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Research Article

Evaluation and mapping of the positive and negative social values for the urban river ecosystem

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Abstract

Urban rivers play a crucial role in providing ecosystem services (ES) that contribute to the social well-being and quality of life of urban inhabitants. However, rapid urbanisation has led to the progressive degradation of these rivers, affecting their capacity to deliver ES and resulting in significant socio-ecological impacts. This study performs a participatory mapping of the non-monetary social values (positives and negatives), in the urban Zamora and Malacatos Rivers and their ESs, in Loja, Ecuador, to understand community perceptions and preferences in a context of degraded landscapes as a complementary category of analysis to traditional approaches. Methodologically, the collection, analysis

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and mapping were carried out using public participation GIS (PPGIS) based on surveys. This method facilitated the integration of social data with biophysical variables. The most relevant of the ten social values studied were positives: Learning, Aesthetic, Therapeutic and negatives: Displeasure, Deficient and Inaccessible Infrastructure and Threat of Flooding. We revealed different spatial patterns for each ES social value, where positive value locations exhibited a dispersed pattern, with clusters in peripheral areas, while negative value locations exhibited a clustered pattern in the city centre. The environmental variable with the most significant contribution was the Horizontal Distance to Green Areas. These findings enhance our understanding of the social values and preferences associated with ES in urban river contexts. Furthermore, they provide valuable insights for identifying areas of opportunity and conflict, informing community planning and effective management of the urban landscape.

Keywords

ecosystem services, anthropogenic landscape, urban ecosystem services, public participation GIS, participatory mapping, stakeholders' perceptions

Introduction

Rivers are not simply bodies of water; they are complex socio-ecological systems that provide a wide range of ecosystem services (ES) to people (Hanna et al. 2018), which are essential for social well-being (Vallecillo et al. 2018). These services include material resources, species habitats, freshwater supply and flood control (Grizzetti et al. 2016), as well as intangible benefits that satisfy the social, spiritual and recreational needs of local communities (Riechers et al. 2018), making them particularly valuable in urban areas where green spaces and blue infrastructure are often limited. However, urban rivers face human activities associated with the processes of urbanisation, leading to continuous modification of the landscape. These processes have a significant impact on the functional diversity of river ecosystems, reducing their capacity to provide ES.

These anthropogenic pressures are particularly exacerbated in the context of developing cities in the Latin American and Caribbean (LAC) Region (International Union for Conservation of Nature (IUCN) and Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) 2016). Despite their high biodiversity and a high degree of endemism, these water bodies face additional stress factors (Tellman et al. 2018, Walteros and Ramírez 2020), mainly due to accelerated urban expansion (NU, CEPAL 2022), alongside practices such as the discharge of contaminated water, channelling works and loss of riparian vegetation. These factors have contributed to the transformation of water ecosystems, shifting from multifunctional and resilient landscapes to monofunctional channels and open sewers (da Cruz e Sousa and Ríos-Touma 2018, Walteros and Ramírez 2020).

These challenges are further compounded by the effects of the climatic emergency, which intensifies the vulnerability of urban rivers (Jiang et al. 2018). Hydrological events, such as floods, have been observed to occur more frequently in areas where rivers have experienced a significant loss of their natural characteristics essential for resilience and mitigation of impacts (Sabater et al. 2018).

Consequently, many urban rivers have become degraded and at risk, with consequences not only for their ecological dimensions, but also for the quality of life of residents. The loss of ecosystem services and anthropogenic pressures generate various negative impacts, such as areas perceived as unpleasant and unsafe due to the presence of waste, unpleasant odours, lack of lighting, fear of crime and inadequate infrastructure, amongst other aspects that affect people's well-being. These aspects have been studied as ecosystem disservices (Shapiro and Báldi 2014, von Döhren and Haase 2015, Rodríguez-Morales et al. 2020, Montes-Pulido and Forero 2021). These negative social perceptions can pose a direct threat to the intrinsic social value of urban river landscapes, which, in turn, could perpetuate aggressive and polluting practices in these coupled socioecological systems (Pascual et al. 2017, Gottwald and Stedman 2020). However, considering these impacts contributes to an integrative framework that enables effective addressing of current challenges in landscape management (Lyytimäki 2015).

For this reason, several researchers emphasise the need to focus attention on the social values and importance that a local community assigns to a given landscape and its ES (Arias-Arévalo et al. 2017, Chen et al. 2017, Rey-Valette et al. 2017, Pascual et al. 2017). However, this category of analysis of ES remains limited compared to the biophysical and economic approaches traditionally used to assess and analyse water bodies (Nedkov et al. 2015, Garcia-Rodrigues et al. 2017, Karimi et al. 2020, Kaiser et al. 2021). Additionally, the scientific literature on ecosystem services has primarily focused on provisioning and regulating services, rather than intangible services, such as recreation and aesthetic values (Hanna et al. 2018, Cheng et al. 2019). This trend can be attributed to the challenge of quantifying cultural services in monetary terms due to their intangible nature. However, overlooking the social dimension, subjective values and cultural benefits of ecosystems (Chan et al. 2012, Plieninger et al. 2015, Ruiz-Frau et al. 2017) leads to incomplete assessments that undermine the inherent pluralistic nature of the concept of ecosystem services.

Therefore, a closer look at the socio-cultural valuation of ES and the landscape provides a crucial perspective to identify and recognise social preferences and areas of particular interest to the community. In the context of altered and degraded ecosystems, these perceptions can have positive or negative connotations. Thus, considering diverse ecosystem values expands the possibilities to identify opportunities and conflicts in the same territory (Reyers et al. 2013, Polizzi et al. 2015), facilitating the identification of management priorities with greater acceptance and social support. These aspects can only be captured through participatory and community-based approaches (Nijnik and Miller 2017, Himes and Muraca 2018), enabling the challenge of traditional visions and prevailing power asymmetries in planning to be addressed.

In this sense, participatory mapping has been applied as an effective tool to collect data from multiple social agents and integrate it with ecological information to reveal socio-environmental relationships and their spatial association (van Riper et al. 2012, Rey-Valette et al. 2017), which allows establishing a dialogue with the actors and, thus, knowing their preferences about the landscape (Alvarado-Arias 2021).

This research aims to assess and map the socio-cultural, non-monetary, positive and negative values of the Zamora and Malacatos Rivers and the ES, in their course through the urban-rural gradient in Loja City, Ecuador. With this, it is possible to identify and know the relative importance of the social value and identify its explicit spatial distribution, patterns and ES hotspot from the mapped preferences.

Finally, this research achieves several contributions: (1) It provides an ES case study in a city from the Global South, in a field where most studies have focused on landscapes and social values within the Global North (Dobbs et al. 2018, Escobedo et al. 2019); (2) It contributes to closing the knowledge gap by enquiring about ES in urban areas since previous works have been applied mainly over large scales in national parks and rural areas and the studies that approach urban environments tend to evaluate specific areas like parks (Palomo et al. 2014, Sun et al. 2019), leaving ES patterns at the city scale largely unknown (Kremer et al. 2015, Rall et al. 2017); (3) Finally, this study contributes to the limited representation of the negative values of the ecosystems, also known as disservices (Blanco et al. 2019, Baumeister et al. 2022), which are more relevant in the context of the anthropogenised landscape.

The findings offer valuable insights into stakeholder preferences for the riverscape, thereby facilitating their incorporation into planning and management processes.

Material and methods

Study area

The Zamora and Malacatos Rivers cohabit with the City of Loja, which is located in the south of the Republic of Ecuador, at 2,100 m a.s.l., with an area of 285.7 km² and a population of 214,855 inhabitants (Instituto Nacional de Estadísticas y Censos (INEC) 2010) (Fig. 1a). This intermediate city of linear configuration is located under the eastern foothills of the Andes Mountains, an area of high biodiversity, especially towards the east where it forms part of the Podocarpus National Park. Its urban fabric and the main green areas are intertwined by the river courses and their union since the Malacatos River (14 km) and the Zamora Huayco River (10 km), give life to the Zamora River, which later pours its waters into the Amazon River. The study area includes an additional extension of approximately 13 km, which corresponds to the Zamora Huayco River before entering the city from the south and corresponds to a peri-urban area (Fig. 1b).

Loja, like many Andean cities in Ecuador, has presented an urban development indifferent to its bodies of water (Di Campli and Universidad Técnica Particular de Loja 2016), aspects that are more noticeable in their urban and peri-urban areas, which means that some problems have been generated, such as polluting discharges and alterations to its basins; for example, the embankment of the entire Malacatos River as it passes through the city.

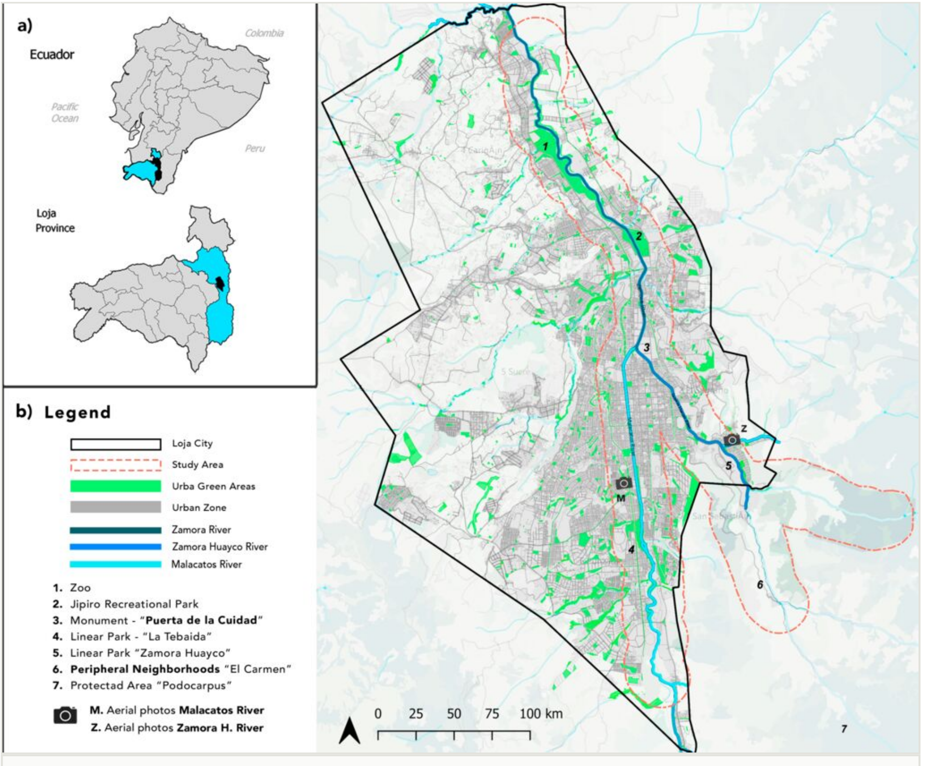

Figure 1.

Case study: Malacatos and Zamora Rivers in Ecuador. Own elaboration.

a: At the top, the position of the Province of Loja in Ecuador. At the bottom, the City of Loja (black) and the Canton of Loja (light-blue), within the Province of Loja.

b: Situation of the rivers within the study area. Some emblematic places of the city are identified with numbers.

In recent decades, the urban growth of Loja has been sustained at an accelerated rate. According to the Ministry of Urban Development and Housing, Loja recorded one of the highest growth rates in the country, reaching 82% (Subsecretaría de Hábitat y Asentamientos Humanos 2015). This trend could potentially exacerbate the degradation of urban rivers, which may negatively impact the well-being of residents and, in turn, affect their social perception of them.

These are several reasons why there has been a growing interest in studies that seek to assess the ecological integrity of water bodies (Iñiguez-Armijos et al. 2022); additionally, in the development of solutions for its comprehensive recovery, with an emphasis on green-blue infrastructure systems and the active participation of citizens (Segarra-Morales et al. 2021). These approaches contributed to the recognition of nature as a subject of rights, as established in the Constitution of the Republic of Ecuador (Art. 71) (Asamblea Nacional Constituyente de Ecuador 2008), which implies fully respecting and guaranteeing its existence, maintenance and regeneration of its life cycles, functions and evolutionary processes, in addition to the right to access and deliberate participation in their care (Art. 23). All of this emphasises the relevance of restoring urban riverscapes and the fundamental role of the community in this process.

Details of the Zamora and Malacatos Rivers can be seen in Fig. 2.

Figure 2.

Oblique aerial photographs of the research area captured with unmanned aerial vehicles (2021). The locations of both intakes are reflected in Fig. 1b, with M for Malacatos and Z for Zamora Huayco. Own elaboration.

a: Malacatos River

b: Zamora River.

Survey data, participatory mapping and social variables: OpinaRíos

The data collection was carried out in 2021 in Loja (field visit), with the dissemination of a web-based questionnaire (named OpinaRíos), prepared under the ArcGIS Survey123 Connect (ESRI 2020). The sampling was conducted randomly, selecting various individuals who were present in the vicinity of the studied riverbanks. The link to the questionnaire was shared in situ through a QR code, or by text message, to the participants' mobile devices. An advantage of digital media as an adaptive resource was to circumvent the restrictions related to the Covid-19 pandemic. Another advantage of conducting digital surveys using the "Survey123" tool is its user-friendly platform, both for the respondent and the interviewer and also the connection between the geospatial part (geographic coordinates) with the alphanumeric part. This made it possible to put aside traditional participatory mapping processes, which involve the subsequent digitising and it also allows reaching profiles of people who, for various reasons, do not attend community meetings.

The survey used a multiple-response format on a Likert scale, divided into different blocks, one part intended to collect information and socio-demographic characteristics and another focused on the degree of satisfaction regarding the state of the rivers, type of relationship and activities carried out on the riverbanks. Finally, the respondents were asked to interact with a map of the city and locate the places with Positive Social Value (PSV) and Negative Social Value (NSV) for the Zamora and Malacatos Rivers and to map the social values. In a last step, participants were asked to assign one to three categories for the PSV and one to three categories for the NSV, to each location, based on a predefined list. (Table 1).

Table 1.

Classification and definition of positive and negative values adapted from Clement and Cheng (2011).

Social Values	Assigned Value	Description
Positive Social Values (PSV)	***Aesthetic***	Sites of particular aesthetic/scenic beauty, sights, sounds or smells.
	Learning	Sites that widen knowledge about the environment, plant and animal species.
	Life sustaining	It helps produce, preserve, clean and renew the air, soil and water.
	Recreation	Sites used for my favourite outdoor recreation activities.
	Therapeutic	It makes me feel better, physically and/or mentally.
Negative Social Values (NSV)	***Flood threat***	Sites are perceived to have a flood threat.
	Unpleasantness	Sites that are neglected, abused, damaged or unpleasant, smelly places.
	Unsafe, delinquency & harassment	Sites that feel dangerous or where anti-social events.
	Little aesthetic value & lack of vegetation	Sites without vegetation.
	Poor infrastructure & inaccessible	Sites with difficult pedestrian access, without furniture.

Ten categories of landscape´s social value and their ES were used: five corresponding to PSV, such as *Aesthetic*, *Learning*, *Recreation* and typologies used in similar studies (van Riper et al. 2017, Sun et al. 2019, Zhang et al. 2019) and five categories of NSV, such as *Flood threat*, *Unpleasantness*, *Unsafe*. These ten values offer a comprehensive reading of the situation. Previous studies point out the importance of analysing them simultaneously (Garcia et al. 2017, Raymond et al. 2009).

Environmental data

For this study, the following biophysical variables were used: *elevation*, *land use* and *land cover* (*LULC*), *slope* and *landscape type*, which are metrics commonly adopted in similar studies (van Riper et al. 2012, Bagstad et al. 2017, Sherrouse et al. 2017). The horizontal distance to green areas (DTGA) variable was also added to represent the degree of influence of urban green areas (parks, squares) on the perception of ES, this layer being processed with the Euclidian Distance tool. The detail of the landscape variables and the formats used can be seen in Table 2.

Table 2.

Description and sources of the biophysical and socio-environmental variables used, adapted from Sherrouse and Semmens (2020).

Abbreviations: Ecuadorian Space Institute (IEE), Geographic Military Institute (IGM), Digital Elevation Model (DEM), Phased Array type L-band Synthetic Aperture Radar (PALSAR), Environmental Rasters (ENV_LAYERS).

Name	Format	Description	Source	Observations
VALUE_TYPES	Table	Types of social values: PSV and NSV	Predefined	Aesthetic, learning, Unpleasantness etc.
STUDY_AREA	Vector	Digitised study area based on rivers	Own elaboration	Format = shp Type = polygon
SURVEY_POINTS	Vector	Social values geospatialised by survey	On-site survey Survey123	Format = shp Type = point
ENV_LAYERS	Table	Raster type determination	Predefined	Variables: Continuous = 0 Categorical = 1
LULC	Raster	Current use and land cover, 24 classes	IEE (current IGM) https://www.geoportaligm.gob.ec/portal/	Source data: Format = gdb Type = polygon Scale = 25 k
LANDFORM	Raster	Terrain morphology, 11 classes	IEE (current IGM) https://www.geoportaligm.gob.ec/portal/	Source data: Format = gdb Type = polygon Scale = 25 k
DTGA	Raster	Euclidean distance based on green areas	Municipality of Loja	Source data: Format = shp Type = polygon
ELEV	Raster	Digital elevation model (DEM) in masl	ALOS PALSAR https://asf.alaska.edu/data-sets/sar-data-sets/alos-palsar/	Format = tiff Pixel = 12.5 m
SLOPE	Raster	Slope map	ALOS PALSAR DEM	Format = tiff pixel = 12.5 m

SolVES model

The Social Values for Ecosystem Services (SolVES 4.0) is a tool utilised for assessing and mapping the social values associated with ecosystem services. It integrates data from two sources, participatory surveys (ten social values: PSV and NSV, Table 1) and environmental data (Table 2), to identify the level of social importance assigned to ecosystems and their ES (Sherrouse et al. 2022), as shown in Fig. 3 (flowchart of the methodology used).

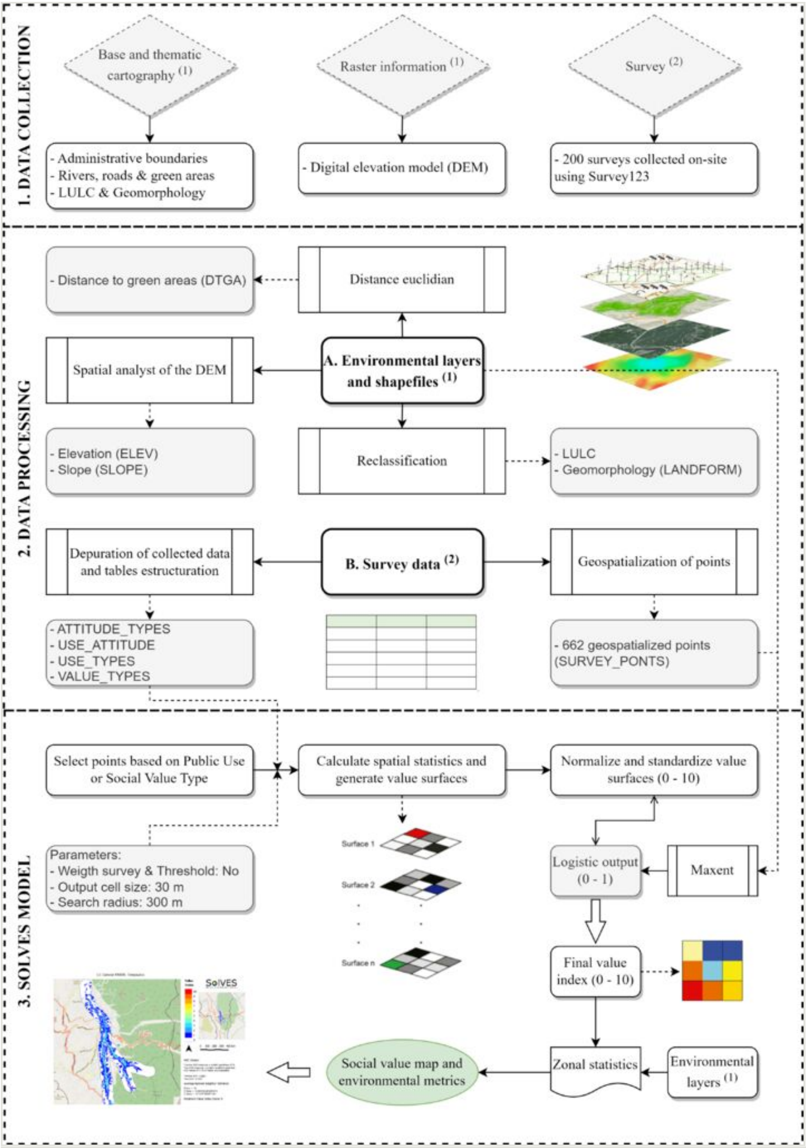

Figure 3.

Flowchart of the methodology. Numerical labels (1) and (2) represent the sources of the input data: (1) Spatial data and (2) PPGIS survey data. Own elaboration, adapted from Sherrouse et al. (2014) and Sherrouse and Semmens (2020).

SolVES integrates Geographic Information Systems (GIS) with a Public Participation approach (PPGIS), (https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/social-values-ecosystem). SolVES is an open-source QGIS plug-in developed by the Center for Environmental Change Sciences and Geosciences of the US Geological Survey (USGS) (Denver, CO, USA). To the authors' knowledge, SolVES has not been implemented before in urban landscapes in the LAC Region.

SolVES tool calculated a 'Value Index' (VI) which corresponds to a non-monetary metric that quantifies the social value of the ES on a 10-point scale (Sherrouse et al. 2014), that is, higher values indicate a greater degree of importance (Sherrouse et al. 2022). These values were used to generate zonal statistics (not shown in this paper) that summarise the relationship between the assigned value and the environmental conditions used, in addition to being a consistent expression of the relative intensity and the spatial distribution of the survey points. To know these spatial statistics, R-ratio and Z-score of the nearest-neighbour tool were used (Brown et al. 2002). The R-ratio represents the relationship between the observed distance between the points and the expected distance between the points; a value < 1 indicates that the assigned points are relatively clustered, = 1 indicates randomness and >1 indicates dispersion. The Z-score, with higher negative scores indicate clustering (Sherrouse et al. 2014).

SolVES integrates the maximum entropy model (Maxent), which was originally developed to model the geographic distribution of species, but was adapted to map the social values of ES (Sherrouse and Semmens 2020). Maxent applies machine-learning methods, based on the data collected to predict the geographic distribution with maximum entropy and the probability of concurrence of social values (Philips et al. 2017).

With the results calculated by Maxent, maps were created, that spatially indicated the probability of the attendance of multiple social values of ecosystem services in both rivers. These maps also consider landscape characteristics.

Maxent also produces additional statistics that allow us to describe the performance of generated models. One of them is the "Area Under the Curve" (AUC), which considers the total area under a "Receiver Operating Characteristic" curve (ROC), for the training (75%) and test (25%) data. To consider whether the model has predictive potential, the recommendations ofvan Riper et al. (2017) and Sherrouse et al. (2022) can be followed: AUC ≥ 0.90 = good, AUC ≥ 0.70-0.75 = useful and AUC ≤ 0.50 = random prediction (poor).

The tool used by Maxent to determine the contribution of each variable studied is the implementation of the Jackknife test. The percentage contribution (Con) of each variable corresponds to the sum of the gain of including them within each iteration of the training algorithm. The importance of the permutation (Imp) represents the contribution of each variable when considered individually after generating the final model. Both are calculated as percentages (Zhang et al. 2021).

With this process, integrated raster data were obtained that allows visualising the results on maps. Graphic and tabular reports were obtained for each of the ten mapped social values.

Results

Socio-demographic characteristics and social preferences

A sample consisting of 200 participants aged between 18 and 70 years was registered. A total of 662 geographical points (representing social values) were obtained, of which 267 correspond to places of "Positive Value" and 381 to places of "Negative Value". The participation of those surveyed registered 44 % women and 53 % men. The age groups with the highest participation are those between 40 - 65 years old (39.5%) and 25 - 40 years old (34%). Regarding the landscape of the rivers, 47% of the participants qualified the landscape of the Malacatos River as "Bad" and, as "Regular", 43.5%, the landscape of the Zamora River (Fig. 2). Finally, 80% of those surveyed stated that the current state of urban rivers negatively affects their quality of life.

Spatial distribution and model results

The results obtained are summarised in Table 3, for each of the 10 Social Values (SV) types of ES. The respective number of mapped points is also included. To identify the order of preference and importance of the SV, the indicators with a small R-ratio, a large negative Z-score, an AUC => 0.9 and the highest Max-VI were considered.

Table 3.

Results of statistical values of the SolVES model, R-ratio (R < 1), Z Score, Training AUC, Test AUC and Maximum Value Index.

Boldface values indicate better results. Abbreviations: Positive Social Values (PSV), Negative Social Values (NSV), Area Under the Curve (AUC), Value Index (VI).

Social Values		**Count #**	**Nearest Neighbour Analysis**		**AUC**		**Max-VI**
			R-ratio	**Z-score**	**Training**	**Test**	
PSV	*Learning*	40	0.53	-5.7	0.93	0.82	**7**
	Aesthetic	**76**	0.32	**-11.3**	0.9	0.85	**6**
	Therapeutic	50	0.38	**-8.4**	0.89	0.87	5
	Recreation	55	0.42	-8.2	0.93	0.73	5
	Life sustaining	46	0.49	-6.7	0.87	0.77	5
NSV	*Unpleasantness*	**121**	0.44	**-11.7**	0.93	0.96	**10**
	Poor infrastructure & inaccessible	**73**	0.44	**-9.1**	0.95	0.94	**9**
	Flood threat	**79**	0.47	-9	0.95	0.98	8
	Unsafe, delinquency & harassment	63	0.49	-7.7	0.96	0.95	8
	Little aesthetic value & lack of vegetation	45	0.53	-6	0.96	0.94	7

In the first phase, we obtain the distribution of social values, based on the locations mapped by the respondents, most of them spread along the rivers. In this regard, the results of the nearest-neighbour spatial statistics, generated by SolVES, show that the geographical distribution of these points was not random, since statistically significant grouping patterns were identified, given that all R-ratios are < 1 with very negative Z-scores (Brown et al. 2002).

Regarding the AUC, to measure the performance and predictive capacity, the model yielded values > 0.9 for most cases, which indicates that it has a good fit for the study area, in addition to the fact that the AUC Test indicates that the model has a useful predictive capacity to transfer social values to other environments (Sherrouse et al. 2014). The results showed that 10 social values are transferable, which would be used in future research to obtain the negative and positive landscape preferences in similar river cities.

Finally, the Maximum Value Index (Max-VI) scores for the two subgroups ranged from 5 to 10. A higher Max-VI indicates stronger interest. In this case, the highest indices are found within the NSV, with "*Unpleasantness*" being the highest (Max-VI = 10) and it also registers the largest number of mapped points (n = 121).

We identify that, for the PSV, the classification in descending order is *Learning*, *Aesthetic*, *Therapeutic*, *Recreation* and *Life-Sustaining*. In the case of the NSVs, the descending order is *Unpleasantness*, *Poor Infrastructure & Inaccessible*, *Flood Threat*, *Unsafe*, *Delinquency & Harassment* and *Little Aesthetic Value & Lack of Vegetation*.

Environmental variables

To interpret the relative importance and relationship of the biophysical variables used in the model, the percentage of contribution (Con) and the percentage of importance of the permutation (Imp) calculated by Maxent were considered. The Distance To Green Areas (DTGA) variable was the most significant contributor, with a percentage between 34 - 63% and with the importance of permutation of 26 - 57% being, in both cases, the highest values for all the social values.

For "*Poor infrastructure & inaccessible*" and "*Flood threat*" 40% and 37%, respectively in permutation importance were obtained with the ELEV variable and "*Poor infrastructure & inaccessible*" with 31% in permutation importance with the SLOPE variable. (Table 4). Therefore, the variables LANDFORM and LULC register the least participation.

Positive (PSV) and Negative (NSV) Social Values Maps

The resulting maps are the product of analysing the statistics obtained from SolVES, considering the distribution of maximum entropy and evaluating the social values in conjunction with the biophysical values. The maps, both PSV and NSV, can be seen in Fig. 4 and Fig. 5, respectively.

The generated value index maps display the spatial distribution and serve as a visual representation of the calculated Max-VI, indicating its range and distribution across the entire city. Warm colours are used to denote the highest values of the value index (VI).

Table 4.

Summary of the environmental variable percentage contribution (Con) and the importance of the permutation (Imp) for each social value (Jackknife test).

Abbreviations: Positive Social Values (PSV), Negative Social Values (NSV), Contribution (Con), Importance (Imp), Elevation (ELEV), Land Use and Land Cover (LULC), horizontal Distance To Green Areas (DTGA).

SOCIAL VALUES		**ELEV**		**LANDFORM**		**LULC**		**SLOPE**		**DTGA**	
		% Con	**% Imp**	**% Con**	**% Imp**	**% Con**	**% Imp**	**% Con**	**% Imp**	**% Con**	**% Imp**
PSV	*Learning*	7	19	20	16	7	11	8	7	59	47
	Aesthetic	8	33	1	3	5	6	25	11	60	48
	Therapeutic	3	9	7	16	14	18	17	6	59	50
	Recreation	7	14	8	11	7	9	15	10	63	57
	Life sustaining	8	18	15	12	7	13	12	12	58	45
NSV	*Unpleasantness*	12	37	4	4	4	1	35	31	45	26
	Poor infrastructure & inaccessible	25	34	15	7	2	1	24	23	34	35
	Flood threat	16	17	4	4	6	4	27	22	47	52
	Unsafe, delinquency & harassment	21	40	5	7	4	1	21	16	48	35
	Little aesthetic value & lack of vegetation	16	36	8	6	3	1	22	16	51	41

Positive Social Values (PSV)

The cartographic results for the five PSV types of the ES generally exhibited a wide distribution throughout the urban river landscape, which influenced the delineation of the study area. Clusters corresponding to high positive scores were observed in certain peripheral areas and the city centre. In terms of spatial distribution, relatively similar patterns were found for the values of Aesthetics, Therapy and Sustainability of Life, especially in the distribution of their lowest values, whereas Recreation and Learning exhibited different distributions as they did not demonstrate concentration patterns, but rather were more dispersed. The latter case, Learning, displayed the highest PSV (7/10) (Table 3).

Negative Social Values (NSV)

The five negative values mapped appeared in the centre area of the city, around the area of confluence of the rivers, which was mainly evidenced in the Unpleasantness map (Fig. 5 a). In terms of distribution, we observed similar patterns for Flood threat and Little Aesthetic Values. There were also small groups in peripheral areas appearing, in the north of the city, specifically in the "Sauces-Norte" zone, near the Zoo.

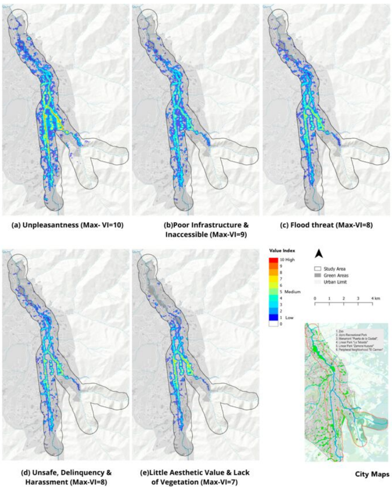

Figure 4.

Spatial distribution of Positive Social Values (PSV). Social Values: (a) Learning, (b) Aesthetic, (c) Therapeutic, (d) Recreation, (e) Life-Sustaining.

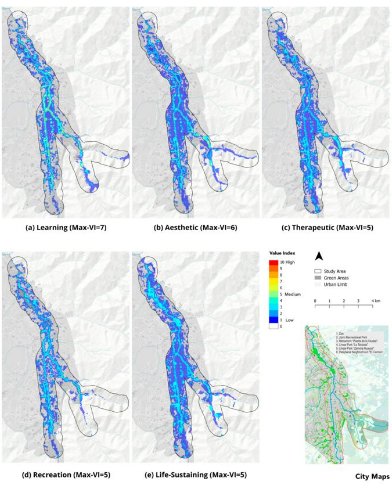

Figure 5.

Spatial distribution of Negative Social Values (NSV), Higher Max-VI represent high negative SV. Social Values: (a) Unpleasantness, (b) Poor Infrastructure & Inaccessible, (c) Flood threat, (d) Unsafe, delinquency & harassment, (e) Little aesthetic value & lack of vegetation.

Discussion

Based on participatory mapping in combination with biophysical data from Loja City, we generated spatially-explicit indicators of social value for each ES and disservice studied.

In general, we found that the ten social values studied received a variety of scores (Table 4), results similar to those found by Larson et al. (2016), Ives et al. (2017), Sun et al. (2019); this plurality of values associated with rivers and their ES indicates that they are perceived in a complex way; consequently, multiple valuations (socio-cultural, biophysical and monetary) need to be considered, which requires transdisciplinary dialogue, as highlighted by Martín-López et al. (2014). We also found different preferences amongst each of the rivers studied; fewer negative locations were recorded for the Zamora River, which is related to the "regular" rating assigned regarding the condition of its fluvial landscape, while Malacatos received a "bad" rating. This means that the community has a worse perception of the Malacatos River, which could be per the anthropogenic condition (highly altered urban river ecosystem) it presents, this coinciding with the idea that the waterscapes' context influences the type of preference (Herzog 1985).

Specific scores and spatial patterns were also revealed for the ESs studied, where mapping negative values indicate that locations closer to the city centre were more strongly chosen compared to places further away. Hence, they were clustered in a smaller section, while the positive hotspots showed greater dispersion.

In addition, a total of 381 location points for NSV and 267 for PSV were collected for the survey (Table 3). This reveals that the respondents showed a greater interest in mapping and identifying negative locations than positive ones, which could be explained given the conditions presented by anthropogenised ecosystems (Campagne et al. 2019), as is the case of the urban rivers studied. The foregoing could also denote that the community is not only conscious and perceives, but can also identify, several of the effects of landscape degradation (Lyytimäki 2015), such as lack of vegetation, pollution, bad odours, garbage, insecurity etc. (Larson et al. 2016, Campagne et al. 2019) and subsequently locate it on a map. Descriptions that, according to authors such as Chapin III et al. (2000), also represent the loss of ES and that together could have influenced the perceptions of evaluation, justifying that there is a greater interest in the negative aspects. In this sense, the highest score was "Unpleasantness" (Max-VI = 10), also more mapped points (n = 121), which suggests that it is the main social perception.

Concerning PSV maps, we observed similar patterns with an emphasis on Aesthetic and Recreation values. Previous research suggested these two Social Values are important indicators of how people connect with nature (Brown and Raymond 2014).

"Learning" corresponds to the highest PSV (7/10) (Table 3), meaning that the community primarily views rivers as providers of educational benefits. This finding is unusual compared to similar studies, where the "Aesthetic" benefit is typically valued more (Sherrouse et al. 2014, Sun et al. 2019) and, moreover, the value attributed to "Learning" tends to have a lower representation and score in many instances (Johnson et al. 2019).

The most valued places mapped were in peripheral areas, but in a scattered way, covering a larger area of the city. Therefore, these hotspots should be considered priority intervention areas due to their ability to provide ES and contribute to the well-being of the community (Martín-López et al. 2012).

The "El Carmen" peripheral neighbourhood was one of them; it corresponds to a territory close to the rural sector that appears on most PSV maps (Fig. 4), mainly on maps of Aesthetics and Learning Values. The previous statement means that respondents consider the area like an interesting place, maybe because of the natural conditions it still preserves; in addition, there are two tributaries of the Zamora River nearby, along with being one of the access roads to the Podocarpus Protected Area. It is also interesting to note that there are no NSV groups for this peripheral area. Therefore, social preferences for this place are only positive, reinforcing the idea that open and riverside areas are valued more in an urban context (Deason et al. 2010, Garcia and Pargament 2015).

In all SVs maps, we notice how the rivers and the surroundings of the parks and squares were outlined by the intensity and the grouping of the points. The previous statement is evident in the areas with a high-Value Index, which appeared very close to green areas of the city, such as: “Zamora Huayco” Linear Park, “La Tebaida” Linear Park, “Jipir” Recreational Park and Zoo. These places are likely to have less anthropogenic conditions that support the sense of place, as well as offer recreational opportunities (Gobster et al. 2007, Martín-López et al. 2012) and, as shown in Table 4, the variable related to the distance to the areas green (DTGA) was the most influential for all models. Other research, although not using the metric in model development, found that the high-priority locations marked by respondents were around urban green spaces (van Riper et al. 2012, Sun et al. 2019).

The importance of considering the role of green areas in perceptions of the urban ecosystem is not only because they provide benefits, but also because their uneven distribution can affect the provision of ES throughout the city, increasing spatial injustice.

Regarding the sites where the spatial distribution of locations with high PSV and high NSV coincides, we found that the urban centre, in general, obtained a high representation in all result maps. The main area of spatial clustering was located at the architectural landmark called 'Puerta de la Ciudad' (City Gate) (Fig. 1b), which corresponds to the confluence area of both rivers and is where the Malacatos River begins its canalisation, thus offering an altered and homogeneous landscape. In this same area, the Zamora River lacks adequate pedestrian infrastructure (Fig. 2b), conditions that have contributed to negative perceptions of it as an unpleasant and unsafe place and an increased risk of floods. The latter is due to the fact that the area is prone to overflowing.

However, around this "Puerta de la Ciudad" landmark, the area with the highest urban density is established, making it a highly frequented public place by its inhabitants. For this reason, it can evoke a high sense of historical, heritage and educative significance at the same time as feelings of concern (McCormick et al. 2015). This suggests that the social perception of ES can vary and that the same landscape can provide a series of different meanings, feelings and values (Milcu et al. 2013, Martín-López et al. 2014). Therefore, it corresponds to a section where different and opposing social values converge. This finding also appears in similar studies (Rodríguez-Morales et al. 2020, Baumeister et al. 2022), which emphasise the non-exclusive nature of ecosystem services and disservices, highlighting the importance of considering and examining both types of ES (Schaubroeck 2017), especially in studies on anthropogenised landscapes. In this sense, our research resolves that, in urban ecosystems, such as rivers, positive and negative social valuations can co-exist in the same place.

The findings of our study offer useful information to identify and establish priority areas for intervention concerning the conditions of the riverscape, where the most valued places can be considered a high priority due to their ability to provide benefits to citizens and represent significant places. In contrast, the negative places need to be recovered. The highest values in both types of ES also deserve special attention; for example, the social value of "learning" highlights the community's interest in environmental education spaces and activities centred around rivers. Conversely, the perception of "unpleasantness" towards the rivers emphasises the urgent need to restore and improve their aesthetic and environmental quality, aspects that urban planners should consider. Excessive anthropogenisation has significantly impacted the natural landscape value of the rivers, which is missed and needed by the community.

Challenges and Opportunities

The mapping methodology focused on PPGIS used in this study employed a web-based survey, ESRI Survey123, which was disseminated *in situ* through a QR code and URL distribution, to capture social preferences of the landscape and georeference them in real-time, without depending on the place and time, thus avoiding the manual digitisation process of data points. It proved to be a user-friendly platform, reaching the 40 - 65 age group as the most participatory. However, surveyors needed to have a good knowledge of the city and the ability to locate places on a map.

SolVES and Maxent tools were successfully used to analyse, quantify and map the social value of ESs and our study demonstrated the utility and flexibility of PPGIS, capturing tangible and intangible insights and facilitating the provision of indices and maps that can provide information for landscape planning and management processes. To the authors' knowledge, this corresponds to the first application of the SolVES model in Ecuador and the third in the LAC region. Furthermore, their portability as open-source software is noteworthy. However, these tools require advanced technical knowledge and detailed cartographic information of the study area (vectorial and raster). These aspects could limit their application in contexts where technical and human resources are limited. Our study demonstrated the utility and flexibility of Public Participation GIS for capturing tangible and intangible information and facilitating the provision of indices and maps that can provide information for landscape planning.

On the other hand, the application of urban ecosystem services mapping, based on social valuation, promotes a participatory approach to the management and planning of socio-ecological landscapes. This approach establishes a dialogue with the local community to understand their perception and interaction with the river landscape, as well as to identify places of perceived importance. This information can be complemented by evaluations focused on the material and monetary services of the ecosystem, as well as with expert opinions (Villa et al. 2014); in this way, it is possible to obtain an integral evaluation.

Conclusions

This study assessed and mapped the socio-cultural, non-monetary, positive and negative values of the rivers and their ES in Loja City, Ecuador. The metrics, indices and cartographies obtained contributed to the development of a pluralism of values by representing socio-cultural preferences, recognising the multiple benefits and disservices offered by the fluvial urban landscape and mapping areas with a greater or lesser supply of ES, providing a useful guide to sustainability landscape planning. The latter suggests that social values play an essential role in drawing new structural and subjective routes in managing and planning degraded urban rivers. It is validated since it directly recognises how and where the community perceives the ESs landscape, facilitating local knowledge integration towards informed management and decision acceptance. In this respect, we encourage researchers and decision-makers to pay more attention to the role of social assessment in the framework of ES, emphasising the global south, where information is insufficient and pressures on the urban riverscape will continue to increase.

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Author contributions

Conceptualisation, methodology, software, investigation, writing—original draft preparation, writing—review and editing, N.A.A., V.M.A. and F.C.T.; validation, resources, data curation, supervision, project administration, funding acquisition, N.A.A. and V.M.A.; formal analysis, visualisation, N.A.A., V.M.A. and F.C.T; N.A.A., V.M.A., F.C.T and A.M.E. resources. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors have declared that no competing interests exist.

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