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ANALYSIS OF URBAN ECOSYSTEM SERVICES FROM WETLAND AREAS. CASE STUDY: INÍRIDA CITY (COLOMBIAN AMAZON REGION)

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Abstract. Colombia as one of the most biodiverse countries in the world has regions, whose Ecosystem Services (ESS) have not been relevantly assessed as established in their recent environmental policies. Although various planning and policy instruments at the national level have formulated guidelines and compiled examples of ESS management strategies in the country in the last 15-20 years have been cases of economic or ecological valuations focused in certain regions of the country like the Andes or the Caribbean, which have contributed to regional socio-environmental development. Nevertheless; there are still large gaps in terms of ESS assessments involving biophysical and cultural aspects in some regions like the Amazon or the Orinoco areas, which would allow for strengthening the environmental management programs and policies in the country. This is a shortcoming this research aims to address in some of the less studied areas in this regard in the northern Amazon region like the Ramsar wetland site, the Inírida Fluvial Star (IFS). This is the first part of an integral, socioeconomic and environmental assessment of the wetland, which at this stage involves the urban area. The natural area of the wetland will be addressed in subsequent studies. The main purpose of this research is to assess the current state of the Urban Ecosystem Services (UES) in the city of Inírida located in the IFS, and its vulnerability to climate risks such as floods. The UES characterization performed so far has allowed identifying the potential zones that provide ESS in the city, as well as the effects of extreme climate events such as floods and nature-based adaptation, and measures that mitigate the effect of these events and in turn, contribute to improving the quality of life of the inhabitants. Several of these measures are in the process of being implemented. It also evidenced the need to generate new information on the current state of the UES to contribute to the development of the city in conjunction with the conservation and management of the wetland. The relevance this study holds is the generation of new in-depth data for this region which will be an asset at the scientific level to be considered for further studies in the country.
Keywords: Urban ecosystem services, inland wetlands, floods, northern Amazon region.

1. INTRODUCTION

The ecosystem services ESS can be defined as processes in which ecosystems provide benefits to sustain human life (Daily, 1997; Lin et al., 2017) and raise awareness about biodiversity and ecosystem conservation (Russo & Cirella, 2021a) In the cities, the urban ecosystem services UES can be described as services produced in urban spaces, i.e., they are embedded within the continuous urban areas defined by the city's infrastructure and not only by its administrative boundaries (CODS, 2020) The ES concept is increasingly vital to sustainable urban development. Today, most people live in cities (over 50%) and have to deal with associated challenges such as urban heat islands, food security, flooding, and pollution, among others (Russo & Cirella, 2019, 2021a).

Compared to other ecosystems such as forests or wetlands, the attention focused on UES has been comparatively moderate (Brzoska & Spāģe, 2020; Gómez-Baggethun & Barton, 2013; Haase et al., 2014; Russo & Cirella, 2021b; Stott et al., 2015). Most studies in this respect have focused on single ecosystem services and/or value dimensions. An example of this is the monetary valuation of UES, widely examined in the literature, e.g., through hedonic price modeling and contingent valuation methods (Brander & Koetse, 2011; Escobedo et al., 2015; Panduro & Veie, 2013; Tyrväinen & Väänänen, 1998) On the other hand, the non-economic assessment of symbolic, cultural, identity, and other values has been explored mainly in the last decade (Bertram & Rehdanz, 2015; Gómez-Baggethun & Barton, 2013; Jones et al., 2022; Langemeyer et al., 2015; Riechers et al., 2016).

Accordingly, there is a growing interest in the UES approach that presents solutions to the issues mentioned above in the city environment (Atif, 2018; Richards & Thompson, 2019; Russo & Cirella, 2021a). Since cities strive to live in harmony with nature, it is necessary to recognize that ecosystem processes are part of them (Inostroza & Sarasti, 2020) Examples of these efforts can be evidenced in many initiatives around the globe, like the Urban Biodiversity and Ecosystem Services (URBES) project, which contributed to the quality of life and sustainability in cities in the European Union and the US through a range of science-based approaches (Urban Systems Lab, 2020), others like Cities4Forests work with 69 cities from around the world to protect and restore forests preserving biodiversity, as a measure to cope with climate change (WRI, 2018), and the initiative Biodivercities by 2030, which contributes to strategies focused on the mutual benefit between nature and urban centers (WEF, 2022).

The importance of studying the UES can also help to mitigate the effects of the expanding urban population and the transition from rural to urban areas (Pauleit et al., 2017). A clear example is evidenced in large cities, especially in Latin America, where urban development did not have a structured planning process from the beginning, it may not be easy to define a clear boundary between urban and rural areas due to their different socioeconomic and environmental conditions. Therefore, the critical factors of urban growth that affect the existence and potential of UES must be taken into account (Dobbs et al., 2019; Haase et al., 2014).

Colombia is no exception to this reality; for example, in the main cities of the Caribbean, the urbanization process has degraded the natural capital, decreasing the present and future supply of ES, and, thus, increasing the vulnerability to climate change (Aldana et al., 2017; Aldana et al., 2018). Presently, there are 15 cities in the country, including large cities with> 1 million inhabitants, intermediate cities 100,000 - 1 million inhabitants, and small cities with < 100,000 inhabitants (DNP 2014 in Arzayús & Caicedo, 2015) which are developing programs and policies focused on UES (MADS, 2021). Those have been mainly based on three national guidelines documents, the National Policy for the Integrated Management of Biodiversity and Ecosystem Services (Acronym in Spanish PNGIBSE) the Integrated Valuation of Biodiversity and Ecosystem Services (Acronym in Spanish VIBSE), and the National Assessment of Biodiversity and Ecosystem Services of Colombia; issued in 2012, 2014 and 2021 respectively.

Similarly, several of these small cities are experiencing rapid population and economic growth, becoming poles of regional development and filters that buffer the excessive sprawl of the country's main cities (Arzayús & Caicedo, 2015). Likewise, in most of them, there have been no ongoing studies related to the present state of the UES, and various of these cities are generally located in areas vulnerable to climate change effects (Inostroza & Sarasti, 2020).

A typical example of this scenario is in the northwestern Amazon, which is one of the regions where in the last 10-12 years important biological and socio-cultural characterizations have been carried out, especially in the wetland and fluvial areas like the Inírida fluvial Star IFS (Lasso et al., 2014; Lasso, 2010; Trujillo et al., 2014; Usma et al., 2014, 2019, 2021) (Figure 1). However, in terms of analysis of wetland ecosystem services in these areas, there is still a need for more concrete studies (Gómez et al., 2019; Matallana et al., 2019; Usma et al., 2021; Vásquez & Matallana, 2016). Even more in urban areas within wetlands, the study of ESS is a pending matter for national environmental programs, considering the socio-environmental dynamics of the territory (Barrera et al., 2019; Betancourt et al., 2021; Gómez et al., 2019; Riaño & Salazar, 2018).

This is the case of the city of Inírida, the capital of the department (main national administrative division) of Guainía, with a population of 33,683 inhabitants that increased by 57% between 2005 and 2018 due to migration from the surrounding rural areas (DNP, 2018). If this trend continues, by 2025, a growth of 118,984 inhabitants is expected, mainly due to various social phenomena such as uncontrolled migration from rural areas to Inírida and neighboring countries such as Venezuela (Alcaldía de Inírida, 2020; Gobernación del Guainía, 2020).

Consequently, intense pressure on habitats has been triggered, which can lead to the loss of biodiversity, leaving ecosystems vulnerable to climate change-related phenomena (CDA, 2016). Given the vulnerability of this region, it is necessary to take into account measures to counteract the impacts of climate change. An approach to this is nature-based solutions NbS, these are actions to protect, sustainably manage and restore natural and modified ecosystems that effectively and adaptively address societal challenges while simultaneously providing benefits for human well-being and biodiversity (Mackinnon et al., 2008; Pauleit et al., 2017).

The concept of NbS encompasses other established 'nature-based' approaches such as ecosystem-based adaptation EbA and ecosystem-based mitigation, eco-disaster risk reduction, and green infrastructure (European Commission, 2020; Seddon et al., 2020). For instance, the EbA approach focuses on a participatory, community-based climate adaptation strategy which may include sustainable management, biodiversity conservation, and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic, and cultural benefits, contributing to reduce vulnerability and increasing resilience to both climate and non-climate risks (Colls et al., 2009; Seddon et al., 2020)

Figure 1. Location and general information of the study area (Gobernación del Guainía, 2020; IGAC, 2018; Usma et al., 2021)

In Colombia, the EbA approach has contributed to formulating strategies for various vulnerable regions in the Caribbean, the Andes, and the insular region, aimed at integrating multiple measures proposed by the different stakeholders into local planning instruments (MADS, 2018). For the study region, several measures were formulated only in Guainía (departmental level) but not at the city scale, focusing on community-based adaptation, infrastructure-based adaptation, and ecosystem-based adaptation considering the political and financial capacities of the local government (CDA, 2016).

However, as registered in official documents from 2012 to 2019 related to risk management plans and climate change adaptation (CDA, 2012, 2016; DNP, 2019, 2018; Equipo Humanitario Colombia, 2018; Gobernación del Guainía, 2020), as well as biodiversity and socioeconomic studies (DNP, 2018; Trujillo et al., 2014; Usma et al., 2019, 2021; Usma & Franco, 2014) among others. There is no mention of whether these measures are being implemented at the urban level in Inírida, In the same form, the lack of concise studies concerning the ongoing state of the ESS in this region limits to a large extent an approach to this situation (Álvarez et al., 2021; Betancourt et al., 2021; Rincón et al., 2014).

In sum, although there are advances in the understanding of the importance of the UES as articulating elements in the integral development of cities, especially the larger ones, nature-based adaptation measures have already been established to counteract socio-environmental challenges; Most of them are focused on large cities in the country, in areas where there is a greater social and economic dynamic, with little consideration of other growing regions, even more, vulnerable to the problems described and where the related information is very little, so it is necessary to analyze the status of ecosystem services, to orient research efforts that allow dealing with future challenges given by the global change scenarios.

Therefore, the scope of the first phase of this study is the following: first, to carry out a preliminary approach to identify the potential areas for providing UES in Inírida and to determine which of them could be affected by reported climate events, and second, to identify and propose measures under the EbA approach that could contribute to increasing the adaptive capacity of the local socioecosystems.

2. METHODS

2.1 Study region

The study is being carried out in the urban area of Inírida, which is the capital city and a municipality, of the department of Guainía in Colombia, located in the transition zone of two natural regions, the Orinoquia (eastern plains) and the northeastern Amazon (Trujillo et al., 2014). The city area comprises an extension of 1000 km^2, the urban zone is bordered to the north by the indigenous reservation of Coayare el Coco and the Guaviare River in between; to the south by the Almidón la Ceiba reservation; to the east by the Puinave Curripaco reservations of Tierra Alta; and to the west by the Inírida River (Alcaldía de Inírida, 2020). It has a total of 33.683 inhabitants with a multiethnic presence; 80% of the population is indigenous, and 20% is comprised of settlers, whites, mestizos, and Afro-descendants (Gobernación del Guainía, 2020).

The urban area is surrounded by the Ramsar site known as the Inírida Fluvial Star IFS, one of the most important ecological areas in the country (Usma & Franco, 2014) (Figure 2). The IFS is the third largest wetland in Colombia, with an extension of 250,158.9 ha. It has a shared governance system between the state and the community; this area is the primary provider of biophysical and cultural ecosystem services in the region (Trujillo et al., 2014; Usma et al., 2021; Usma & Franco, 2014) (Figure 3).

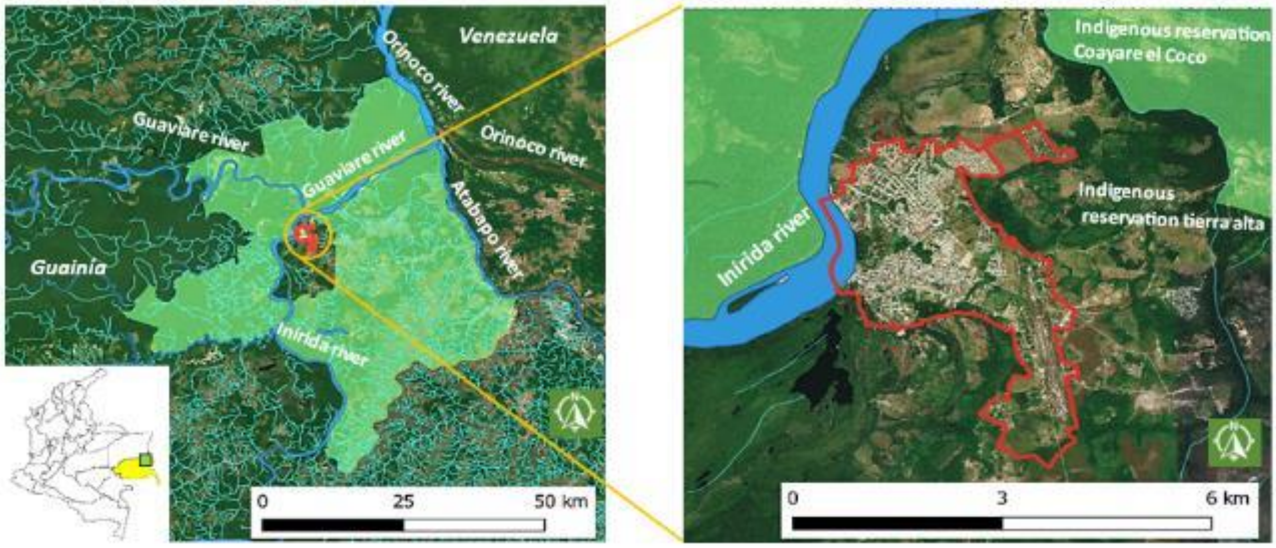

Figure 2. City of Inírida surrounded by the IFS wetland. Conventions**:** Department of Guainía, Area of the IFS, Location of the city of Inírida. Source (IGAC, 2020).

Figure 3. View of the city port and collection of fish on the banks of the river (Trujillo et al., 2014; Usma et al., 2021)

2.2 Characterization of UES in the study area

For this phase, information has been collected mainly from the available bibliographic review (gray and scientific literature), geographic information, as well as some questions to some relevant actors in the area.

2.2.1 Identification of potential areas for the provision of UES

By reviewing data obtained from Google Earth Pro™ and shapefiles obtained from the Geographic Institute Agustin Codazzi (Acronym in Spanish IGAC) at the available scales of 1:40000 and 1:2000, the landscape elements likely to provide ES were identified, these make part of green and blue infrastructure GBI. GBI can be defined as strategically planned natural or semi-natural structures or networks that provide various ecosystem services within city boundaries (European Commission, 2013).

Following the classification compiled by (Veerkamp et al., 2021). These areas can be categorized as follows: (1) building greens (e.g., green roofs, green walls), (2) green and blue structures connected to grey structures (e.g., street trees, vegetated swales), (3) parks and (semi-) natural green areas (e.g., forests, cemetery), (4) gardens (e.g., allotment and community gardens), (5) water areas (e.g., lake, river), (6) abandoned land (e.g., vacant land, brownfield), and (7) unspecified GBI (e.g., summarized as 'green space' or combination of different GBI types).

2.2.2 Identification of UES

Regarding the identification of UES, the classification formulated by The Economics of Ecosystems and Biodiversity TEEB framework (TEEB, 2010) was adopted (Provisioning, Regulating, Cultural and Supporting services); because they are issued in most studies at the national level based on the PNGIBSE guidelines. In the same form, the UES were classified according to (Gómez-Baggethun & Barton, 2013; McPhearson et al., 2013).

Since there are no specific studies of UES in the region, the information was supplemented with documented data on ESS from 2012 to the present, which provided a hint of the UES that can be identified in the study area in official national studies (referring mainly to the country or large capital cities such as Bogotá), and regional and local studies (regional level considers the Amazon region and the local includes the department of Guainía and the municipality of Inírida).

2.2.3 Identification of risks associated with meteorological and extreme climate events that affect the provision of UES

Colombia is one of the most vulnerable countries to the effects of climate change, being in a medium-high category based on the Global Climate Risk Indicator GCR (Germanwatch, 2021). However, climate change has not been comprehensively analyzed in the country; therefore, it has not been fully incorporated into territorial planning and planning processes, limiting economic and social development in some regions. Between 2010 and 2011, events such as El Niño-Southern Oscillation ENSO had the greatest economic impact on the country as it caused significant losses, equivalent to almost 2% of the national GDP (CDA, 2016). As a result, programs focused on mitigation and adaptation to climate change began to be developed as a national priority.

At the study site level, the vulnerability of the territory to various hazards of geological (mass movements, rock falls, flows, avalanches) and hydrometeorological origin (floods, droughts, extreme precipitation, fires), together with the process of land occupation and use have contributed to the increase in disaster risk conditions. In the 2006 - 2009 period, 4286 events of hydrometeorological character were recorded compared to 8504 in 2010 - 2013; this represents an increase of 2.6 times the number of events (DNP-SDAS, 2014, p. 12 in CDA, 2016).

In order to identify the risks associated with extreme meteorological and climatic phenomena that affect the provision of UES, official documents on the issue like risk management plans and development programs were reviewed from 2000 to 2020 at the regional (Amazonia) and local (Guainía and Inírida) levels.

2.2.4 Identification of measures based on the EbA approach

Based on the review of official documents and guidelines from 2010 to the present, it was consulted which measures based on the EbA approach have been proposed and which of these are being or have the potential to be applied in the study region.

3. RESULTS AND DISCUSSION

3.1 Potential areas for the provision of UES and types of UES identified

The **Figure 4** shows the location of five potential providing areas of UES according to Veerkamp et al. (2021), 1) Green and blue structures, 2) Parks and semi-natural green areas, 3) Gardens, 4) Water areas, and 5) Abandoned land.

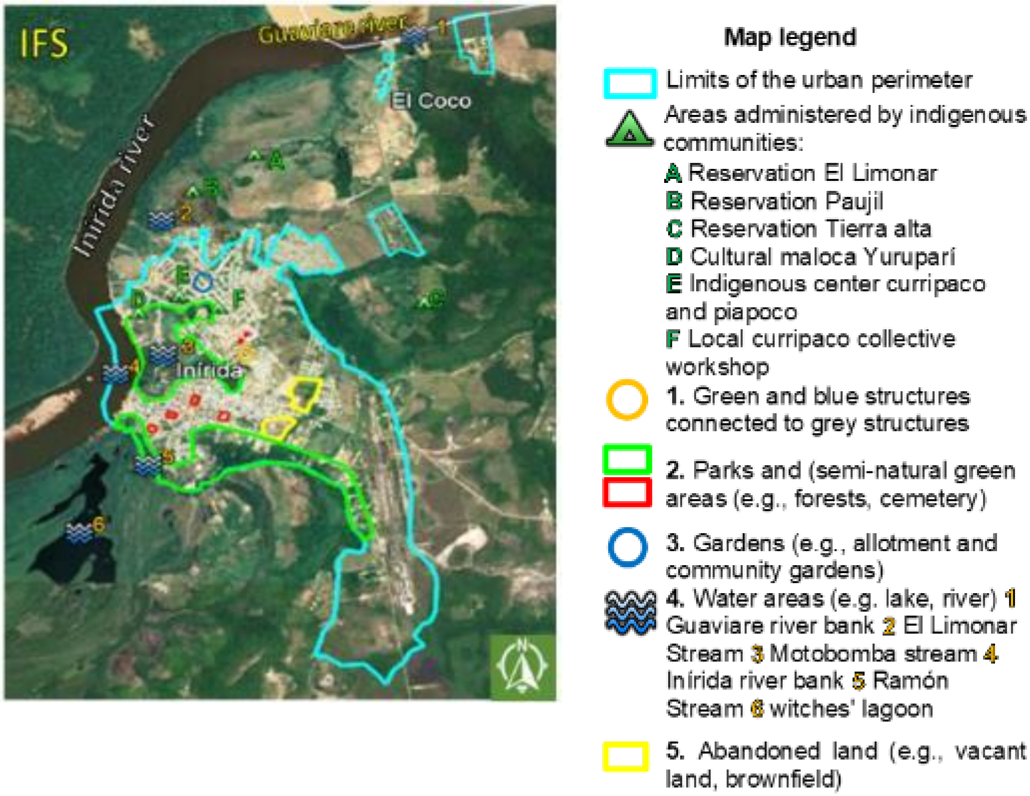

Figure 4. UES potential supplying areas. Scale 1:70000 (Alcaldía de Inírida, 2000; CDA, 2016; Gobernación del Guainía, 2020; Google Earth, 2020; IGAC, 2020; Veerkamp et al., 2021)

Structures such as green buildings (e.g., green roofs, green walls) are not discernible or identifiable, as there are no large gray areas, constructions, facilities, or other major infrastructure works. Nevertheless, some places where those green roofs can be located have been identified. The **Table 1** shows the five areas previously identified, together with the potential UES and their preliminary description.

Table 1. Areas identified as providers of urban ecosystem services.

Detailed area	Classification	Type of ESS	UES	Location in the city and description
	**1) Green and blue structures connected to grey structures (e.g., street trees, vegetated swales)**	Regulating	• Local climate and air quality regulation	These structures are scattered throughout the city, but there is no inventory or diagnosis of their condition.
 	**2) Parks and (seminatural green areas), e.g., forests, cemetery**	Cultural, regulating, supporting	• Local climate and air quality regulation • Carbon sequestration and storage. • Moderation of extreme events	These areas offer a wide range of ecosystem services; **patch 1** has approximately 5.4 km^2 and has cultural and spiritual importance, especially for the local indigenous communities. **Patch 2** has 7.8 km^2 and is essential, as it is a point of connectivity and regulation with two water bodies, the Stream Ramón, and the Witches' Lagoon.

(Continued on next page)

Table 1. (continued)

Detailed area	Classification	Type of ESS	UES	Location in the city and description
  	**2) Parks and (seminatural green areas), e.g., forests, cemetery**	Cultural, regulating, supporting	• Pollination • Erosion prevention and maintenance of soil fertility • Habitats for species • Recreation and mental and physical health • Tourism • Aesthetic Benefits • Cognitive development • Spiritual experience and sense of place	On the other hand, four sports areas, **1,2,3,4** and cemetery **5**, were identified, two other parks have a greater relevance from a cultural point of view, the central park Flor de Inírida **6** since represents one of the most renowned non-timber forest products of ancestral use in the region, two herbaceous species, the inírida flowers *Guacamaya superba* and *Schoenocephalium teretifolium*, which are widely used for handicrafts, fibers, and construction materials, and dye There is also the Inírida Princess park **7** of the Puinave tribe from which the capital is named. In these parks, there is an exchange of knowledge between locals and tourists that takes place also in the *Malocas* indigenous cultural centers located there **8**.
	**3) Gardens (e.g., allotment and community gardens)**	provisioning, cultural	• Food supply • Medicinal resources	These areas can be owned or shared, mainly for subsistence crops such as plantain, cassava, maize, Inírida flower, fruit trees, and medicinal plants, besides small farm animals. Extensive agricultural lands belong to private producers of cacao and maize.

(Continued on next page)

Table 1. (continued)

Detailed area	Classification	Type of ESS	UES	Location in the city and description
	**4) Water areas (e.g., lake, river)**	provisioning, cultural	• Water supply • Food supply • Habitats for species • Recreation and mental and physical health • Tourism • Aesthetic benefits • Cognitive development • Spiritual experience and sense of place	These are among the most crucial areas since they have a notorious faunistic diversity, with approximately 80% of the species identified in the entire Amazon. It is a relevant source of food supply and trade of ornamental fish. The banks of the Inírida and Guaviare rivers are especially attractive for tourism and biodiversity because of the cultural background associated with the native ethnic groups. The water supply is constant, as it supplies the municipal aqueduct and extraction wells; however, the water quality is not good and must be treated and filtered several times.
	**5) Abandoned land (e.g., vacant land, brownfield)**	provisioning, regulating	• Local climate and air quality regulation • Carbon sequestration and storage, • Moderation of extreme events • Pollination • Erosion prevention and maintenance of soil fertility	There is no inventory of these areas; nonetheless, two sites were identified as brownfield sites.

Source: Own elaboration based on literature review. Scale of the images 1:2000 (Google Earth, 2020; IGAC, 2018)

The main potential areas identified can be visualized based on the classification proposed by Veerkamp et al. (2021); as part of a first approximation. However, with the information to be supplemented and at a more detailed scale, it is possible to assess the current state of these areas, as well as other ecosystem services that have not been described.

3.2 Identified risks associated with meteorological and extreme climate events that affect the provision of UES

There are frequent reports of phenomena cataloged as risks in the study area: fires, windstorms, droughts, erosion due to undermining, and floods. These place the department of Guainía with a high-risk vulnerability index > 70 % (DNP, 2019), and the lack of implementation of concrete risk management and mitigation measures related to technical, financial, and-or political aspects exacerbates this status.

Among these risks, the effects of floods are the most documented and recurrent, affecting mainly agricultural areas and small settlements located on the river flood plains, which has caused economic losses and occasional migration of riverside dwellers. Between 1998 and 2013, 10 floods were reported due to increased precipitation resulting from the El Niño-Southern Oscillation ENSO (CDA, 2016; DNP, 2019).

The average monthly precipitation is around 275 mm, and by 2100 an increase of about 10% (302.5 mm) is expected. Nevertheless, if the current forest cover, which corresponds to 86% of the municipal area, is affected, the increase could be up to 40% (385 mm), affecting ecosystem functions and the supply of ecosystem services (Alcaldía de Inírida, 2016; DNP, 2019) (Figure 5) shows the areas that have been affected by flooding events up to 2013 caused by the ENSO.

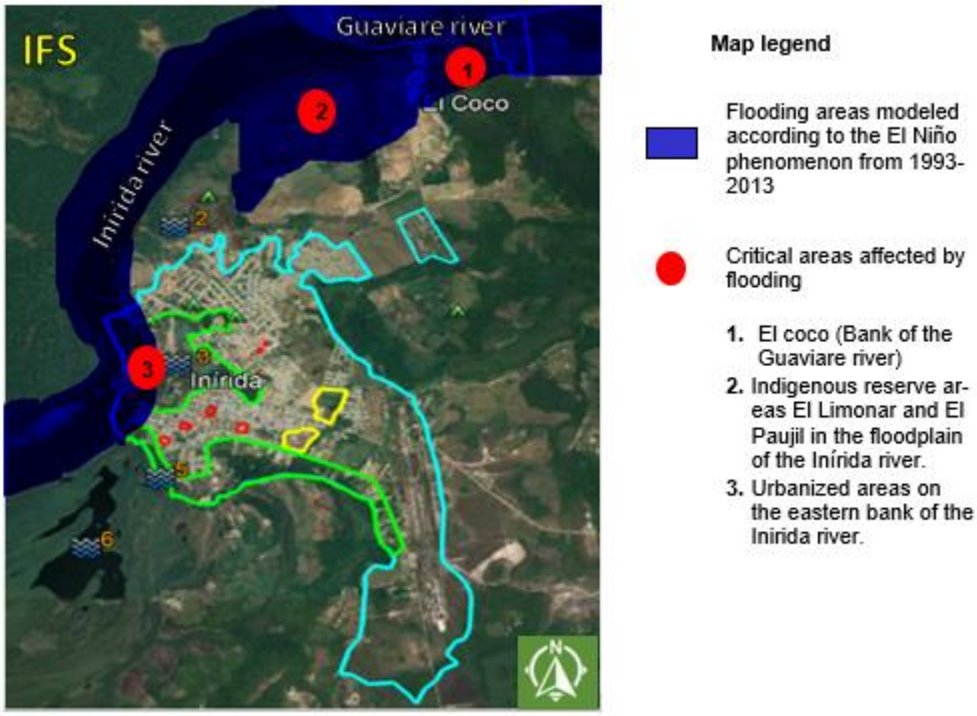

Figure 5. UES potential supplying areas affected by floods. Scale 1:70000 (CDA, 2016; Gobernación del Guainía, 2020; Google Earth, 2020)

To the north, the sector of El Coco 1 has been the most affected by these phenomena, as well as the areas of flood plains managed by the indigenous reserves of Limonar and Paujil 2, where most of the communities' crops and their small farm animal breeding areas are located, and the urban zones on the river bank 3. Although there are no current local data or maps of the economic, environmental, and human damages caused by these catastrophes, it is possible to identify the areas and estimate the effects of such events, which might be the following (Table 2).

Although floods are the most frequently reported risk, it should be stressed that other events, including erosion, deforestation, and fires, are little documented, even though those are risks that may increase if enforcement measures formulated by authorities are not effectively implemented (CDA, 2016; Giraldo & Casto, 2020). Therefore, it is also necessary to include this information and develop models to assess them.

Similarly, the lack of more recent data available on floods makes it challenging to know the general status of the possible critical areas identified and others that are equally or more vulnerable to these phenomena. In addition, the impacts of the effects described above require present data that will make it possible to develop more precise management measures, also taking into account the accelerated demographic growth occurring in the city (Gobernación del Guainía, 2020; Riaño & Salazar, 2018)

Table 2. Effects of flooding in the study area

Expected effects caused by flooding
• Increased incidence of flooding because rivers and streams fill with sediment, and the water leaves its natural course due to erosion. • Increased concentration of pollutants in the water, such as heavy metals derived from activities such as artisanal or illegal mining located a few kilometers from the urban area, as well as nitrates and phosphates, and hazardous solid waste. • Negative economic impacts on livelihoods due to flooding of arable areas, loss of crops, or the farming of ornamental fish and other minor species. • Loss of food sources, resulting in the consumption of other protected wildlife species, such as tapir *Tapirus terrestris*, river turtles *Podocnemis sp*, monkey species *Saimiri sciureus*, *Alouatta sp.*, *Cebus sp.*, armadillo *Dasypus novemcinctus*, curassows fam. Cracidae and moorhens fam. Rallidae. • Displacement of wildlife species that could pose a risk to the population, such as crocodiles *Crocodylus intermedius*, *Caiman crocodilus*, and snakes fam. Viperidae and Colubridae, and a decrease in the number of species of birds and insects. • Affecting ecosystem functions and biological resources in the most flood-prone areas inside and outside the urban area would cause the displacement of inhabitants to less flood-prone preserved sites. • Possible negative economic consequences on the region's tourist attractiveness due to the impact on the land and structures available for this purpose. • Increased surface runoff, preventing water from infiltrating the soil, affecting its permeability as well as drinking water reserves.

Source: Literature review and responses of some interviewees

3.4 Potential measures to be implemented according to the EbA approach

Based on the literature review and responses of some interviewees, some actions have been identified as suitable for this context (Table 3).

Table 3. Measures to be considered for possible implementation

List of measures
• **(*)** Sustainable use, exploitation, and management of non-timber forest products like the Inírida flower species *Schoenocephalium teretifolium* and *Guacamaya superba*. Plant fibers and fruits extracted from palms such as chiquichiqui *Leopoldinia piassaba*, moriche *Mauritia flexulosa*, and seeds of the camu-camu tree *Myrciaria dubia* would help to alleviate the livelihoods of local communities.
• Establish seed banks and greenhouses of native tree species for multiple purposes, including restoration and sustainable use of their subproducts, integrated with community gardens.
• Inventory and registration of local medicinal plants and their multiple uses and their future commercialization potential through green market programs.
• **(*)** Implementation of a community-based early warning system through participatory mapping to identify vulnerabilities and potential hazards, complemented by climate scenario modeling and climate profiling, with hydrodynamic modeling to generate flood risk scenarios and detailed cartography.
• Certification of apiculture and permaculture projects for the commercialization of honey and associated products, like pollen, propolis, jellies, and waxes, among others.
• **(*)** Establish programs for in situ and ex-situ repopulation and conservation of wildlife species, their rescue and transfer, and the organization of cooperatives for ornamental fish sustainable farming
• Inventory and maintenance of green and blue structures and the construction of structures such as green walls and roofs (including roof gardens) that maintain the supply of diverse regulation, cultural, and provisioning services.

Source (GIZ, EURAC & UNU-EHS, 2018; MADS, 2018; Riaño & Salazar, 2018; UICN, 2012)

Of the measures proposed above, those marked with (*) are the ones that have been implemented for approximately 12 years in the area; the others are still in the process of being evaluated by the local entities for their application. However, it is important to consider that to implement these actions the technical, financial, political, and community interest analysis criteria must be optimized (CDA, 2012, 2016; Forero et al., 2015; Gobernación del Guainía, 2020).

The interviewees also expressed that although these measures are adequate, they should be complemented with other solutions based on engineering or infrastructure to help mitigate the impact of floods. On the other hand, no single action can be classified as relevant, as it could be based on one or a combination of the different previously identified approaches (MADS, 2018; UICN, 2012).

Additionally, benefits derived from the implementation of the measures are multiple, including disaster risk reduction, maintenance of livelihoods and food security, biodiversity conservation, carbon sequestration, integrated water resource management, landscape appreciation, and cultural value, creation of employment, and diversification of alternative economic activities, among others (Chaves et al., 2021; UICN, 2012).

3.5 Identified ecosystem disservices EDS

Another interesting finding was the report of indications of ecosystem disservices EDS, which can be defined as functions or properties of ecosystems that cause effects that are perceived as detrimental, unpleasant, or undesirable (Lyytimäki, 2015).

Examples of EDS include damage caused by pests in agriculture, pollen causing allergic reactions or fear related to night urban parks, competition for habitat between humans and animals, blocking of view due to tree growth, damage to infrastructure, or accidents caused by tree parts, such as roots or falling branches (Gómez-Baggethun et al., 2013). The latter, in particular, is usually reported in the city (Alcaldía de Inírida, 2016); however, there is no data on costs or affectations caused by the same.

Other EDS reported in the study area are those related to the presence of vectors such as rats and mosquitoes that can transmit various diseases like chikungunya, dengue, or malaria, which can be fatal in some cases if they are not adequately treated (Alcaldía de Inírida, 2016). For example, this latter can be exacerbated because the remaining ponds in flooded areas are the perfect breeding sites for these agents (PAHO, 2022).

Likewise, others, such as ophidian accidents, are not known how often they occur; for example, there is only data from 2015 with eight registered incidents (Alcaldía de Inírida, 2016). Although common in this region, other EDS such as stings caused by wasps and other insects (Gómez-Baggethun et al., 2013) have not been documented.

In terms of the identified EDS, it could be inferred that specific measures based on ecosystem-based adaptation, together with community-based actions such as participatory risk assessment, could alleviate the effects of EDS (Forsyth, 2013). For instance, the local stakeholders can perform activities such as an inventory of trees that may cause injuries to people and damage to infrastructure and develop indicators that estimate the costs generated (MADS, 2018; UICN, 2012).

Other measures like including allelopathic plants in gardens or green infrastructure could help keep some vectors like mosquitoes under control. Nevertheless, considering an increase in flooding, the sanitary and management measures established must be adopted immediately to avoid the spread of vectors and, therefore, a public health problem (Alcaldía de Inírida, 2016; Gobernación del Guainía, 2020).

4. CONCLUSIONS

Through the approximation and preliminary categorization and identification of the areas with potential for the provision of UES, a general picture of their current status was presented, which can be considered as an advance in the updating of this data that would be useful as input for future studies by different interested actors.

Concerning the ecosystem services identified, it can be noted that the largest supply is available in areas such as parks or green spaces and aquatic areas. Nevertheless, further information is needed on their present state, for instance, to know how UES could be spatially integrated into planning processes by analyzing their compensation, synergies, and subsequent valuation.

The little information documented in the region regarding the other risk scenarios mentioned above, which may be increased by climate change and-or anthropic actions, should be updated and integrated into the various risk management or local development plans. In this way, it can be detailed which other zones and ESS may be affected by these phenomena and generate measures that mitigate the impacts of these events.

There is still a lack of information relative to the ongoing state of the identified EDS in the region since several of these do not necessarily derive from the subsequent effects of climate change. However, the increase in the frequency of flooding can influence the spread and emergence of vectors; therefore, activities based on ecosystem and community-based adaptation would be a tool to counteract the adverse effects of these agents.

Implementing the previously mentioned actions would allow a better understanding of the natural environment, recognizing the desirable and undesirable properties of ecosystems and integrating this knowledge to apply it in their management, respecting their functioning, enhancing the positive effects of EDS, and limiting the negative ones.

The EbA approach is one of the tools that not only contribute to addressing climate change in the region but is also a window to the social and economic transformation of the territory. Nonetheless, the effectiveness and benefit of existing and proposed measures should be estimated together with other complementary actions such as infrastructure or engineering and community-based approaches, especially taking advantage of the existing multicultural potential of the city.

As the city is expected to grow in the short and medium term, the UES must be taken into account and valued in decision-making processes related to planning strategies by critical stakeholders, especially considering the scarcity of information in the region, so the research efforts to be performed are urgent, particularly having in mind the plus that this city has, as one of the few ones surrounded by an area of national ecological importance such as the IFS.

It is important to understand that the city is an integral part of the wetland and that its development processes should follow the area's conservation and management plans so that the impact on the ecosystem and the inhabitants' way of life is minimal.

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