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Defining priority areas through social and biological data for the pig-nosed turtle (*Carettochelys insculpta*) conservation program in the Kikori Region, Papua New Guinea

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ABSTRACT

Environmental, biological, social, economic and political values influence the creation of protected areas. In some instances, the main aim of protected areas is to conserve a particular threatened species. The pig-nosed turtle (*Carettochelys insculpta*) in Papua New Guinea is a typical example of a species that would benefit from the introduction of small protected areas aimed to reduce overharvest. This species is highly prized as food and it is the most exploited turtle in the country. This study aims to identify priority areas for *C. insculpta* conservation in the Kikori region, taking into account the data available on biology, demography and harvest, as well as the distribution and demography of the Kikori human population. We identified seven potential priority areas for conservation and no-take areas, which comprise remote nesting sandbanks and feeding grounds. The conservation goals of these protected areas should be clearly linked with the local community aspirations of maintaining and increasing the number of eggs and adult turtles for future harvest. Monitoring of human and *C. insculpta* populations inside and outside priority areas are crucial to ensure that the vital areas for *C. insculpta* life cycle are maintained and protected, since feeding and nesting areas, as well as hunting areas, are likely to change in response to food and sandbank availability. The method presented in this paper has the potential to be adapted and applied while defining priorities in remote locations, where the implementation of protected areas are likely to affect communities livelihoods.

1. Introduction

One of the most common practices for the conservation of natural values is to set aside areas for special protection. Approximately 12% of the planet's terrestrial surface is encompassed by protected areas, which are also expected to contribute to poverty reduction and national development, especially in third world countries (IUCN, 2004). Although larger parks (>10,000 ha) have a greater potential to slow long-term species loss, small protected areas have significant local importance, and the size of the protected area does not necessarily correlate with positive conservation outcomes (Naughton-Treves, Holland, & Brandon, 2005). In many cases, the success of a given protected area relies on the balance between integrating the conservation goals and the needs and aspirations of local stakeholders (Wells & McShane, 2004). Sustainable long term community-based conservation programs around protected areas benefit from species and ecosystem based knowledge as long these are situated in the social reality of the region (Campbell & Vainio-Mattila, 2003).

Environmental and biological priorities are not the only factors influencing the creation of protected areas, which also takes into account social, economic and political values (Margules & Pressey, 2000). In some instances, the main aim of protected areas is to conserve a particular threatened species. The pig-nosed turtle (*Carettochelys insculpta*) in Papua New Guinea (PNG) is typical example of a species that would benefit from the introduction of protected areas aimed to reduce overharvest. This species is highly prized as food and it is the most exploited turtle in New Guinea (Cann, 1972; Georges, 1987; Georges, Guarino, & Bito, 2006). *C.*

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insculpta is currently listed as Vulnerable in the IUCN Red List of Threatened Species and on CITES Schedule II restricting its trade.

In the Kikori region (Gulf Province, PNG) the introduction of outboard motors and modern fishing equipment is related to increased capture rates of *C. insculpta* (Eisemberg, Rose, Yaru, & Georges, 2014; Georges, Alacs et al., 2008; Georges, Doody, Eisemberg, & Alacs, 2008), which have led to a severe population decline of 57% from 1980 to 82 to 2007–09 (Eisemberg, Rose, Yaru, & Georges, 2011). Both turtle and eggs are collected for trade or consumption by local villagers (Georges, Alacs et al., 2008; Georges, Doody et al., 2008). During the nesting season, local villagers harvest the pig-nosed turtle eggs with efficiency close to 90% (Eisemberg et al., 2011). Arising from the urgent need to reverse this decline, the "Piku Project" was created in 2008, to generate relevant scientific knowledge, raise awareness and promote community action.

The complete elimination of pig-nosed turtle harvest in Kikori is unrealistic, as it is the protection of the entire Kikori catchment, and neither actions are likely to be aligned with the complex community aspirations for the species and its environment. The perception of a population decline and a conservation ethic has yet to penetrate many in the local community. They do however perceive this species as a traditional source of food and income and are concerned for the sustainability of this important resource (Eisemberg et al., 2011). Furthermore, close to 100% of the land in Papua New Guinea is privately owned (Lynch & Marat, 1993) and the "Piku Project" region is divided among six distinct ethnic groups, each one of them with their own language, culture, aspirations and view of the resource (Eisemberg et al., 2014).

Under these constraints, it is necessary to prioritize areas where conservation efforts should focus. Broadly, from a biological point of view, efforts should focus on protecting nesting sandbanks in the Kikori riverine and coastal areas, and on protecting feeding grounds in the mangrove areas (Eisemberg et al., 2014; Eisemberg, Rose, Yaru, Amepou, & Georges, 2015; Georges, Alacs et al., 2008). However, a creation of non-take zones should also focus on the effect of the prohibition on local communities (Eisemberg et al., 2011, 2014; Georges, Doody et al., 2008). While designing a conservation plan, it is necessary to acknowledge not only the biological aspects of *C. insculpta* harvest, but also the social aspects if we are to avoid generating community resentment, reduce the likelihood of conflict and increase the chances of positive outcomes.

This study aims to identify priority areas for *C. insculpta* conservation in the Kikori region taking into account data available on *C. insculpta* biology, demography and harvest, as well as the distribution and demography of the Kikori human population. We used *C. insculpta* harvest and nesting biology data collected during the 2007–2008 and 2008–09 nesting seasons, coupled with government census and village locations, to identify areas where conservation efforts would deliver the best outcomes for the conservation of the *C. insculpta* population in the Kikori region.

2. Material and methods

2.1. Study area

The Kikori drainage extends from the alpine grasslands of Doma Peaks of the Southern Highlands Province of PNG to the extensive mangrove wetlands of the Gulf Province. The river system is highly confined within its limestone bed and meanders and oxbows are absent. The delta is a large alluvial plain below 40 m elevation, dissected by a tributary system of river channels and formed where soft silts and clays have been deposited over the underlying limestone plain. The coast comprises the delta islands exposed to the Gulf of Papua. Wind and wave action creates coastal beaches, sand bars and sand islands in what is a very dynamic system (Enesar Consulting, 2005).

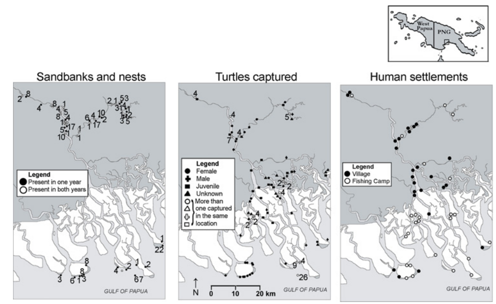

Fig. 1. Location for nesting sandbanks, nests and harvested *C. insculpta*, and human settlements in the Kikori region. Number of nests are given adjacent to its respective sandbank. Number of harvested animals are given when more than one individual were captured at the same location. White areas in the map represent mangroves.

The "Piku Project" encompass an area from Kaiam Village (7°5′40.96″S; 143°59′37.00″E) upstream on the Kikori River to Dopima Island (7°48′12.02″S; 144°13′20.32″E) on the coast. Its eastern boundary extends from Kuru-Sire Junction (7°9′4.45″S; 144°23′6.84″E) on the Sirebi River and Veraibari Village (7°40′49.69″S; 144°31′2.86″E) on the coast (Fig. 1). There are 51 villages and fishing camps in this area. *Carettochelys insculpta* nesting season occurs from September to March during the "dry" season (Georges, Alacs et al., 2008).

3. Methods

Data on *C. insculpta* harvest and nesting were collected during the 2007-08 and 2008-09 nesting seasons. We visited 19 villages and associated fishing camps across the Kikori region at least twice in each nesting season. Volunteers were recruited to record information on turtle harvest, and in particular, the location of capture, day of capture, sex and maturity status (female, male or juvenile) of harvested turtles. We identified nesting sandbanks and surveyed them monthly for signs of nests and predated nests, and to verify sandbank persistence. The numbers of nests, sandbanks and turtles were plotted according to their location in the Kikori region on a map divided into 2 × 2 km quadrats ($n = 287$).

Values recorded for each quadrat included four biological and three social attributes (Table 1). *Carettochelys insculpta* has a high dispersal capacity, over 2 km^2 (Doody, Young, & Georges, 2002). To calculate turtle density in a given quadrat we summed the total number of turtles in a given quadrat (TNT) and the total number of turtles in the adjacent quadrats (TNTA) divided by two [TNT + (TNTA/2)]. Sandbanks were classified as temporary (present in only one nesting season) or semi-permanent (present in more than one nesting season). The value of sandbanks in a given quadrat was calculated as the sum of the number of semi-permanent sandbanks (SPS) and the number of temporary sandbanks (TS) divided by two [PSP + (TS/2)]. Nest density was calculated as the number of nests present in the quadrat. The fourth biological factor we considered was feeding habitat. Mangrove plants, such as *Sonneratia lanceolata* and *Nypa fructicans*, are found mostly in the delta and compose the main part of the *C. insculpta* diet in the Kikori region (Eisemberg et al., 2015; Georges, Doody et al., 2008). The quadrat value for feeding habitat was calculated as 1 if mangroves were present in the quadrat, 0.5 if mangrove was present in any adjacent quadrats and 0 if no mangroves were present in the quadrat or adjacent quadrats.

In Kikori, protected areas close to high human inhabitancy weighted less because they are less likely to be accepted as a suitable area for closure by the local community. In Papua New Guinea, landowners are more prone to set aside areas at greater distances from the villages (Ancrenaz, Dabek, & O'Neil, 2007) and customary closures are more likely to succeed in areas sparsely populated

Table 1
Values attributed for the Kikori Region 2 × 2 km quadrats in relation to biological and social characteristics of *C. insculpta* harvest. Quadrat value = (Primary value) + (Secondary value/2) + (Tertiary value/4). Secondary values are given as half of the gross value and tertiary values are given as a quarter of the gross value.

Aspect	Attribute	Primary value (x)	Secondary value (x/2)	Tertiary value (x/4)
Biological	Turtle density	Total number of turtles in the quadrat	Total number of turtles in adjacent quadrats	NA
	Sandbank availability	Two seasons sandbanks	One season sandbanks	NA
	Nest density	Number of nests	NA	NA
	Feeding habitat	Presence of mangroves	Presence of mangroves in adjacent quadrats	NA
Social	Human population	Village population in the quadrat	Village population in adjacent quadrats	NA
	Fishing areas	Fishing camp in the quadrat	Fishing camp in adjacent quadrats	Fishing camp in quadrats surrounding adjacent quadrats
	Travelling route	Number of villages using quadrat as main travelling route	NA	NA

and distant from the markets (Cinner, Sutton, & Bond, 2007). Areas with high human population densities and fishing camps should result in a lower weighting for inclusion in any protected area. We used the PNG 2000 census (Census, 2000) to calculate human density in each quadrat. We took into account the fact that the use of outboard motors is greatly moderated by the scarcity and cost of fuel and most fishing excursions around the village are done using canoe and walking, which presents a constraint on how far the local community can go in a daily basis (Eisemberg et al., 2014). The effect of human density in a given quadrat was calculated as the sum of the village population (VP) in a given quadrat and the village population in adjacent quadrats (VPA) divided by two [VP + (VPA/2)].

A second social factor to take into account is the presence of fishing camps in a given quadrat. Fishing camps are temporary settlements scattered around the Kikori region, where groups of a certain clan spend a short period intensively hunting and fishing. These fishing camps are important areas that are rotated and where a significant amount of protein is obtained for communal use. While staying in a fishing camp, the group will focus on harvesting activities and undergo longer distances to fish and hunt. The value for a given quadrat in relation to fishing camps was calculated as Number of fishing camps in the quadrat + (Number of fishing camp in adjacent quadrats/2) + (Number of fishing camp in quadrats surrounding adjacent quadrats/4).

A third social aspect considered was traveling routes. Areas used by many villages to travel to the market or other villages should preferably not be included in any protected area, because the effort to monitor these areas would need to be intense and disputes between villages are likely to occur. The value for a given quadrat in relation to traveling was calculated as the number of villages using the quadrat as its main route.

Biological and social attribute values varied greatly from 0 to 1–0 to 2728. In order to give a similar weight for each attribute, the quadrat gross attribute value was divided by the maximum quadrat value found in the region and given an index from 0 to 1 (Table 2). Overall Biological Quadrat Value was calculated as the sum of turtle density, sandbank availability, nest density and feeding habitat indexes. Overall Social Quadrat Value was calculated as the sum of human population, fishing camps and traveling route indexes. The Total Biological Index for each quadrat was calculated by dividing the Overall Biological Quadrat Value of by the maximum Overall Biological Quadrat Value found in the region (final range between 0 and 1, where the highest value is considered the most desirable area for conservation).

The initial quadrat Total Social Index was calculated likewise (Overall Social Quadrat Value divided by the maximum Overall Social Quadrat Value found in the region). However, quadrats with the highest Total Social Index were considered the most undesirable areas for conservation (high human density and activity). Therefore, these values were inverted by subtracting the quadrat value from 1. The quadrat final total index was calculated by summing its Total Biological Index and the Total Social Index and dividing this value by the sum of the maximum Total Biological Index quadrat and Total Social Index values found in the region. Values were categorized as very low, low, moderate, high and very high (Table 3). These categories were defined arbitrarily to help graphically illustrate priority areas for the conservation of the *C. insculpta* population in the Kikori Region.

4. Results

We recorded 142 *C. insculpta* (95 females, 15 males, 19 juveniles and 13 unknown). We identified 43 nesting sandbanks, of which 27 were present in both years (i.e., semi-permanent) and 16 were present in only one year (2007–2008 or 2008–2009) (i.e., temporary). In total, 291 nests were recorded. The 2000 census recorded 6379 people living in the Kikori lowland region (Piku Project region) with an average of 255 ± 105.9 (15–2688) people per village. Villages and fishing camps were scattered around the Kikori lowland with a higher concentration of villages in riverine areas (upstream from mangrove areas) and fishing camps in the mangrove and coastal areas (Fig. 1). Biological and Social index values for individual quadrats ranged from 0 to 0.51 and from 0.33 to 1, respectively. The total quadrats average index value (Biological and Social) was 0.77.

Sandbanks, and consequently nests, were concentrated in riverine and coastal areas (upstream and downstream from mangrove areas), while turtle density was higher in the upper and lower parts of the mangrove areas (Fig. 2). Transport intensity was higher in the Kikori main channel. Human population was concentrated largely on the lower parts of the riverine areas

Fishing camps were in higher numbers on the coastal and mangrove areas, but also present in high numbers on the lower reaches of the Sirebi River (Fig. 3). Priority areas using only social or only biological attributes differed considerably (Fig. 4). When both attributes were combined, we identified seven potential priority areas for conservation and non-take areas for the Kikori region: Gaarobari-Kerewo (4945 km^2); Ravo-Toro-Kerewo (4663 km^2); Turuvio-Kerewo (68,273 km); Kikori-Porome (25,829 km^2); Otoia-Urama (7829 km^2); Wau-Rumu (2.672 km^2); and, Siri-Rumu (1.902 km^2) (Fig. 4).

5. Discussion

Our results represent the first attempt to identify priority areas for conservation of *C. insculpta* in the Kikori lowlands. Areas far from the most frequently used sites, and with higher numbers of turtles

Table 2
Gross values and index values attributed to 2 × 2 km quadrats according to their biological and social characteristics in relation to the pig-nosed turtle population in the Kikori Region. Quadrats (*n* = 287) means are given with their standard deviations and ranges (in brackets). Index Value = quadrat gross value/maximum gross value found in the region (range: 0–1). Quadrats with higher values were considered more suitable for *C. insculpta* conservation.

Aspect	Attribute	Gross value	Index value
Biological	Turtle density	1.58 ± 2.91 (0–26)	0.06 ± 0.11 (0–1)
	Sandbank availability	0.28 ± 0.94 (0–8)	0.03 ± 0.12 (0–1)
	Nest density	1.22 ± 6.84 (0–84)	0.01 ± 0.08 (0–1)
	Feeding habitat	0.68 ± 0.43 (0–1)	0.68 ± 0.43 (0–1
		Total	0.20 ± 0.11 (0–0.51)
Social	Human population	75.96 ± 241.23 (0–2728.25)	0.03 ± 0.09 (0–1)
	Fishing areas	0.35 ± 3.25 (0–0.55)	0.11 ± 0.17 (0–1)
	Travelling route	1.71 ± 1.77 (0–12)	0.14 ± 0.15 (0–1)
		Total	0.91 ± 0.09 (0.33–1)
	Total	1.11 ± 0.14 (0.34 –1.43)	0.77 ± 0.10 (0.24–1.00)

Table 3
Index ranges used to group the 2 × 2 km quadrats within "very low", "low", "moderate", "high" and "very high" categories. These categories were used to illustrate and identify priority areas for the conservation of the *C. insculpta* population in the Kikori Region. Quadrats with higher values were considered more suitable for *C. insculpta* conservation.

Figure legend	Very low	Low	Moderate	High	Very high
Turtles index	0	0.01–0.24	0.25–0.49	>0.5	NA
Mangrove index	0	0.5	1	NA	NA
Nest index	0	0.01– 0.09	0.10–0.20	>0.25	NA
Sandbank index	0	0.01–0.24	0.21–0.49	>0.50	NA
Total biological index	0	0.01–0.09	0.10–0.19	0.21–0.29	>0.30
Transport index	0	0.01–0.09	0.10–0.19	0.20–0.49	>0.50
Village index	0	0.01–0.05	0.06–0.09	0.10–0.49	>0.50
Fishcamp index	0	0.01–0.09	0.10–0.24	0.25–0.50	>0.50
Total social index	0–0.89	0.9–0.94	0.95–0.96	0.97–0.99	1
Total index	0–0.59	0.60–0.69	0.70–0.79	0.80–0.85	0.86–1

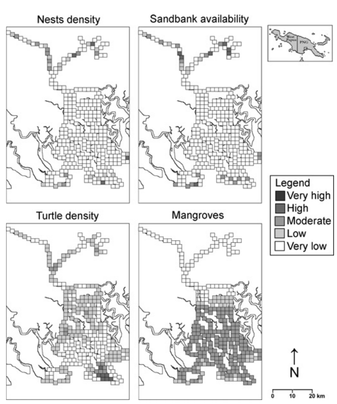

Fig. 2. Biological index categories for the 2 × 2 km quadrats according to their biological characteristics (Sandbank availability, nests and harvested *C. insculpta* density, and mangrove presence) in relation to the pig-nosed turtle population of the Kikori region.

and nests, were considered the most suitable areas for *C. insculpta* protected areas. Five of these priority areas (Gaarobari-Kerewo, Ravo-Toro-Kerewo, Turuvio-Kerewo, Otoia-Urama, Wau-Rumu and Siri-Rumu) are relatively small and surround main nesting sandbanks, where females congregate before and after nesting. The Kikori-Porome priority area is larger in size and probably encompasses an important feeding ground for this species. Another larger area is the Turuvio-Kerewo, and this area seems to have a vital role for *C. insculpta* in this region, being used both for feeding and nesting.

Papua New Guinea Protected Areas Policy (Independent State of Papua New Guinea, 2014) reiterates the importance of protected areas in the country, which should be created in partnership with the local people. The Policy includes terrestrial and marine Special Management Areas which are described as areas where special management is needed for the protection of a particular species or ecosystem. Currently, the PNG national protected area system covers 3 % of PNG's total land area and comprises over 30 Wildlife Management Areas (WMAs) and National Parks (Shearman & Bryan, 2011). However, the conservation efforts inside most protected areas are neither adequate nor effective, with several WMAs forests having been almost completely deforested (Shearman, Ash, Mackey, Bryan, & Lokes, 2009). The Neiru Wildlife Management area is the only current protected area located in lower Kikori River Basin and it encompasses the delta island of Aird Hills (Shearman & Bryan, 2011). This WMA does not include any of the priority areas suggested in our results for the conservation of *C. insculpta*.

Traditional no-fishing zones in the Pacific islands are the best examples of management regimes that are designed to meet community goals and successfully maintain wildlife (Cinner, Marnane, & McClanahan, 2005; Johannes, 1978). Conservation programs of charismatic animals and plants in developing countries are usually successful when the action produces tangible local benefits such as the protection of breeding grounds (Kaimowitz & Sheil, 2007). This approach is suggested in remote tropical regions, where there is usually a lack of resources for enforcement (McClanahan, Marnane, Cinner, & Kiene, 2006). In such cases, smaller strategically located protected areas, such as the IUCN category IV Habitat/Species management area (Dudley, 2008) are usually recommended (Zuidema, Sayer, & Dijkman, 1996).

The cooperation and support of local communities are essential for the success of protected areas in developing countries. However many efforts to balance community interests and the management of protected area has resulted in unsatisfactory outcomes (Wells & McShane, 2004). Sea turtle conservation projects in Africa, for example, present various degrees of success depending on the country, partnerships and funding sources (Formia, Tiwari, Fretey, & Billes, 2003). Successful conservation projects in the tropics, such as the Kinabatangan Orang-utan Conservation Project (Ancrenaz et al., 2007) and the Brazilian Sea Turtle project TAMAR (Marcovaldi & Marcovaldi, 1999) employed a multidisciplinary approach that combined scientific research with community engagement, capacity building and education, taking into account the needs and aspirations of local communities.

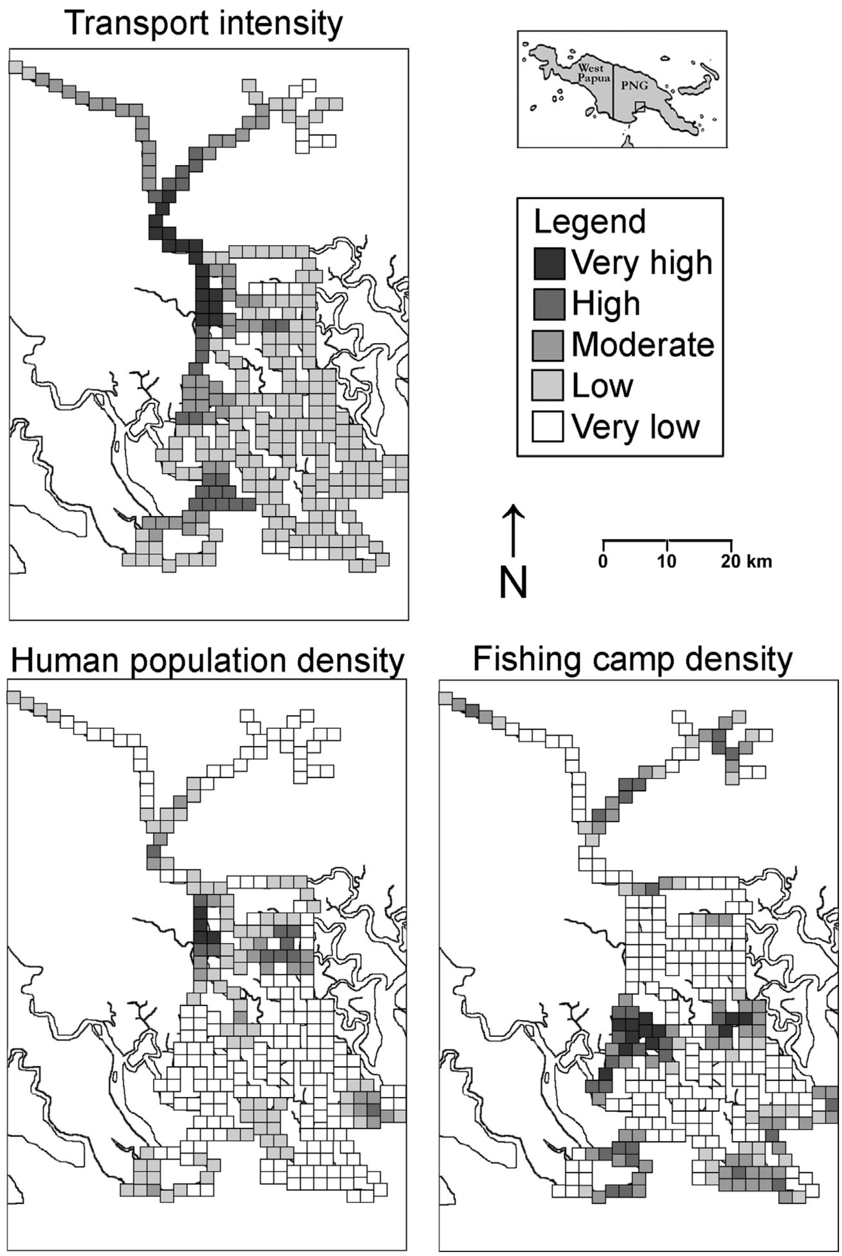

Fig. 3. Social index categories for the 2 × 2 km quadrats according to their social characteristics (transport intensity, human density in villages and fishing camp presence) in relation to the human population of the Kikori region.

The Tree Kangaroo Conservation Program and the Sea Turtle Restoration Project are examples of successful conservation projects in PNG. The Tree Kangaroo Conservation Program prevented the over-exploitation of the endemic Matschie's tree kangaroo with the support of local land owners that outlined portions of intact habitat to be set aside as a conservation area (Ancrenaz et al., 2007). The Sea Turtle Restoration Project utilized traditional laws for marine protection in the community to establish the first Conservation Deed Trust to protect leatherback turtle (*Demochelys coriacea*) nesting beaches (Pincetich, Ong, & Steiner, 2012). These projects outline the importance of the participation of the local community at all stages of project planning and managing as a key for their success (Campbell & Vainio-Mattila, 2003; Wainwright & Wehrmeyer, 1998; Wells & Brandon, 1993). Long-term species protection can only be achieved in PNG if local community and especially landowners are involved in all aspects of the management plan and parallel community projects are provided (Ancrenaz et al., 2007; Sillitoe, 2001).

The harvest of the large Amazon freshwater turtles presents a similar scenario to the pig-nosed turtle in PNG. In Amazon, adult females are harvested during the nesting season and this practice is considered traditional to its riverine communities (Caputo, Canestrelli, & Boitani, 2005; Fachín Terán, Vogt, & Thorbjamarson, 2004; Kemenes & Pezzuti, 2007). Government control through regulations and penalties is limited (Rebêlo, Pezzuti, Lugli, & Moreira, 2005) and subsistence consumption is legal for traditional communities (Miorando, Rebêlo, Pignati, & Pezzuti, 2013). In the lower Amazon, communities have implemented actions to control turtle harvest, not only protecting nesting beaches but also managing the use of fishing nets (McGrath, de Castro, Futemma, de Amaral, & Calabria, 1993). This local fishing restrictions had a positive result on turtle population (Miorando et al., 2013), since the pro-

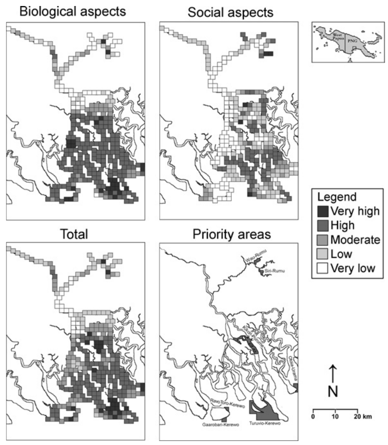

Fig. 4. Priority areas conservation projects and non-take areas for *C. insculpta* in the Kikori region according to biological, social and combined (Total) index values. Seven high priory areas were identified: Gaarobari-Kerewo, Ravo-Toro-Kerewo, Turuvio-Kerewo, Kikori-Porome, Otoia-Urama, Wau-Rumu and Siri-Rumu.

tection of juveniles and adults is essential to recover population numbers (Mogollones, Rodríguez, Hernández, & Barreto, 2010). Other community-based programs have also demonstrated that long-term beach and feeding grounds protection can be an inexpensive and effective tool to reduce the harvest of females and eggs and consequently increase population numbers (Dutton, Dutton, Chaloupka, & Boulon, 2005; Garcia, Ceballos, & Adaya, 2003).

Turtles have been an important source of protein for indigenous communities for many centuries (Milner-Gulland & Bennett, 2003; Smith, 1979). However, chelonians life history attributes (e.g., late maturing, slow-growing, long-lived) are susceptible to chronic disturbance and overexploitation and are particularly vulnerable to the removal of large reproducing females (Congdon, Dunham, & Sels, 1993; Tucker & Moll, 1997). The protection of nesting habitat therefore is a common practice in conservation programs for endangered species of turtles. Similar to Amazon, turtles in Kikori are often captured incidentally with fishing lines and nets, but most turtles are captured during the nesting season, when females are harvested while laying their eggs in riverine sandbanks and coastal beaches. Pig-nosed turtle eggs are collected with an efficiency close to 90 % in Kikori. Hunters can capture up to 26 females in one night, although this is very rare (Eisemberg et al., 2011, 2014). There is no evidence of trade in turtles, eggs or turtle products with markets outside Kikori (Georges, Doody et al., 2008) with all harvested animals and eggs consumed or traded locally. The harvest, consumption and sale of turtles are considered legal activities (Eisemberg et al., 2011).

The conservation goals of the "Piku Project" to stop the recent *C. insculpta* decline in the Kikori region should be clearly linked with the local community aspirations of maintaining and increasing the number of eggs and adult turtles for future harvest (Eisemberg et al., 2011). The involvement of local communities through education programs and during the management decisions and data collection is crucial while setting aside protected areas for *C. insculpta* recruitment, during its critical life history stages (Escalona & Fa, 1998; Marcovaldi & Marcovaldi, 1999). Since 2008, the "Piku Project" has initiated conservation projects at the Wau-Rumu and Turuvio-Kerewo priority areas. The project has been remarkably successful at the Wau-Rumu priority area, where a research station has been constructed, landowners have decreed a partial moratorium on turtle and nest harvest and a monitoring program has been established. Furthermore, landowners of the Wau-Rumu are applying in a partnership with WWF to transform this area into a WMA. According to Shearman and Bryan (2011), despite the past failures, WMAs still remain a suitable start for creating multiple sustainable uses areas in PNG.

Besides the sustainable use component of this program, a major part of the "Piku Project" consists of promoting awareness and instilling a sense of pride within the community as protectors of such iconic species. School materials have been produced and introduced in local schools (Eisemberg et al., 2009). On-going community meetings are held to access the present program and plan future actions. The local community has acknowledged the declining numbers of *C. insculpta* due to overharvest of adults and eggs and suggested management strategies in customary lands. However, these actions have encountered some resistance within landowning clans since it will prevent, even if partially, the access to a traditional delicacy. There is also frustration with the lack of government and NGO assistance in managing what they consider an important resource. The success of these first management and conservation attempts in Wau-Rumu and Turuvio-Kerewo are vital for landowners from other priority areas to join the project in the near future.

More data on *C. insculpta* demography, biology and status is necessary to complement the results found in this study. The Kikori region has a highly variable environment and both *C. insculpta* and human populations are constantly adapting to its fluctuations. Although conservation planning is a spatial science, its effectiveness must acknowledge that biodiversity is not static in time or space (Pressey, Cabeza, Watts, Cowling, & Wilson, 2007). Feeding and nesting areas, as well as hunting areas, are likely to change in response to food and sandbank availability. Monitoring of human and *C. insculpta* populations inside and outside priority areas are crucial to ensure that the vital areas for *C. insculpta* life cycle are maintained and protected.

The methods to identify priority areas for conservation presented in this paper have the potential to be adapted and applied both for other taxa and regions. This is an integrative approach which considers both biological and social data and it will be particularly suitable while defining priorities in remote locations where the implementation of protected areas are likely to affect communities livelihoods.

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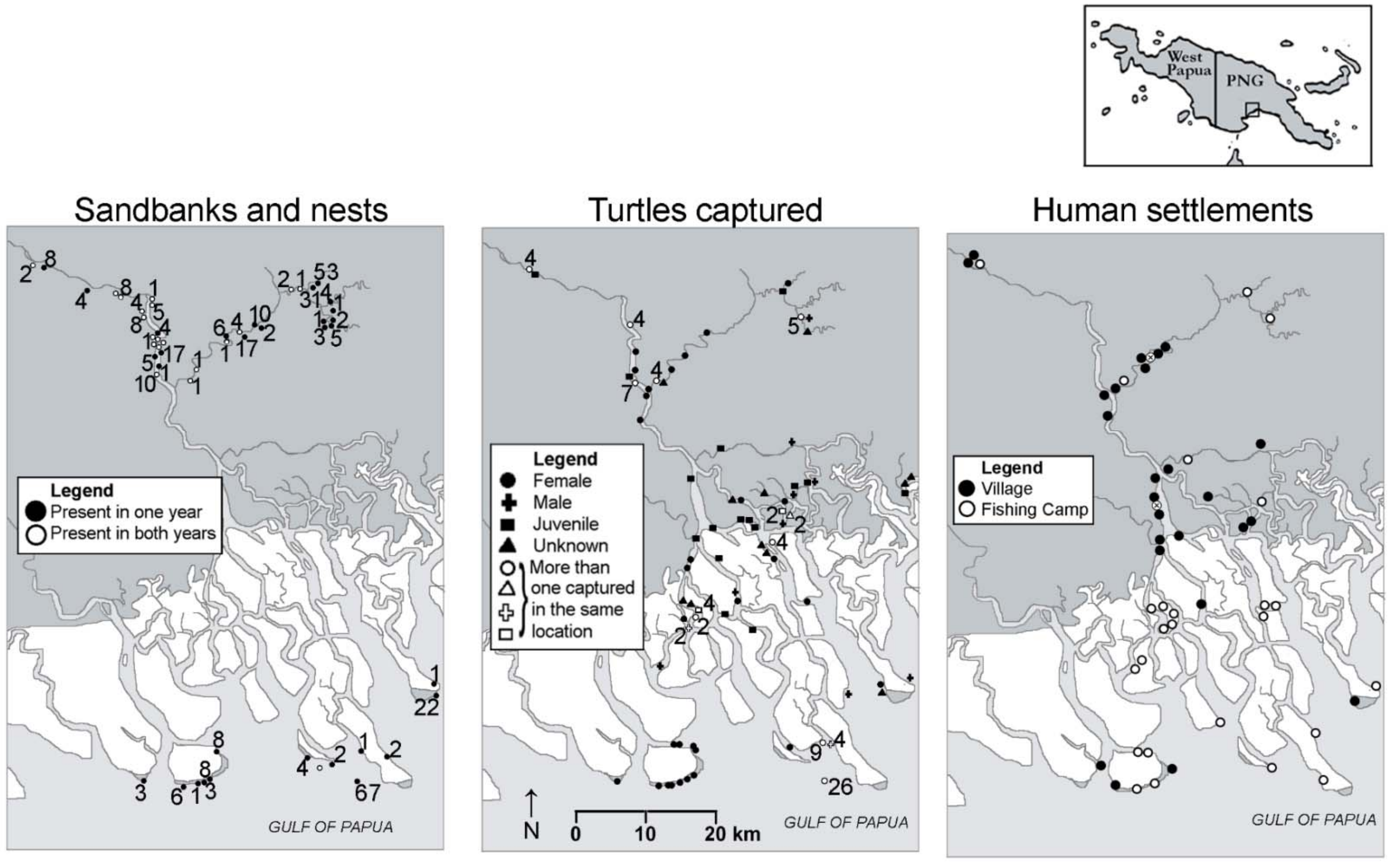

Figure 1. Location for nesting sandbanks, nests and harvested *C. insculpta*, and human settlements in the Kikori region. Number of nests are given adjacent to its respective sandbank. Number of harvested animals are given when more than one individual were captured at the same location. White areas in the map represent mangroves.

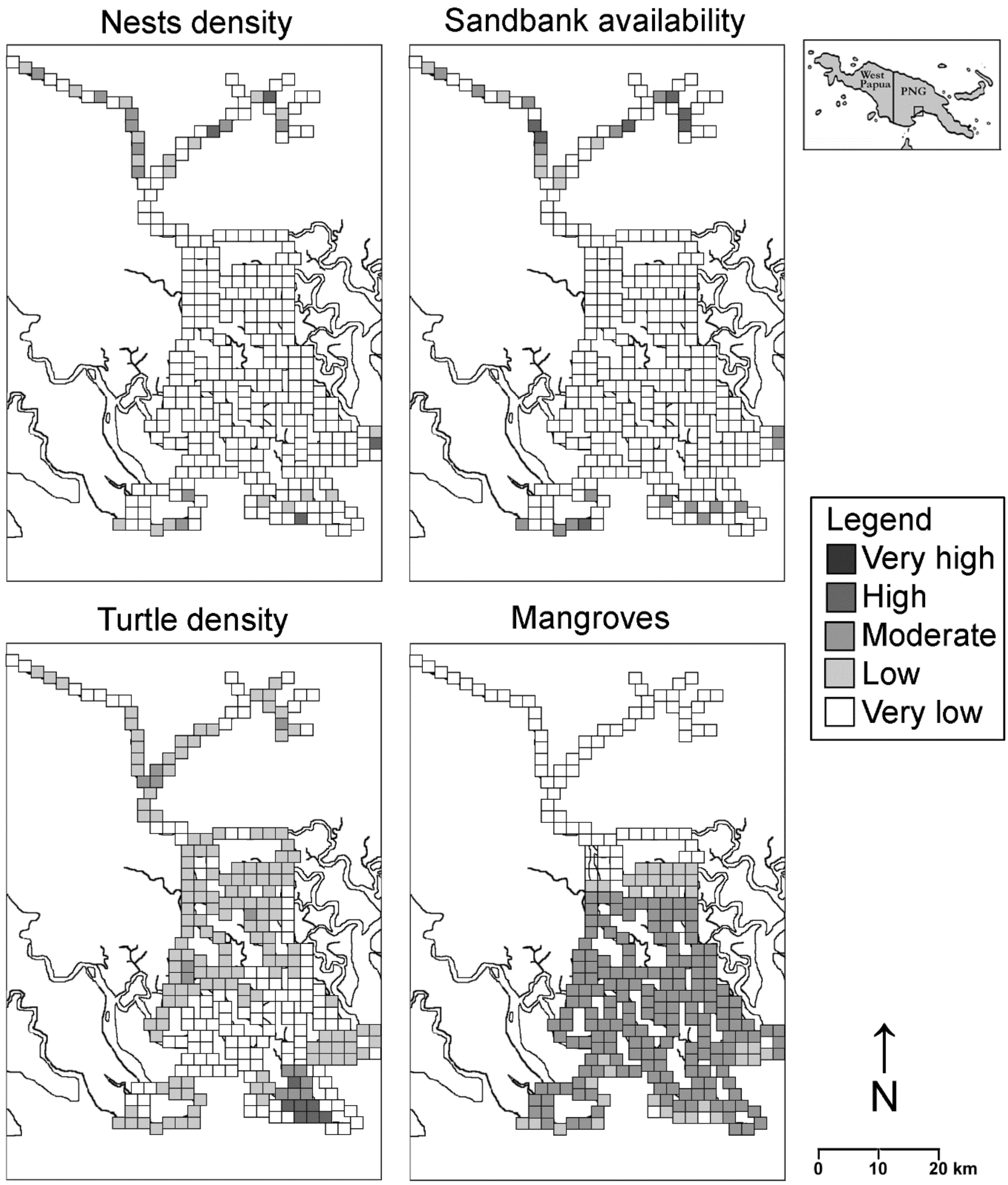

Figure 2. Biological index categories for the 2 x 2 km quadrats according to their biological characteristics (Sandbanks availability, nests and harvested *C. insculpta* density, and mangrove presence) in relation to the pig-nosed turtle population of the Kikori region.

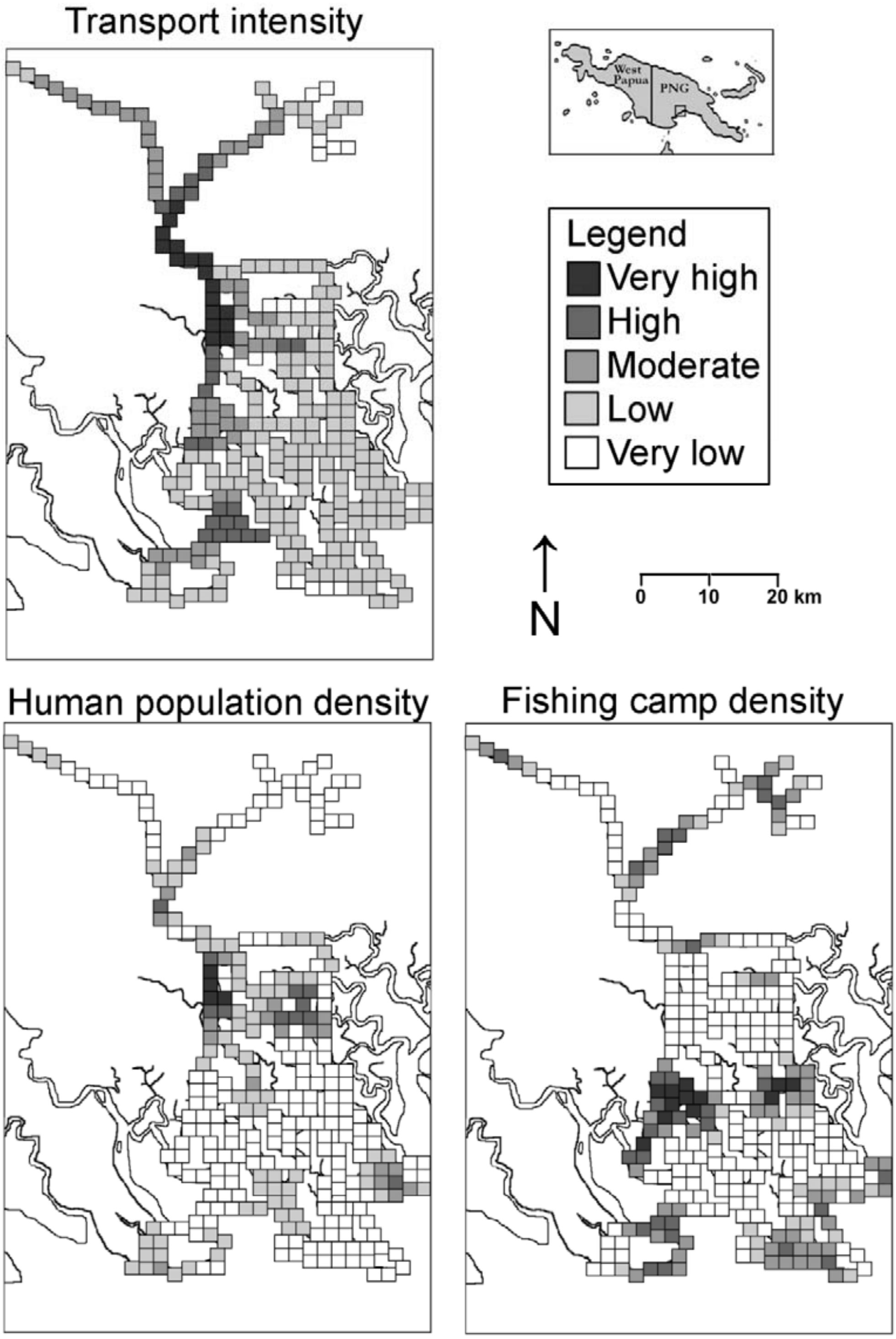

Figure 3. Social index categories for the 2 x 2 km quadrats according to their social characteristics (transport intensity, human density in villages and fishing camp presence) in relation to the human population of the Kikori region.

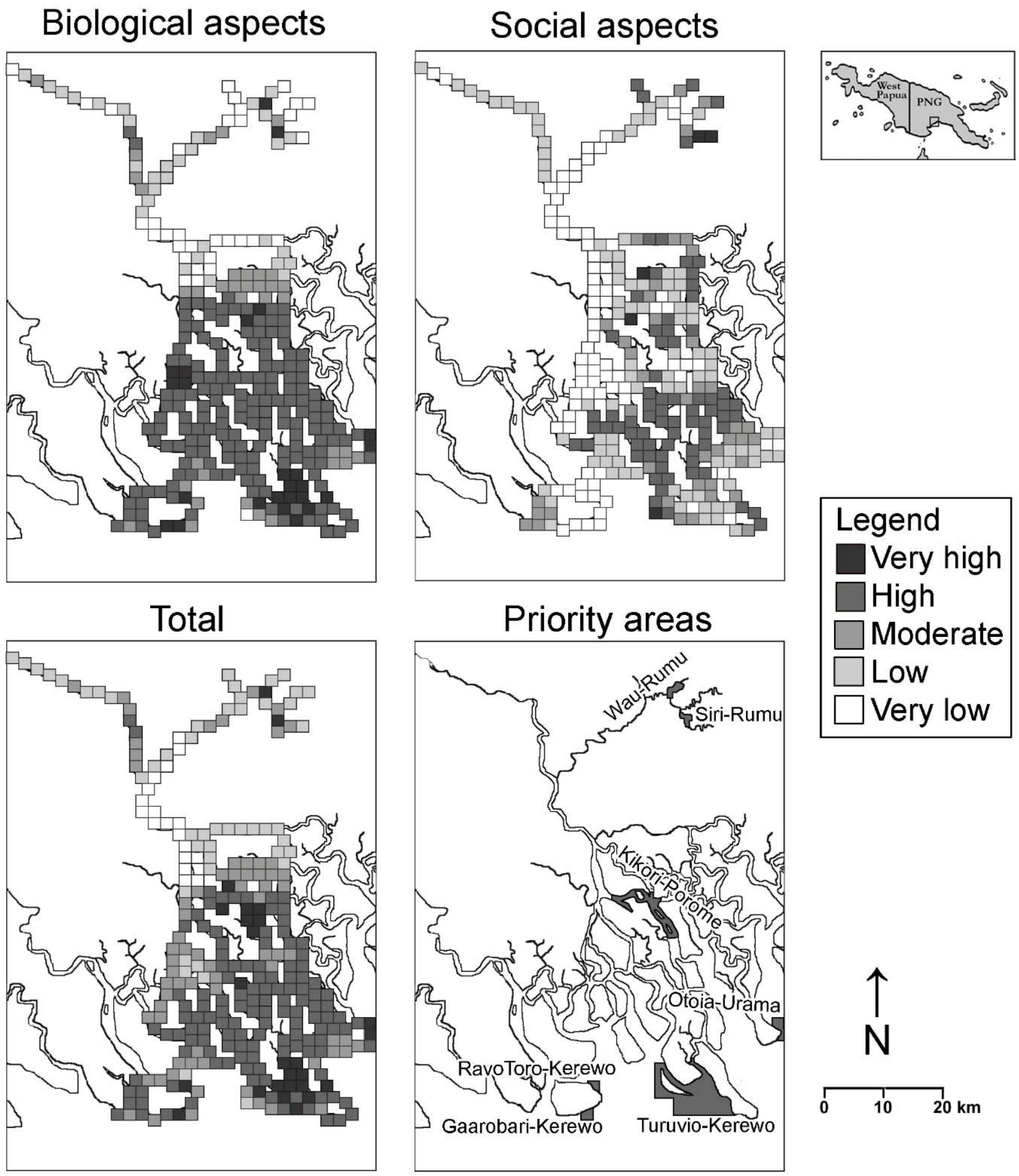

Figure 4. Priority areas conservation projects and non-take areas for *C. insculpta* in the Kikori region according to biological, social and combined (Total) index values. Seven high priory areas were identified: Gaarobari-Kerewo, Ravo-Toro-Kerewo, Turuvio-Kerewo, Kikori-Porome, Otoia-Urama, Wau-Rumu and Siri-Rumu.