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Socio-Cultural Importance of Mangrove Forest and Its Implication for Multiple-Use Management in the Sheran Sandy Bay Sirpi Community, Nicaragua

Master's thesis

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Declaration:

This is to certify that this thesis titled “Socio-Cultural Importance of Mangrove Forest and Its Implication for Multiple-Use Management in the Sheran Sandy Bay Sirpi Community, Nicaragua,” submitted in partial fulfilment for the award of the MSc. Degree in Tropical Crop Management and Ecology under the Department of Crop Science and Agroforestry, Czech University of Life Sciences Prague, was written by me, the undersigned Maynor Marlon Carias Garcia, and is my own work done with technical and scientific support from my supervisor doc. Ing. Zbyněk Polesný, Ph.D. Hereby I confirm that all the information used here, have been cited and that this work has never been published anywhere before.

Prague: ___________________________Maynor Carias: ________________________

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Abstract:

For this ethnobotanical study, there were surveys conducted with 40 participants and a workshop with 10 participants in the community of Sandy Bay Sirpi, which is located on the South Caribbean Coast of Nicaragua. This study provides detailed information about the key species of mangrove and their importance in terms of wood, habitat, socio-cultural and socio-economic value, and a short description of the mangrove ecosystem's environmental condition of the area in question. We identified two types of mangrove species: the red mangrove (Laulu pauni) and the black mangrove (Laulu siksa). We found that the Miskitu people from this community mostly exploit mangrove trees in the following manner: wood products; firewood (100%), charcoal (20%), timber (90%), posts (70%), walls (25%), fences (100%), planks (15%), traps (35%) and beams (60%) non-wood products; medicine (10%) and repellents (20%).

The local people earn their living by fishing and harvesting firewood to sell in the market. The highest direct use value (DUV) was generated from fish production (341 kUSD per year), shrimp production (306 kUSD per year) and firewood (108 kUSD per year). All these data were obtained only from the participants of this study. A sustainable and effective management is needed in view of the rising pressures of demographic change and pollution to ensure food security and sources of income for future generations, mitigating at the same time the negative effects of climate change which have already become visible. We need to raise awareness and explain that the traditional ethnobotanical knowledge of the indigenous people is disappearing. The collected ethnobotanical data can serve as a warning to the local people so that everyone can understand the value and importance of mangrove forests, enabling them to collaborate with environmental institutions in protecting and conservation of mangrove ecosystems in their area.

Key words: mangrove tree, wood economy, management, Sandy Bay Sirpi, Nicaragua.

Shrnutí:

Při zpracovávání této etnobotanické studie byl proveden průzkum se 40 účastníky a setkání s 10 účastníky v domorodém společenství Sluneční pláže Sirpi, která se nachází na jižním pobřeží Karibského moře Nikaraguy. Výsledek této studie přináší podrobné informace o klíčových druzích mangrovových porostů a významu těchto druhů jako zdrojů dřeva a jako biotopu se socio-kulturní a socio-ekonomickou hodnotou, ve stručnosti pak také přináší popis podmínek životního prostředí mangrovových ekosystémů studované oblasti. Identifikovali jsme dva druhy mangrove ve studované oblasti, konkrétně červené mangrove (Laulu pauni) a černé mangrove (Laulu siksa). V přehledu věnovaném hlavním způsobům využití těchto druhů jsme dospěli k závěru, že národ Miskitu z tohoto společenství využívá mangrovové stromy hlavně k následujícím účelům: a) dřevěné produkty: palivové dříví (100%), dřevěné uhlí (20 %), klády (90 %), kůly a sloupky (70 %), stěny (25 %), ploty (100 %), prkna (15 %), dřevo na pasti (35 %) a trámy (60%); b) nedřevěné produkty: léky (10%) a repelenty (20%).

Místní lidé získávají příjmy z rybaření a ze sběru palivového dříví, které prodávají, nejvyšší příjem byl získán z produkce ryb 341 USD na osobu ročně, 306 UDS na osobu ročně z produkce krevet, následovaný 108 USD na osobu ročně z produkce dřeva. Všechna tato data byla získána pouze od účastníků této studie. Na druhou stranu udržitelná a efektivní správa je zapotřebí nejen s ohledem na vzrůstající demografický tlak a narůstající znečištění, nýbrž i za účelem zajištění dostatku potravin a ekonomických příjmů pro následující generace a za účelem zmírnění efektu klimatických změn v posledním období, kdy se tento stal viditelným. Je zapotřebí zvýšit naši obezřetnost a vysvětlovat, že etnobotanické znalosti domorodého obyvatelstva postupně mizí. Shromážděná data mohou být varováním pro místní obyvatelstvo, neboť na jejich základě každý může porozumět hodnotě mangrovových porostů a nezbytnosti vytvořit prostor, aby se domorodé obyvatelstvo společně s institucemi zahrnutými do ochrany životního prostředí podílelo na akcích za účelem přispět k ochraně mangrovových ekosystémů.

Klíčová slova: stromy mangrove, užití dřeva, hospodářská správa, Slunečná pláž Sirpi, Nicaragua.

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List of abbreviations:

AWALTARA (Big river, Meaning in Miskitu Language)
BICU (Bluefields Indian and Caribbean University)
CM (Centimetres)
DOG (Dissolved Organic Carbon)
FAO (Food and Agriculture Organization)
Fw V (Firewood Value)
HKND (Hong Kong Nicaragua Canal Development Group)
ICRAF (International Center for Research in Agroforestry)
INETER Instituto Nicaraguense de Estudios Territorial
(Nicaraguan Institute of Territorial Study)
ISNAR (International Service for National Agricultural Research)
IUCN (International Union for Conservation of Nature)
km2 (Square Kilometres)
LEK (Local Ecological Knowledge)
M (Meter)
MARENA Ministerio del Ambiente y los Recursos Naturales
(Ministry of Environment and Natural Resources)

MM	(Millimetres)
RSJ	(Rio San Juan)
RACS	(South Caribbean Autonomous Región)
RACN	(North Caribbean Autonomous Region)
SERENA	Secretaria de Recursos Naturales y el Ambiente (Secretary of Natural Resources and the Environment)
TEK	(Traditional Ecological Knowledge)
UV	(Use Value)
Urs	(Use Reports)
URACCAN	(Universidad de las Regiones Autonomas de la Costa Caribe de Nicaragua (University of the Autonomous Regions of the Nicaraguan Caribbean Coast)
UNEP	(United Nations Environment Program)
UCA	(University of Central America)
WLBC	(William L. Brown Center 'Missouri Botanical Garden')
WHO	(World Health Organization)

Foreword

Literature on mangroves in Central America is mostly related to biological (Gross et al., 2013), ecological (Lovelock et al., 2004; Gross et al., 2013) and socioeconomic characteristics (Fürst et al., 2000). According to FAO (2007), the mangroves in Nicaragua are found along some 30% of the coast and are approximately equally distributed between the Pacific and the Caribbean coasts.

In Mosquitia on the Nicaraguan Caribbean coast, the mangrove ecoregion covers a large expanse spreading from the coastline beginning in Honduras at the delta of the Patuca River to the south of Punta Gorda Bay in Nicaragua, and also includes some offshore islands like Corn Island. The mangrove here consists of four major species: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*) (Polanía and Mainardi, 1993).

Mangrove ecosystems have social and cultural functions, as well as recreational and aesthetic value (ecotourism), not to mention their religious and spiritual value (UNEP, 2014). Mangroves support many socioeconomic activities including forestry, fisheries, aquaculture, agriculture etc. (Walters et al., 2008). The main use of mangrove wood is to provide fuel and material for rural construction; poles are also extracted for the construction of fish traps (Glaser et al., 2003).

Many human activities of various kind (subsistence, artisanal, and industrial) have reduced the mangrove area (Wolanski et al., 2000). These wetland areas are impacted by clay extraction, aquaculture, agriculture, salt extraction and industrial activities (Senna et al., 2002). Heavily populated coastal zones have spurred the widespread clearing of mangroves for coastal development, aquaculture, or resource exploitation. At least 40% of the animal species that are restricted to mangrove habitat and have previously been assessed under IUCN Categories and Criteria are at heightened risk of extinction (Luther and Greenberg, 2009). It is estimated that 26% of mangrove forests worldwide have been degraded due to over-exploitation for fuelwood and timber production (Valiela et al., 2001). Similarly, clearing of mangroves for shrimp farming is responsible for about 38% of global mangrove loss. (Ellison, 2008).

This study focuses on the socio-cultural use of mangroves by the community people of Sandy Bay Sirpi. It has also a more universal import because mangrove forest is one of the natural ecosystems where many indigenous communities practice their socio-economic activities in a different form, acquiring food and material for construction. With this study, we also intend to raise awareness so they can fully appreciate the importance of these species and their ecosystems and implement a proper management of the mangrove habitat.

1. Introduction

1.1 *Mangrove distribution around the world*

The total area of mangroves in 2000 was 137,760 km^2 in 118 countries and territories in the tropical and subtropical regions. Approximately 75% of the world's mangroves are found in 15 countries, but only 6.9% are covered in the existing protected areas network IUCN (International Union for Conservation of Nature). The world's mangrove forests grow in areas of warm oceanic currents, the largest percentage of mangroves being found between 5° N and 5° S latitude. (Giri et al., 2011). On a worldwide scale, mangrove forests extend from Florida (US) to the Argentinian coast in South America. Mangrove forests are scattered along both coasts of Africa and spread across the ocean to the Indian sub-continent and all the way up to Ryukyu (Okinawa) in Japan. Further to the south, this forest type reaches down to Australia and New Zealand and is found throughout the Indo-Malay area (Sarva et al., 2008).

Table 1. Mangrove distribution around the world (Aizpuru et al., 2000)

America		Africa		SE Asia		Oceania	
Brazil	13,800	Guinea-Bissau	2,500	Vietnam	2,500	Australia	11,700
Colombia	3,700	Nigeria	10,500	Bangladesh	6,300	PNG	4,100
Cuba	5,600	Gabon	2,500	Indonesia	42,500		
Mexico	5,300	Cameron	2,400	Malaysia	6,400		
Venezuela	2,500	Madagascar	3,200	Myanmar	5,200		
				India	6,700		
Total	30,900	Total	21,100	Total	69,900	Total	15,700

1.1.1 *Mangrove distribution in Central America*

Wetlands including mangrove forests cover approximately 40,000 km^2, which represent 8% of the total area of Central America. However, the exact extent of mangroves is not known since ecological studies so far have been focused on Costa Rica and Panama wetlands (Ellison et al., 2004). However, mangrove swamps which epitomize tropical wetlands occur in both oceans, as well as in the Caribbean and the Pacific coasts, accounting for at least 6,500 km^2 (Groombridge, 1992). There, the tidal amplitude is lower than 0.9 m, but rarely penetrates more than several kilometres upstream the rivers. Also, many mangrove cays occur within the lagoon complex (Stoddart et al., 1982). Several rivers flow into the Caribbean Sea, such as the Sartoon River between Belize and Guatemala, the Coco River between Honduras and Nicaragua, San Juán River between Nicaragua and Costa Rica, and Sixaola River between Costa Rica and Panama. These rivers transport large volumes of sediments, the absence of large deltas being probably due to the strong coastal currents that disperse the sediments (Denyer and Cardenas, 2000). Since more research has been conducted in mangroves than in any other Central America wetland type, there are excellent floristic data for these wetlands. In this natural ecosystem, there are four primary mangrove species: *Rhizophora mangle* (Rhizophoraceae), *Avicennia germinans* (Avicenniaceae) *Laguncularia racemosa* and *Conocarpus erectus* (Combretaceae) (Tomlinson, 1986).

1.1.2 *Mangrove forest distribution in Nicaragua*

The Gulf of Fonseca is a shared ecosystem that encompasses the periphery of El Salvador, Nicaragua, and Honduras on the Pacific coast of Central America (Benitez et al., 2000). The entire coastal area of the Gulf of Fonseca covers about 1,000 km^2 of estuaries (mangrove forests, creeks, and tidal flats), islands, and seasonal lagoons (Vergne et al., 1993). Some major rivers that flood the estuaries of this coastal region are the Choluteca River which drains into La Jaguar and El Pedregal estuaries, while the San Bernardo estuary comprises the mouth of the Negro River (Vergne et al., 1993). In this region, mangrove forests are composed of *Rhizophora mangle*, *Avicennia germinans*, *Avicennia bicolor*, *Laguncularia racemosa*, and *Conocarpus erectus* which also surround the estuaries of the Gulf of Fonseca (Oyuela, 1994). The northern part of Nicaragua ecoregion marks the transition from dry to moist zone on the Pacific coast (Spalding et al. 1997). In this region, there is lower annual rainfall, ranging from 1,300 mm to 2,000 mm, the annual temperature fluctuating between 25°C and 27°C (Polanía and Mainardi, 1993). The vegetation in this ecoregion is represented by mangrove ecosystems including dominant mangrove species such as R. mangle, R. harrisonii, R. racemosa, A. germinans, A. bicolor, A. tonduzii, L. racemosa, Pelliciera rhizophorae and C. erecta in less flooded areas (Polonía, 1993). In this part of the region, Rhizophora species are found at the seaward edge, and Avicennia along the inland fringe (Jimenez, 1999).

The Nicaraguan Mosquitia mangrove ecoregion covers a large expanse of coastline, starting in Honduras at the delta of the Patuca river, continuing through Nicaragua to the Bahía of Punta Gorda. This coastal area generally consists of low alluvial floodplains that range from the sea level up to 20 m, covered with palm swamps and mixed rainforest, and numerous black water canals and creeks. The sparseness of mangroves is due to the dominance of freshwater. In this coastal region, many rivers flow into the Caribbean Sea, for example the Cruta, Coco, Likus, Wawa, Kukalaya and Punta Gorda. There are also many lagoons along this coast, some of them forming a complex system (Ryan et al., 1998). This Caribbean coastal region is part of the biological corridor that biogeographically links North and South Americas. (Roth, 1997). Mangrove species are diverse in this ecoregion and include red mangrove (*Rhizophora mangle, R. harrisonii*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*) (Roth, 1997).

Figure. 1 Distribution of mangroves along the Caribean coast of Nicaragua. Adopted from Encyclopaedia Britannica, retrieved 2007

1.2 *Geodemographic of the Caribbean coast of Nicaragua*

The humid Caribbean coastal zone of Nicaragua traverses a broad range of environments that include brackish wetlands (Ryan, 1998). This region is divided into the South Caribbean Autonomous Region (RACS), North Caribbean Autonomous Region (RACN), and Rio San Juan (RSJ), which altogether comprise over 50% of Nicaragua's national territory including the entire Caribbean border of Nicaragua from Honduras to Costa Rica, and are the most forested regions remaining in the country. The Indio Maíz Biological Reserve and the Bosawás Biosphere Reserve are part of this region. The joint forested ecosystems of the RACS, RACN, and RSJ were recently assumed to serve as an active genetic corridor for the globally endangered Baird's tapir species (Jordan and Urquhart, 2013). However, increasing deforestation has led to extensive destruction of wild animals' habitats, at the same time triggering erosion along many of the watersheds. This resulted in higher sediment loads that are believed to have killed several of the large nearshore reef complexes (Ryan, 1998).

In terms of cultural diversity, there are six main ethnic groups which occupy and depend on RACS and RSJ regions. The Miskito, Rama and Ulwa are some of the indigenous groups, the Garifuna and Kriol are some of the Afro-descendant groups, and the colonist Mestizo peoples descend from Amerindians and Europeans. According to the Laws No. 445 and 28, the indigenous and Afro-descendant groups have legal and communal tenure to all lands of the Caribbean coastal region. The Afro-descendant and indigenous groups use the land for hunting and agriculture which is more sustainable than the lifestyle of the colonist Mestizo, who usually turn the forest area into a grazing area (Jordann et al., 2014). For the Miskitu people, hunting and fishing are the main activity, with little emphasis on agriculture, *Manihot esculenta* and *Zea mays* being the principal cultivated crops (Coe and Anderson,1997). For practical purposes, the population of this region can be divided as follows: Miskito (17.75%), Creoles (2.95%), Mayangna (1.1%), Garifuna (0.19%), Rama (0.23%). The Mestizos are believed to account for approximately 73%, which makes them the largest ethnic group in the region (Brunnegger, 2007).

Since the Mestizos are the largest ethnic group, shifting of the cattle grazing frontier has become the primary environmental issue in the region. This irrational activity threatens to effectively eliminate all remaining protected areas in the Caribbean region of

Nicaragua within the next 10–20 years, having already severely degraded or destroyed three nature reserves since 2000 (Petracca et al., 2014). In this already environmentally precarious context, in June 2013 the Nicaraguan National Assembly passed the Law 840, by which the government of Nicaragua granted a concession of an undefined tract of land in Nicaragua to the Hong Kong Nicaraguan Canal Development Group (HKND) to construct an interoceanic canal (Huete-Pérez et al., 2015). According to the Canal Development Group HKND (2014), in addition to building the canal and its related infrastructure, the Law grants HKND the right to implement a variety of development projects along the canal route, including international airports, tourist complexes, an oil pipeline, free-trade zones, and two deep water ports. The canal itself will traverse 272 km of Nicaragua, including 105 km through the lake of Nicaragua. The ecosystems of the Caribbean region will also be affected.

Certainly, this international canal may trigger an environmental disaster in Nicaragua. Hundreds of kilometres' excavations from coast to coast, traversing Lake Cocibolca in western Nicaragua, will not only destroy the largest drinking-water reservoir in the region, but also pose a threat to around 400,000 hectares of wetlands. Approximately 240 kilometres north, the canal route crosses the Bosawás Biosphere Reserve in which about 2 million hectares of tropical rain forest, the last refuge of many disappearing species, are at risk. On the other side of the canal, less than 115 kilometres to the south, Indio Maíz Biological Reserve with its more than 318,000 hectares of tropical dry forest will also be affected. At the same time, the project puts in danger multiple autonomous indigenous communities such as the Rama, Garifuna, Mayangna, Miskitu and Ulwa, as well as some of the most fragile, pristine, and scientifically important marine, terrestrial and lacustrine ecosystems in Central America (Meyer et al.,2014).

1.3 *Morphological characteristics and adaptations of mangrove trees*

Red mangroves are distinguished from other mangroves by a network of prop roots that originate in the trunk of the tree and grow downward towards the substratum. They may attain heights of 25 m, with glossy leaves, bright green at the upper surface, with pale undersides. Trees flower throughout the year, peaking in spring and summer. Propagules are pencil-shaped and may reach 30 cm in length as they mature on the parent tree (Savage, 1972). Black mangroves may grow 20 m high and are characterized by their conspicuous pneumatophores, with vertical branches that may extend upward from the cable roots lying below the soil. Pneumatophores develop into extensive networks of finger-like projections that surround the bases of black mangroves to provide them with proper aeration. The leaves tend to be somewhat narrower and are often encrusted with salt. Black mangroves flower throughout spring and summer and produce bean-shaped propagules (Savage, 1972; Odum and McIvor, 1990).

Laguncularia racemosa (white mangrove) is a medium-sized tree or shrub, often reddish in colour. Its smooth, leathery leaves up to 7 cm in length and a yellow-green cast distinguish it from other mangrove species. White mangroves also exhibit nectar-producing glands (extra-floral nectaries) found on either side of the stem at the leaf base. These structures excrete sugars which may attract ants that protect the plant from herbivorous insects (Hogarth, 2007).

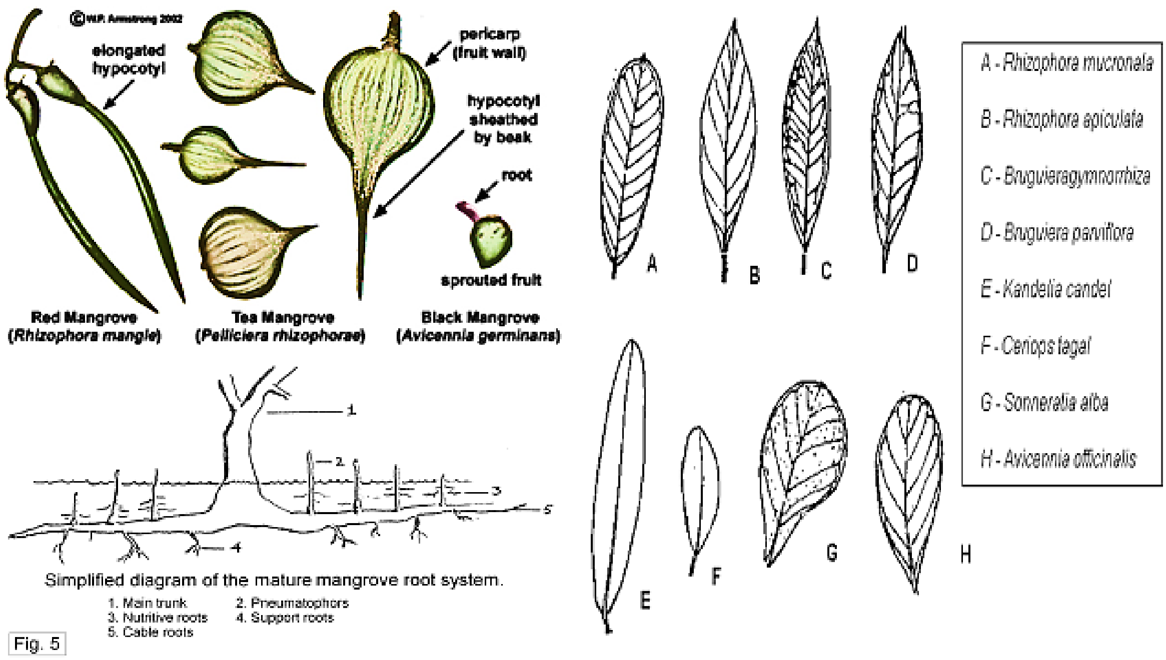

Figure. 2 Morphology description of the mangrove tree, source: Armstrong, 2002

The most important factors controlling mangrove zonation are substratum and water flow regime. Zonation patterns in mangrove forests vary on a local scale and the occurrence of species may differ across estuary, apparently in response to differences in freshwater input. For example, species found at the seaward end of the estuary may be absent from the headwaters. (McClain et al., 2014). Mangroves are probably best viewed as steady-state cyclic systems migrating toward or away from the sea. Preservation of these dynamic flow regimes is important for maintaining riverine ecosystems (Lugo, 1980).

Another adaptation exhibited by mangroves is observed in root aeration. Soils in mangrove areas tend to be fairly anoxic, preventing many types of plants from taking root. Mangroves have adapted to this condition by evolving shallow root systems rather than deep taproots. Red mangroves aerate their roots by way of drop roots and prop roots which develop from lower stems and branches and penetrate the soil only a few centimetres. Prop roots act to both stabilize the tree and provide critical aeration to the roots. The above-ground areas of these roots are perforated by many small pores (lenticels) that allow oxygen to diffuse first into cortical air spaces called aerenchyma, and then into underground roots (Odum and McIvor, 1990). Black mangroves utilize a different strategy for aeration of root tissues. They have cable roots which lie only a few centimetres below the soil surface and radiate outward from the stem of the tree (Odum and McIvor, 1990). Many observations refer to aerial roots, such as stilt roots, buttress roots and pneumorhizae (Jeník, 1993). A network of erect aerial roots extends upward from the cable roots to penetrate the soil surface. These erect roots, called pneumatophores, contain lenticels and aerenchyma for gas exchange and may form dense mats around the base of black mangrove trees, with pneumatophores attaining as much as 20 cm or more in height depending on the depth of flood tides (Odum and McIvor, 1990). Shallow-rootedness of tropical trees is frequently assumed (Mensah and Jeník, 1968), although underground organs of tropical trees are little-known and their structure and distribution in soil horizons remain rather obscure.

Water is prevented from entering the tree via lenticels due to their highly hydrophobic nature which allows the red mangrove to exclude water from prop roots and drop roots even during high tides (Waisel, 1972). However, shallow humus horizon and corresponding flat tree root systems cannot be taken for granted, and scattered observations confirm an array of adaptations and diversified underground organs for emergency water supply and nutrition in rain forest soils (Jeník, 1993; Bruenig, 1996).

Another adaptation of R. mangle is that they shed leaves throughout the year and new leaves are also produced continuously. Leaf production is higher in the rainy season, leaf age is variable but rarely exceeds one year (Mehlig, 2006). R. mangle also produces flowers throughout the year and flowering peaks at the end of the rainy season (Mehlig, 2001; Carvalho, 2002; Mehlig, 2006). Propagule release is mostly restricted to the rainy season (Mehlig, 2006; Carvalho, 2002). The time span between pollination and maturation of propagules is about 8 months (Mehlig, 2006). According to Mehlig (2001), the comparison of propagule production between brackish and saline mangroves suggests that differences in salinity regime might play a role in premature abscission of flowers and fruits. On the other hand, when A. germinans leaves fall, new leaves appear mainly during the transition from rainy to dry season when the salt stress is lower (Mehlig, 2001; Santos, 2005). Median leaf life time is 275 days (Santos, 2005). Flowering is restricted to the dry season (Mehlig, 2001; Santos, 2005). Ripe fruits are released in the rainy season (Carvalho, 2002). The time span between the peak of flowering and fruit fall is 4-5 months (Mehlig, 2001).

1.4 *Ecological services of mangrove forests*

Mangrove forest ecosystems fulfil several important functions and provide a wide range of services. They are among some of the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and coastal and marine systems (FAO, 2007). The forests help to stabilize shorelines and reduce the devastating impact of natural disasters such as tsunamis and hurricanes. They also provide breeding and nursing grounds for marine and pelagic species (Giri et al., 2011).

Mangroves also help protect coral reefs, seagrass beds and shipping lanes by entrapping upland runoff sediments. This is a key function in preventing and reducing coastal erosion, which provides nearby communities with protection against the effects of wind, waves and water currents. In the aftermath of the 2004 Indian Ocean tsunami, the protective role of mangroves and other coastal forests and trees received considerable attention, both in the press and in academic circles (FAO 2007). Mangroves could absorb approximately 22.8 million metric tons of carbon each year. Covering only 0.1% of the earth’s continental surface, this forests account for 11% of the total input of terrestrial carbon into the ocean (Jennerjahn and Ittekot, 2002)

Mangroves support the conservation of biological diversity by providing habitats, spawning grounds, nurseries, and nutrients for several endangered animal species, ranging from reptiles (crocodiles, iguanas and snakes) and amphibians to mammals (tigers, including the famous Panthera tigris, also known as the Royal Bengal tiger, deer, otters, manatees and dolphins) and birds (herons, egrets, pelicans and eagles). A wide range of commercial and non-commercial fish and shellfish also depends on these coastal forests (Odum and Heald, 1972).

1.5 *Importance of mangroves for fisheries and aquaculture*

Fish species that use mangroves as habitat can be classified as permanent residents, spending their entire life cycle in mangrove systems, temporary long-term residents, associated with mangroves during at least one stage in their life cycle, and temporary short-term residents or sporadic users of the mangrove habitat (Robertson and Duke, 1990). Through the abundance of early life stages of aquatic species, mangroves also attract carnivorous fish that conduct feeding migrations to mangrove areas. The post-larvae of many commercial penaeid shrimps enter mangrove dominated environments, where they develop into juveniles and sub-adults before migrating back to sea to complete their life cycle (Vance et al., 1996; Rönnbäck et al., 2002). Yet few studies have evaluated the importance of mangrove habitats as nursery areas relative to adjacent habitats, such as seagrass beds and mudflats, that are also associated with estuarine areas (Blaber et al., 1992).

A major threat to mangrove wetlands is their conversion to aquaculture farming area (Ellison and Farnsworth, 1996). Mangrove ecosystems are used for aquaculture, both open-water estuarine mariculture (oysters and mussels) and pond culture (mainly for shrimps) (Wells S and Ravilious C, 2006). Shrimp farming industry has often been promoted in developing countries as a means of diversification of the economy, technological transfer, rural employment, and foreign exchange. The commercialisation of shrimp culture has been driven by profits from export markets and fuelled by governmental support and private sector investment. Many bilateral and multilateral agencies have continued to support aquaculture with large loans (Primavera, 1998). In this type of farming the exchange of coastal waters in shrimp aquaculture ponds is important to assure the optimal survival and high yields of shrimp. (Martinez-Cordova et al., 1996).

1.6 *Uses of mangrove by the local communities in tropical region*

Local ecological knowledge (LEK) or traditional ecological knowledge (TEK) are relevant types of knowledge, ranging from traditional use of specific plants (Davis and Wagner, 2003). Many coastal communities in the tropics are characterized by dependence on the harvest of coastal resources for their livelihood (Kunstadter et al., 1986). Considering the potential of tree species for firewood, the Miskitu peoples recognize certain species as possessing superior burning qualities, the species with the best burning qualities being Caribbean pine, guayabon, nancite, mangrove and sapodilla (Coe and Anderson,1997). It is very common that people living near mangrove areas harvest mangrove wood for fuel and construction material, as well as for sale, mangrove forest products being an important income supplement (Walters, 2005; Lopez-Hoffman et al., 2006). Harvesting of mangrove for fuelwood is widespread throughout the coastal tropics. In some countries, mangrove wood historically served as important commercial fuel for industries like bakeries and clay-firing kilns (Naylor et al., 2002; Walters, 2003). Remote coastal communities in the tropics frequently sell mangrove charcoal to nearby towns and urban centres (Dahdouh-Guebas et al., 2000; Glaser, 2003). The Rhizophora species produces wood that is dense and hard (Bandaranayake, 1998). Such wood burns long and hot, and so is highly attractive for making charcoal or consuming directly as firewood (Walters, 2005; Dahdouh-Guebas et al., 2006).

The qualities of strength and durability including pest- and rot-resistance make mangrove wood well-suited for use in construction (Kairo et al., 2002; Walters, 2005). The extraction of construction wood from mangroves is limited mostly to domestic consumption and sale of small-sized posts targeted at local and regional markets. Mangrove wood is widely used in coastal communities for residential construction as posts, beams, roofing, fencing and making fish traps (Primavera et al., 2004; Walters, 2004). Fronds from the mangrove nipa palm (*Nypa fruticans*) are particularly useful in roofing and as thatch in walls and floor mats (Walters, 2005). Mangrove wood is also used in some countries for building boats, furniture, telegraph poles, construction scaffolding, railway girders etc. (Primavera et al., 2004; Lopez-Hoffman et al., 2006). In addition to wood for fuel and construction, mangroves are also widely valued for their bark (used in tanning and dyes) and wood fibre (used to make rayon and paper). Mangroves are also the main source of many traditional medicines and toxicants (Bandaranayake, 1998).

Miskitu people use taxonomically diverse groups of plants, including 353 species among 262 genera and 89 families, about 310 of these medicinal (Coe and Anderson 1997). They obtain about 77% of their medicine from the forest, most of these species being herbs (39%) and forest trees (29%). Usually they use bark, flowers, fruits, leaves, roots, seeds, and stems. Sometimes the entire plant including the root is used, the two most frequently cited modes of preparation of herbal remedies being decoctions and poultices (Coe and Anderson,1997). Mangrove and mangrove-associated plants are traditionally used to treat diabetes, although very few species have been evaluated and reported scientifically (Bandaranayake, 2002). Some recent studies have shown that the medicinal value of mangroves and associated plants provide invaluable treatment medicine, both in modern and traditional systems of medicine (Kathiresan and Ramanathan, 1997). More recently metabolites, some with novel chemical structures, have been identified in mangroves, which makes them interesting for modern industry and medicine: flavonoids, polyphenols, rotenone and triterpenes, essential oils, sterols, carbohydrates, alkaloids, amino acids, pheromones, gibberellins, sulphur compounds, lipids, and saturated acids (Bandaranayake, 1998).

Table 2. Valuation of mangrove products

Community level	**National level**	**Global level**
Timber and firewood	Timber production	Conservation
Fodder for animals	Charcoal production	Education
Traditional medicine	Shrimp and crab industries	Preservation of biodiversity
Food	Mangrove silviculture	Indicator of climate change
Local employment	Trade	
Recreation	Ecotourism	
Shell collection	Education	
Erosion control	Water quality management	
Protection from storm damage	Coastal and estuary protection	

(**Sources:** Dahdouh-Guebas et at., 2000, Kairo, 2001)

1.7 *Ethnobotany and ethnobotanical research in Latin America*

Throughout history, people interacted with their environment in multiple ways. Direct and indirect interactions with natural resources resulted in historical relationships that are extremely important to human societies (Alves RRN et al., 2013). These interactions can be studied from ethnobiological perspective (Posey et al., 1987). Information on how indigenous people interact with their natural environment can be collected and analysed in several ways depending on the study objectives and research questions. Such analyses may range from evaluation of traditional knowledge and laboratory analyses (identification of biologically active compounds) to the assessment of priorities for conservation management which may lead to further ecological studies (Khan et al., 2013). Ethnobotany focuses particularly on the poorest people who will remain most dependent on wild plant resources, but who could strongly benefit if these resources are well managed. Therefore, applied ethnobotany research might play a significant role in alleviating poverty, conservation and sustainable development (Hamilton et al., 2003). In addition, apart from teaching on the subject of ethnobotany in developed countries, there is an urgent need for capacity building of applied ethnobotany in developing countries because of the strong links between rural people and local plants (Hamilton et al., 2003). Recent reviews have demonstrated a notable increase in the number of publications on ethnobiology in Latin America, especially in Brazil, Colombia, and Mexico (Villamar et al., 2012). In their study about the interrelations between mangrove ecosystem, local economy, and social sustainability in the Caeté Estuary, North Brazil by Marion Glaser in 2003, the authors conclude that mangrove use will never reach the market, but this same study assumes its economic and social importance for many people. It is also clear that better quality education and social infrastructure in mangrove villages would enable significant numbers of households to realize their own strong aspirations of reducing their dependence on local natural resources by taking up alternative livelihood options, which would simultaneously improve their socio-economic and ecological perspectives. Another study was conducted about assessing mangrove use on a local scale by John Michael in 1999. It took place in Mexico, Teacapan-Agua Brava lagoon–estuarine system of the state of Nayarit. He concludes that *L. racemosa* was identified as the species most frequently used in this region of Mexico, being employed quite regularly in the construction of tobacco galleries, poles for fish traps, fences, and walls. Also, he reports that this species was formerly employed as an important source of medicine and tannins. However, *Rhizophora mangle* is currently used, and this only occasionally, for ceiling support in rural homes.

There are very few studies on mangroves in Nicaragua. One of them is 'Effects of Hurricane Joan, October 1988 on the Vegetation of Isla del Venado, Bluefields, Nicaragua,' carried out by Roth LC in 1992. He concludes that the hurricane inflicted the most severe damage to the largest trees and markedly reduced their population, and appears to favour abundant regeneration of all the original mangrove species. Another study is about mangroves, shrimp aquaculture and coastal livelihood in the Estero Real, Gulf of Fonseca, Nicaragua, conducted by Karina Benessaiah in 2008. First, this study shows that aquaculture has encroached primarily on salt and mud flats; however, the activity has led to significant indirect changes in mangrove plant communities. Second, small-scale shrimp producers were found to be better off in terms of income, assets and livelihood opportunities. This was especially evident in the case of seasonal lagoon fisheries where the access is ultimately controlled by the local elite formed by small-scale shrimp producers. Third, aquaculture brought wealth to the community but also lead to privatization of former estuary commons and consolidation of social inequality among community members. On a regional scale, small scale shrimp producers were found to be increasingly vulnerable to market and natural disturbances.

Table 3. Mangrove use – wood and non-wood forest products (**Source:** Modified from FAO 1994 to FAO 2007)

Fuel	Construction	Fishing	Textile, leather	Other natural products	Food, drugs and beverages	Agriculture	Household items	Other forest products	Paper products
Fuelwood	Timber, scaffolding	Fishing stakes	Synthetic fibres (rayon)	Fish	Sugar	Fodder	Glue	Packing boxes	Paper–various
Charcoal	Heavy construction	Fishing boats	Dye for cloth	Crustaceans	Alcohol		Hairdressing oil	Wood for smoking sheet rubber	
	Railway sleepers	Wood for smoking fish	Tannin for leather preservation	Honey	Cooking oil		Tool handles	Medicines	
	Mining props	Tannin for nets/lines			Vinegar		Rice mortar		
	Boat-building	Fish-attracting shelters		Mammals	Tea substitute		Toys		
	Dock pilings			Reptiles	Fermented drinks		Match sticks		
							Incense		
	Beams and poles			Other fauna	Dessert topping				
	Flooring, panelling				Condiments (bark)				
	Thatch or matting				Sweetmeats (propagules)				
	Fence posts, chipboard				Vegetables (fruit/leaves)				

1.8 *Statement of the problem*

There is a consensus that natural vegetation of the world is disappearing or being altered at a worrying rate (Shingu et al., 2005). According to FAO (2013). Tropical rain deforestation is caused by subsistence activities on a local scale by people who simply use the rainforest’s resources for their survival. Many coastal communities heavily depend on the coastal and marine resources and ecosystems for their livelihood. Coastal ecosystems, mangrove and wetlands are some of the world’s richest storehouses of biological diversity and primary productivity. However, today the coastal ecosystems are under severe pressure. It is estimated that about half of the world’s coastal ecosystems, including mangroves, are facing a significant risk of degradation from human activities and other development interventions. In this context, coastal ecosystems are perhaps among the most threatened regions. According to WLBC (2013), after cutting trees for building material, these people use the slash-and-burn technique to clear the surrounding forest for short-term agriculture. These are needed to alleviate poverty, provide food security and ensure sustainable development. Various cultures and societies which live in close relationship with nature, depending on its products for their basic needs, are currently suffering from environmental and cultural changes. (Sheldon, 1995).

2. Objectives

- Many communities of the tropical region commonly obtain goods and services from mangrove ecosystems. There is a growing research interest in ethnobiology, socio-economics, and management of marginal ecosystems. People living in tropical coastal areas have considerable botanical and ecological knowledge of coastal ecosystems, particularly mangrove forests, which, among other services, provide fuelwood, construction materials, tannins, and medicines to the local communities. This thesis aims to document modalities traditional ethnobotanical knowledge regarding mangroves, of the resident peoples of Sheran Sandy Bay Sirpi community situated on the east coast of Nicaragua, and their interactions with the surrounding mangrove forest.

2.1 *Particular aims:*

- To document ethnobotanical knowledge and management patterns on key mangrove species among Miskitu people.

- To identify taxonomically the key species of local mangrove forest useful to the community.

- To analyse perceptions of the local Miskitu people of mangrove forest conservation issues.

3. Materials and Methods

3.1 *Study area*

The fieldwork was performed in Nicaragua, tropical zone of the Caribbean coast region, specifically in the village of Sandy Bay Sirpi. It is located at the coordinate 12° 57' 38" N. latitude and -83° 31' 43" W. longitude. On the north, it is bordered with the community of Prinzapolka, on the south with the community of La Barra, on the east with the Caribbean Sea and on the west with the community of Walpa, approximately 311 km east of Managua, the capital city of the country (INETER, 2009). The population is about 3,740, of which 90% are indigenous Miskitu (Awaltara, 2013). The name derives from the nickname 'musket' given to them by buccaneers and traders (Smutko, 1985). Sandy Bay Sirpi is one of the least developed communities, characterized topographically by the nearness of extensive broadleaf forests, dominated by ultisols land (relatively low native fertility), slopes ranging from 5% to 8% composed of sandy loam soil (sand along with clay soil, with good drainage), with temperatures ranging from 26°C to 32°C and rainfall between 3,200-4,000 mm (INETER, 2009).

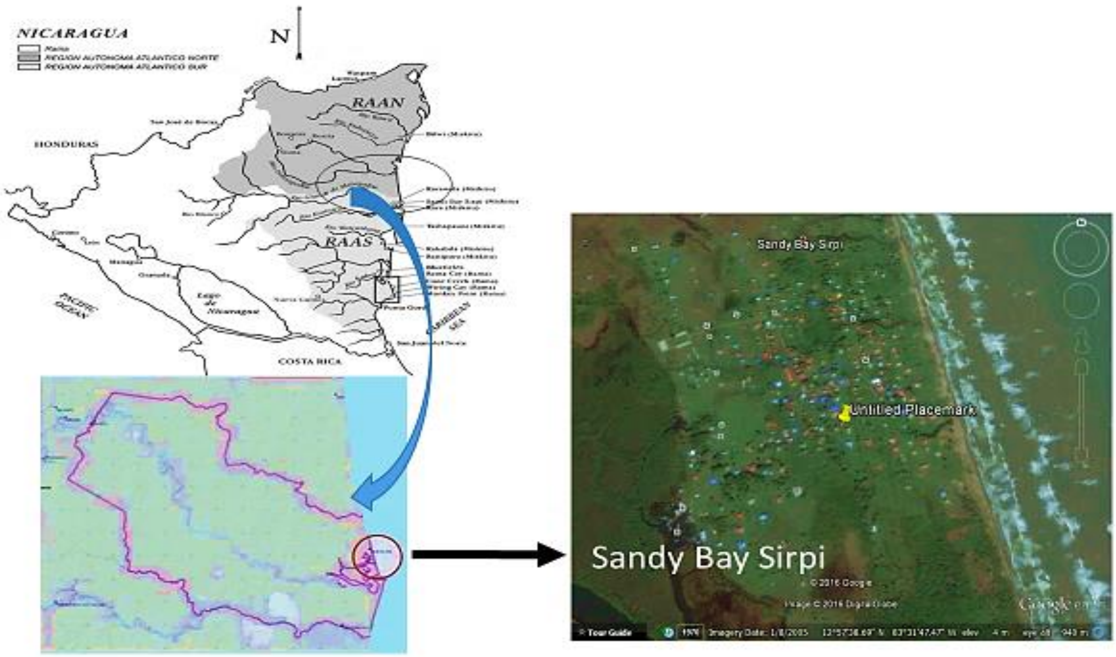

Fig. 3 Location of the study area

Fishing is the main source of income both for this community and for the neighboring communities e.g. Karawala, Kara, Barra, Walpa (Awaltara, 2013). Agriculture is practiced mainly on banks of the rivers, but some families have farms in highland areas. They chiefly produce grains, tubers, and fruit in moderate quantities, either for self-consumption or to sell in the market (Awaltara, 2013). Another activity is hunting, practiced in the mountains to diversify the diet. People usually go hunting twice a month and the catch can either be sold or consumed by the hunter's family. The most frequently hunted for species are the deer ('Sula' in the local language) and the wild pig ('wari' in the Miskitu language) (Awaltara, 2013). They are mostly Christians belonging to either of the following churches: Moravian, Maranatha, Episcopal (Anglican) and Catholic. The Moravian church was the first church to be founded in this community (URACCAN and BICU, 2005).

4. Data collection

The field study was carried out over the period from July to September 2015. Several members of the community highly knowledgeable in mangrove use were selected, capable to provide information concerning the traditional use of mangrove trees. Purposive sampling method was thus applied in the selection of participants.

Several steps were done to collect the data and follow the research ethic. To carry out the questionnaires, all participants were familiarized with the research intention. After clarifying that this research was guided by academic and not political interest, the work was started by receiving verbal consent by the participants. The questionnaires were undertaken with the participation of forty key informants, 18 women from 20 to 60 years old, 22 men from 20 to 60 years old. Initially, the respondents were asked to provide basic sociodemographic information (age, gender, amount of family members, occupation and ethnicity). Subsequently, ethnobotanical information about mangrove use was asked, such as local names, tree part(s) used, the main use, collecting season, place of collecting, mode of preparation, harvesting process, market of mangrove wood etc. Since all the interviewed speak Miskitu language, the interview was conducted in Miskitu, but the redaction was in English. Botanical samples were collected through the harvesting of the most representative specimens and each sample was stored in a pressing box. At the same time, general information about the sample was written describing the circumstances under which the respective sample had been found, the habitat, growing place etc. The collected specimens were supplemented with digital photographs to facilitate subsequent taxonomic determination of the species. Voucher specimens were deposited at the UCA University (University of Central America), located in Managua, Nicaragua with Dr Alfredo Grijalva, teacher and botanist, to carry out the taxonomic determination of the specimens. Another method used was a workshop which was carried out to determine the actual mangrove ecosystem condition and its importance in food security and ecological equilibrium. The workshop was attended by ten persons, six men and four women aged between 20 and 40, and took place in the premises of Rev. Jonny Hoocker secondary school which is part of the community. The participants were people dedicated to farming work, fishermen and people who have some economic income from mangrove resources, because they are the ones who benefit from these natural resources directly.

5. Data processing

Data analysis of this work was based on the descriptive data gathered during the field work through the questionnaire and the workshop. Ethnobotanical data were analysed and summarized using Microsoft Excel and Word, but primarily, collected ethnobotanical information was processed to reflect its usefulness and socio-economic importance.

5.1 *Quantification of ethnobotanical data*

The social value of mangrove (SV) and the economic valuation of mangrove (EV) was used to verify the cultural value of the mangrove species in the study area.

Social value

$$(1)\mu \boldsymbol{kv} = \frac{\sum_{i=1}^{N}(Pikv)}{N}$$

where:

μ_{kv} = mean percentage distribution of affirmative response for social value variable (k) in community (v).

P_{ikv} = percentage distribution of affirmative responses to each question used to measure variable (k) in community (v).

I = question used to measure variable (k).

N = total number of questions used to measure variable (k).

K = variable used to measure social value

V = community where survey was conducted.

Economic income from mangrove ecosystem

The DUV of mangrove products has been derived from benefit values of fishery products (fish, crab and shrimp capture) and forestry products (firewood collection and charcoal production), which have been estimated using market prices and the following formulas:

- Fish, crab, and shrimp capture values (FV; CV; SV): FV; CV; SV = production (kg/year) × price (USD/kg) − production cost (USD)

- Firewood value (FwV): FwV = wood collection (bundle/year) × price (USD/bundle) − production cost (USD) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 to 8 cm)

- Charcoal value (CcV): CcV = Production (sack/year) × price (USD/sack) − production cost (USD) (1 sack = 25 kg)

5.2 *Key species identification and management of their habitat*

Taxonomic identification of the key species was carried out by Dr Alfredo Grijalva. All botanical samples with their respective general information were delivered to him. Besides the workshop, observation was an important source of information to understand more clearly the current management of mangrove ecosystems by the community people.

6. Results

6.1 *Informants characteristics*

Sandy Bay Sirpi is characterized by multi-ethnic population composed predominantly of Miskitu people; in this study 32 people (80%) of our respondents were Miskitu, 4 people (10%) Ulwa and 4 (10%) Creole born in this community. Informants were mostly fishermen or subsistence farmer people, occasionally selling their product in the local market.

6.2 *Social value of mangroves*

Percentages of affirmative responses to the survey questions are presented in Table 4, corresponding to the following variables: a) wood products (firewood, charcoal, timber, post, wall, fences, planks, traps, and beams), b) non-wood products (medicine and repellent).

Table 4. Different uses of mangrove products by the community people

Id	**Mangrove use in the community**	**positive answer (%) (*n*= 40)**
F1	Firewood obtained from the mangrove	100%
F2	Mangrove wood for charcoal making	20%
F3	Mangrove used as timber	90%
F4	Mangrove wood used as post	70%
F5	Mangrove wood used as beams	60%
F6	Mangrove wood for building walls	25%
F7	Mangrove wood used as planks	15%
F8	Mangrove wood for making fences	100%
F9	Mangrove wood for making traps	35%
F10	Mangrove used as medicine	10%
F11	Mangrove wood used as repellent	20%

6.3 *Use of mangrove wood products by the community people*

Practically 100% households claim they use mangrove as firewood. According to the respondents, mangrove wood is hard and burns hot. Due to its quality, it is often used in households as cooking fuel. The Miskitu people recognize certain species as possessing good burning qualities, such as the Caribbean pine (*Pinus caribaea*), nancite (*Byrsonima crassifolia*), mangrove species (red mangrove and black mangrove), guayabon

(*Terminalia oblonga*), Cedro macho (*Carapa guatemalensis*) etc. From the species mentioned above, resident people prefer to use the nancite and the red mangrove for firewood, the reason being that these two species are easily accessible.

Also, mangrove is occasionally used to make charcoal by around 20% households, mainly for cooking fuel and sometimes for sale in the market. Charcoal is a lightweight black residue, consisting of carbon and some remaining ash, obtained by removing water and other volatile constituents from vegetation substances like wood. The respondents usually use the stem of nancite and mangrove, owing to its availability, easy accessibility, inflammability and fast-drying nature. Red mangrove is used more often than black mangrove, but many times other species such as Cedro macho (*Carapa guatemalensis*), Palo de agua (*Vochysia hondurensis*), Zopilote (*Vochysia ferruginea*), Nancitón (*Hyeronima alchomeoides*) are used for the same purpose. To be economically viable, charcoal is mostly made by digging a pit in the ground to stack the wood and covering the stack with earth. According to the respondents, this process takes around nine days (1 day to cut the wood, 1 day to prepare and set the fire, 3 to 4 days to supervise the pyrolysis, 2 to 3 days to cool the kiln and 1 day to extract and bag the charcoal).

Also, 100% of the participants confirm that mangrove can be used as timber, post, and beams in the community. About 90% (36 people) have used it as timber, 70% (28 people) as posts, and 60% (24 people) as beams for building houses, bathrooms, toilets etc. The Rhizophora species is not much valued as timber because of its tendency to split and warp when being dried. On the other hand, it is heavy, strong, and hard, able to support moisture and saline soils. For this reason, it is very useful in construction, especially preferred as posts and comer pillars. For posts, mainly the black mangrove is used, which is also employed in making traditional chairs, benches, and tables. Some interviewees explained that in ancient times, this species was normally treated by burying the timber in the soil for 15 to 20 days to cure the wood, which increased its endurance up to 6 to 8 years more, but currently the only treatment is drying in the wind.

Fig. 4 Mangrove used as a construction material in the local community

According to the respondents, construction of a house can last for over 30 years, depending greatly on the quality of the poles. Also, mangrove is used as planks by 15% (6 respondents), and for walls by 25% (10 respondents). Practically 100% respondents (40 people) reported that mangrove is used to make fences.

Fish traps constructed from wire mesh and mangrove sticks are widely used throughout the Caribbean coast. Fishermen use bamboo tree Poaceae (65%) and black mangrove (35%) as timber to make traps for fish, lobster, and crabs, because its quality, accessibility, and resistance to rotting under the water is very high. Those who use bamboo wood are fishermen working at the sea who catch fish and lobsters. Bamboo wood is not too heavy, which makes it easier to transport from the community to the islands and from the islands to the fishing place or the fishing bank. Another reason is that it becomes harder in contact with saltwater. Those who use mangrove wood are fishermen working in lagoons and rivers. For them, mangrove wood is preferable because it is easy and inexpensive to obtain and is also more durable. Fishermen working in rivers and lakes earn much less compared to those working in the sea.

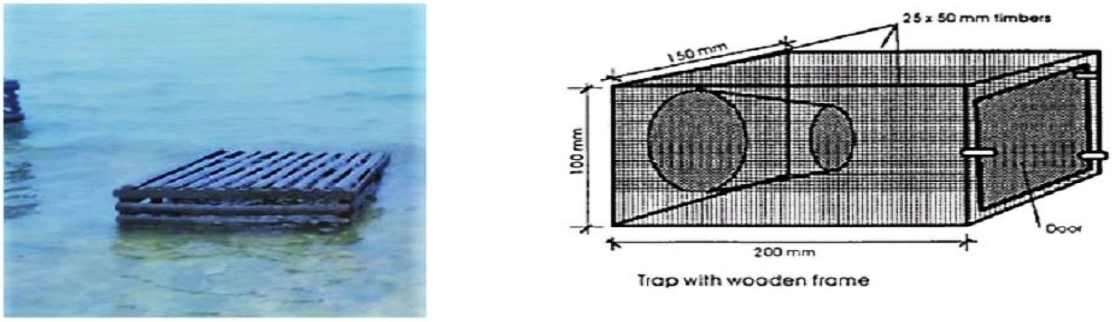

Fig. 5 Example of a rectangular fishing trap (right for fish and left for lobsters)

Community people usually harvest the trunk and the branches of two or three mangrove trees during each visit to the mangrove forest. They commonly visit 2-3 times a month to harvest firewood, cutting in to truncated pieces, to facilitate the transportation. They usually harvest dry and semi-dry trees. When they collect mangrove for construction material, trees in the best shape are used. The harvest takes place every four to six years as required, the number of trees depending on the size of the building, but they usually harvest between 20 to 30 pieces (10 to 15 mangrove trees) during each visit to the mangrove forest.

6.4 *Use of mangrove non-wood products by the community people*

The indigenous knowledge about traditional home remedies is closely linked with the local flora. In the opinion of 10% (4 respondents), mangrove tree has medicinal properties. They sometimes prepare tea from the leaves of *Avicennia germinans*, especially for the treatment of gastric diseases.

Fig. 6 Mangrove leaf in its natural habitat

About 20% of fishermen (8 respondents) use *Avicennia germinans* as repellent. They sometimes use the green wood of this species to make smoke by burning, to keep away mosquitoes and other insects, which commonly bite during the night, when the fishermen sit out on the beach at night, awaiting the right tide amplitude to set out fishing nets. However, the younger generation in the local communities has only limited knowledge about the medicinal use of mangroves.

6.5 *Income from mangrove ecosystem*

People who live around the mangrove area are highly dependent on mangrove ecosystems for various fishery and forestry products, both for domestic and commercial purposes. In fisheries, mangrove ecosystems support fish, crab, and shrimp capture. In forestry, they support the production of firewood and charcoal.

The results of the household survey showed that of the 40 participants, 35 households directly use mangroves for fishing, 6 for crab capture, and 15 for shrimp capture. They use traditional fishing gear such as fishing rods, fishing nets, and traps. Annually, fish capture is conducted around eight months (February to September) when the sea conditions are good, whereas the remaining four months (October to January) are characterized by high waves and strong winds which mean that during this time the fishing activity is not successful. All the households use mangrove to harvest firewood and eight households harvest for charcoal production.

The average production of fish, crab, and shrimp capture per household per year is 150 kg, 53 kg, and 173 kg, respectively. The production of firewood, charcoal per household per year amounted to 28 bundles and 15 sacks, respectively. The total of fish and shrimp production was 5,250 kg/year and 2,595 kg/year respectively (crabs are captured only for home consumption). Harvested mangrove forests for firewood reached 896 bundles per year, charcoal production was 120 sacks per year.

The highest benefit of DUV was obtained from fish production, earning 341 kUSD per year, shrimp production for 306 kUSD per year, followed by firewood for 108 kUSD per year.

Table 5. The Direct Use Value (DUV) of mangrove in Sandy Bay Sirpi

No.	Products	Household users (n = 40)	Net use value (USD/year)	Net use value/household (USD/year)
		Fishery products		
1	Fish capture	35	11,935	341
2	Crab capture	6		
3	Shrimp capture	15	4,590	306
		Sub Total of DUV: 16,525 (USD)		
		Forestry products		
5	Firewood	32	3, 456	108
6	Charcoal	8	528	66
		Sub Total DUV: 3, 984 USD		
		Total of DUV: 20,509 USD		

A large number and variety of fish species are found in mangrove ecosystems for nursery, spawning and feeding. The main fish, shrimp, and crab species most commonly fished for in the mangrove area are the small pelagic fish, snapper, milkfish (Chanos Forsskål), catfish (Siluriformes), guapote, whiteleg shrimp (Penaeus vannamei Boone) and mud crab (Scylla serrata Forsskål). We could say that the capture of fish, crabs, and shrimps as well as the firewood and charcoal are mostly connected to Rhizophora sp ecosystems. Over the last decades, human activities in this ecosystem are causing mangrove areas to decrease and degrade rapidly, which has led to a decrease in fish production and fishermen's income.

6.6 *Diversity of mangrove species in the study area*

On the Caribbean coast of Nicaragua, *Rhizophora mangle* (red mangrove) and *Avicennia germinans* (black mangrove) are often found in the seaward zone, whereas *Laguncularia racemosa* (white mangrove) is often found in the most landward position. As a result, from the key species identification in Sandy Bay Sirpi remain two mangrove species: the red mangrove and the black mangrove.

Table 6. Mangrove species identified in the study area

N^0	Family	Scientific name	Common name	Local name	(%)
1	Rhizophoraceae	R. mangle	Red mangrove	Laulu pauni	80
2	Acanthaceae	A. germinans	Black mangrove	Laulu siksa	20

Both species were taxonomically identified by studying the morphological characteristics. Curiously, the distribution patterns of these mangrove species were heterogeneous. Some areas at the border of estuaries and rivers are dominated by a single species, e.g. *Rhizophora Mangle*, whereas in other areas *R. Mangle* and *A. germinans* were mixed.

6.7 *Management of mangrove ecosystems by the local people*

With regard to perceptions from the workshop about the past and current extent of the mangrove forest, 90% of the participants reported it has been reduced, while 10% said they didn't notice any change in the area covered by mangroves. Similar results were recorded for the future of the mangrove forest: about 85% of the respondents feared that there would be a further decrease in mangrove, associated with anthropogenic pressures, pollution caused by rubbish and motor oils, as well as by the overexploitation for timber and fuel etc. The damage to mangrove habitat was clearly identifiable through information collected from the questionnaires, from the workshop and through observation. It is a complex network of causes such as overharvesting, housing, and clear-felled corridors. For this reason, mangrove forest in the study area needs an effective management strategy in view of the rising pressure of demography and pollution, both factors being a serious ecological problem.

Fig. 7 Demography pressure and pollution at the study area

A clear understanding of mangrove ecosystem dynamics will be the best guide to any restoration program, for which it is necessary to approach and involve the local people by educating them about mangrove ecosystems. This task requires a lot of responsibility among residents and their activities in the mangrove forest, active participation of the existing local communities so that they can express their opinion and make decisions regarding the management plan and regulations related to the utilization of mangrove resources. Through this, the local community will become more aware of the importance of mangrove ecosystems.

7. Discussion

7.1 *Use of mangrove wood and non-wood product by the local people*

Table 6 enumerated the species of mangrove found in the study area, and table 4 was concerned with the use of these species by the local people. Firewood and timber being the principal ends, the results of this part of our study are in accordance with the studies of Dahdouh and Guebas (2006) and Brucher (1989). The significant use of mangrove as firewood (100%) by the community people coincides with Dahdouh and Guebas (2006) when they mention that such wood burns long and hot and so is highly attractive for making charcoal or direct use as firewood. The species most frequently used as firewood is red mangrove, whereas the principal utilization of black mangrove is in construction as timber (90%). This coincides with Brucher (1989) when he says that black mangrove is mainly used as a building material (timber). In terms of construction, mangrove is characterized by its hard nature. Local people recognize the usefulness of mangrove as wood in building, but often they also use other species such as Palo de agua (*Vochysia hondurensis*), Almendro (*Terminalia catappa*), Guayabón (*Terminalia oblonga*) and some others. As they say, the reason is because these species have a proper size and good volume which makes them attractive as building material. Still, using mangrove is a common practice (Mantra, 1986).

During the field work, the respondents mentioned some forest species which are in demand as timber because of their superior quality. Table 7 below presents a list of such species, as well as clearly indicating the knowledge that local people possess about the individual species.

Table 7. List of other forest species and their use by local people

Species	Ecosystems	Use					
		Energetic	Industrial	Medicinal	Life barriers	Shadow	Forage
Palo de agua (Vochysia hondurensis)	cold and wet area		●	○	○	●	○
Zopilote (Vochysia ferruginea)	warm and humid	○	●		○	○	○
Almendro (Terminalia catappa)	fresh and very moist	○	●		●	●	○
Pochote (Bombacopsis quinata)	warm and humid	○	●	●	●	○	○
Roble encino (Quercus oleoides)	warm and humid	●	●	○	○	●	○
Coyote (Platymiscium dimorphandrum)	fresh and very moist	●	● s		●	○	○
Caoba del Atlántico (Switenia macrophylla)	fresh and very moist	○	●				
Casuarina (Casuarina equisetifolia)	fresh and very moist	●	●				
Cedro real (Cedrela odorata)	fresh and very moist	●	●				
Nancite (Byrsonima crassifolia)	warm and humid	●	●				
Guayabón (Terminalia oblonga)	very humid and warm	●	●		●	●	●
Laurel (Cordia alliodora)	humid and warm area	●	●		●	●	●
Madero negro (Gliricidia Sepium)	humid and warm area	●	●	●	●	●	●
kerosin (Tetragastris panamensis	rainforests moist	●	●				
Mangrove (Rhizophora mangle)	warm and humid	●	●				
Guapinol (Hymenaea courbaril)	warm and humid	●	●				
Leucaena (Leucaena leucocephala)	warm and humid	●	●	●	●	●	●

● **= YES**

○ **= No**

With the process of acculturation, most families are changing the style and construction material of their houses according to URACCAN and BICU (2005). But for many decades, the material used for building was extracted from the forest (palm for the roofs, wood and bamboo for the walls and floor, poles, and beams), the negative side of this process being that many local people are forgetting important indigenous knowledge which is deeply rooted in their environment, so that with the passage of time, this can probably lead to the loss of their cultural identity.

On the other hand, around 35% still make traps for fishing. Local people report they incorporate other materials such as wire-net for the same purpose, and while they still use bamboo and mangrove wood its amount is low. By using wire-net, they hope to reduce the consumption of wood and keep mangrove in its natural habitat for a longer time, thus contributing to environment conservation.

Another important mangrove product is traditional medicine, which has been used since ancient times in many parts of the world and today survives especially in the areas where access to formal and modern healthcare is limited (Kunwar et al., 2010). The knowledge of medicinal plants is directly related to their use. The loss of ethnobotanical knowledge related to mangrove medicine in the community of Sandy Bay Sirpi was obvious. The younger generation among the local community's people has only limited knowledge about the medicinal use of mangroves and many times does not know anything. Traditional healers commonly advised people on how and when to use natural medicine taken from the forest. According to Reyes-Garcia (2010), folk healers were considered custodians of ethnopharmacological knowledge.

However, local people sometimes still use the leaves of *Avicennia germinans* as a complementary remedy, especially for the treatment of gastric diseases. The analysis of data has shown that local medicinal plants are used most frequently for the treatment of gastro-intestinal system disorders and diarrhoea. There are four healers in this community (URACCAN and BICU, 2005), and besides, some fishermen use the wood of the green Avicennia germinans as fuel for repellent (wood of this species causes a lot of smoke when it burns, keeping away mosquitoes and other insects). Today the use of mangrove as natural medicine is not as common as about 15 or 20 years ago. In addition, traditional knowledge is under threat because of urbanism and adoption of the western lifestyle especially by the younger generation, which brings about gradual erosion of ethnomedicinal knowledge. Little by little, communities are losing their access to traditional health care.

7.2 *Mangrove species in the study area*

Mangrove species diversity in the study area can be clearly seen in table 6. The identification was based on inflorescences, leaf rosette and propagules. The results partly coincide with earlier studies in which four mangrove species were recorded in the Caribbean coast of Nicaragua: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*) and buttonwood (*Conocarpus erectus*) (Hogan, 2014).

The identification of these two species in the study area corresponds with the findings of Flores-Verdugo in 1992. It is very probable that there are other mangrove species in the Caribbean coast region of Nicaragua, but the distribution of this species depends on the adaptability of each species. For example, McKee (2000) says that in the Caribbean, *R. mangle* often occupies the seaward zone, followed by *A. germinans*, while *L. racemosa* grows in the most landward position.

Another reason can be the dominance of freshwater from Rio Grande de Matagalpa. Beach ridges are the main geomorphologic features in the study area that control freshwater and seawater mixing. According to Jimenez (1999), beach ridges are common on the Central America coast. Several authors describe beach ridges as essential geomorphological features of mangrove ecosystems (Thom, 1967).

7.3 *Threat to mangrove ecosystems by the local people*

Thom (1967) established that the most important factors controlling mangrove zonation are substratum and water flow regime. This shows that the preservation of dynamic flow regimes is a priority if riverine ecosystems like mangrove forests are to be preserved. Local people settled around the mangrove forests can provide information that contributes to the evaluation of factors such as environmental disturbances in mangrove forests, since their observation spans over a long-term.

Practically all participants agreed that the mangrove forest of Sheran Sandy Bay Sirpi needs an effective management strategy in view of the rising pressure of demography and pollution, which both are perceived as a major problem in mangrove ecology. Active engagement of local communities can be a sustainable practice because it can increase the awareness of collective responsibility. We must not forget that this community is exposed to natural events coming from the sea, which makes the implementation of a good mangrove management program necessary.

8. Conclusion

The study investigated the ethnobotanical knowledge of mangrove, the key species, the main uses of these species and the actual management of their ecosystems. We found two species: red mangrove (R. mangle) Laulu pauni in Miskitu and black mangrove (A. germinans) known as Laulu siksa by the local people. The presence or sparseness of these two species depends on the dominance of freshwater mixed with salt water. Still today, most local people in Sandy Bay Sirpi depend on mangrove as a source of energy for cooking, timber for construction and occasionally for medicinal purpose. They prefer nancite and red mangrove as a source of fuel, black mangrove as a source of timber, but they also use three other species because of their properties and availability as timber: Palo de agua (Vochysia hondurensis), Almendro (Terminalia catappa) and Guayabón (Terminalia oblonga). For natural medicine, they use leaves of black mangrove. Since local people in Sandy Bay Sirpi use many other tree species as source of fuel and timber, this practice does not appear to represent a significant risk to the mangrove forest. However, the population is increasing and the promotion of methods for more efficient consumption of mangrove wood is absent, which means that mangrove habitat may gradually deteriorate. These ecosystems are extremely important for the local people, for which reason sustainable and effective management is needed in view of the rising pressures of demography and pollution, to ensure food security and economic income for the future generations, but also to mitigate the effects of climate change since its effect has already become visible. At present, the knowledge of biology, productivity, relative abundance, and distribution of mangrove in Sandy Bay Sirpi area is lacking and needs to be documented, to quantify the biological and economical capacity of the local vegetation.

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10. Appendices

Questionnaires of the research

1)Data about the informants:

Name: ________________________
Gender: _______________
Age/age range: ____________
Occupation/livelihood: ___________________________
Region: _________________________________
Community: ____________________________________
Ethnic group: ___________________
Number of household members: _________

2)Questions:

Do you use any wild plants? If so, for which purposes you mainly use them?

Yes_____ No_____

Purpose:

____

____

Do you know the names of mangrove species that grow in the neighbourhood?

Yes_____ No_____

Can you specify them?

A// ____
____

What are these species called in your local language?

A// ____

Do you harvest any parts of mangrove trees?

Yes_____ No_____

List of products:

1) 5)
2) 6)
3) 7)
4) 8)

What other products do you harvest from mangrove trees?

A// ____

Generally, when and how often do you visit mangrove forest to collect these products?

A// ____
____

Who from your household is mostly engaged in collecting products from mangrove trees?

A// ____

What kind of tools do you use to harvest such product?

R// ____
____

Table 1: Plant parts collected in mangrove

Nº	Amount of plant part/product (s) collected during one visit to the forest.? (bundles, sacks, pieces)	Plant part(s) used.	Mode of preparation before using	Main use	Are the plant parts/products sold on the market.? Yes/No	Measurement Unit	Price/year $	Do you harvest any other products from mangrove ecosystems? Yes/No	Measurement unit	Price/year $
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Workshop with the community people

- How do mangroves contribute to food security for the community people?
- How do mangroves contribute to natural medicine?
- What is the condition of mangrove in the ecosystem?
- Is the mangrove forest area larger, same, or smaller, compared to 10 years ago?
- In your opinion, who is responsible for the protection of the mangrove ecosystem?
- Why is it important to protect mangrove ecosystems?

Herbarium's file

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE Institute of Tropics and Subtropics Department of Crop Science and Agroforestry HERBARIUM.

Collection:
Scientific Name:
Synonym(s):
Family:
Vernacular Name(s):
Habitat (Locality):
Description:
Name of the collector:
Date:
Collection No.:
Signature:

11. **Annex:**

Fig. 1: Mangrove forest, during the sample collection

Fig. 2: Leaf of red mangrove in his habitat and has sample

Fig. 3: Sample collection for botanical identification study

Fig. 4: Field research with questionnaire and workshop

Fig. 5: Mangrove used as firewood (traditional way of cooking and baking)

Fig. 6: Mangrove wood used as construction material

Fig. 7: Sandy Bay Sirpi mangrove landscape