system. If a type of ES was referred to in a way that linked it to the meaning of an ES concept or that contains any example stated in the coding system, it was marked (Li et al., 2015). We coded terms and phrases in the documents by using manuscript extraction techniques and NVivo software. A range of well-established coastal ESs integrated in documents was accordingly identified (listed in Table 2). In this step, all the references to ESs were noted, which permitted us to further analyze the ES interrelationships as formulated by planners and policy-makers in the strategic plans.

Step 3: Identifying drivers, ESs and their effects

We identified the activities that act as drivers affecting the delivery of ESs, as well as the ESs themselves. This analysis was based on an interpretation of narratives mentioning at least one activity and two coastal services as coded earlier. The different types of activities (i.e., key drivers) that were highlighted and associated with certain ESs in these four plans were summed up in a table. Each of these mainly perceived relations was regarded and named as one type. This allowed us to not only identify the main drivers, but also to consider more ESs in this stage. The effects of these activities were analyzed according to two types of mechanisms identified by Bennett et al. (2009): "effects of drivers on multiple ESs" and "interactions among ESs." Thus, the direction of the effect is either from drivers to ESs or from ES to ES, that is, bidirectional or unidirectional. This can be interpreted through the contents involving both the driver and ESs identified earlier. We considered words such as "cancel," "forbidden," "limit," "control," "reduce", or "avoid" as negative effects. Narratives that included words such as "enhance," "stimulate," "provide," "explore," "preserve," "restore," "create," "improve," "benefit", and "guarantee" were seen as indicating positive effects, depending on their textual position.

Step 4: Constructing relational diagrams

We depicted the identified relationships in diagrams, providing a straightforward way to analyze the initial inclusion of activities, ESs involved and their effects as stated in the strategic plans. We employed the structuring method proposed by Bennett et al. (2009). In each relational diagram, the topmost rectangle is the driver affecting ESs and the rectangles below are ESs; the solid arrow indicates a positive influence, while the dotted arrow indicates a negative effect; arrows illustrate the directions of effects. We classified these relational diagrams in terms of trade-off and synergy. The former group focused on managing services that may co-vary negatively (more of one means less of another; Ring et al., 2010), while the latter group co-varies positively (more of one means more of another; Ring et al., 2010) as a result of certain activities. Each group was further classified in terms of the attributes of a driver (i.e., shared or independent effects on multiple ESs) and the degree of ES interactions (generally, the more ESs involved, the stronger the interactions would be). This step portrayed the relationships in a visual way, enabling us to observe which links were included and which were overlooked. To confirm and complement the document-based analysis, we then double-checked our assumptions by interviewing eight planners and policy-makers from key sectors who had been involved in any of the four plans. Key stakeholders for interviews were mainly selected from six main institutions including the Shandong Peninsula Blue Economic Zone Construction Office, the Shandong Environmental Planning and Design Institute, the Qingdao Urban Planning Bureau, the Qingdao Ocean and Fishery Bureau, the Qingdao Environmental Protection Bureau, and the Qingdao Institute of Marine Geology.

4. Analyzing ES interrelationships in the strategic plans for Jiaozhou Bay

4.1 Inclusion of drivers and ESs

The Jiaozhou Bay strategic plans show attempts to concisely consider some relationships in terms of trade-offs and synergies among coastal ESs that are impacted by human activities. Table 3 summarizes the results, showing drivers and ESs identified through the second step of content analysis across the four selected strategic plans. We found that various activities were listed in plans, which in reality may influence ESs in different ways. However, there were ten typical types (four trade-offs and six synergies) that could be mainly derived from the narratives of affecting ESs. Among all the activities identified in the four plans, three (controlling reclamation, restoring natural shoreline, and building wetlands park/reserve) were referred to in all the plans. Plans 1 and 3 underlined two activities (i.e., constructing new town and upgrading port function) for stimulating multiple ESs. The rest of the drivers were each referred to at least once in at least one strategic plan. The "category" columns in Table 3 show which category each service involved belongs to; this was done to facilitate a general awareness that the provisioning services were most often regarded to be under direct management. Cultural services more often appeared as positively co-varying services with other ESs where synergies were concerned. The diagrams in Sections 4.2 and 4.3 reveal the detailed interplay of driver-ES and ES-ES relationships as formulated and mentioned in these strategic plans.

4.2 Trade-offs of ESs' inclusion

Figure 2 shows the four typical types of trade-offs that were considered and managed in the four strategic plans for Jiaozhou Bay. Planners and policy-makers clearly recognized that increasing some provisioning services can result in severe damage to other services. The plans recommended various activities to directly limit certain provisioning services: for example, “strengthen efforts to protect the coastline by stopping intertidal/pond aquaculture to restore its natural coastal condition” (Plan 1, Type 3) and “designate island protected areas in which any economic development that may change the island’s topography and geomorphology is forbidden” (Plan 2, Type 1). The plans also referred to some (but not all) indirect effects of coastal actions. For instance, Plan 4 (Type 4) acknowledged that “strictly controlling the coastal development and construction projects around Jiaozhou Bay will limit the erosion of the bay area and water quality, thereby protecting the marine hydrodynamic conditions and self-purification capacity”; meanwhile, it stipulated that industrial and port businesses should not be allowed “to occupy high-quality beaches and shoreline” (Plan 4, Type 4). This suggests that the planners recognized the value of provisioning services in influencing several regulating and cultural services. This kind of indirect influence can also affect some supporting services (i.e., in Types 1 and 2) described in the four strategic plans.

Another driver-ES mechanism is a shared driving force that directly impacts multiple ESs rather than one. Although no specific references were given, the general knowledge and straight links between some certain drivers and ESs indicated that planners and policy-makers took them for granted. Here are two examples: 1) restoring the natural shoreline can directly create landscape value for cultural services (Type 3), and 2) defining an island’s protected area can preserve natural conditions for biodiversity (Type 1).

4.3 Synergies of ESs’ inclusion

Figure 3 illustrates the six typical types of synergies among ESs derived from the plans. These synergies show that most of the drivers create direct and positive influences on multiple ESs as a shared force in each relational type. The central focus of the drivers can be categorized into two groups. The first group of drivers is related to ecological restoration activities, such as establishing a wetlands park/reserve and restoring natural waterways (see Types 7 and 9). Drivers in this group directly stimulate cultural, supporting, and regulating services. Plan 1 underlined several outcomes arising from the provision of an urban wetlands park or reserve, including “moderately developing eco-tourism” and “enhancing the urban spatial landscape.” Meanwhile, the benefits of wetlands park or reserve “restore the waterfowl habitat to promote the conservation of wetland biodiversity and urban self-purification” (Plans 1 and 3). The activity of restoring natural waterways (Type 7) was only discussed once in Plan 1: it was aimed at “creating a chain of ecological islands in northern Jiaozhou Bay,” “enhancing the capabilities of urban areas to prevent damage from flooding, drainage and storm surges,” and “increasing the environmental capacity for better water quality.” In these cases, there were interrelationships between regulating and cultural services; relationships between supporting and regulating services were not described at all. Only two pairs of services, i.e., wetlands habitat and biodiversity maintenance, and wetlands habitat and tourism, were often cited together in all the documents studied, indicating bidirectional relationships.

The other group of drivers concerns developing an integrated functional area. On the one hand, these drivers can directly provide spatial and resource advantages for activities such as “creating a tourism industry that features a large industrial port” (Plan 1), “developing high-efficiency agriculture in coastal areas within a leisure and tourism corridor” (Plans 2 and 4), and “establishing multi-functional urban areas with an exhibition business, a residential area, leisure activities, marine research and history based on the local ecological environment” (Plans 1 and 3). On the other hand, these examples contained no detailed information about how the wide range of ESs could be enhanced together or how they could produce negative effects.

5. Discussion

5.1 Reflection on the inclusion of ES interrelationships

The case study results demonstrate how the four-step method presented in this paper could be useful in identifying a range of drivers and ES interrelationships implicitly considered by planners and policy-makers. The results of the analysis will remind policy makers of the need to focus on intangible, vulnerable services and indirect impacts, which could contribute to reducing conflicting uses and enhance the integration of interests in planning processes. Our findings suggest that planners and policy-makers in the Jiaozhou Bay case emphasize the need to encourage certain coastal activities, which at the same time limits trade-offs of different services, and constrains their synergies.

To put this understanding in a further international context, Table 4 illustrates a review of international case studies on ES interrelationships derived from recent international literature. These cases confirm that trade-off decisions, as perceived by decision-makers, experts, researchers and communities, show a general preference for provisioning services. As suggested by some scholars (Carpenter et al., 2006; Rodríguez et al., 2006; Hauck et al., 2013), two main reasons may explain why trade-offs are frequently linked to provisioning services. One could be that this group of services are utilized in regard of exclusive types of spatial use (i.e. landscape or seascape), and another reason is that they are highly tangible and always directly identified. Our findings accord with these general assumptions and reported findings. However, in the Jiaozhou Bay case, there appears to be a relatively broader consideration of the negative impacts caused by an emphasis on provisioning services: management that sets sights on providing a single provisioning service will typically reduce biodiversity and other services (Ring et al., 2010). Therefore, planners and policy-makers have attempted to reduce or restrict such negative impacts by spatially locating and developing strategies for ES provision.

Our findings are also in agreement with other research that found regulating services and supporting services are more likely to shape synergistic links (Table 4). In Jiaozhou Bay, there was an increasing focus on conserving and restoring the supporting services (e.g., wetlands habitat and biodiversity). Chinese planners and policy-makers have invested in supporting services rather than solely in provisioning services, with the former aiming at generating multiple benefits and avoiding a tension between development and the environment. However, the four plans failed to fully recognize many indirect effects of these activities on other ESs created through supporting services. For instance, defining an island protection area (Type 1) could maintain the habitat function. The long-term maintenance of coastal and marine habitats would increase biodiversity, which may provide an enormous fishery resource from the reserve because of the spillover effect (Grafton & Kompas, 2005; Shen et al., 2011). Moreover, maintaining the habitats may contribute to landscape protection as well as cultural heritage, benefiting scientific research and education (Ma et al., 2013). Interrelationships pertaining to regulating services were also generally underappreciated (e.g., carbon storage, algal blooms prevention, and erosion and siltation control). The plans barely reflected indirect contributions that natural regulating services would make to ecosystem resilience and other services, which has been highlighted by researchers such as Bennett et al. (2009). Reduced stress on natural services could result in an overemphasis on the engineered infrastructure as well as the loss of coastal buffering and other regulating services (O’Farrell et al., 2012). Therefore, we argue that these partial and fragmented acknowledgments fail to identify the bundle of ESs directly and indirectly affected by a driver, which likely results in an unbalanced appreciation of different ES categories.

Similar to several cases researched by other scholars (Rodríguez et al., 2006; Halpern et al., 2008), the selected strategic plans put little emphasis on temporal and spatial issues that were crucial for ES interrelationships. In the governance of Jiaozhou Bay, planners and policy-makers mainly focused on provisioning services at the local scale (e.g., agriculture, transport and navigation services). They overlooked the spatial aspect of regulating and supporting services that, “although delivered at a local scale, are dependent on ecological functioning that span broader spatial boundaries” (Duraiappah et al., 2014). One example is the wetlands park, which could be influenced by pollution from the upper reaches outside administrative boundaries – its management plan was restricted to the local scale. The frequency of activities relative to ecosystems' temporal dynamics is also critical for a better understanding of how a particular activity influences ES changes (Halpern et al., 2008). However, only the management of reclamation restriction in the bay indicated an awareness of the need to control long-term severe cumulative impacts. There was no other mention of such awareness in the plans. Accordingly, this weakness may nullify the definition of acceptable levels of activities permitted under certain ES levels, and affect decisions about how much one ES can be sacrificed in order to obtain another (Halpern et al., 2008).

Overall, the outcomes reported give planners and policy-makers insights into the importance of using multiple ESs by managing their interrelationships at different temporal and spatial scales. However, it is also important to recognize that clarifying ES interrelationships is not a simple task in practice. Strategic planning and policy-making will also face new challenges: for instance, how ES interrelationships can be comprehensively interpreted, when it is necessary to broadly balance different ESs, and how governance can maintain a grip on ES trade-offs and synergies.

5.2 Institutional implications

Not only did our method reveal interrelationships among ESs pertaining to diverse activities considered in coastal strategic plans but the method and the results also point out several reasons to explain the different levels of inclusion of drivers and ESs in the strategic documents of Jiaozhou Bay. These outputs could enhance actors' ability to reflect institutions and governance systems that fundamentally determine drivers and ES interrelationships.

First, our results show that strategic planning mainly underlines coastal economic development activities (e.g. the construction of agriculture, new towns, regional industrial cultural clusters and sea ports) to create multiple ES synergies associated with higher market value rather than ecological importance. This emphasis is understandable due to the socio-economic focus, and the initial market-oriented preferences of the majority of related authorities, particularly the coordinating sector that was responsible for each plan (see Table 1). The narrow ecological goals of most authorities probably lead to a lower diversity of drivers that may prevent ES trade-offs. Second, the financial appropriation discussed in the strategic documents also implies a lack of balance in the focus on ecological protection and marine economic activities. Funds could therefore wield a significant influence on activities that may benefit regulating and supporting services. Third, we cannot overlook the implications of the essentials of planning institutions on the inclusion of drivers and ESs. The essentials include the mutually related national, provincial and local legislations and regulations, and the approved specific plans focusing on, for instance, coastline protection and comprehensive river regulation. These current institutional arrangements (e.g. the Marine Functional Zoning, the Qingdao Provisions of Marine Environment Protection, and the Reclamation Control Line) mainly formulate the spatial features of most activities in order to avoid conflicts in ES use (see Figure 2). The arrangements also suggest that abiotic benefits are usually best recognized by local authorities as they are easy to integrate into planning processes (Piwowarczyk et al., 2013). Moreover, as regards the spatial and temporal mismatches, without a regional ES benefit-sharing institution based on broad cooperation, objectives, such as “realizing environment co-protection, industrial interaction and information sharing” across administrative boundaries” (Plan 1), were less likely to be met. Technical support was limited or not formally enhanced to strengthen the analysis of spatially and temporally accumulative effects on ESs. Project-oriented and regionally-oriented environmental impact assessments have proven to be particularly difficult for identifying spatial and temporal issues in strategic plans (Partidario & Gomes, 2013).

Overall, the analysis shows that when discussions of drivers and ES interrelationships were integrated in the plans, they were usually specific to policy concerns present in the institutional context in which the plans were embedded. Consequently, the existing institutional arrangements in Jiaozhou Bay should be adjusted. Efforts could be invested in enhancing initial ecological-value preference among planning sectors, expanding the scope of ecological goals and the investments of environmental projects, promoting coastal-related legislation and specific urban ecological plans, providing ES benefit-sharing schemes based on a broad participation of stakeholders, and strengthening technical planning support by integrating ES concepts.

5.3 Methodological reflection

We have developed a methodological framework, i.e. a four-step method, for identifying and analyzing which and how different activities and ES interrelationships may be included in coastal strategic planning. Content analysis has helped to establish straightforward and detailed qualitative insights. Its advantage is generally more pronounced when a contextual understanding is required to understand how institutional settings shape the use of ES concept (Piwowarczyk et al., 2013). Analytical tools that can inform such contextual understanding would enhance decision-making on ES trade-offs and synergies through planning processes (Wilkinson et al., 2013). The typology promoted by Bennett et al. (2009) provides a more causal description of ES interrelationships than the modeling and mapping methods (Lautenbach et al., 2010). By adopting this typology, our method provides a step towards an explicit identification of a set of policy interventions (i.e. drivers) that may modify relationships of services. Not only the scope of underlying driving forces could be expanded and observed, but a whole range of ESs was taken into account through the coding system. This expanding perspective enables more comprehensive discussions on specific driving elements and impacts than other single-issue ways, encouraging stakeholders to straightforwardly realize that most of their benefits from ESs are vulnerable due to their activities. Although we used a broad and perhaps partly inexplicit ES definition and classification promoted by the MA (2005) to create the coding system, its flexibility leaves sufficient space for further detailed mechanism analysis and, more importantly, an understanding among multiple stakeholders about ES concepts and classifications.

The scope of the findings suggests that our method and the other three existing groups of approaches, i.e., mapping, modelling, and social-survey analysis, in particular the social-survey analysis, could cross-fertilize each other. Apart from the contextual information and the broad scopes informed by our method, its qualitative understanding about planners' and policy-makers' ways of implicitly managing activities and ES interrelationships are likely to enhance non-scientific audiences' acceptance of ES quantification approaches (Kelble et al., 2013). In turn, the explicitness and accountability of quantitative information concerning each ES-interrelationship mechanism can be supplemented by spatial, biophysical, economic and social-value data. In particular, specific winners and losers created by certain drivers could be investigated through social methods, which in turn may complement the identification of indirect ES interrelationships that have been ignored in planning. Therefore, links can be clear between drivers and the benefits that related stakeholders may gain or lose from ES changes. The identification of these links provides a way of translating social values back into management strategies or even abstract goals for ES governance, and ultimately creates space for solutions.

Our method would be useful to promote the identification of ES interrelationships during the real-life planning processes, making decision making more rational and informed. For instance, in the early stage of defining the goals and the scope of plans, our method could assist planners to consider the balance in social-economic goals and ecological goals that affect drivers and related ESs, and to analyze the spatial and temporal scales for managing ES s. During the stage of designing actions to achieve the goals, the visualized causal description could make the current proposal explicit and understandable for actors, reminding planners some underlying links that have been previously overlooked. This method could also be helpful to select different options on ESs together with quantifying approaches in biophysical, economic and social-value terms. In the stage of planning revision and approval, assessment and suggestions on managing key drivers and their indirect, cumulative impacts to reduce conflicts could be put forward based on this method. Finally, the visualized causal description could work as a monitoring approach when patterns of natural resource or use evolve, requiring adaptive solutions.

Overall, our approach is only a preliminary step towards incorporating ES trade-offs and synergies into coastal strategic planning, and there are challenges facing implementation. First, different planning and policy contexts determine which and to what extents diverse ESs can be acknowledged and employed within a coastal area. This is a key precondition for identifying the majority of potential ES interrelationships and the effects of activities. However, unclear identification of each service in strategic plans would probably restrict the analysis of their relationships. Second, a dominant activity (one with an intensive or frequent influence) co-exists with other activities that have relatively minor effects (Halpern et al., 2008). This fact adds complexity to ES interrelationships and the long-term cumulative impacts analysis. Thus, it is a real challenge to identify and manage all possible drivers and the different extents of their impacts. Finally, given the guiding role played by strategic planning, only a few detailed ES interrelationships could be described in these strategic documents. This issue suggests that a specific assessment focusing on explicit ES-interacting analysis would be highly useful (e.g., as part of strategic environmental assessment, and ecological assessments of landscapes). Moreover, quantifying ESs across landscapes or seascapes and through time, and monitoring small changes in the relationships among services is also difficult (Bennett et al., 2009), but it would further refine the approach.

6. Conclusion

This paper argued that a more explicit and integrated inclusion of trade-offs and synergies among ESs will make coastal strategic planning more adaptive and sustainable, and that a systematic method to identify and assess this inclusion is needed. We presented a four-step research method that mainly depends on ES-interrelationship mechanisms to identify which drivers and ES interrelationships may be formulated in policy language in coastal strategic planning. Our approach revealed which driver-ES and ES-ES interrelationships (assessed in terms of direct or indirect, and positive or negative impacts) should be included. Again, the results showed that interrelationships involving regulating and supporting services were less appreciated in Jiaozhou Bay’s strategic planning than those concerning provisioning and cultural services, which is similar to most international case studies. The findings illustrated several direct institutional implications for considering different drivers and ESs. The four-step method used distinguishes itself among ES-interrelationship assessment approaches by identifying a wide scope of drivers and ESs and their consequences based on a more causal mechanism, broadening strategic planning discussions and making ES integration more explicit. Meanwhile, this methodology is valuable for reflecting the institutional context underlying ES interrelationships, and for providing potential for quantitative measurements.

Lessons learned from more case analyses and scientific knowledge informed by multi-disciplined research would benefit its further development. Although integrating ES interrelationships into policy strategies is difficult, further efforts for developing ecosystem-service thinking are appropriate, and will have to include efforts to invent policy rules for fundamental services (regulating and supporting) and interactions between users and services.

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List of Tables

Table 1. Summary of four strategic plans related to Jiaozhou Bay

No.	Document	Year	Sponsoring organization [a]	Implementing organization [b]	Source
Plan 1	"Conservation and Development Around Jiaozhou Bay" Strategy of Qingdao	2008	Qingdao Municipal Government	Qingdao Urban Planning Bureau (QUPB)	http://upb.qingdao.gov.cn
Plan 2	The Development Plan of Shandong Peninsula Blue Economic Zone	2011	National Development and Reform Commission, the People's Government of Shandong Province	Shandong Province Development & Reform Commission	http://www.sdlb.gov.cn
Plan 3	The Twelfth Five-year National Economic and Social Development Plans of Qingdao	2011	Qingdao Municipal Government	Qingdao Development & Reform Commission	http://www.qddpc.gov.cn/qddpc/
Plan 4	The Overall Urban Plan of Qingdao (2011-2020)	2012	Qingdao Municipal Government	QUPB	QUPB records office (paper documents)

a: The municipal government, provincial government and some national ministries mainly take the responsibility for developing strategic plans with regard to managing behaviors of communities and individuals.

b: A particular sector was assigned as the coordinating body to implement a plan. The coordinating sector would be assisted by all the other related sectors, an expert advisory committee and the general public in terms of providing diverse ES information for decision-making that lies with the municipal or provisional government.

Table 2. Coastal ESs identified in the four spatial plans for Jiaozhou Bay (Li et al., 2015)

Category	ES & Examples
Provisioning	Fish & seafood
	Energy production (biomass fuel, offshore oil and gas, wind, tide and wave power)
	Biochemical and pharmaceutical uses
	Transport and navigation (use of waterways for shipping)
	Coastal space for industrial development and infrastructure
	Residential and industrial water supply (abstraction of water for residential and industrial purposes)
	Urban ecological intervals (dividing different developing groups/function zones)
Regulating	Prevention of floods, storms, tsunamis and typhoons (protection by biogenic structures)
	Seawater intrusion
	Algal blooms
	Erosion and siltation control (maintenance of productive sediments, mitigating the effects of sea-level rise)
	Water purification and waste treatment
	Climate regulation (balance and maintenance of the atmosphere)
Cultural	Tourism and recreation (beach tourism, sunbathing, diving, windsurfing and kite-surfing, fishing, spas and wellness centers, bird-watching)
	Cognitive values (education and research arising from the marine environment, school excursions, monitoring global environmental change and indicators of ecosystem health, long-term environmental records)
	Aesthetic beauty (landscape)
	Cultural heritage and identity (value associated with the marine environment itself)
	Sea sports (competitive sailing, yacht races and other seawater competitions)
Supporting	Maintenance of biodiversity
	Maintenance of habitats

Table 3. Drivers and ESs of trade-offs and synergies included in strategic planning for Jiaozhou Bay

Type	Driver	Service A	Cate*	Service B	Cate*	Service C	Cate*	Service D	Cate*	Service E	Cate *
Trade-off											
1	Defining an island protection zone	Economic development that changes topography and geomorphology	P	Biodiversity	S						
2	Development of estuarial wetlands	Modern manufacturing industry	P	Wetlands	S						
3	Natural shoreline restoration	Intertidal/pond aquaculture	P	Coastal aesthetic sense and landscape	C	Water purification	R				
4	Shoreline division for reclamation control, industrial development, petrochemical zone control	Land use for industry, agriculture, port development	P	Environmental capacity within the bay, self-purification capacity	R	Landscape resource	C				
Synergy											
5	Special agriculture construction	Marine food supply	P	Leisure and tourism	C						
6	Upgrading port function	Shipping	P	Port tourism	C						
7	Excavating artificial river, restoring natural waterways	Protection from flood and storm surge	R	Water purification	R	The landscape of ecology island chain	C				
8	Constructing regional industrial cultural clusters	Marine culture	C	Tourism	C	Technology	C				
9	Building wetlands park or wetlands reserve	Habitat protection	S	Ecotourism	C	Biodiversity	S	Urban air and water purification	R	Urban spatial landscape	C
10	New town construction	House	P	Tourism	C	Wetlands	S	Business	P	Marine scientific research, history & culture	C

* **Cate**gory: P-provisioning service, R-regulating service, S-supporting service, C-cultural service

Table 4 Common ES trade-offs and synergies of different types of ecosystems analyzed by diverse methods

Source	Type of ecosystems	Study areas	Drivers	Trade-offs (vs.)	Synergies (&)	Methodology
Piwowarczyk et al., 2013 [a]	Coastal	Polish coastal municipalities	No specific	• (P-C) ports and fishery vs. beaches recreation • (S-C) biodiversity vs. leisure activities • (C-C) tourism vs. landscape		Content analysis
Wilkinson et al., 2013 [b]	Urban	Melbourne and Stockholm	Land use change	• (P-R) timber production vs. freshwater supply	• (P-C) agriculture and forestry production & recreational services	Content analysis
Salzman et al., 2001 [c]	Watershed	USA	Water management	• (P-S, P-R) agricultural food vs. soil erosion, flood protection and protection of species	• (R-R) watershed preservation & flood control	
Hauck et al., 2013 [d]	Agriculture, forestry, water	Finland, Germany, and Poland	No specific	• (P-S, P-R) industrial forestry vs. biodiversity, erosion, natural flood protection, purification of groundwater and natural carbon sinks	• (S-P, C-P) biodiversity and tourism & organic agriculture • (R-R, R-S) flood protection & water purification, erosion prevention, climate regulation and biodiversity	Survey, interview, focus group discussion
Holt et al., 2011 [e]	Estuary wetland	UK	No specific	• (P-C, P-R, P-S) fishing and farming vs. recreation, algae and biodiversity maintenance	• (C-C) aesthetic enjoyment & natural heritage	Workshop, content analysis
Potts et al., 2014 [f]	Marine	UK	Marine Protected Areas management		• (S-C) species & cultural wellbeing and tourism/nature watching • (S-S, S-R, S-P, S-C) habitats & supporting, regulating, provisioning and cultural services	Expert workshop
Busch et al., 2011 [g]	Coastal	Schleswig-Holstein, German	Offshore wind farm construction	• (P-C, P-S) offshore wind vs. recreation and habitat	• (P-R, P-P, P-C) renewable energy production & climate regulation, fishery and marine culture	Questionnaire, researchers workshop
Martín-López et al., 2012 [h]	Territorial	Spain, the Iberian Peninsula	No specific	• (P-R, P-C) provisioning vs. regulating and almost all cultural services		Questionnaire, statistical analysis
Butler et al., 2013	Floodplain	Tully–Murray	No specific	• (P-R) food and fibre production vs. water	• (R-C) water quality & floodplain	Statistical

		catchment, Australia		quality	recreational and commercial fisheries	analysis
Raudsepp-Hearne et al., 2010	Pre-urban agricultural	Quebec, Canada	No specific	• (P-R, P-C) crop and pork production vs. both regulating and cultural services		ArcGIS, ES proxies
Turner et al., 2014	Territorial	Denmark	No specific	• (P-C, P-R) crop production vs. sense of place, carbon storage, and wetland water purification	• (R-C) carbon storage & sense of place and nature appreciation • (P-P) crop production & livestock production	ArcGIS, ES proxies
Nelson et al., 2009	Watershed	Willamette Basin, Oregon	Land use change	• (P-R, P-S) agricultural crop products, timber harvest, and rural–residential housing vs. hydrological services, soil conservation, carbon sequestration, and biodiversity conservation	• (S-R, S-P, S-C) biodiversity conservation & other ES	InVEST
Eigenbrod et al., 2009	Watershed	Lake Victoria Basin, East Africa	No specific	• (P-R) agricultural production vs. sediment control		Biophysical models and GIS
Gee, K Burkhar, 2010	Forrest	Jonkershoek Valley, South Africa	Afforestation	• (P-R) timber production vs. water supply	• (R-P) carbon sequestration & timber production	Ecological-economic model
Haase et al., 2012	Rural-urban	Leipzig-Halle region, Germany	Soil sealing; brownfield restoration	• (P-C) food supply vs. recreation potential • (P-R) food supply vs. climate regulation • (C-R) recreation vs. carbon storage	• (S-C) bird species diversity & recreation • (P-R) food supply & carbon storage • (S-R) biodiversity potential & carbon storage	Biophysical models, mapping
Van der Biest et al., 2014	Watershed	Grote Nete Basin, Belgium	No specific	• (P-R) food production vs. climate regulation • (P-R) wood production vs. climate regulation		Model and mapping

a, b, c: ES trade-offs and synergies perceived by decision-makers and planners

f, g: ES trade-offs and synergies perceived by experts or researchers

d, e, h: ES trade-offs and synergies perceived by stakeholders (e.g. fishers, NGOs, planners, sectoral workers and local communities)

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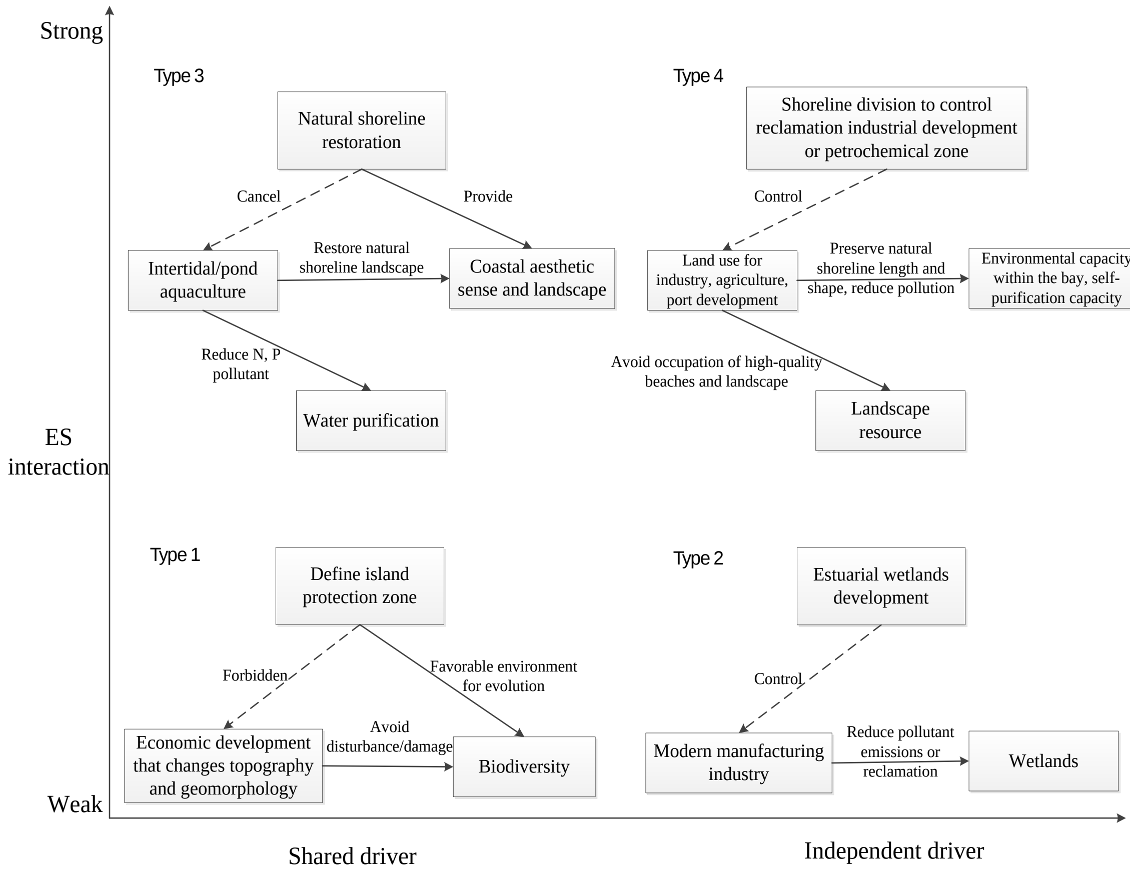

Figure 2. Relational diagrams of ES trade-offs identified from the Jiaozhou Bay strategic plans

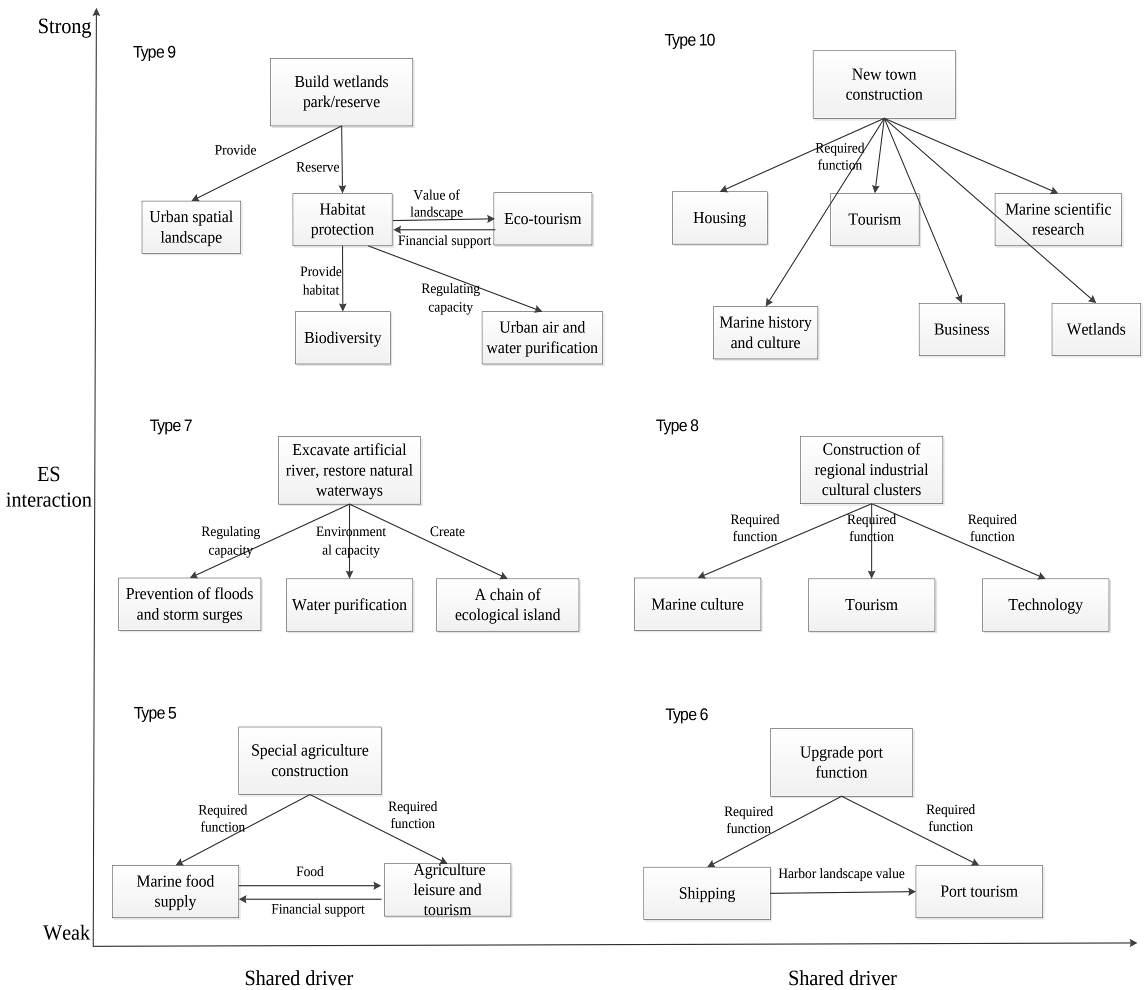

Figure 3. Relational diagrams of ES synergies identified from the Jiaozhou Bay strategic plans