



SPATIAL DIAGNOSIS AND CONCEPTUALISATION OF GREENING PLAN OF SEME-PODJI, BENIN (WEST AFRICA)

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Abstract

Conservation and sustainable management of natural resources are increasingly recommended in decentralized territories. The most effective approach for this process is the participation of local communities because their knowledge is valuable in policy implementation. The study aims to propose a sustainable management model of a territory based on the needs of communities in order to conserve the natural resources in the Sèmè-Podji municipality in Benin, West Africa. Local knowledge and community's needs have been used in association with GIS technics to make a diagnosis of the territory and propose a land use map for the municipality. The spatial diagnosis revealed an anthropization of the land cover, with a predominance of agro-systems, built up areas, croplands and fallow which represent 80.03% of the total area of the municipality. The marshlands which mostly serve as a refugium and support biodiversity represent 5.42%. The proposed plan showed that 84.79% ($p < 0.001$) of socio-professional needs are explained. Therefore, the proposed actions were related to the restoration of ecological continuity, creation of new green recreational spaces, the protection of marshlands, the management of natural protected areas and the creation of fuel wood tree plantations. The current information can contribute to a sustainable and inclusive landscape planning for such municipalities, like our study site at Sèmè-Podji in Benin.

Keywords: green space, natural resources, participative cartography, land planning, Sèmè-Podji, Benin

INTRODUCTION

The importance of natural resources in human daily lives has been widely demonstrated around the world and the conservation of these resources depends on how people interact with them (Peterson and Fisher, 1977). In this context, the lack of an adapted planning policy leads to environmental and natural resources degradation and raise the attention of development actors (Dallimer et al., 2012). Globally, the territory of forests was reduced by 40% due to commercial agriculture, and by further 33% to provide agricultural lands for livelihood (FAO, 2020). In Africa, FAO (2020) estimated that the annual rate of forest loss was around 3.9 million hectares between 2010 and 2020. Thus, it can be recognized that human pressure on forest resources is important and it is imperious to identify the responsible communities and the actions to implement for the forest conservation in order to contribute to the sustainable economic and social development.

In Benin Republic, the situation has the same trend, but with a high demand for forest products for the population daily uses. In the wetlands of the country in south, in particular at Ramsar sites 1017 and 1018, current wood needs are estimated to be more than 50 million m³, and could increase until 2027 (Yo et al., 2018). However, these environments form the basis of local biodiversity,

which provides ecosystem services. With an aim to maintaining them, Benin has adhered to the Ramsar international convention adopted in 2000 on wetlands in order to halt the degradation of their ecosystems and limit the reduction in their areas (Hunyet, 2013). Despite these efforts, we still witness the overexploitation of natural resources in these environments.

Moreover, the implementation of environmental projects aiming to save natural resources and lands usually fails due to the non-involvement of local communities (Amadou Siako et al., 2021). In urban cores where resources are limited and subject to high pressures (Kpedenou et al., 2016), the desire to preserve biodiversity is reflected in the design of planning scheme that set out priority actions to promote (Hand et al., 2016). Thus, municipalities are committed to preserve biodiversity through urban planning policies that are more respectful of nature, opting for ecological management of green and natural spaces (Cáceres et al., 2015).

The town of Sèmè-Podji is a transitional area between two city's municipalities in Benin such as Cotonou and Porto-Novo. In recent years, the municipality of Sèmè-Podji has seen a considerable increase in its inhabitant (INSAE, 2016), given the advantages it offers in terms of residential comfort, economic activities and its strategic position between the two cities. Ecologically, the Sèmè-Podji territory is mostly a wetland area included in the Ramsar site 1018

(ABE, 2010), and has been listed as biosphere reserve of the lower Ouémé valley since 2020. These assets endow the municipality of an area of interest for natural resources conservation specially mangroves (Padonou et al., 2021). However, the urban expansion, the economic development activities and the agriculture along the riverbanks constitute land anthropisation objects, thus hindering the vision of sustainability in which this town is embedded (Ryan et al., 2017). Furthermore, the exploration of the Gulf of Guinea's blue wool showed a connectivity between various water bodies and rivers from Badagri in Nigeria through Benin and Togo to Accra in Ghana (Hunyet, 2013). Unfortunately, the filling in of water circulation corridors and water pollution by industrial discharges and household solid waste (Brun et al., 2018), create a fragmentation of ecological continuities (Wolch et al., 2014), and consequently disrupt the functioning of local ecosystems (Diédhiou et al., 2020). In addition to environmental problems, there is the almost total lack of green spaces, urban gardens for recreation and nature that can play a role in attractiveness and health comfort. Likewise, aspects related to green spaces are often neglected and sometimes limited to the creation of pleasure or recreational gardens in cities. Yet greening is a determining factor for the sustainability of cities and can help to anticipate the problems of pollution, loss of biodiversity and environmental degradation in general, by ensuring the availability of ecosystem services to people (Osséni, 2021).

For these challenges, it is important to identify the natural areas around the hydrographic network within this town that could be managed or protected to maintain biodiversity in situ and conserve natural resources in general. This strategy is even more effective when it takes

into account local communities' involvement (Shibia, 2010). Therefore, within the frame of the presented research we aimed to answer the following questions: What are the favorable advantages of land use for the conservation of natural resources in the Sèmè-Podji municipality? How people's perceptions can contribute to the sustainable development of the territory's natural resources? Thus, this study proposes an investigation applying a participatory approach, and to give a suggestion on the way of development or restoration of the influence of communities in the choice of natural spaces, with a view to the preservation of natural resources and control of the territory (Shrestha et al., 2010).

DATA AND METHODS

Study Area

Belonging to the Department of Ouémé (south-east of Benin Republic) and to the Atlantic coast, the municipality of Sèmè-Podji is located between $6^{\circ}19'59''$ and $6^{\circ}27'34''$ north latitude and between $2^{\circ}27'42''$ and $2^{\circ}42'34''$ east longitude (Fig. 1). According to the latest territorial division, the municipality of Sèmè-Podji covers an area of 250 km² and it is subdivided into six boroughs (Aglangandan, Aholouyèmi, Tohouè, Sèmè-Podji, Djèrègbé and Ekpè). The municipality counts 222,701 inhabitants. The major socio-cultural groups in this area are the Xwla and the Seto (INSAE, 2016).

Sèmè-Podji has a wet tropical climate (Subequatorial climate) with annual rainfall estimated at 1100 mm/year due to cyclical disturbances under the influence of the coastal wind, which makes this town one of the wet areas in southern Benin. The average

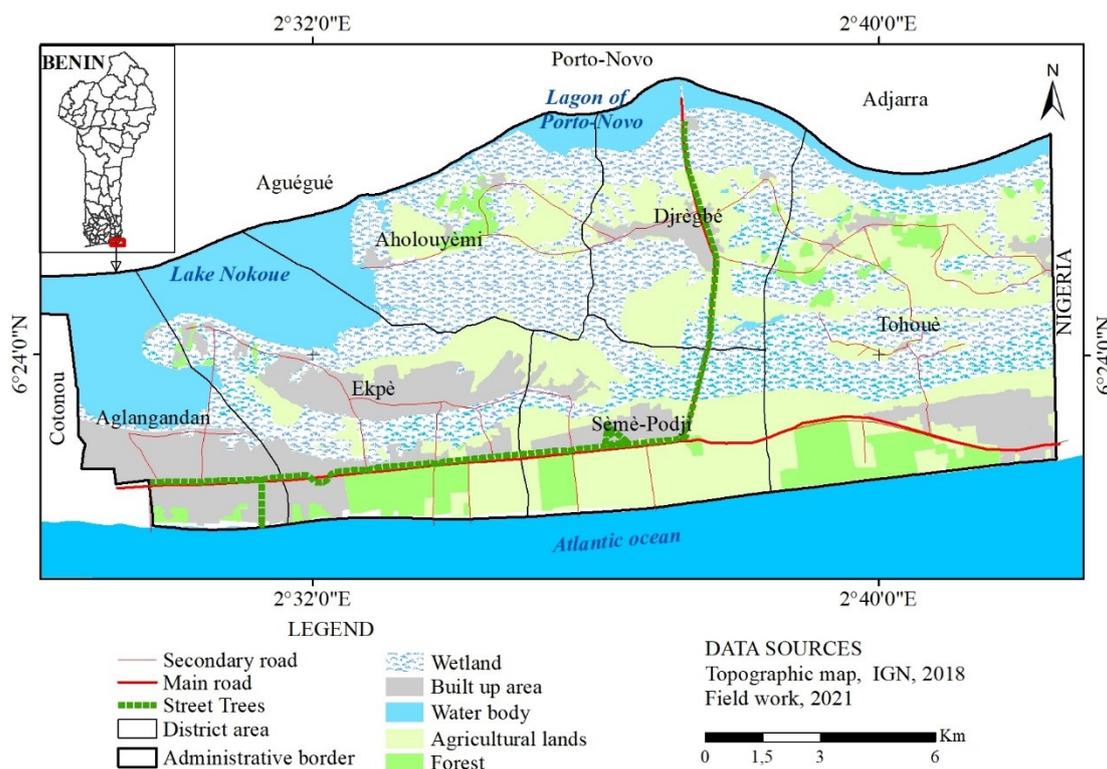


Fig. 1 Map showing the location of the study area and its land use and land cover

temperature is about 27°C with a high relative humidity. Two rainy seasons (usually from April to July and September to November) and two dry seasons (month of August and December to March) characterize the area.

In this coastal plain of Benin, the characteristic soil type is hydromorphic. The hydrographic network is well supplied and defines a continuum between the Atlantic Ocean, the lagoon of Porto-Novo, the Ouémé River and the Lake Nokoué (Fig. 1). The plant associations belong to the coastal Guinean phytogeographic sector. Despite that the biophysical conditions of this area are favourable to the development of natural ecosystems, there is a progressive disappearance of natural habitats due to the pressure exerted by local populations.

GIS and Remote Sensing methods

Spatial data were used to understand the spatial configuration of the municipality's territory in relation to its potential for natural resources to be developed for green and natural spaces. Thus, topographic maps (scale: 1:1.200,000) were used for georeferencing and to support landscape analysis. Then, the 191-56 and 192-56 Landsat satellite imagery scenes of the December 2021 period were used to classify the land use units. The December period was selected because during the dry season the phenological contrast between the different land use classes is the greatest (Justice et al., 1985; Fisher et al., 2006; Simonetti et al., 2014). A pre-processing was carried out on the topographic sheets and the satellite image. The sheets were georeferenced (reference system: WGS84 UTM 31N) and digitized. Geometric and radiometric corrections, increase colour contrast and enhancement were made on the satellite image to eliminate atmospheric biases, easy superimposition on topographic sheets and to facilitate processing and interpretation (Leboeuf et al., 2015). ENVI 5.3 software was used for image digitalization. An image interpretation is carried out in order to obtain a recognition of the land cover classes by creating digital layers of control points on the image. Then, coloured compositions in true colours were made by combining the bands (Tohozin, 2016). A supervised classification of the satellite image was therefore carried out through the selection of the training plots and the use of the Maximum Likelihood algorithm which is based on the principle of calculating the probability of belonging of a pixel to a given class or not. A confusion matrix was generated to assess the quality of the classification in its overall accuracy. Finally, the data from the digital processing was vectorized and exported to ArcMap 10.7 to be integrated into the GIS for the production of maps, area calculations and statistical analyses.

Questionnaire Survey

The survey data comes from a questionnaire on resource users to collect their perception and opinions on the choice of projects corresponding to the natural potential of the territory of their municipality. The outline of the questionnaire used concerns on (i) the restoration of ecological continuities; (ii) the creation of green recreational spaces; (iii) the protection of natural wetlands; (iv) management of existing protected areas; (v)

restoration of local forest plantations and (vi) creation of harvest plantations.

In total, 220 respondents in 7 socio-professional categories were interviewed. There were mostly farmers and stockbreeders (40), craftsmen (40), hunters and traditional healers (10), traditional chiefs (10), traders (40), office workers (40) and fishermen (40). Although it was not a representative random sampling (Baribeau, 2009), the choice of these socio-professional categories was made according to their influence on natural resources. Then, a focus group was carried out with the stakeholders to control the divergences around the opinions expressed on the developable natural resources.

The data of the social survey were entered into Excel spreadsheet. Response rates provided by the employment categories on the perceptions of green and natural spaces were calculated. An analysis of variance was carried out in order to understand the spatial perception of natural resources and box diagrams were performed. Moreover, the opinion of these socio-professional categories on the potential natural resources that could be developed in the form of green and natural spaces was subjected to a Chi 2 independence test. This test was carried out on the response rates provided by individuals in each category of respondents made it possible to verify whether there is a relationship between these employment categories, with regard to the accommodation options offered. Then, a factorial analysis of the correspondences was made to appreciate the level of dependence of these two variables.

Finally, a field survey was carried out to validate actors' proposals according to the characteristics and potential of area biodiversity included hydrographic potential, ecological continuity and coastal biodiversity. During this stage, GPS and land use maps were used to georeference waypoints and track the sites suggested by the communities to host these projects. This analysis allowed to build a shared vision of greening which can be translated into a development of green spaces planning in the municipality.

RESULTS

Spatial diagnosis for developing green spaces in the municipality of Sèmè-Podji

The spatial analysis of land use and land cover in the municipality of Sèmè-Podji resulted in five land use classes, such as swamps, agrosystems (plantations), crop lands and fallows, water bodies and build up areas (Fig. 2). The field observation showed that agrosystems were consisted of plantations such as coconut trees, palm, and firewood trees such as *Eucalyptus camaldulensis*. The greening areas included marshlands, tree plantations and farmlands. These green areas were bordered by water bodies including the Atlantic Ocean, the lagoon of Porto-Novo and the Lake Nokoué. Finally, the residential areas were along the coast and the shores of Lake Nokoué.

In the study area, the plantations (agrosystems) occupied the largest area (6,168.14 ha). This was followed by built-up areas (5,964.10 ha). The mosaics of crop lands and fallows covered 5,812.39 ha and water bodies, about 3,254.58 ha.

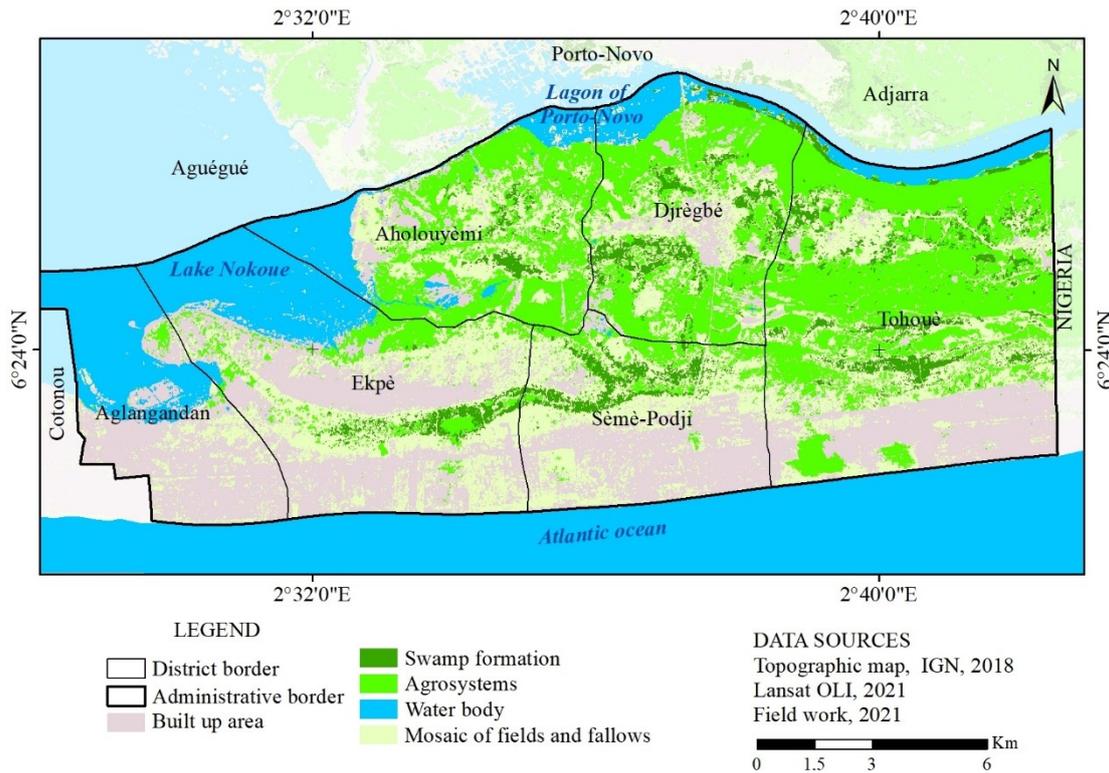


Fig. 2 Land cover in the municipality of Sèmè-Podji in 2021

Finally, the marshlands covered 1,215.07 ha covering the smallest area of the municipality’s territory (Fig. 3).

Local communities highlighted the following perception on the availability of green spaces in the municipality (Fig. 4). According to their opinion, the green recreational areas were almost scarce, and the existing natural areas were not accessible to the population, due to the long distances and the difficulty to cross. The marshlands were almost ignored during the green space planning activities. Only the beach areas fulfilled the recreational function in the municipality. The important vegetated areas were located in the northern part of the municipality and were specifically dominated by mangroves, but they are not accessible as green spaces.

These perceptions varied significantly in the municipality and according to socio-professional category ($F = 111.7$; $P = 0.008$). Therefore, a participative typology on the needs for sustainable green space development was drawn up for the municipality.

Vision of the stakeholders on the potential development of green and natural spaces in the municipality of Sèmè-Podji

The opinion of the population of the municipality of Sèmè-Podji on the sustainable management of their territory through the development of green and natural spaces were collected. The socio-demographic profile of the respondents is presented in Table 1.

Most of the farmers and breeders who gave responses were men (92.5 %) and only 7.5 % of them were women, with an average age of 40.1 ± 10.7 years. Among them, 10 % had a university level, 42.5 % had reached secondary level and 47.5 % had a level lower than or equal to primary school. Most of the craftsmen were male

(72.5 %), but every fourth was female (27.5 %), with an average age of 36.7 ± 11.93 years. Among them, 7.5 % had a university level, 45 % had reached the secondary level and 47.5 % had the primary level. The interviewed hunters and traditional healers were all men, with an average age of 52.7 ± 8.51 years. Among them, 20 % had a university level and 10 % had reached secondary level and 70 % had a level less than or equal to primary school.

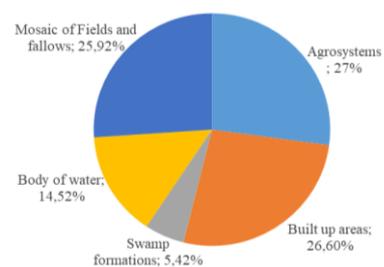


Fig. 3 Territory of the various land cover classes at Sèmè-Podji

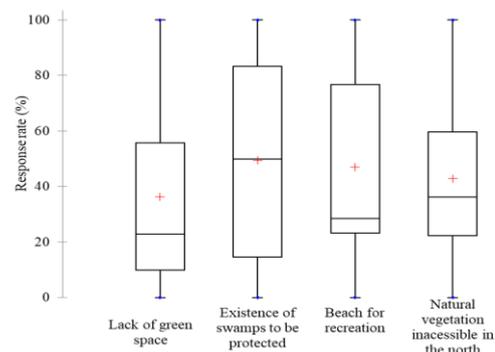


Fig. 4 Variation in responses on the availability and distribution of green and natural spaces

The traditional leaders were all also men, with an average age of 61.2 ± 7.68 years. Among them, 10 % had a university level and 40 % had reached secondary level and 50 % had a level less than or equal to primary school. The traders interviewed were constituted of 77.5 % men and 22.5 % women, with an average age of 41.4 ± 8.83 years. In this group, 12.5 % had a university level and 32.5 % had reached the secondary level and 55 % had the primary level. Most of the workers were men (90 %) and only one tenth (10 %) were women, with an average age of 34 ± 5 years. Half of this group had university level and the second half high school level. Finally, the fishermen are composed of 87.5 % men and 12.5 % women, with an average age of 37.6 ± 12.75 years. In this group, nobody had university degree, but 42.5 % had reached the secondary level and 57.5 % have had the primary level. These characteristics testify to the relative maturity of the respondents to provide reliable information, and to highlight all the view points on the subject.

Thus, six major points can summarize stakeholder perception in sustainable management of their territory through the development of green and natural spaces. Over one third (39.5%) of the respondents thought about the restoration of ecological continuity through green and blue woofs of the municipality. Over half of them (54.1%) proposed to create recreational green spaces such as urban gardens and parks close to the core of the town. According to 57.3% of the respondents maintaining and integral protection of natural wetlands can be made in the perspective of biodiversity conservation. Moreover, 55.45% of the people thought to create buffer zones around natural protected areas to develop friendship activities to the conservation. Over one third of them (35.9%) bent over on the restoration of planting forests.

Finally, 64.54% thought about the creation of fuel wood plantations for daily and domestical uses.

There is significant dependence between the perception and the employment categories (χ^2 : p-value < 0,001). The diagram on employment categories and development proposals (Fig. 5) represents the distance between two variables indicating their degree of similarity. The eigenvalues extracted by the first two factorial axes are 55.78 % and 29.01 %, corresponding to a total inertia of 84.79 %, which makes it possible to use the results to draw reliable conclusions. Thus, the interpretation of this figure informs on the factorial axis 1 (F1), a strong contribution of employment categories such as civil servants, craftsmen and farmers in the establishment of a planning logic. On factor axis 2 (F2), there is a strong contribution from fishermen and traders. The projection of the coordinates in the system of factorial axes makes it possible to distinguish three development tendencies. A first trend that brings together traders and workers around the creation of green spaces for recreation and the management of protected areas. Their choice is justified by the importance they gave to plant cover in the sustainability of the natural resources of the Sèmè-Podji municipality. A second trend which brings together craftsmen and farmers around the restoration of forest plantations, the creation of harvest plantations and the protection of wetlands. According to this group of actors, the availability of ecosystem services from plant resources, in particular the mangrove, is a major concern for the populations of this municipality. The third tendency consists in restoring ecological continuities and it was exclusively supported by sinners. Because the latter believe that the blue frame which constitutes the support of their activities is strongly split and anthropized. It is

Table 1 Sociodemographic profile of the respondents

Employment categories	Variables	Modalities	Proportions (%)	Employment categories	Variables	Modalities	Proportions (%)
Farmers and breeders	Age	40.15 ± 10.7	-	Traders	Age	41.45 ± 8.83	-
	Sex	M	92.5		M	77.5	
		F	7.5		F	22.5	
	Education level	University	10		University	12.5	
		Secondary	42.5		Secondary	32.5	
Primary	47.5	Primary	55				
Craftsmen	Age	36.77 ± 11.93	-	Workers	Age	34 ± 5	-
	Sex	M	72.5		M	90	
		F	27.5		F	10	
	Education level	University	7.5		University	50	
		Secondary	45		Secondary	50	
Primary	47.5	Primary	0				
Hunters and traditional healers	Age	52.7 ± 8.51	-	Fishermen	Age	37.65 ± 12.75	-
	Sex	M	100		M	87.5	
		F	0		F	12.5	
	Education level	University	20		University	0	
		Secondary	10		Secondary	42.5	
Primary	70	Primary	57.5				
Traditional leaders	Age	61.2 ± 7.68	-				
	Sex	M	100				
		F	0				
	Education level	University	10				
		Secondary	40				
Primary	50						

also noted that the opinion of traditional healers and breeders is close to this third trend, but without much significance.

The above data have led to the conceptualisation of a master plan for green and natural spaces development that was illustrated by Figure 6. Indeed, the sustainable management of natural resources by local communities in Sèmè-Podji should follow this plan.

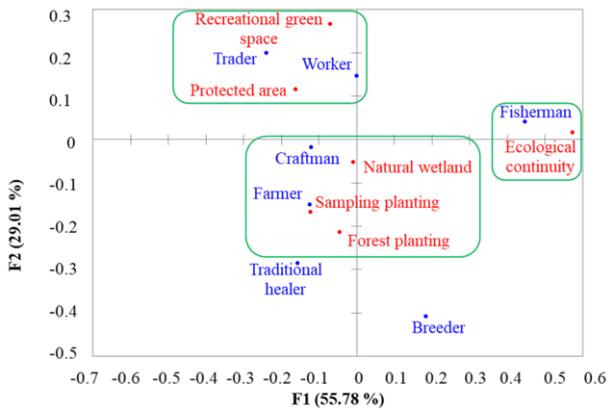


Fig. 5 Positioning of stakeholder perception and the employment categories of Sèmè-Podji. Red color: Employment categories; Blue color: Proposed land planning

DISCUSSION

Spatial configuration of the territory: a natural asset for the greening of the municipality of Sèmè-Podji

The identified land use classes at Sèmè-Podji are also characteristic of southern Benin (Kidjo et al., 2011, Lederoun, 2015), thus the results of this study could be applied in other areas as well. The three main land use classes in terms of areas are the agrosystems including plantations (27.51%), built-up areas (26.60%) and mosaics of crop lands and fallows (25.92%). These land uses classes reflect the high land anthropisation in the municipality. This finding corroborates with Brun et al (2018) who realized that the municipalities belong to the country's wetlands and specifically in those of Ramsar site 1018 undergo high land mutation in profit of built up areas, agricultural areas and tree plantations.

Appropriation of the spatial configuration through participatory discussion with local communities and field verification were decisive not only for natural resources conservation but also for the choice of actions to be carried out for sustainable development implementation. It is acknowledged that the approach is widely used in spatial diagnosis studies (Diédhiou et al., 2021) and highly recommended for the establishment of protected areas (Chan et al., 2014). People in Sèmè-Podji therefore reflected six major greening management and development activities that could be integrated into their daily practices. This led to the dissipation of all susceptibility to sabotage or exclusion of certain categories of actors. This step should guarantee the

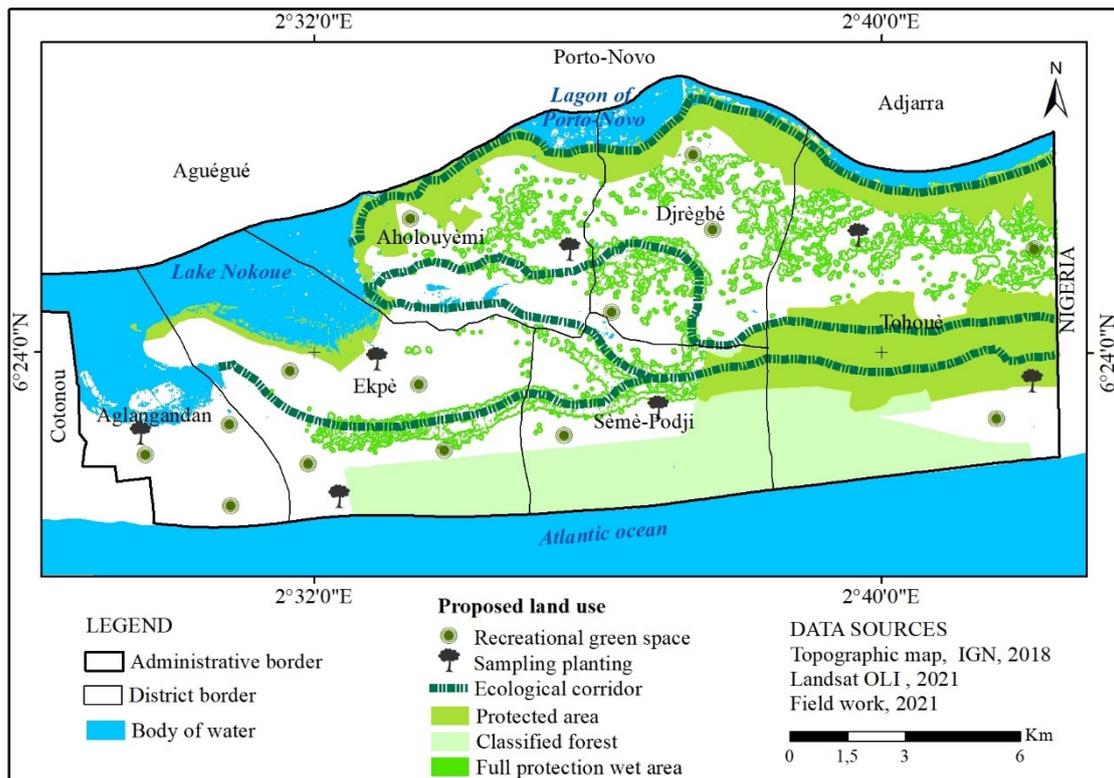


Fig. 6 Conceptual map of green and natural spaces of the municipality of Sèmè-Podji created based on the vision of the local people

development success (Shirkochidi, 2013, Forrester et al., 2015). However, the implementation of the ambition may require the guidance of local authorities and decision makers who are in charge for integrating conservation projects into the development plans.

The relief of the municipality is a flat with dense hydrographic network, thus, the development of green and blue infrastructures could not be difficult (Sahraoui et al., 2016). The ecosystem is characterized by wetland (Lederoun, 2015) and the membership of Ramsar site 1108 and Lower Ouémé Valley Biosphere Reserve network constituted an asset for the conservation (Brun et al., 2018). According to Shrestha et al. (2010), the conservation and development of these ecosystems are essential for the sustainable development of the land. On one hand, this promotes local biodiversity and makes ecosystem services available (Adanguidi et al., 2020). On the other hand, it requires stakeholders to implement a management framework that may specify a strong participation of local communities (Coldwell & Evans, 2018) with the definition of measurable monitoring indicators over time.

Stakeholder view on option choice for landscape planning in Sèmè-Podji

Discussions between stakeholders enabled to clarify the context and the need to manage resources that were previously used without precautions in order to reach a compromise and alternative solutions in the forms of use (Ballet, 2007). Thus, out of the six development proposals, four are supported by more than half of all stakeholders. These are the creation of green spaces for recreation, the protection of wetlands, the management of protected areas and the creation of harvest plantations. This assumes that the resource needs of the communities are directed in priority towards the areas that will host these developments (Shibia, 2010). Indeed, it was observed that a strong contribution of the actors was noted around the options on which their activities depend on. For example, the restoration of ecological continuities, exclusively supported by fishermen, constitutes proof that they are aware of the state of degradation of the blue wefts, and the need for their restoration. Taking these opinions into account is therefore an opportunity to begin a process of balancing the resources availability and their use by populations (Ryan et al., 2017). Thanks to this approach, the hope of sustainable development of the territory is possible in the Sèmè-Podji municipality, with the specificity of taking into account the beneficiaries concerns (Haaland and van den Bosch, 2015; Lubis and Langston, 2015). Elsewhere, all the proposed management actions seem relevant and likely to contribute to solving problems of availability or accessibility to plannable resources. This is why the positioning of the areas to be developed is made on suitable sites and capable of meeting the objectives set. For instance, recreational green spaces are positioned on exposed land, near or within settlements to reduce the effect of mineralization in urban centers. Hence, it is important to take into account the socio-professional categories in order to identify needs by affinity (Amadou Siako et al., 2021). While fishermen advocated for the

restoration of ecological continuity in order to facilitate the circulation and availability of fisheries resources, farmers proposed the establishment of tree plantations and the restoration of forest plantations. These actions aim to compensate land degradation caused by any human activities. Such results prove the existence of stakeholder awareness on the impact of their activities on the environment (Ilboudo et al., 2020), and therefore the need to find alternative solutions (Jennings et al., 2016). The results may be justified by a people commitment to contribute to the sustainable implementation and management of development proposals (Acharya, 2004). These initiatives can also show that community involvement helps to strengthen territorial cohesion, increase people's well-being and health, and ensure sustainable development (FAO, 2017). In addition, it will enable the community to address contemporary challenges related to attractiveness, connectivity, mobility, adaptation to climate variability, conservation and sustainable management of ecosystems, and employment.

CONCLUSION

This study enabled us to understand the spatial configuration of municipal territory of Sèmè-Podji in southern Benin through a participatory drawing and field verification approach. This approach allowed the deconstruction of old practices and an awareness of the sustainable management of natural resources. Thus, the different greening area types were described and a development proposal was made in the perspective of conserving biodiversity and making the territory more attractive. At the end of this exercise, a conceptual master plan for the development of green and natural spaces, integrating the needs of the communities and the requirements of conservation, was proposed. However, there is a need for political will to support its integration into the development plan of the municipality.

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