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Natural resource use conflicts and priorities in small islands of Vietnam

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Abstract
Small islands of Vietnam witness increasing natural resource use conflicts among stakeholders resulting from their isolation from the mainland, combined with more recent pressures of urbanization, tourism, and socio-economic development. A challenge facing both residents and governments is identifying more appropriate inter-sector cooperation to minimize conflicts taking into account short-term economic feasibility and long-term sustainability. This study deals with conflicts and priorities in natural resource use as perceived by residents and local officials in the Ly Son Island of the Vietnamese Southern-Central Coast Region. A decision tree on conflict and priority analysis is structured at four hierarchical levels: sector, sub-sector, socio-economic activity, and objective. While a Likert 5 scale's weighted mean (wMean) was applied to the survey data and to rank conflicts, the Analytic Hierarchy Process was used to estimate the weight values by priority. The results show that, although conflicts are limited, conflict hotspots exist in mountainous forested areas, farms, residential locations, and along coasts. Both residents and local officials shared the opinion that priorities help dealing with conflicts on the island. Over-all, perception analysis contributes to integrated spatial planning, marine spatial planning, and integrated coastal zone management for Ly Son Island with a consideration of improving inter-sector cooperation between agriculture, fishery, forestry and conservation, industry and service, tourism, and army.

Keywords Conflict · Priority · Small island · Perception analysis · Analytic hierarchy process (AHP) · Vietnam

1 Introduction

Worldwide, small islands face challenges caused by their ecological, cultural, and economic isolation from the mainland, their relative limited surface and their relatively limited natural resource bases (WTO, 2004). This results in limited foreign currency, small domestic

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markets, a limited economic scale, and increasing population and natural hazard pressures (Beukering, 2007). However, small islands have also strengths, such as oversea inputs, fish resources, export services, domestic manufacturing, tourism, and marine preservation to develop the local economy (Masalu, 2000). Scientific research revealed characteristics of conflicts in natural resource use on islands worldwide: They have interdisciplinary causes and cover a wide array of social, economic, environmental, political ecological, and other disciplines. Most often they relate to fishery and marine issues, ecological and coastal zone management conflicts (Bramati et al., 2014; Stepanova, 2015; Stepanova and Bruckmeier 2013; Sairinen et al., 2017). Particular concerns of small islands entail the intensity of tourism, seasonality, accessibility, water supply, sewage treatment, solid waste management, energy, access to natural resources, retention of benefits on the island, out-migration to places with more economic opportunities, preservation of unique cultural traditions, and climate change (WTO, 2004). Conflicts on small islands result from the economic demands, the pressure of local users on the coastal space and its scarce natural resources, such as arable land, fresh water, mineral resources, and conventional energy (https://www.ourplanet.com/imgversn/94/khaka.html). Poor funding and lack of institutional support by the government also contributes to conflicts (Abdelgalil & Cohen, 2007; Masalu, 2000; Dimelu, 2016). Competition among the demand of stakeholders for these resources can be recognized using perception analysis. The perception of fishermen on conflicts between aquaculture and commercial fisheries showed that the expanding aquaculture industry displaces local fishermen, which degraded environmental quality around aquaculture sites, and killed significant sea product stocks as lobsters, crabs and shrimps (Wiber et al., 2012). Krausmann et al. (2014) used an econometric model, showing the main relationships between land use, population and economic development as drivers of environmental conflicts. This pointed to demographic pressure and the environmental risks as the key significant factors driving the conflicts on natural resources. Bramati et al. (2014) and Chambers et al. (2017) concluded that, the differences between the costs of conservation and tourism, and their resulting inequalities were at the basis of conflicts between the island stakeholders. Next to the environmental issues, social and political conflicts emerging from natural resource scarcity were considered (Knudsen, 2016; Matthew & Gaulin, 2001; Meur & Hochet, 2010; Slatter, 2014). Particularly this type of conflicts was observed for a long time on islands in the South China Sea. Continuous attention was paid to conflicts on population growth and concentration, the development of recreational, industrial and non-renewable resource extraction and use in these areas (Valencia, 1979). Values of social conflicts in the Philippines were perceived through benefits and costs of conservation (Majanen, 2007). In South Bali (Indonesia), tourism caused rural–urban water conflicts because it is a main consumer of fresh water in urban areas, which results in the shortage of irrigation water for agriculture during dry years in rural areas (Strauß, 2011). A study on ranking spatial conflicts and allocating priorities for small-scale fisheries in the Hoai Nhon near-shore seascapes of the Central Coast of Vietnam showed that social conflicts among local and non-native fishers originate from their different fishing operations in the same sea water areas. Integrated spatial planning and integrated coastal zone management were proposed to adopt data on the local perception of conflicts (Nguyen et al., 2016). Stepanova and Bruckmeier (2013) concluded that, although the studies are abundant, research on conflicts on resource use in small islands is not a separate subject in the literature.

Because a conflict is accepted as a fundamental part of the society (Dimelu et al., 2016), local people perceive quite obviously its pattern, causes, processes, and outcomes. Quantitative methods of perception analysis allow understanding conflicts and inter-sector cooperation on natural resource use between both local users and economic sectors. Causes of

conflicts, conflict resolution, lessons learnt and best practices from the policy and legal responses were subject of research. Descriptive statistics is widely used in perception analysis, e.g., Majanen (2007) and Nguyen et al. (2016), as cited above. The technique is also used in combination with mathematical models. Malczewski et al. (1997) introduced an application of multiple-criteria group decision making (MCGDM) to analyze environmental conflicts and priorities over land resource allocation in the Cape Region, Mexico. Components of the hierarchical structure of land suitability include: interest groups, socio-economic activities, objectives, and attributes. Participatory planning workshops commonly involve representatives of policy makers, socio-economic sectors, and non-governmental organizations (NGOs). Water catchment comes out as the most significant driver of environmental conflict, which prevented the allocation of the intensive activities with the less intensive ones. Three strategies of conflict management were proposed. Masalu (2000) deals with minimal solutions for conflicts on resource use in coastal and marine areas in Tanzania based on a statistical analysis of the survey. Dimelu et al. (2016) combined structured interviews, focus group discussion, personal observation, and descriptive statistics to study conflicts in Kogi State, Nigeria. They compared perceptions between crop famers and herdsmen on the causes of conflicts and the effectiveness of the management strategies. A combination of a political ecology framework and empirical measurements of the environmental changes allowed analyzing local resource conflicts in Agro-Pastoral West Africa. Relationships between environmental changes, agro-pastoral livelihood adaptations and resource tenure arrangements are significant in the genesis of conflicts (Brottem, 2016). A comparative analysis on the main causes of conflict between resource-user groups in arid and semi-arid areas was performed in Sub-Saharan Africa. The results show that resource scarcity, extreme weather, local autochthonous and exclusionary claims, and national-level political processes contribute to the complexity of conflicts in this area (Seter et al., 2018).

Vietnam has 2,773 islands, mainly in the Gulf of Tonkin ("Vinh Bac Bo" in Vietnamese); others are near the Vietnamese Central Coast and in the Gulf of Thailand (Le et al., 2012). Islands in Vietnam are important for the socio-economic development, environmental protection, and the national safety of the country (Le, 2008a). Vietnamese Southern-Central Coast Region has 200 islands, with a total surface of approximately 172 square kilometers which coincides with about 7.21% of total number of islands and about 10% of coastal islands surface in Vietnam. The islands are organized in two administrative districts (Ly Son and Phu Quy) and five island communes. The natural landscape, biodiversity, land use, and abundant marine resources, which traditionally support fishing, local livelihoods, and military are diverse on the islands. Ecotourism and cultural tourism are based on the marine ecosystems, natural landscapes, and cultural heritages. In response to the increasing stress on marine ecosystems, biosphere reserves (BRs) and marine protected areas (MPAs) were established and contribute to the biodiversity conservation, e.g., in Cham BR, and Ly Son, Hon Mun, Cu Lao Cau, and Phu Quy MPAs. Most of the islands are small, have a limited surface and small amounts of fresh water. The largest islands are Hon Lon (41.7 square kilometers), Hon Tre (33.15), Phu Quy (16), Cu Lao Cham (15), Ly Son (9.97), Cu Lao Xanh (3.5), Hon Binh Ba (3.6), Cu Lao Mai Nha (1.2), and Cu Lao Cau (1.2). One hundred and eighty-two islands (as over 90% of the total) are smaller than 1 square kilometer (Le, 2008b). Natural hazards, environmental pollution, and poorly organized socio-economic development influence the marine and island environment in a negative way. Conflicts on natural resource use are emerging more and more frequently among both different sectors and the local inhabitants. Natural resources of islands are often over-exploited, which challenges the sustainability of the islands.

Until now no study identified the hierarchy of the conflicts on resource use in a small island of Vietnam. This study identifies the shortcomings in the exploitation and use of natural resources and environmental protection. It proposes inter-sectorial cooperation to minimize conflicts and to prioritize socio-economic activities on the Ly Son Island. Data in this study are collected using questionnaires completed by both residents and local officials. The surveyed data were processed by descriptive statistics to rank conflicts, and by AHP to prior conflict groups. This paper is organized as follows: An introduction with literature review in Sect. 1; the study area, questionnaires and perception analysis methodology are dealt with in Sect. 2; the results of ranking conflicts and priorities are presented in Sect. 3; and finally, conclusion and policy implication are drawn in Sect. 4.

2 Materials and methods

2.1 Study area

The Ly Son District (Quang Ngai Province, Southern Central Coast of Vietnam) covers two off-shore volcanic islands: the Ly Son Island ("Ly Son big," or "Cù Lao Ré," with an extent of about 10 square kilometers) and the Cu Lao Bo Bai Island (or "Ly Son small," which covers nearly 0.7 square kilometers). Ly Son Island is selected as a study area because it is the main part of the Ly Son District, and entails three communes (An Vinh, An Hai and An Binh), where the major activities of residents and visitors happen (Fig. 1). The island is about 23 km away from the Sa Ky seaport, 44 km North-East of Quang Ngai city, and 37 km South-East of the Dung Quat Economic Zone (EZ). Ly Son Island has specific characteristics as compared to other islands in the Southern Central Coast of Vietnam. The proximity to the mainland of the Quang Ngai Province offers opportunities for fisheries and tourism. The larger surface provides more space and more natural resources for agriculture, fishery, construction, natural protection, and national defense. By 2015, Ly Son had 21,794 inhabitants, and a population density of 2,111 people per square kilometer. The local economy depends on agriculture, forestry, fishery, service, and tourism, and partly on industry. The district totals 5,575 households, of which, 4,036 (accounting for 72.4%) are active farmers, foresters, and fishers. The main agricultural products are onion *(Allium cepa)* (397 hectares with the yield of 10.7 tons per hectare in average), and garlic *(Allium sativum)* (302.5 hectares, 6.03 tons per hectare) (LSGOS, 2016). Garlic from Ly Son is registered as a brand-name agricultural product "Ly Son garlic" ("Tỏi Lý Sơn," in Vietnamese). Approximately 37,300 tons of fish including fishing and aquaculture are produced yearly, and provide a total revenue of about 11.5 million $U.S. The trade-service output was over 14 million $U.S. accounting for about 49% of total value of economy in 2015 (LSGOS, 2016). Ly Son shows a considerable island and seascape biodiversity, especially the richness of macrophytes at the reef (Astakhov, 2015; Latypov, 2013). The Ly Son Marine Protected Areas (MPA) was established in 2016; it covers Ly Son Island, Cu Lao Bo Bai Island and the surrounding sea over a total area of 7,925 hectares. The island attracted about 95,000 visitors in 2015 (LSGOS, 2016). The most attractive tourist sites are Hang Cau, Bac An Hai, and Nam An Vinh resorts, Sau volcanic cave, the garlic fields, and the beaches of Chua Duc, Bac An Hai, and Hang Cau. Beside, a large area of land surface is used for army camps, both on the mountains and in the plains.

Natural resources on Ly Son Island are managed by the district government agencies and handled by both residents and businesses. The use of natural resources for long periods

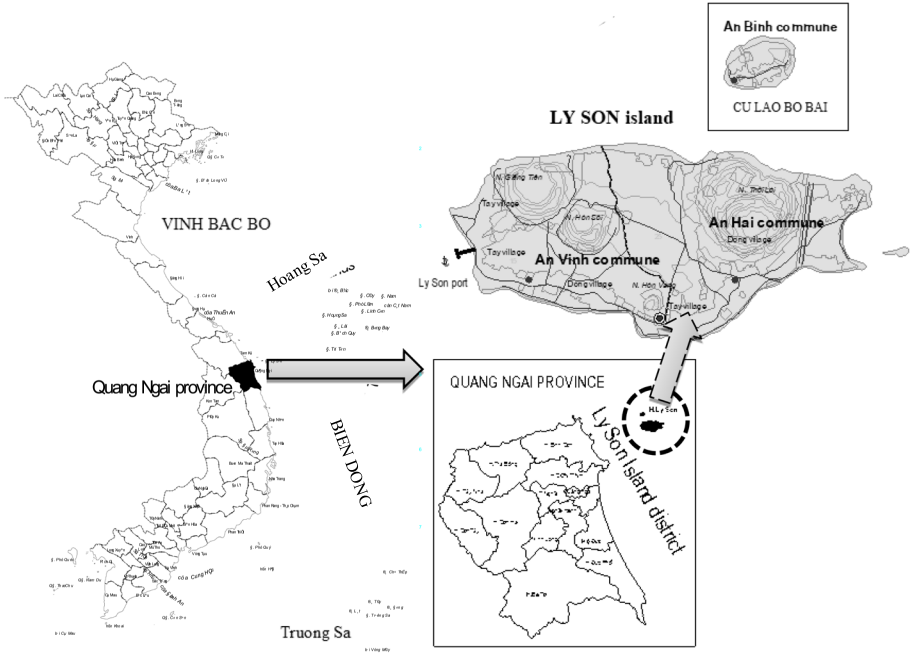


Fig. 1 Ly Son Island as part of the Ly Son District (Quang Ngai Province, Vietnam)

in small areas causes conflicts between stakeholders. National and local stakeholders have different considerations on local development, tourism, biodiversity conservation, and national defense. Results of a field study show that the island covers four main areas of conflicts: on mountainous forests (denoted by *M*), on farming (*F*), on residential locations (*R*), and along coasts (*C*). Problems are that serious management based on a more in-depth study of the conflicts and priorities in natural resource uses over conflict areas became imperative.

2.2 Data collection

a. Decision tree on conflict and priorities

The used decision tree on conflict and priority covering 4 hierarchical levels is shown in Fig. 2. The top of the tree consists of 3 sectors: agriculture-forestry-fishery (ALU), industry-services-tourism (NLU), and the army (DLU). Below this top level, 6 sub-sectors have been defined: agriculture (AG), fishery (FS), forestry and preservation (BC), industry and service (SV), tourism (TM), and army (AM). Level 3 represents 15 socio-economic activities which are split over 37 objectives in level 4. The socio-economic activities entail: crop cultivation (AGR), cattle ranching (CAR), agricultural service (AGS), fishing (CAF), aquaculture (MAR), fishery service (FIS), forestry (LAP), marine preservation (MPA), marine logistics (MAS), infrastructure building (BIN), cultural tourism (CSP), marine tourism (MAE), leisure (REL), military operation (PRS), and manufacturing (SDE). The objectives include: onion and garlic (1), corn and beans (2), watermelon (3), cow (4), pig (5), poultry (6), special cattle breeding (7), irrigation (8), vegetable agriculture (9), near-shore fishing (10), offshore fishing (11), lobster farming (12), fish farming (13), fishery port (14), seafood processing (15), fishing logistics (16), transport of passenger (17), transport of goods (18), house construction (19), hotel building (20), road building (21), public infrastructure building (22), cultural tourism (23), eco-tourism (24), diving and surfing (25), marine exploration (26), sea bathing (27), homestay (28), mainland security (29), marine security (30), manufacturing (31), natural hazard prevention (32), afforestation (33), reforestation (34), forest protection (35), mainland biodiversity conservation (36), and marine biodiversity conservation (37).

b. Conflict and priority questionnaires

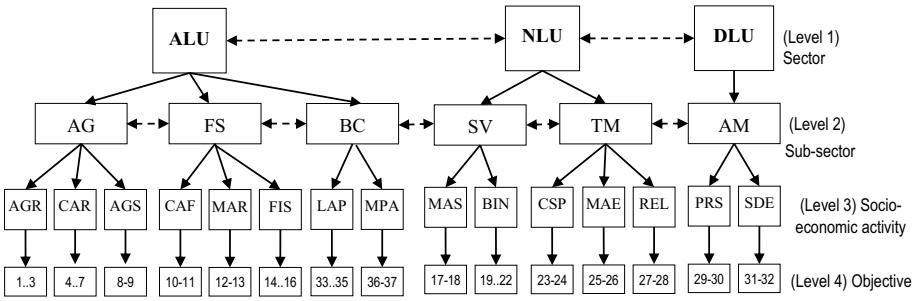


Fig. 2 Decision tree on conflicts and priority analysis. The tree is structured in 4 hierarchy levels: Sectors (level 1); Sub-sectors (level 2); Socio-economic activities (level 3); objectives (level 4)

Data on conflicts and priorities in resource use were collected using a structured questionnaire for both residents and local officials. The questionnaires were completed during a field trip in January 2016. In total 250 questionnaires were completed by residents and 16 questionnaires by local officials. The data were converted on a Likert 5 scale to detect main conflicts and ranking conflict levels in resource use. The questionnaire aimed inventorying the perception of the resource use conflicts and their importance in the identified conflict areas. The four hierarchical levels of conflict and priorities were addressed by the questionnaire: sector, sub-sector, socio-economic activity, and objective (Fig. 3). The questionnaire provides 4 levels of conflict and priority for each of conflict areas (Table 1). The intensity of the conflict is addressed in a Likert 5 scale (from 1 to 5) estimating the intensity of the negative influence among different groups: from the highest level (point 5) to the lowest level (point 1) (Vagias and Wade, 2006). On top respondents were invited to explain the reasons for their choices. The questionnaire for residents entails 16 questions. While selected residents were first invited to choose the area they live in or their livelihood depends up on, the questionnaires for the local officials include 64 questions relating to all conflict areas. On average, it took about an hour and a half to complete the questionnaire of the residents; while the officials spent almost a day to complete the questionnaire.

c. Likert scale for ranking conflictsLikert scale for ranking conflicts

As shown in Table 1, the weighted mean (wMean) of the Likert's score was used to rank the conflict. A weighted mean shows the average value as the sum of the values divided by the number of values, and is calculated using all obtained data. It allows grouping individual opinion data and classifying their rank in 5 levels. The weighted mean is the sum of the values called X_i $p(Xi)$, is expressed as:

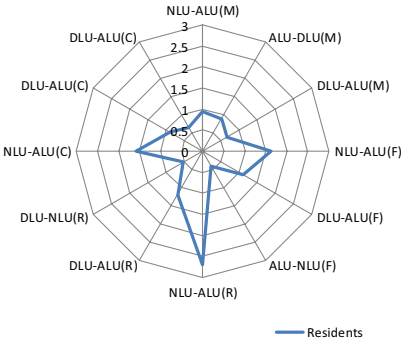
$$w\text{MEAN} = \sum_{i=1}^{5} Xip(Xi) \tag{1}$$

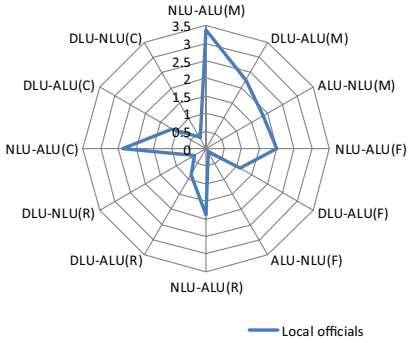
Where $p(X_i)$ is the proportion of respondents selecting each option. An option corresponds with a scale rating X_i ($X_i = 1,\ldots, 5$).

Based on wMean, conflicts are ranked in 5 levels: not at all influential (wMean = 1.000 ÷ 1.499); slightly influential (1.500 ÷ 2.499); somewhat influential (2.500 ÷ 3.499); very influential (3.500 ÷ 4.499); and extremely influential (4.500 ÷ 5.000) (Vagias and Wade, 2006).

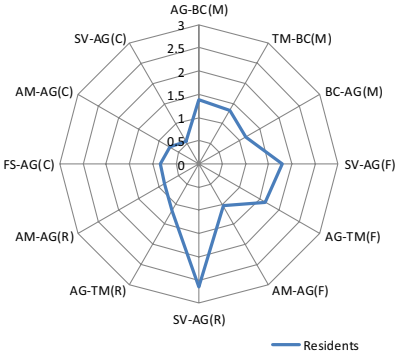
d. Analytic Hierarchy Process (AHP) for ranking priority

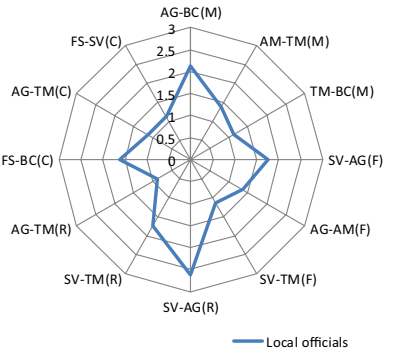
The level of inter-sector cooperation on natural resource uses was assessed using priorities based on the Analytic Hierarchy Process (AHP). Multi-criteria decision making (MCDM) in general, and AHP in particular applies to this assessment because they allow addressing multiple-conflicting attributes (Diaz-Balteiro et al., 2017). The hierarchical structure is measured through pairwise comparisons. Basic steps of an AHP procedure include: establish hierarchical structure, generate pairwise comparison matrices at hierarchical levels, calculate the weight hierarchy of priorities, and validation (Saaty, 2008). Comparisons are performed according to an AHP pairwise comparison matrix A, which is structured as



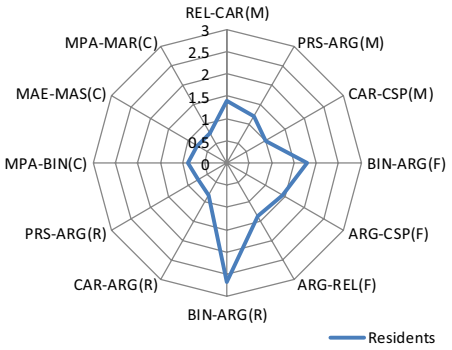


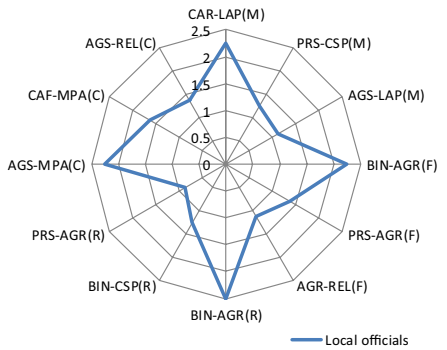
(a) Conflict by sector





(b) Conflict by sub-sector

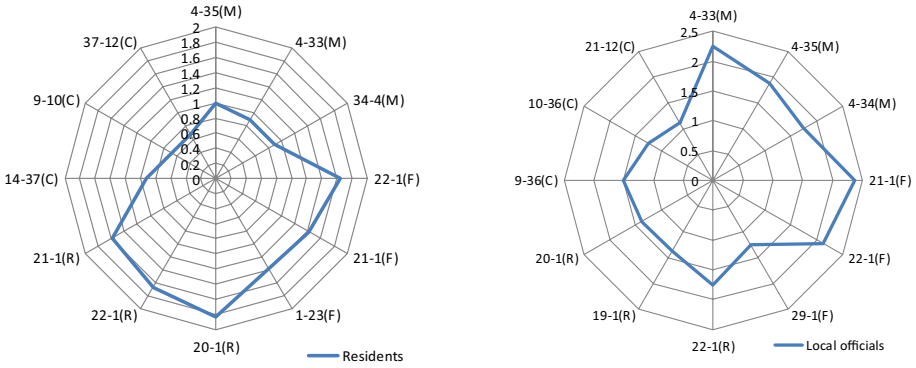




(c) Conflict by socio-economic activity

Fig. 3 Comparing wMeans of residents and officials' perception on ranking conflicts in the Ly Son Island

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{\dots} & a_{nn} \end{bmatrix} \tag{2}$$



(d) Conflict by objective

Fig. 3 (continued)

Where: a_{ij} is the pairwise comparison rating between the *i*th element and *j*th element of each hierarchical level.

Pairwise comparison rating is governed by the following rules:

$$a_{ij} > 0; a_{ij} = 1/a_{ji}; a_{ii} = 1 \rightarrow \forall I \tag{3}$$

Verbal judgment of priority is: 1 = equal priority (as two elements contribute equally); 3 = moderate priority (experience and judgment favor one element over another); 5 = strong priority (an element is strongly favored); 7 = very strong priority (an element is strongly dominant); 9 = extreme priority (an element is favored by at least an order of magnitude); 2, 4, 6, and 8 are intermediate values of priority (used to compromise between two judgments).

The dimension of the matrix A depends on the number of elements at each hierarchical level. The normalized similarity vector and eigenvalue are calculated once all matrices have been established. The estimation of the priorities is based on the eigenvector w and expressed as:

$$Aw = \lambda_{\max} w \tag{4}$$

$$\text{with } w = \left(w_1, w_2, \ldots w_n\right) \text{ and } w_1 + w_2 + \ldots + w_n = 1 \tag{5}$$

Where: w is eigenvector and $\lambda_{\max}$ is the maximum eigenvalue of the matrix A.

Validation rating is based on the Consistency Ratio (CR), which relates the Consistency Index (CI) and the Random Index (RI) in the following way:

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \rightarrow \text{with} \rightarrow \text{CI} = \frac{\lambda_{\max} - n}{n - 1} \tag{6}$$

The judgment is reliable when the Consistency Ratio (CR) ≤ 0.1.

AHP's weight value is used for identifying level of priority in natural resource uses. Priority which is something considered very important and is ranked from "highest priority" (or "essential") down to options "high priority," "medium priority," "low priority," and "lowest priority" (or "not a priority") (Vagias and Wade, 2006).

Table 1 An example for conflict and priority questionnaire at sector level

Sectors	Conflict between elements			Priority between elements		
	Agriculture-forestry-fishery (ALU)	Industry-services-tourism (NLU)	Army (DLU)	Agriculture-forestry-fishery (ALU)	Industry-services-tourism (NLU)	Army (DLU)
ALU		[1]-[2]-[3]-[4]-[5]	[1]-[2]-[3]-[4]-[5]		[1]-[2]-[3]-[4]-[5]-[6]-[7]-[8]-[9] [1/2]-[1/3]-[1/4]-[1/5]-[1/6]-[1/7]-[1/8]-[1/9] Reason:……	[1]-[2]-[3]-[4]-[5]-[6]-[7]-[8]-[9] [1/2]-[1/3]-[1/4]-[1/5]-[1/6]-[1/7]-[1/8]-[1/9] Reason:……
NLU			[1]-[2]-[3]-[4]-[5]			[1]-[2]-[3]-[4]-[5]-[6]-[7]-[8]-[9] [1/2]-[1/3]-[1/4]-[1/5]-[1/6]-[1/7]-[1/8]-[1/9] Reason:……
Level of Influence (Likert 5 scale): 1 = Not at all influential; 2 = Slightly influential; 3 = Somewhat influential; 4 = Very influential; 5 = Extremely influential (Source: Vagias and Wade, 2006)		Verbal judgment of priority: 1 = equal priority; 3 = moderate priority; 5 = strong priority; 7 = very strong priority; 9 = extreme priority; 2, 4, 6, and 8 = intermediate values of priority (Source: Saaty, 2008)				

3 Results

3.1 Ranking perceived conflicts by residents and local officials

Figure 3 indicates the intensity of perceived conflicts in natural resource use in Ly Son. At the sector level, residents and officials generally mention similar events reflecting the importance of the impacts of the industry-services-tourism sectors on the agriculture-forestry-fishery activities: they perceive that groups of sectors produce the most intensive conflicts. While conflicts between these sectors in residential areas according to residents reach almost a value ($wMean_{(ALU\text{-}NLU)}(R) = 2.699$), local officials provide the highest conflict rank to mountainous forest areas ($wMean_{(ALU\text{-}NLU)}(M) = 3.375$).

For the sub-sectors, residents and local officials conclude on a relative consensus while ranking the most important conflicts in the mountains. For the residents, none of the conflicts among all sub-sectors along the coast is significant. The conflict between fisheries and agriculture is driven by the policy support to marine resources: this moved farmers to fishing. Conflicts between agriculture and other sub-sectors were identified. Major conflicts exist between agriculture and forestry-preservation in the forests of the mountains ($wMean_{(AG\text{-}BC)}(M) = 3.375$, perceived by officials); and between agriculture and the industry-service group in residential areas ($wMean_{(AG\text{-}BC)}(M) = 2.660$ and 2.625, by residents and officials, respectively). This refers to agriculture which affects afforestation and protected forests in the mountains. Deforestation on the volcanic soil which is used to grow crops and rising livestock, became recently more serious in the mountains. Both residents and local officials associate grazing by cows and goats in the mountains with destroying trees, negative impacts on reforestation and forest conservation. In residential areas, industry and service affect agriculture in a negative way. The officials agree that the unstable price and price squeeze of agricultural products causes negative effects, especially on local products as onion and garlic.

Conflicts on socio-economic activities were recognized in all sectors. The construction of infrastructure affects agriculture negatively in residential areas and on farms: $wMean_{(BIN\text{-}ARG)}(R) = 2.677$ and 2.500, and $wMean_{(BIN\text{-}ARG)}(F) = 1.778$ and 2.250, perceived by residents and local officials, respectively. The conflict originates from the construction of roads, and public works. At these occasions top soil is removed crop and the crop fields are contaminated. Respondents show that farmers not only lost their land, but received a low and insufficient monetary compensation. Officials pointed to two more important conflicts which emerged in the mountains and along the coasts: cattle ranching and forestry in the mountains ($wMean_{(CAR\text{-}LAP)}(M) = 2.250$); and agriculture and marine conservation along coasts ($wMean_{(AGS\text{-}MPA)}(C) = 2.250$). In the mountains, grazing is prohibited at the present, but still occurs.

A total of 24 possible conflicts between objectives were identified by the respondents. Among them, the most critical ones are these between growing onion and garlic which conflicts with building hotels, roads, and other public infrastructure in the plains ($wMean_{(20\text{–}1)}(R) = 1.828$, perceived by residents, whereas $wMean_{(21\text{–}1)}(F) = 2.375$, perceived by officials). Officials also indicated the conflict between ranching of cows and afforestation in the mountains ($wMEAN_{(4\text{–}33)}(M) = 2.250$). Public infrastructure and transport demands farm land and drives this conflict. The demand for accommodations for tourists increased during recent years and causes the loss of part of farm land near the residential areas. Noticeable conflicts along coasts perceived by the respondents include: fishery ports and marine protection ($wMEAN_{(14\text{–}37)}(C) = 0.925$, by residents); sand mining

and nearshore fishing ($wMean_{(9–10)}(C) = 0.675$, by residents); sand mining and biodiversity conservation ($wMEAN_{(9–36)}(C) = 1.500$, by officials); and fishing and biodiversity conservation ($wMEAN_{(10–36)}(C) = 1.250$, by officials). Fishery seaports pollute the marine environment. Waste water treatment in ports is weak to non-existing along the coast. Sand beach mining is most impacting and contributes to land loss. People collecting clams argue that less sand reduces the oyster fields. Other conflicts originate from fishing with mines and explosives that influence marine protection and the biodiversity of fish, and shrimps. Sand winning destroys habitats of oysters, and mussels, and impacts the biodiversity.

3.2 AHP priority ranking

Table 2 shows the relative consensus among the perception of the residents and the officials on the importance of the conflicts by sector, sub-sector, and socio-economic activities. Consistency Ratio (CR) values are below 0.1, which indicates a reasonable level of consistency in the pair-wise comparison that is sufficient to accept the AHP weights.

In the mountains, agriculture and forestry emerge as the most important sectors ($wALU_{(M)} = 0.678$ and 0.618, as perceived by residents and officials, respectively), next to military ($wDLU_{(M)} = 0.180$ and 0.296). At the sub-sector level, mountains were perceived most important for forestry and preservation ($wBC_{(M)} = 0.329$ and 0.378), and tourism ($wTM_{(M)} = 0.410$ and 0.342). The highest perceived priorities for socio-economic activities in the mountains were forestry ($wLAP_{(M)} = 0.470$ and 0.454), crop cultivation ($wAGR_{(M)} = 0.343$, as perceived by residents), and cattle ranching ($wCAR_{(M)} = 0.412$, as perceived by officials). Forests are important for the soil and water quality and this service of nature should remain a top priority. Agriculture should be limited because farming and irrigation are difficult and impacting on the mountains. Because the arable land on the island is limited, farmers strive towards maximum afforestation. Ly Son is a major strategic place for the national security. Respondents state the second priority in the mountains is military. Military infrastructure in the mountains targets optimal visual inspection. The army, also contributes to afforestation, reforestation, forest management and protection. The extinct volcanic mountains attract tourists. The role of the island in protecting Vietnam's national sovereignty in the South China Sea is of key importance and prevails on agriculture and tourism.

Both groups agree on the priority for agriculture. The farms are located in the plains and behind the dams, which is suitable for crops. Crops account for 60–70% of the total agricultural production and were traditionally a top priority for development (LSGOS, 2016). This explains the priority for farming ($wALU_{(R)} = 0.678$, and 0.894). Farms are not only important for agriculture ($wAG_{(R)} = 0.329$, and 0.378), but also attract tourism ($wTM_{(R)} = 0.342$, by officials). Socio-economic activities with the high priority include crop production ($wAGR_{(R)} = 0.242$, and 0.237), and leisure ($wREL_{(R)} = 0.215$, by officials). Crop fields necessitate tourists. This area also witnessed a significant land use land cover change recently: crop land was converted to roads and residential lands ($wBIN_{(R)} = 0.242$, by residents).

On the use of residential areas, residents and officials do not agree. Residents favor agriculture ($wALU_{(R)} = 0.726$), because agricultural products are their main source of income. Officials however give the highest priority to non-agricultural land use ($wNLU_{(R)} = 0.740$). Beside agriculture ($wAG_{(R)} = 0.432$), industry and service rank among the preferences ($wSV_{(R)} = 0.471$), as both of them stimulate the local economy. Services support agriculture by providing fertilizers and pesticides. Similar to farms, residential areas in the plains

Table 2 AHP results on prioritizing by sector, sub-sector, and socio-economic activity

Conflict areas	Sectors	Weight value of priorities		Sub-sectors	Weight value of priorities		Socio- economic activities	Weight value of priorities	
		Residents	Officials		Residents	Officials		Residents	Officials
Mountainous forest areas (M)	$ALU_{(M)}$	0.678*	0.618*	$BC_{(M)}$	0.329	0.378	$LAP_{(M)}$	0.470*	0.454*
				$AG_{(M)}$	0.158	0.108	$AGR_{(M)}$	0.343*	0.034
							$CAR_{(M)}$	0.113	0.412*
							$AGS_{(M)}$	0.074	0.100
	$NLU_{(M)}$	0.142	0.086	$SV_{(M)}$	0.410*	0.171			
				$TM_{(M)}$	0.103	0.342*			
	$DLU_{(M)}$	0.180	0.296						
Sum of eigenvalues (*M*)		1.000	1.000		1.000	1.000		1.000	1.000
Consistency ratio (*CR*)		0.032*	0.045*		0.056*	0.068*		0.057	0.083
Farming areas (F)	$ALU_{(F)}$	0.678*	0.894*	$AG_{(F)}$	0.158	0.108	$AGR_{(R)}$	0.176	0.018
							$CAR_{(R)}$	0.058	0.214
							$AGS_{(R)}$	0.038	0.052
				$BC_{(F)}$	0.329	0.378*	$LAP_{(R)}$	0.242*	0.237*
	$NLU_{(F)}$	0.322	0.106	$SV_{(F)}$	0.410*	0.171	$BIN_{(R)}$	0.242*	0.215*
				$TM_{(F)}$	0.103	0.342	$CSP_{(R)}$	0.150	0.079
							$REL_{(R)}$	0.094	0.185
Sum of eigenvalues (*F*)		1.000	1.000		1.000	1.000		1.000	1.000
Consistency ratio (*CR*)		0.085	0.015		0.074	0.059		0.083	0.046

Table 2 (continued)

Conflict areas	Sectors	Weight value of priorities		Sub-sectors	Weight value of priorities		Socio- economic activities	Weight value of priorities	
		Residents	Officials		Residents	Officials		Residents	Officials
Residential areas (R)	$ALU_{(R)}$	0.726	0.167	$AG_{(R)}$	0.236	0.432	$AGR_{(U)}$	0.284*	0.284*
							$CAR_{(U)}$	0.215*	0.069
							$AGS_{(U)}$	0.059	0.024
				$BC_{(R)}$	0.284	0.030	$LAP_{(U)}$	0.122	0.283*
							$BIN_{(U)}$	0.320*	0.340*
	$NLU_{(R)}$	0.212	0.740*	$SV_{(R)}$	0.427*	0.471			
				$TM_{(R)}$	0.053	0.067			
	$DLU_{(R)}$	0.062	0.093	–	–	–			
Sum of eigenvalues (*R*)		1.000	1.000		1.000	1.000		1.000	1.000
Consistency ratio (*CR*)		0.086	0.058		0.024	0.095		0.045	0.063
Coasts (C)	$ALU_{(C)}$	0.660*	0.501*	$AG_{(C)}$	0.063	0.044	AGR	0.069	0.062
				$FS_{(C)}$	0.373*	0.385*	$CAF_{(C)}$	0.185*	0.018
							$MAR_{(C)}$	0.033	0.187*
							$FIS_{(C)}$	0.030	0.037
				$BC_{(C)}$	0.063	0.070	$MPA_{(C)}$	0.185*	0.214*
							$MAS_{(C)}$	0.083	0.161*
	$NLU_{(C)}$	0.275	0.396	$SV_{(C)}$	0.334*	0.445*	$BIN_{(C)}$	0.166*	0.080
				$TM_{(C)}$	0.167	0.056	$CSP_{(C)}$	0.081	0.024
							$MAE_{(C)}$	0.103*	0.183*
							$REL_{(C)}$	0.065	0.034
	$DLU_{(C)}$	0.165	0.103	–	–	–			

Table 2 (continued)

Conflict areas	Sectors	Weight value of priorities		Sub-sectors	Weight value of priorities		Socio- economic activities	Weight value of priorities	
		Residents	Officials		Residents	Officials		Residents	Officials
Sum of eigenvalues (*C*)		1.000	1.000		1.000	1.000		1.000	1.000
Consistency ratio (*CR*)		0.075	0.082		0.068	0.087		0.023	0.079

(**high value of weight for priorities*)

attract significant activities, such as crop cultivation ($wAGR_{(R)}=0.284$), cattle ranching ($wCAR_{(R)}=0.215$, and 0.283), and the construction of infrastructure ($wBIN_{(R)}=0.320$, and 0.340). Residential areas show the highest consensus on their priorities. The highest rank is for infrastructure, which is a prerequisite for any development. Road construction, buildings, motels and hotels are expected not only to improve the local living standard, but are also a necessity to develop tourism on the island.

Local people and officials have the same coastal priorities. They give the highest rank to the agriculture-forestry-fishery sector ($wALU_{(C)}=0.660$, and 0.501). More in detail, sub-sectors rank first in fishery ($wFS_{(C)}=0.373$, and 0.385), industry and service ($wSV_{(C)}=0.334$, and 0.445). No doubt beaches have a high tourism potential ($wMAE_{(C)}=0.103$, and 0.183). Coastal areas also provide resources for fishing ($wCAF_{(C)}=0.185$, by residents), aquaculture ($wMAR_{(C)}=0.187$, by officials), marine preservation ($wMPA_{(C)}=0.185$, and 0.214), and marine logistics ($wMAS_{(C)}=0.161$). Residents estimate that fishing is the first priority because it is their main source of income. Protecting seascapes and marine ecosystems should support tourism on the island.

Over all residents and officials share the priority objectives for Ly Son (Table 3). **In the mountains**, the following objectives are most important: planting garlic and onion ($w(1)_{(M)}=0.203$ and 0.194, as perceived by residents and officials, respectively); ranging livestock ($w(4)_{(M)}=0.160$ and 0.162); irrigation ($w(8)_{(M)}=0.223$ and 0.228); and afforestation ($w(33)_{(M)}=0.142$, by officials), and reforestation ($w(34)_{(M)}=0.118$). The main reasons provided are: garlic and onion are local crops with comparable demands and provide a decent income for the farmers; cows and goats belong on the hills, this should bring down the number of household livestock animals and limit pollution in the residential areas; irrigation supports agriculture; more reforestation and afforestation of the bare hills contribute to environmental quality.

Farming of onion and garlic ($w(1)_{(F)}=0.126$ and 0.104), irrigation ($w(8)_{(F)}=0.138$ and 0.121), hotel construction ($w(20)_{(F)}=0.118$, by officials), road building ($w(21)_{(F)}=0.110$, by residents), eco-tourism ($w(24)_{(F)}=0.106$, by residents), and homestay ($w(28)_{(F)}=0.104$, by both residents and officials) emerge as priorities. On residential areas less consensus exists. **Residential areas** give priority to land protection. As Ly Son is improves its infrastructure, tourism on the island is on its increase and the number of trade–services–tourism activities expands. Therefore, safety, security and the military become increasingly necessary. The second priority is about onion and garlic as a traditional crop. This is supported both by the residents and the officials.

Along **the coast**, the following objectives come in the forefront: offshore fishing, lobster farming, passenger transport, marine exploration, marine biodiversity preservation, and sea bathing. Lobster farming replies to the policy of the province and district to raise income ($w(12)_{(C)}=0.084$ and 0.088). The marine environment and ecosystems should be better protected which includes counteracting the demand of sand mining ($w(37)_{(C)}=0.086$ and 0.088). The officials give priority to transport services ($w(17)_{(C)}=0.092$). Because Ly Son is far from the mainland, a high-speed boat connection is essential for the visitors. Also offshore fishing ($w(11)_{(C)}=0.079$, by officials) and aquaculture ($w(12)_{(C)}=0.084$ and 0.088) should be in focus.

3.3 Structured models of hierarchical conflicts and priorities in resource uses

A structured model of hierarchical conflicts (Fig. 4) shows the complexity of the perceived conflicts on resource uses in Ly Son. The model points out perceived conflicts,

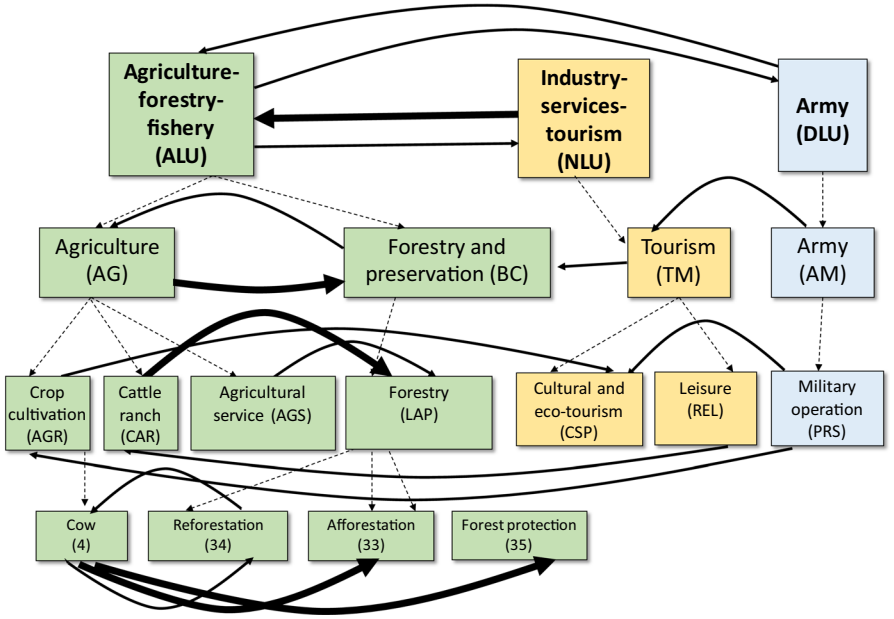
Table 3 AHP results on prioritizing by objectives

Sectors	Sub-sectors	Socio-economic activities	Objectives	**Local resident's perception**				**Official's perception**			
				(M)	(F)	(R)	(C)	(M)	(F)	(R)	(C)
Agriculture-forestry-fishery (ALU)	Agriculture (AG)	Crop cultivation (AGR)	(1)	0.203*	0.126*	0.089*	0.065	0.194*	0.104*	0.082*	0.074
			(2)	0.039	0.024	0.000	0.016	0.050	0.027	0.000	0.021
			(3)			0.067*				0.074*	
		Cattle ranch (CAR)	(4)	0.160*	0.099			0.162*	0.086		
			(5)	0.036		0.053		0.031		0.033	
			(6)	0.052	0.032	0.032		0.041	0.022	0.059	
			(7)								
		Agriculture service (AGS)	(8)	0.223*	0.138*	0.056		0.228*	0.121*	0.072*	
			(9)	0.032	0.020	0.056		0.033	0.017	0.036	
	Fishery (FS)	Fishing (CAF)	(10)				0.082				0.026
			(11)				0.016				0.079*
		Aquaculture (MAR)	(12)				0.084*				0.088*
			(13)				0.014				0.018
		Fishery service (FIS)	(14)				0.069				0.070
	Forestry and conservation (BC)	Forestry (LAP)	(33)	0.072	0.044	0.037		0.142*	0.076	0.053	
			(34)	0.118*	0.073	0.037		0.049	0.026	0.021	
			(35)	0.065		0.037		0.068		0.034	
		Marine preservation (MPA)	(36)				0.012				0.018
			(37)				0.086*				0.088*

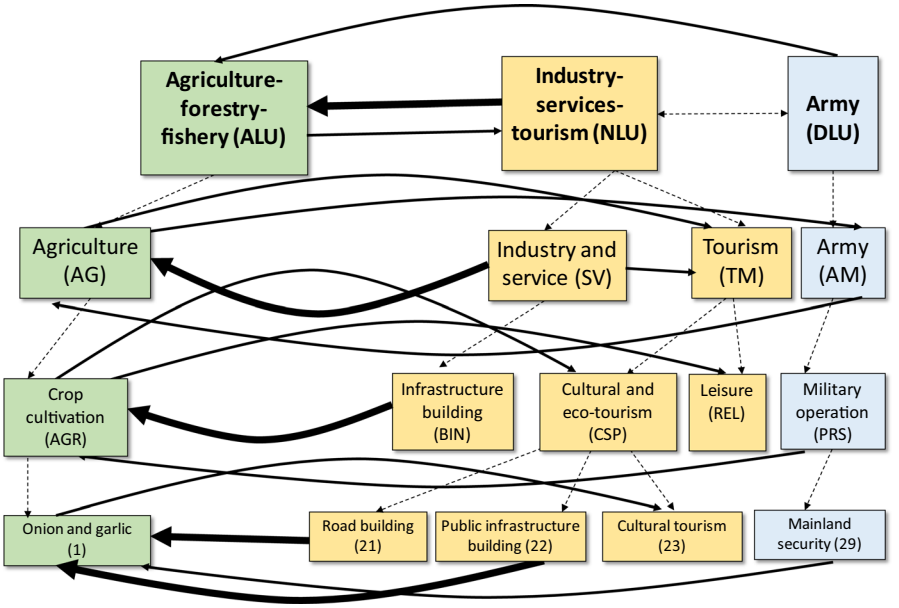
Table 3 (continued)

Sectors	Sub-sectors	Socio-economic activities	Objectives	**Local resident's perception**				**Official's perception**			
				(M)	(F)	(R)	(C)	(M)	(F)	(R)	(C)
Industry-services-tourism (NLU)	Industry and service (SV)	Marine logistics (MAS)	(17)				0.065				0.092*
			(18)				0.033				0.013
		Infrastructure building (BIN)	(19)		0.007	0.006	0.039		0.054	0.034	0.009
			(20)		0.010	0.014	0.071		0.118*	0.015	0.033
			(21)		0.110*	0.069	0.051		0.070	0.051	0.053
			(22)								
	Tourism (TM)	Cultural tourism (CSP)	(23)		0.053	0.028	0.020		0.046	0.054	0.035
			(24)		0.106*	0.084*	0.079*		0.093	0.054	0.070
		Marine tourism (MAE)	(25)				0.016				0.070
			(26)				0.082*				0.035
		Leisure (REL)	(27)		0.018	0.028	0.087*		0.035	0.072*	0.091*
			(28)		0.141*	0.084*	0.011		0.104*	0.036	0.015
The army (DLU)	Army (AM)	Military operation (PRS)	(29)			0.084*				0.095*	
			(30)			0.028				0.015	
		Manufacturing operation (SDE)	(31)			0.037				0.036	
			(32)			0.075*				0.072*	
Sum of eigenvalues	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
Consistency Ratio (*CR*)	0.037	0.064	0.075	0.048	0.073	0.092	0.053	0.029			

(**high value of weight for priorities*)

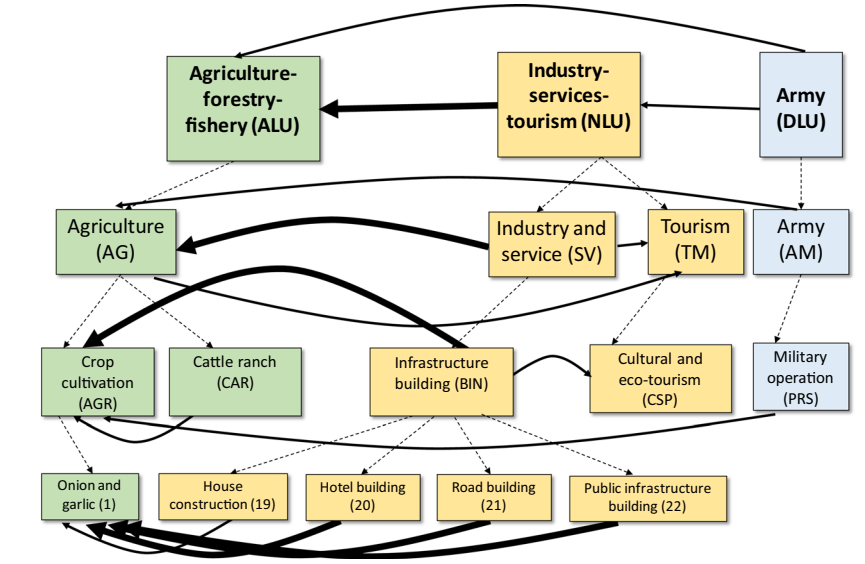


(a) Conflicts in mountainous forest areas

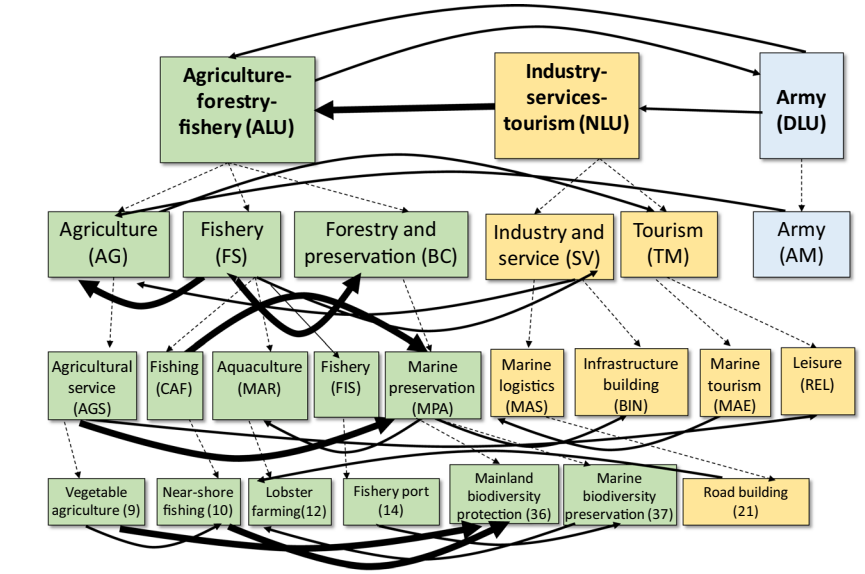


(b) Conflicts in farming areas

Fig. 4 Structured models of hierarchical conflicts in resource use over Ly Son Island



(c) Conflicts in residential areas



(d) Conflicts along coasts

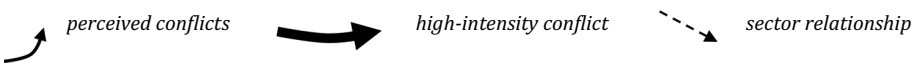


Fig. 4 (continued)

high-intensity conflict, and sector relationship in the interconnections between the levels and within the level. At sector level (level 1), conflicts in the agriculture-forestry-fishery and the industry-service-tourism groups are most significant because of the limitation of arable land on the island. At the sub-sector level (level 2), the most intense conflicts exist

between agriculture and forestry-preservation in the mountains, and between industrial-service and agriculture in farming and residential areas. Particularly in farming areas, negative effects of industry and service on agriculture are driven by the conversion of agricultural land into non-agricultural land. The most pronounced socio-economic conflicts exist among tourism activities, forest protection and cattle ranching in the mountains because grazing cattle affects tourism and forest protection (level 3). The second most important conflict is between building infrastructure and agriculture in the villages, because residential construction demands agricultural land. Six pairs of conflicts (level 4) exist on the objectives of cattle ranching and afforestation and forest protection in the mountains; public infrastructure construction and onion crops in the farming areas; fishing port operations, marine sand mining and biodiversity conservation along the coast. As the island is involved in planning the Ly Son Marine Protected Area (MPA), these results are coherent with previous studies about conflicts between local livelihood and natural conservation in MPAs (Jentoft et al., 2012; Majanen, 2007; Tang & Tang, 2010).

Figure 5 shows a structural model of hierarchical priorities for inter-sector cooperation in conflict areas of Ly Son Island. While vertical combination of existing resource use forms four main areas of conflicts (forested mountains, farms, residential areas, and coasts), horizontal prioritized activities structure potential areas for inter-sector cooperation. For instance, areas of growing onion and garlic are prioritized at the high to highest level over Ly Son where there is suitable land for these most valuable crops; however, their growth in necessitates irrigation. In particular, in the mountains, respondents give a high priority to a combination of afforestation and cow ranching. Irrigation systems, growing garlic and onion combined with agricultural tourism are given highest priority on farms. Residential areas have a preference for tourism (roads, homestay) and military operations (army, natural hazard prevention). Along the coast, lobster farming, marine biodiversity conservation, and sea bathing attract the highest priority value. While lobster farming provides high income for local fishers, conservation of the marine biodiversity is an important aspect of the environmental management in Ly Son.

4 Discussions

Conflicts on natural resource uses on islands in the South China Sea were common in the past (Valencia, 1979). They were observed across and within sectors, and between different communities (Wiber et al., 2012). In Ly Son (Vietnam), the conflicts appeared, however with limited intensity: wMean reaches roughly a value ranging between 1 and 3 in the 5-point rating scale. The perception of the residents is compared with the opinion of local officials. The opinions were inventoried based on completed surveys. The result shows a consensus among residents and officials when it comes to the negative impacts in the conflict areas. Conflict hotspots exist about the forests in the mountains, farming, and residential areas. Conflicts along coasts are limited because of the low population density in this area. However, coasts attract more determinants of conflicts than other areas. Internationally, main determinants of conflicts exist on agriculture (crops, aquaculture, and commercial fishery), industry, and tourism (Matthew & Gaulin, 2001). These determinants were also observed in Ly Son.

Inter-sector cooperation enables stakeholders minimizing conflicts on natural resource use in small islands. Conflicts result from a lack of coordination between stakeholders, and natural resource management based on priorities (Masalu, 2000; Strauß, 2011).

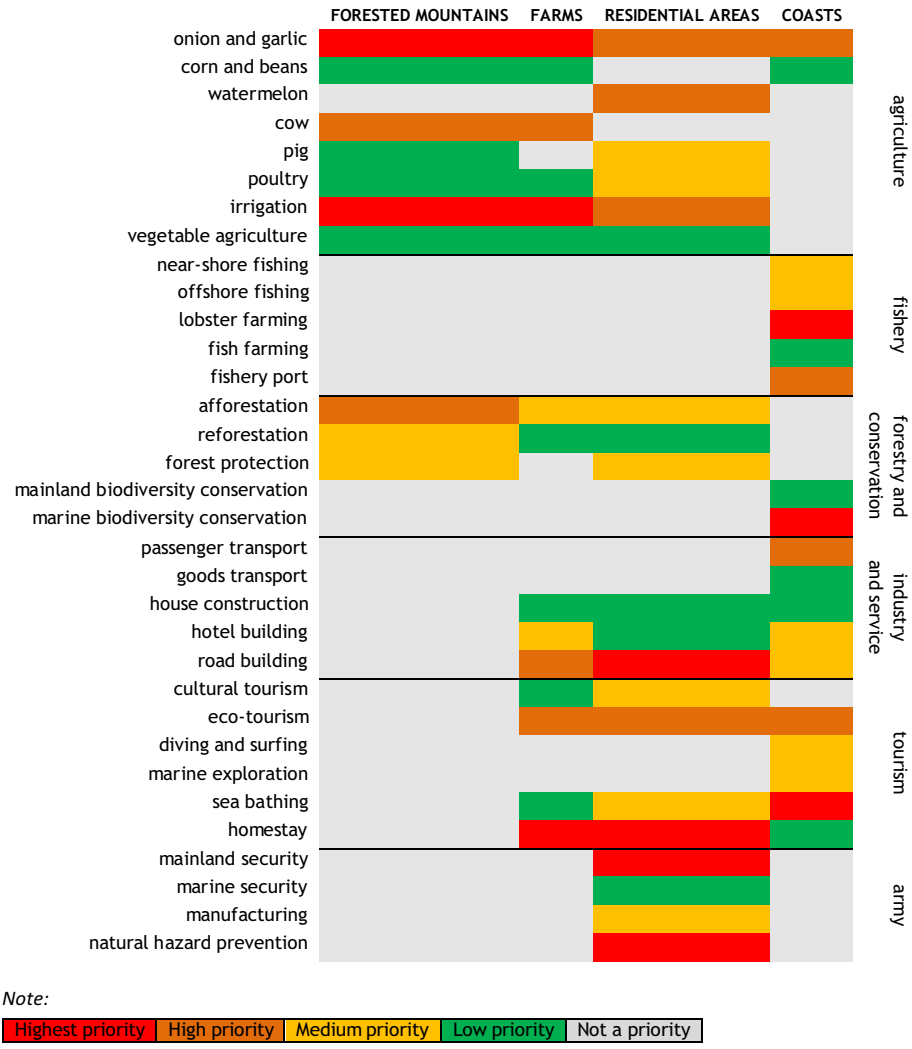


Fig. 5 Structured models of hierarchical priorities for inter-sector cooperation in conflict areas of Ly Son Island

Conflict is complex as it is about multiple threats, multiple jurisdictions and scales, multiple stakeholders and perspectives (Coffey and Toole, 2012). Conflicts on islands emerge from resource scarcity which mainly results from increasingly intense human activities (Abdelgalil & Cohen, 2007; Mmoleele & Mainah, 2003; Turner, 2004). However, resource scarcity did not prove the most significant driver of conflicts on resource use (Seter et al., 2018); limited contact between stakeholders also contributes to conflicts (Poria & Ashworth, 2009). In this study, local residents and officials shared their opinion on the importance of identifying priorities to promote inter-sector cooperation between agriculture-forestry-fishery, industry-services-tourism, and the army in Ly Son.

Priority ranking can be used to solve conflicts in small islands (Malczewski et al., 1997; Nguyen et al., 2016). The necessity of transforming the conflicts into cooperation through

dialogue, reconciliation, negotiation and participation of stakeholders was pointed out by Bruckmeier (2005). Interconnected components of transformation of power relations, knowledge integration and joint learning should be considered key components of conflict resolution (Stepanova, 2015). In Ly Son, one of the major difficulties in managing conflicts and promoting inter-sector cooperation is defining all relevant elements in natural resources use. Knowledge and judgments about the conflicts and priorities allow formulating rational activities. Integrated management, in which, natural resources on land and at sea are managed interdisciplinary, inter-regionally and taking into account national interests, combining the benefits of the sectors, villages, and organizations involved in the management, is the way out. Integrated management mitigates conflicts of interest during the mining process and use of resources between sectors, with the government, and among the residents in Ly Son.

This study has some limitations. The first limitation is that we restrict our considerations on managing conflicts and priorities in some types of natural resource use to imply policies for sustainable resources management on small islands in Vietnam. Managing conflicts requires combining formal and informal resolution methods (Stepanova, 2015). Minimizing resource conflicts can be approached using conflict analysis and integrating them in a wider strategy of sustainable resource management (Cumming, 2011). Researchers and resource managers need to integrate elements dovetailing in political science, sociology, economics, geography, and ecology for conflict analysis and resolution (Stepanova & Bruckmeier, 2013). Integrated coastal zone management and ecosystem-based management come out as the most indicated approaches to manage the conflicts and to define priorities among the resource users (Tuda et al., 2014). The second limitation is that dataset on resource use conflicts and priorities are collected from perceptions of residents and officials. The perception analysis as inventoried by this study contributes to sustainable resources management for Ly Son for two main reasons. First although other stakeholders, such as businesses, tourists, provincial and national governments are ignored, residents and officials are selected because they are the most important stakeholders. Residents should be involved in the project and policy planning, decision making, and implementation affecting them directly. Second is an ineffective conflict management resulted from coastal and marine resources management based on a sectorial approach (Masalu, 2000).

5 Conclusions

The paper deals with an application of perception analysis for residents and officials in Ly Son Island (Vietnam) to develop decision tree on conflict and priorities, Likert scale for ranking conflicts, and AHP for ranking priority. Perceived conflicts and priorities by residents and local officials are ranked. Conflict hotspots exist in the forests in the mountains, farming, and residential areas. At sector level, conflicts in the agriculture forestry-fishery and the industry-service-tourism groups are most significant. At sub-sector level, the most intense conflicts exist between agriculture and forestry-preservation in the mountains, and between industrial-service and agriculture in farming and residential areas. At socio-economic activities level, the most pronounced socio-economic conflicts exist among tourism activities, forest protection and cattle ranching in the mountains. At objectives level, there are six pairs of conflicts: cattle ranching and afforestation and forest protection in the mountains; public infrastructure construction and onion crops in the farming areas; fishing port operations, marine sand mining and biodiversity conservation along the coast. We suggest that the prioritized activities

should be onion and garlic production, irrigation at forest mountains; onion and garlic production, irrigation and homestay at farms; road building homestay, mainland security and natural hazard prevention at resident areas; lobster farming, marine biodiversity conservation and sea bathing at coast area. Ly Son needs more investment in transport enhancing the human and physical capitals; and an Integrated Spatial Planning (ISP) for Ly Son should concern inter-sector cooperation between agriculture, fishery, forestry and conservation, industry and service, tourism, and the army.

Study findings provide scientific basis for policy implications. For Ly Son, a number of spatial planning approaches were developed in the past. In the most recent master plan for socio-economic development (MPSED) until 2020, the district was structured into an urban center, rural settlements, forestry and farming areas, areas for processing and selling aquatic products, tourist areas on islands, beaches and sea water bodies, and military areas (LSG, 2015). The Ly Son MPA entails a marine restricted area, ecosystem restoration areas, and economic development zones on land (QNG, 2016). Land use planning (LUP) for Ly Son is revised every 5 five years according to the Vietnamese Land Law 2013. In the LUP, Ly Son is organized in three parts: agricultural, non-agricultural, and non-used areas (LSG, 2015). However, these zones just focus on specific purposes: while MPSED attracts economists, MPA fascinates biodiversity protection experts, and LUP draws interest from land use managers. Therefore, an integrated spatial planning (ISP) is essential to support the sustainable resources management of Ly Son. The government options for strong investment in the socio-economic development in Ly Son. In practice they are mainly concerned about building a system to upgrade the port, maritime traffic, embankments preventing coastal erosion, and the conservation of valuable cultural and historical monuments. Ly Son needs more investment in transport enhancing the human and physical capitals. This means an offshore fishing center, fishing logistics, marine transport and emergency services supporting agriculture, forestry and tourism, and becoming a strong base to protect the sovereign nation of the country over sea spatial of the South Central Coast.

Integrated spatial planning (ISP), marine spatial planning (MSP), and integrated coastal zone management (ICZM) have been applied in selected coastal provinces in Vietnam since 2000s. The results from previous ISP, MSP, and ICZM projects show increasing conflicts and social tensions among different communities using marine resources along the coast and on the islands. However, some cases offer examples of agreement on common approaches for the conflicts (Shipman and Stoijanovic, 2007). Ly Son should appoint a general manager with the following competences: local authorities need to monitor fishing activities, using resources of organizations and individuals in the district; strengthening the operational capacity; implementation of the Vietnamese Law of Marine and Island Resources and Environment; interdisciplinary control to monitor and regulate the activities degrading the natural resources and the pollution of the marine environment. Over-all, an ISP for Ly Son should concern inter-sector cooperation between agriculture, fishery, forestry and conservation, industry and service, tourism, and the army.

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