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Blue Growth and the relationship between ecosystem services and human activities: The Salento artisanal fisheries case study

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ABSTRACT

This paper proposes a tool for the management of marine and coastal areas based on the ecosystem service framework and the Bayesian network approach. The participative methodology used makes this tool very suitable for addressing issues related to community-led coastal development and Blue Growth. The Salento (Italy) artisanal fisheries case study is used to test the usefulness of our approach. Salento is characterized by declining fisheries and increasing tourism development. Cause–effect relationships between human activities and ecosystem services are modeled to show the differences in stakeholder behavior under different scenarios. Results indicate that increasing tourist flow and related infrastructure are not perceived as threats to the local ecosystem equilibrium, but the problem of water quality should be carefully considered to prevent future negative feedback. The model can be used as a methodological guide by local public authorities as well as economic and civil society groups. It may be particularly useful for the Fisheries Local Action Groups, which have been explicitly created to design and implement bottom-up strategies that fit their regions' needs to increase economic, social, and environmental welfare.

1. Introduction

Marine and coastal ecosystems support numerous economic activities. This is strongly related to the recently proposed concept of “Blue Growth,” which is defined by the European Union (Communication from the Commission 13.09.2012) as the maritime contribution to achieving the EU goal of sustainable growth. Seas and oceans are considered, in other words, as drivers for the economy. Blue Growth includes all the economic sectors related to seas and coastal areas including tourism, shipping, fishing, mining, and biotechnology, among others. All these sectors are valued, according to the EU approach, considering their contribution to gross value added (GVA) and employment. Emphasis is on the growth of all sectors as a whole, rather than on the maximization of only one sector's objectives. Furthermore, to achieve positive long-term results, economic activities and ecosystem potential must be in equilibrium.

According to the EU's definition and previous examples, not all Blue Growth activities (e.g., shipping and mining) are supported by ecosystems, but many others are, especially fisheries, aquaculture, tourism, and biotechnology. However, even if they are not directly supported by the ecosystem, all Blue Growth components may nonetheless affect the stock and quality of ecosystem resources. This, in the long run, can affect the activity of stakeholders that use these resources (e.g., fishers), causing changes in behavior and diversification of income-producing activities.

Under this context, the ecosystem service approach seems to be the most suitable way to show the connection between costal/maritime human activities and the environment, and consequently, it is an effective methodological framework to analyze Blue Growth.

This paper applies an analytical framework based on the ecosystem service literature (Boyd and Banzhaf, 2007; Fisher et al., 2008; Haines-Young and Potschin, 2009a; Potschin and Haines-Young, 2011; TEEB, 2010). The framework is first presented from a theoretical perspective and then adapted for a Bayesian network application. In the case of aquatic, marine, and coastal ecosystems, Bayesian networks have been used for several different objectives, such as predicting natural events (Johnson et al., 2010), assessing climate change adaptation (Richards et al., 2016), modeling species

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interactions (Stafford et al., 2016, 2015), evaluating fish population viability (Marcot et al., 2001), managing potential conflicts (Tiller et al., 2013), and supporting marine planning (Stelzenmüller et al., 2010).

Further, the Bayesian network was developed to create a qualitative model that could be used to simulate the main socio-ecological relationships of coastal and marine areas, and to show the likely changes under different scenarios. In particular, we want to focus on the environmental changes caused by human activities and the manner in which these environmental changes, in turn, affect the outcomes and behavior of other stakeholders.

We examine these relationships in Southeast Italy (Salento, Apulian peninsula), where artisanal fisheries and tourism are closely connected. However, while fisheries are currently declining due to the overexploitation of fish stocks, tourism is developing rapidly. Given the specific characteristics of this area, the study mainly focuses on the behavior of artisanal fishers and on the possibilities of economic diversification provided by the natural environment.

The model can be useful as a management tool, in order to understand the cause–effect relationships between economic activities and ecosystem services, and can be applied by both public authorities and local associations to manage bottom-up development initiatives. The participation of stakeholders, including managers of local institutions (public, economic, and civil society), was crucial for building the model, and this participative approach should be a further aid to increase the management capacities of the population.

2. Material and methods

2.1. Description of the study area

The Salento region (corresponding with the Province of Lecce) is located at the southeastern tip of the Apulian Peninsula (Fig. 1). It has approximately 807 000 inhabitants, of which 309 000 (38%) are located in coastal municipalities. Excluding the coastal municipality of Lecce (93 000 inhabitants), the remaining population lives in towns and villages with fewer than 30 000 inhabitants (ISTAT, 2013).

Fisheries and tourism are the most iconic activities of the coastal area. In the Apulia region as a whole, fisheries and aquaculture account for 0.4% of the total gross value added, while the share of restaurant and hotel services is about ten times larger. Tourist arrivals registered an 80% increase between 2002 and 2009, followed by a more moderate 7% increase between 2009 and 2013 (ISTAT, 2013).

There are approximately 428 vessels operating in the Salento area, of which 334 use passive gears and 94 use towed gears. Vessels smaller than 12 m using passive gear, which are usually classified as artisanal vessels, number 313, or 73% of the fleet. In addition to these, about 30 vessels are used for diving fisheries. There was an 11% drop in the number of artisanal vessels from 2004 to 2015 (Community Fishing Fleet Register, 2015).

Catch statistics for the Apulia Region as a whole show that in the last nine years (2004–2013), catches have decreased by 46% (by 56% for artisanal fisheries), revenue has decreased by 19% (by 46% for artisanal fisheries), and catches per vessel have decreased by 30% (by 51% for artisanal fisheries) (IREPA-NISEA, n.d.).

In the recent past, Salento's cooperatives of artisanal fishers have implemented voluntary management initiatives (such as rest periods) to decrease the impact on fish resources and have initiated testing activities to improve the selectivity of fishing gears. At present, all the cooperatives have together established a coordination body that will prepare a local management plan.

In the Salento area, we find two Fisheries Local Action Groups (FLAGs), which are institutional partnerships between fishery actors and other local public/private/environmental/NGO stakeholders. These FLAGs are promoted by the European Fisheries Fund to foster bottom-up coastal development projects (e.g., direct sale, pesca-tourism, and environmental protection). Salento is also characterized by the presence of a small Marine Protected Area[1] and several inland protected areas.

2.2. The ecosystem service framework

After the Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005), several ecosystem services frameworks have been developed (e.g., Tallis et al., 2008; Haines-Young and Potschin, 2009b; Wainger and Mazzotta, 2011; Salles, 2011; Plieninger et al., 2012). One of the most successful is probably the ecosystem service cascade first designed by Haines-Young and Potschin (Haines-Young and Potschin, 2009a; Haines-Young, 2011), which describes ecosystem services as nature's free gifts that linearly flow from biophysical structures and processes to human populations. Most of the latest cascade versions accept the idea that ecosystem services must be distinguished as either final or intermediate (Boyd and Banzhaf, 2007). Final ecosystem services are defined as the components of nature directly enjoyed, consumed, or used to yield human well-being. Intermediate services have been referred to under different terms, such as structures, processes, or functions (Haines-Young and Potschin, 2009a; Spangenberg et al., 2014), where structures (natural ecosystems) are generally seen as assets able to produce a flow of beneficial services over time (Barbier, 2007). Furthermore, it is also widely accepted that final ecosystem services are used to produce benefits (Boyd and Banzhaf, 2007; Fisher et al., 2008; Haines-Young and Potschin, 2009a; Potschin and Haines-Young, 2011; TEEB, 2010), and that such benefits are the result of some human intervention, such as investments of labor, time, resources, or money. In marine and coastal environments, these human interventions can be defined as Blue Growth activities. Finally, benefits are normally seen as physical outputs (goods or services) to which a monetary value can be attributed (Potschin and Haines-Young, 2011; TEEB, 2010). However, here an important difference between the Blue Growth approach and the ecosystem service approach does exist. In fact, in the EU Blue Growth approach, only market activities are valued (using GVA). On the contrary, in the ecosystem service approach, the Total Economic Value is normally considered, including the value of services provided by the environment that have not a market (e.g. bathing, recreational fishing, scuba diving, but also non-use values such as in the case of biodiversity conservation).

We propose a theoretical framework (Fig. 2) which combines the key steps of the classic ecosystem service cascade with a second cascade that includes the major drivers of change, degradation, or loss of marine and coastal ecosystems (UNEP, 2006). In the cascade, we employ the terms *intermediate services*, *final ecosystem services*, and *benefits*, which are the result of a human activity. The level of benefits supply, clearly depends on several entrepreneurial choices. Furthermore, the value of the benefits depends both on the level of supply and on the level of demand (linked to consumer preferences), where entrepreneurs (e.g., fishers) clearly try to maximize their utility (i.e., the net value of the benefit).

We follow UNEP (2006) for identifying the direct and indirect drivers of change of marine and coastal ecosystems. With indirect drivers, we mainly refer to large-scale (national/regional/global) sociopolitical, demographic, economic, scientific, and technological

[1] The Porto Cesareo MPA, with a sea surface area of 16.654 ha.

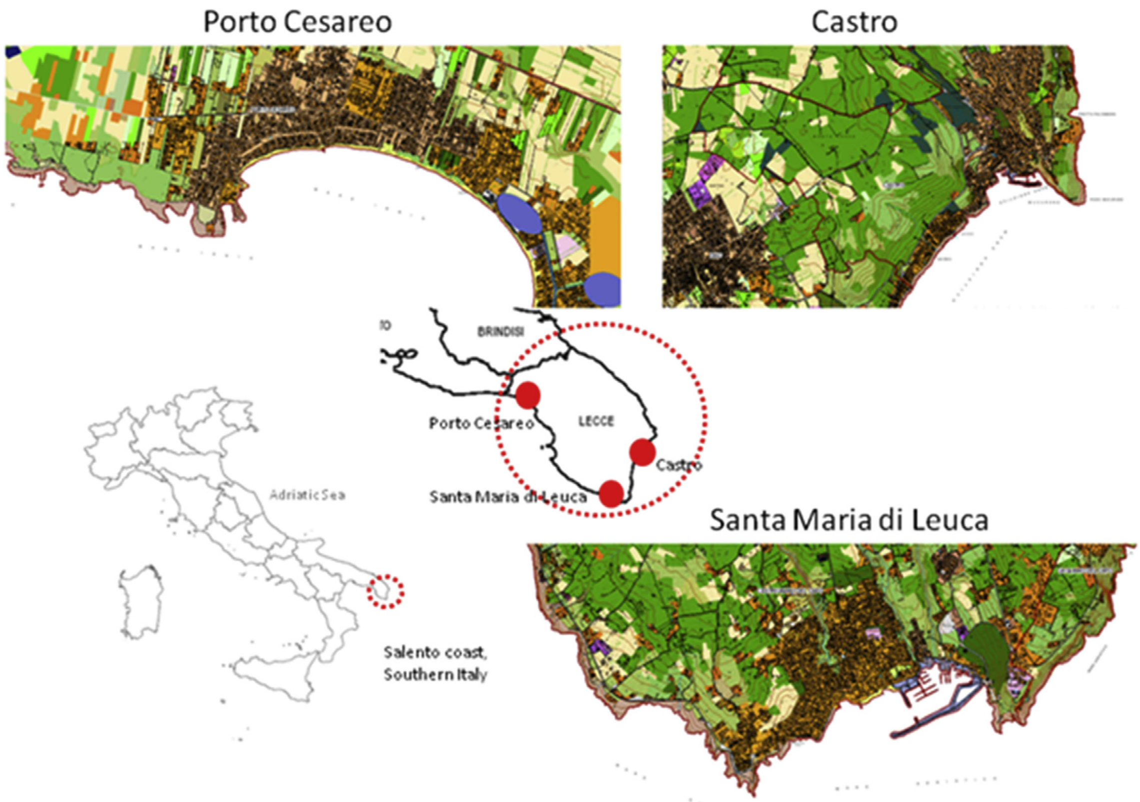

Fig. 1. The Salento case study area with the coastal villages where interviews were conducted. (source: http://webapps.sit.puglia.it/).

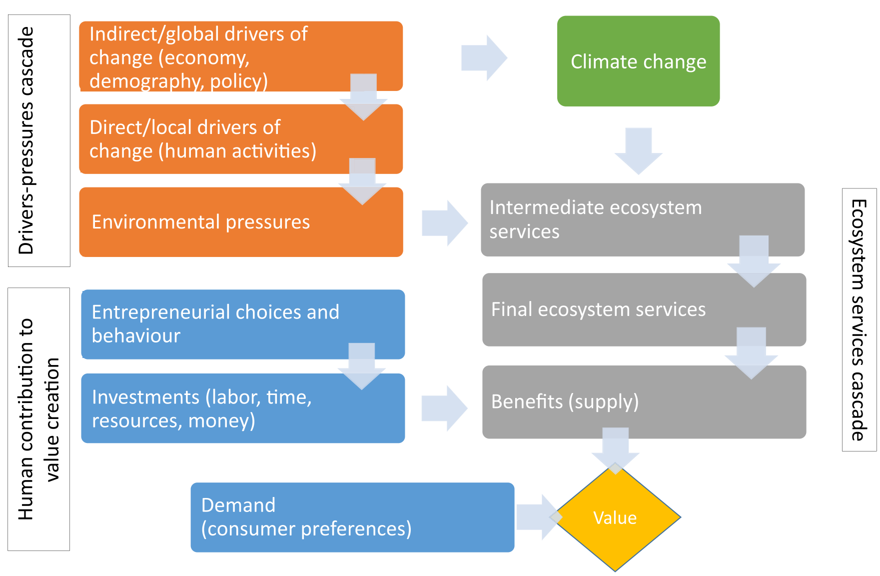

Fig. 2. The theoretical framework, including the ecosystem service cascade, drivers of change, and behavior of people.

trends. By contrast, direct drivers are local human activities, regardless of whether these are linked to Blue Growth (e.g., coastal development, fisheries, mining, aquaculture). Finally, drivers produce outputs that can be considered as environmental pressures causing modifications to the structure or flow of the ecosystem services: for example, agriculture is a driver, and it may produce environmental pressures such as pollution owing to the use of herbicides and fertilizers. In this framework, climate change has a special position, being the result of global drivers and, at the same time, the cause of changes at the local level (Fig. 2).

2.3. Bayesian networks

Ecosystem services theoretical frameworks have given rise to different types of mathematical models (Gómez-Baggethun et al., 2010; Haines-Young and Potschin, 2009b; Kareiva et al., 2011;

Villa et al., 2014). A Bayesian belief network (BBN) is a semi-quantitative approach that has gained importance in ecosystem service modeling due to its high transparency, the possibility to combine empirical data with expert knowledge, and its explicit treatment of uncertainties (Landuyt et al., 2013). Landuyt et al. (2013) and McVittie et al. (2015) show the excellent conceptual fit between the structure of BBNs and the ecosystem service production cascade.

BBNs are based on two structural model components: a qualitative part represented by a directed acyclic graph (DAG) that denotes dependencies and independencies between the model's variables, and a quantitative part represented by conditional probability tables (CPTs) denoting the strengths of the links in the graph. Each variable contains a limited number of states. The statistical dependencies between different variables are indicated in the DAG by arrows, which represent cause–effect relationships. Since the graph is acyclic, feedbacks are not allowed. Both the DAG and the CPTs can be based on expert and stakeholder knowledge or can be learned by empirical observations.

Prior (unconditional) probabilities P(X) express the probability that some input parameter will be in a particular state. Conditional probabilities P(X|Y) represent the likelihood of the state of a parameter given the states of input parameters affecting it. Finally, posterior probabilities represent the likelihood that some parameter will be in a particular state given the input parameters, the conditional probabilities, and the rules governing how the probabilities combine (Marcot et al., 2001). Inference in a Bayesian network is based on the notion of evidence propagation and refers to the process of computing the posterior marginal probability distributions of a set of variables of interest after obtaining some observations of other variables in the model (Nadkarni and Shenoy, 2001).

For the construction of our BBN, we followed a procedure similar to that of Marcot et al. (2006). The initial selection of the variables and the structure of the DAG was decided after a double step procedure including (a) a consultation between six members of the interdisciplinary research team (including biologists and economists), and (b) three meetings with groups of stakeholders in three coastal villages of the study area (see Fig. 1). In total, 50 stakeholders participated in these meetings, all involved in different activities related to Blue Growth, including artisanal fisheries (52% of participants), recreational fisheries (8%), diving (6%), and other inland activities (mainly tourism activities: 34%). Almost all participants were males. Meetings were used to define the anthropic activities or pressures perceived to have played an important role in environment modification. Furthermore, the main adaptive behaviors of fishers were selected as well. The model was designed based on the research team's experience and the information collected through literature and meetings. The parameterization process was based on evaluations of general patterns of the functioning of coastal and marine ecosystems, the effects of drivers of change, and the theoretical behavior of fishers. Probabilities were intended to reflect qualitative relationships between the different states of the variables (e.g., low, medium, and high) rather than absolute values.

The cause–effect relationships included in the model have undergone peer review by three experts, managers of local institutions, who substantially confirmed the initial structure. The institutions involved at this stage were a FLAG, the fisheries cooperative leading the coordination body to prepare the fisheries management plan, and the regional office of parks and natural reserves.

With the defined DAG and parameterization, the functioning of the BBN has been tried for different scenarios, simulating the reactions of fishers under different situations of ecosystem service shortage and degradation. The model was developed using GeNIe 2.0, an open source Bayesian network-modeling program.

Since the model mainly represents a simulation of hypothetical scenarios, rather than a quantification of empirical situations, there is no way to calibrate or validate the models on the basis of case data (Marcot et al., 2006). To partially remedy this problem through a qualitative procedure, we conducted an in-depth interview with a panel of 25 stakeholders (different from those previously consulted in the meetings) focusing on the perceived importance of the cause–effect relationships included in the model. At this stage, interviewees included 36% of artisanal fishers, 12% of recreational fishers, 32% of divers, and 20% of people involved in inland activities. Again, almost 90% of interviewees were male. Quantitative questions based on Likert scales as well as open questions were included, but due to the small sample size, we preferred to avoid a quantitative analysis of results. Questions were about stakeholders' opinions on recent trends regarding the variables included in the BBN and on the relationships between variables. Compared to the BBN, a few variables were added in the questionnaires in order to verify the necessity of a more integrated framework.

3. Results

3.1. The directed acyclic graph (DAG)

The DAG focuses on the aspects, processes, and problems that were found to be most important through the experience of the research team members and the meetings with stakeholders and local experts. These are mainly related to the processes affecting artisanal fisheries and to the processes that could lead to a diversification of fishery activities.

Following our theoretical framework, we used, as initial inputs of the model, the direct (local) drivers of change (i.e., human activities), excluding the indirect drivers that affect the entire system. The five variables selected as drivers of change were urbanization (concerning residents), tourism infrastructure, recreational fisheries, artisanal fisheries (small-scale fisheries), and industrial fisheries (trawling fisheries).

From these drivers, a few environmental pressures were derived, namely, the emission of water contaminants as well as light and noise pollution, consequences of urbanization and expansion of tourism infrastructure. In the case of fisheries, we consider that effects are directly linked to the quantity and quality of ecosystem services (i.e., fish stocks). Four final ecosystem services are included in the model: water quality, the beauty of the landscape, the level of fish stocks, and a qualitative attribute of fish stocks, their location. Only water quality also has a function as an intermediate ecosystem service, being one of the causal nodes linked to the level of fish stocks. Finally, water quality and the beauty of the landscape directly affect the flow of tourists and indirectly, through the presence of tourists, the demand for fish at the local level.

The state of ecosystem services and the level of demand affect several decisions of fishers who, in theory, want to maximize their utility. In our model, three decisions have to be made by fishers: first, they have to decide whether to continue to be fishers or to change their activity, in particular, as providers of some tourism service (fishing/tourism decision), or to be unemployed, or choose a different job (neither fishing nor tourism). Second, if they decide to continue fishing, they have to decide whether to fish close to or far from the coast (location decision). These two decisions, together with stocks level and position, affect the level of catches (which is the physical benefit of fisheries). Finally, fishers have to decide between selling their product at the wholesale market and directly to consumers, restaurants, or hotels (market strategy).

No policy or management nodes, which are often used in BBNs, are included in the model. Actually, many different policy/management nodes could be used, at least one for each of the drivers of change (and for fishers' decisions as well), showing the effects of rules on these elements. We thought that this solution would unnecessarily complicate the model, since inference on policy needs can be easily made from the analysis of the nodes representing local drivers.

3.2. Scenarios

Since the main scope of this BBN lies in its capacity to simulate the effects of alternative scenarios on human behavior, we show the results of cause–effect relationships under four different situations (Table 1). These are (a) a standard scenario; (b) a scenario with low levels of fish stocks; (c) a scenario with low levels of fish stocks and high levels of tourist inflow; and (d) a scenario with high levels of water contaminants.

In Fig. 3, we show the results of the basic scenario (a) with standard (and not clearly defined) levels of drivers of change (fisheries, urbanization, and tourism infrastructure with all states set at 50% probability) and standard levels of ecosystem services. In this scenario, artisanal fishers are led to continue fishing (52%), to fish close to the coast (32%), and to have a balanced market strategy (26% selling to the wholesale market and 27% engaged in direct sales).

Scenario (b) considers low levels of fish stocks ("low" stocks is manually set at 100%). Consequences of this change are clearly visible on the fishing/tourism decision. The probability that fishers continue fishing decreases (19%), while there is an increase in the likelihood of selecting either a differentiation to tourism activities (38%), or the third alternative, fishers pursuing neither fishing nor tourism (43%). Consequently, the level of catches decreases. The state of the drivers of change is also modified in order to find an explanation for this new situation. In fact, the BBN considers abductive inference (from effects to causes) besides deductive

Table 1
Difference in posterior probabilities of fishers' decisions in the different scenarios.

Variable	Scenarios							
	Standard (a)		Low stock (b)		Low stock and high tourist demand (c)		High water contaminant (d)	
Fishing/tourism decision	Fish	52%	Fish	19%	Fish	10%	Fish	51%
	Tourism	26%	Tourism	38%	Tourism	70%	Tourism	19%
	None	22%	None	43%	None	20%	None	30%
Location decision	Close	32%	Close	11%	Close	6%	Close	29%
	Far	20%	Far	8%	Far	4%	Far	22%
	No fishing	48%	No fishing	81%	No fishing	90%	No fishing	49%
Market strategy	Wholesale	26%	Wholesale	12%	Wholesale	3%	Wholesale	30%
	Direct	27%	Direct	8%	Direct	7%	Direct	21%
	No sale	48%	No sale	81%	No sale	90%	No sale	49%

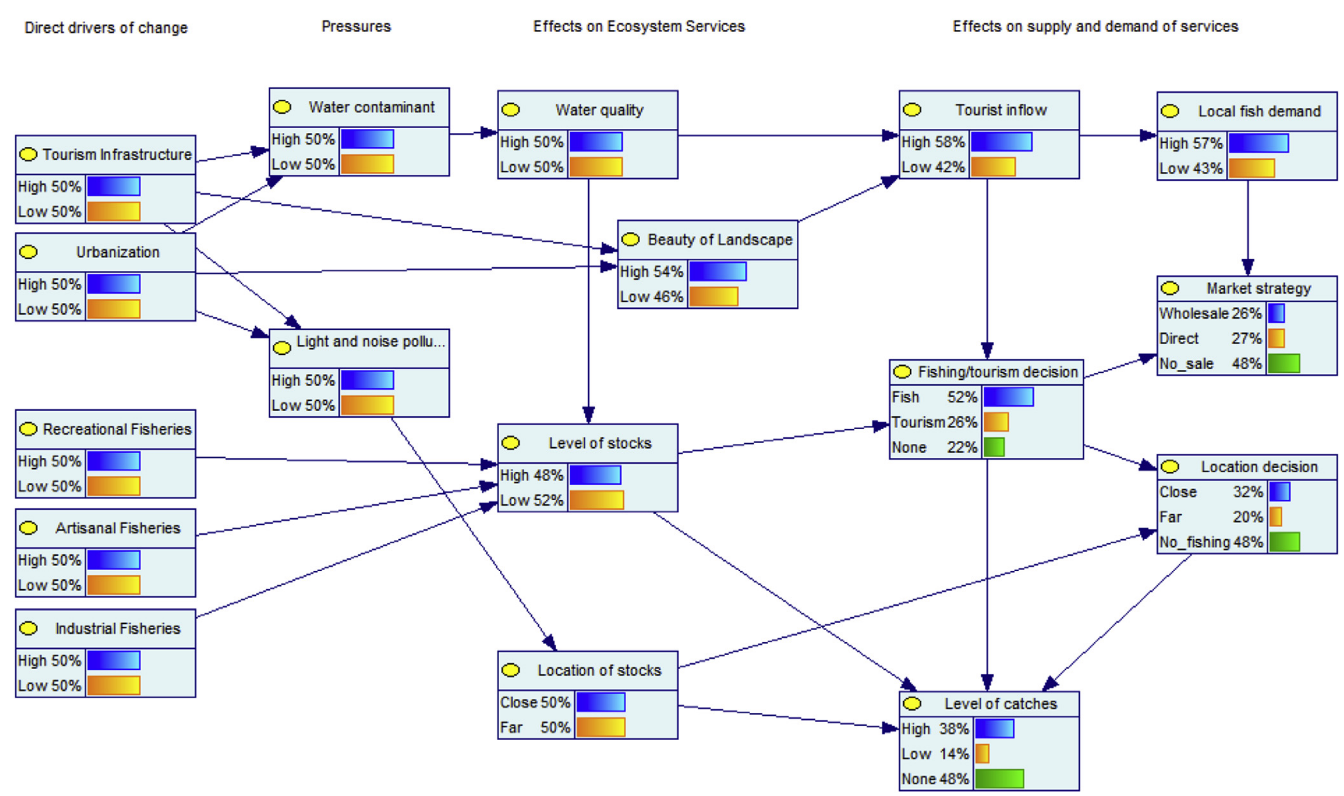

Fig. 3. The BBN with the values obtained for the standard scenario (a).

inference (from causes to effects). Thus, in absence of further information, a decrease in stock levels is explained as an increase in fisheries and as a decrease in water quality. Since water quality affects tourist inflow (with lower water quality attracting fewer tourists), it is probable that fishers choose an alternative that is not a tourism activity.

During economic crises, this third alternative can coincide with unemployment. Thus, tourism activities represent an interesting option when fishing is not profitable anymore. That is what is observed in the third scenario (c), where fish stocks are low (100%) but tourist inflow is high (100%). To allow this situation, however (all external variables held constant), the water quality should increase (to "high," at 59%), as well as the beauty of the landscape ("high," at 72%). In this case, the probability that a fisher invests in some tourism activity is very high (70%), while the probability that he remains without a job is low (20%). On the other hand, fishers who continue fishing will probably decide to sell their products directly, due to an increase in the local demand of fish.

Finally, the fourth scenario (d) (Fig. 4) is a situation where the level of water contaminants is high (100%). This scenario is particularly interesting since water contaminants can affect both fisheries and tourism. Which of these are more affected depends on the conditional probabilities set by the research team. Compared to the standard scenario, it is more probable that the level of stocks and the tourist inflow be low; thus, in the fishing/tourism decision, the probability of both "fish" and "tourism" decrease. The fishers who continue fishing would probably fish "far", since contamination is linked to urbanization and, indirectly, to light pollution. Additionally, since local demand is low, they likely sell their products to the wholesale market.

All these scenarios, characterized by different states of the variables included in the model (especially the ecosystem services), should be considered as the effects of different management options. In particular, fisheries management plans and urban plans can be seen as the main tools for the regulation of the drivers of change, and consequently for the development of the coastal area.

3.3. Qualitative validation

The validation procedure showed that, in general, answers fit the relationships of the model, although some opinions may need further investigation. Furthermore, for some issues, substantial differences were observed depending on the occupation of the interviewees, similar to what was observed during the initial meetings with stakeholders. Some of these differences will be highlighted in the next paragraphs. These patterns reveal, from one side, that BBN parametrization, if performed through the opinion of stakeholders, can be very sensitive to their status and social-economic group. From the other side, it is clear that management decisions may affect groups differently: in other words, it is always important to assess physical/economic tradeoffs between different ecosystem services and between different social groups.

We will summarize the main findings of these interviews following Fig. 3 from the drivers of change to the effects on supply and demand of services. Tourism infrastructure and urbanization have certainly increased in the last ten years; both are judged the cause of increased water contaminant emissions, which did increase in this period. However, according to the interviewees' opinions, other causes have to be researched for the emission of water contaminants. Among these, stakeholders mainly indicated factories, agriculture, and, to a lesser degree, pleasure crafts and fishing vessels (e.g., wastes, fuel). People involved in touristic activities are less inclined to see a direct relationship between tourism infrastructures and water pollution.

Due to this emission of contaminants, the quality of the water is clearly decreased. In the BBN, one of the assumptions was the negative relationship between the level of tourism infrastructure/urbanization and the beauty of the landscape. However, the

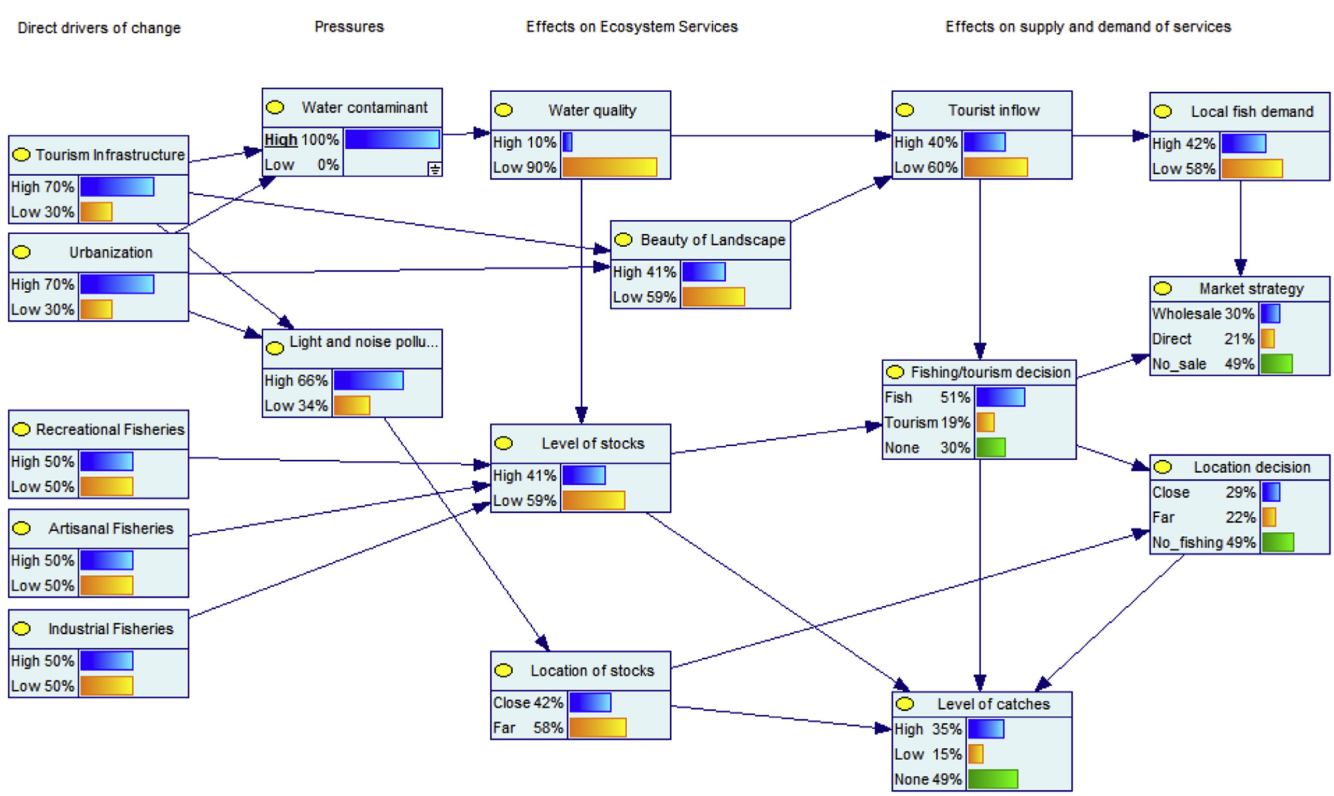

Fig. 4. The BBN with the values obtained for the scenario with a high level of water contaminants (d).

perception of stakeholders did not completely support this assumption. In fact, the beauty of the landscape is judged on average to have slightly increased in the past several years. In order to better understand this issue, we asked if tourism infrastructure was perceived to damage the beauty of the landscape or if infrastructure was able, in some situations, to improve the perception of the area. Answers were quite conflicting on this issue, so it cannot be assumed that a negative relationship exists between tourism infrastructure and the beauty of the landscape, at least in local stakeholders' perception. Different results could be obtained with interviews to tourists.

Water quality and the beauty of the landscape surely are important factors to attract tourism. However, despite the decrease in water quality, tourism inflow has certainly increased recently, so other external factors should be found to explain this situation, such as cultural activities and tourism marketing. Furthermore, it should be questioned if the water quality problem is perceived by tourists. This issue (which was perceived as very serious by all types of local stakeholders) has to be carefully considered in order to prevent future negative effects on tourism.

Strictly linked to the strong increase of tourist inflow is the strong increase in demand for fish by tourists, restaurants, and hotels. Fish demand by residents has also increased, although at a lower level. These demand trends, contrary to BBN assumptions, do not seem to have changed considerably the market channels preferred by artisanal fishers, who continue to sell both to intermediaries and to final consumers.

Recreational fisheries have increased considerably in the last ten years, while artisanal fisheries have decreased and the number of trawling fisheries is more or less constant. For this very reason, recreational fisheries are considered the main fishing-related cause of the decrease in fish stocks. Professional and recreational fishers blame each other for the environmental effects of their activities, while people with other occupations have intermediate positions. Divers, in particular, blame recreational and professional fisheries, but in general, the former are considered to have more impact than the latter. This opinion is clearly based on historic trends. However, these opinions only pertain to the causal relationship between recreational fisheries and fish stocks, and it would not be correct to infer that artisanal fisheries have no effect on fish stocks.

Beside recreational fisheries, water quality is considered very important for its effects on fish stocks. Furthermore, most stakeholders have added that (increasing) water temperature (not included in the BBN) should be considered a major contributor to stock decrease. Competition from alien species was considered negligible.

Fish stocks are considered to be decreasing, but not by all stakeholders. A commonly held opinion is that stocks are now located farther from ports compared to the recent past. Again, this situation is considered to be linked to recreational fisheries and water quality. Light and noise pollution could also have a causal effect, and this opinion is quite prevalent among artisanal fishers. As a direct consequence of the changing location of fish stocks, artisanal fishers are now fishing farther from shore compared to the recent past. The size and location of stocks affect the size of catches, which are decreasing. It should be noted that this opinion is not shared by all stakeholders, including inside the artisanal fishers group.

Finally, stakeholders agree that the trends for both fish stocks and tourism inflow are affecting the decisions of fishers about changing or differentiating their activity, similar to the results obtained in scenario (c). In fact, in the past 10 years, the number of fishers who have abandoned fishing for a tourism-related activity or for a different activity unrelated to tourism, or are now simultaneously involved in fishing and tourism has increased considerably.

A final question aimed to understand the effect of recent policies and public funds on the fishers' decision to continue fishing or differentiating in tourism activities. Of the respondents, 29% judged that public funds had no significant effects on this decision, while 54% thought that funds favored continuation in the fishing sector and only 17% thought that public policy pushed fishers toward tourism activities. However, it is curious to observe that while among artisanal fishers there is a moderate prevalence of answers in favor of the tourism conversion, among the other categories the opposite opinion prevails.

4. Discussion and future development

The validation procedure based on stakeholders' opinions confirms most of the assumptions used to build the BBN, and rejects or modifies a few others, such as the effect of tourism infrastructure on the beauty of the landscape and the effect of water quality on tourist flow. On the other hand, the increasing development in the Salento region, strongly driven by tourism, has caused a few environmental problems, especially related to water quality, that in the future could have a negative impact on tourism.

The scenarios and simulations of this study refer to a qualitative model due to the lack of more precise, quantitative data. Both the initial model and the validation procedure are based on opinions of experts and stakeholders. Thus, substantial work is required to collect significant information on the ecological, economic, and social connections of this case study and on the more general behavior of coastal communities. In particular, the true variables affecting the dynamics of fish stocks remain poorly understood, and interactions of elements such as types of fisheries, water quality, water temperature, species competition, and even light and noise pollution are generally ignored. Additionally, more information and analysis is needed to better understand the socio-economic behaviors of stakeholders.

Several nodes could be added to the model. In particular, we have not explicitly attempted to evaluate the benefits generated by ecosystem services. This could be done, starting from the BBN previously developed, through a few different approaches. For example, we could transform the BBN into a Bayesian decision network (BDN, also known as influence diagram), which is used to represent and analyze decision making under uncertainty. A BDN is a Bayesian network augmented with decision variables and utility functions specifying the preferences of the decision maker (Kjærulff and Madsen, 2013). The utility nodes represent the value of costs and/or benefits generated by the decisions, enabling cost–benefit analysis of alternatives. Solving a decision problem amounts to determining an optimal strategy that maximizes the expected utility for the decision maker (Kjærulff and Madsen, 2013).

In the specific situation of our case study, the three decisions made by fishers should be explicitly transformed into decision nodes, from which utility nodes are determined. In the example shown in Fig. 5, utility nodes correspond with the net benefit obtained by fishers who changed their activity to tourism services, with the gross benefit obtained by fisheries if fishers do not change their activity, and with the costs linked to fisheries. These three values are then summed up to obtain the net benefit to the entrepreneur.

Since solving a BDN means to indicate the decision (or set of decisions) that yields the highest expected utility, this tool would help to clarify the reasoning behind stakeholders' (i.e., fishers') decisions. It could explicitly explain why behaviors change under different scenarios (e.g., different stock levels, tourist flows, or water quality). For instance, due to a shortage of fish stocks, the

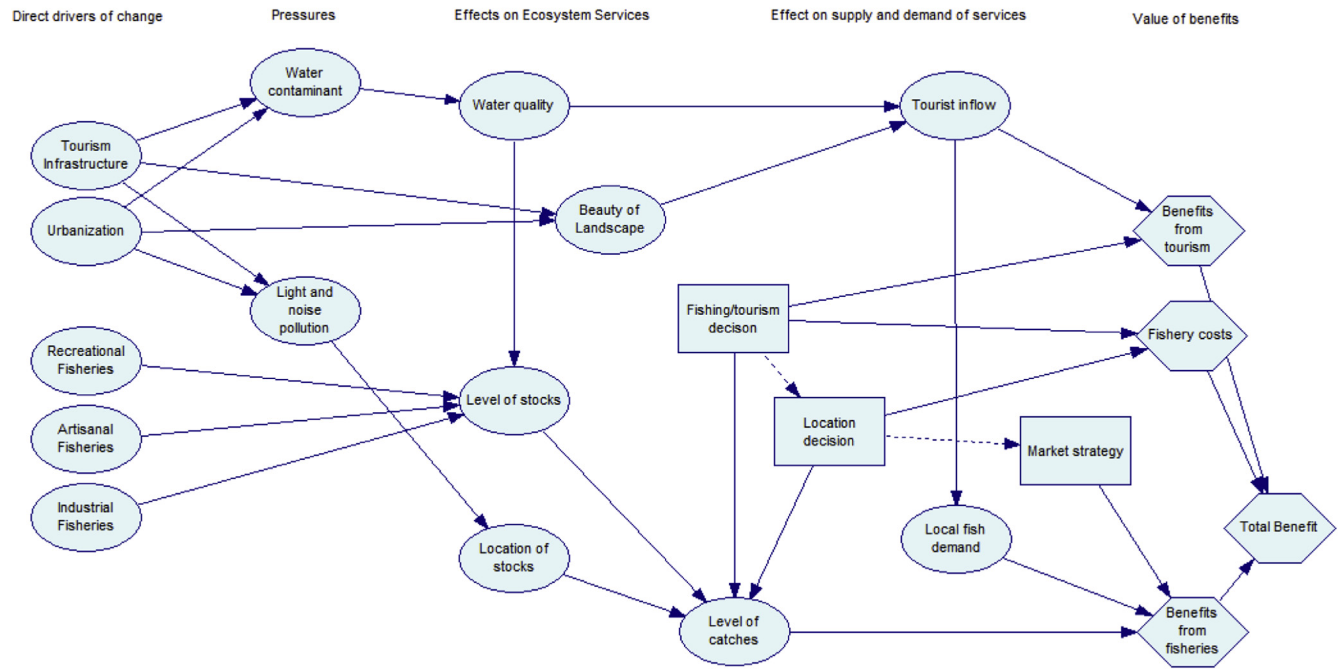

Fig. 5. A Bayesian decision network version of the model. Decision nodes are shown as rectangles, and utility nodes, as hexagons.

benefit obtained by fisheries should decrease and fishers would find it optimal to change their activity to the tourism sector.

The use of BDNs compared to BBNs should be evaluated considering the availability of information (i.e., utilities) and analysis objectives. BDN is a decision support tool that helps to identify, for a specific stakeholder (or a group of homogeneous stakeholders), the choices with the highest expected utility. On the other hand, it is clear that not all entrepreneurs follow the same choices and the same strategies. If this were the case, once the expected utility of investing in tourism activities is shown to be higher than continuing fishing, then *all* fishers should immediately change their occupation. Reality is more complex, and every entrepreneur differs in terms of beliefs about the future, abilities, information, risk aversion, and utility functions, and hence, given the same situation, one could decide to change work and another could decide to continue fishing. These differences in behavior are better modeled using the traditional BBN rather than the BDN.

BDNs have been generally used in ecosystem services studies to evaluate the effects of different management decisions, normally taken by public authorities, for generating social benefits (i.e., changes in the well-being of people), which correspond to the social value (or Total Economic Value) of ecosystem services under different scenarios. By contrast, we considered decisions taken by private stakeholders, and the value generated by the different choices of these stakeholders over the use of ecosystem services is mainly a private value. An integrated model should consider both public and private decisions. Such a model would be substantially more complex than traditional Bayesian networks. In fact, different utility functions should be defined for public and private stakeholders. The public stakeholder should maximize the social value of benefits, while the private stakeholder should maximize the private value of the benefits he/she achieves. This contrast of objectives should be examined using a game theory approach.

5. Conclusions

Bayesian networks are useful tools to address environmental management problems and to assess the impact of alternative management measures (Stelzenmüller et al., 2010). This study has shown how different scenarios, which are implicitly driven by different management decisions, affect environment quality, stakeholder behavior, and coastal area development. BBNs cannot be considered substitutes for empirically based, quantitative (stochastic) analyses (e.g., bioeconomic models of fisheries), but they can complement such models, and are particularly useful when empirical data are unavailable (Marcot et al., 2001). Furthermore, BBNs can be successfully used to work in a participatory way with stakeholders (Haines-Young, 2011), and stakeholders' experience can be explicitly utilized to test and improve the quality of the model. In addition to their importance for data collection, the participation of stakeholders in similar studies is essential to increase collaboration with scientists and, in this specific case, to empower small-scale fishing communities with information about their role and opportunities in the coastal and marine environment (Krueger et al., 2012).

The maximization of benefits linked to ecosystem services, in tandem with the Blue Growth approach, represents the natural strategy for coastal area development. Communities must recognize the potential of such development and build sustainable strategies. It is important to remember that private benefits represent only a part of social benefits. Benefits obtained by non-marketed services (including non-use values) are normally not considered in the Blue Growth approach. Clearly, without careful planning, private initiatives with counterproductive effects might proliferate because many ecosystem services are common goods. In fact, negative externalities are often the result of negative trade-offs between benefits generated by marketed goods and services and benefits generated by non-marketed goods and services.

The qualitative framework developed in this study for the Salento area can be considered a methodological tool for planning at several geographical and institutional levels, including that of public authorities and economic or civil society groups. In particular, it should be useful for the objectives of Fisheries Local Action Groups, which have been explicitly created to design and implement bottom-up strategies that address their area's needs to increase local welfare. The participatory approach used to build the framework, at the level of both private stakeholders and managers of local institutions, should be considered itself as an empowering exercise for the population of the area.

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