International Journal of Innovation Scientific Research and Review
Vol. 04, Issue, 01, pp.2245-2251, January 2022
Available online at http://www.journalijisr.com
SJIF Impact Factor 4.95

ISSN: 2582-6131

Research Article

AN APPROACH OF RAPID ASSESSMENT OF WETLAND ECOSYSTEM SERVICES IN KOTTE MARSHLAND, SRI LANKA

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Received 15th November 2021; Accepted 16th December 2021; Published online 30th January 2022

ABSTRACT

Freshwater marshlands are a more productive ecosystem that, influenced by anthropogenic activities, causes degradation and loss of wetlands. Kotte marshland has been located in the urban administrative area of the capital city in Sri Lanka, which is threatened by rapid development and population growth. This study aims to explore wetland ecosystem services and the loss of marshes in the Kotte marshland area from 2004 to 2021. Google Earth Pro and Open Street Map were used to identify the loss of marshes. Observation and discussion were used to implement the rapid assessment of the ecosystem services approach to wetlands. Numerical values were assigned to the evaluation sheets of the marshland ecosystem services to achieve the findings. 21 of the 37 ecosystem services listed in the evaluation method were registered a positive contribution to the surrounding environment in the Kotte wetland. However, no negative assistance ecosystem services were found in the Kotte marsh. The decline of the marshland reduces the quality and quantity of the ecosystem services in this area. As an urban wetland, the protection of the Kotte marshland is essential to avoid impacts such as air pollution, flood hazard, local climate regulation and habitat loss. Thus, this finding can be helpful to developing ecosystem services regulations to protect the wetland environment in the future. Finally, this study contributes to Ramsar strategic plan goal 1, which focuses on addressing wetland loss and degradation drivers to achieve the sustainable development goals.

Keywords: Wetland, Marshland, Ecosystem services, RAWES approach, Ramsar.

INTRODUCTION

Wetlands are complex, dynamic, and productive ecosystems that are the most endangered today (Kaplan and Avdan 2018). More than half of the world's wetlands have been lost in the last two centuries due to drainage and conversion to cropland or urban sprawl (Dugan 1993). Wetlands were known as wastelands in the past. People never know the value of wetlands that have been drained or used as landfills (Kotagama and Bambaradeniya 2006). Coastal and floodplain wetlands are rapidly becoming urbanized, making them very vulnerable to loss of biodiversity, biological invasion, and climate change worldwide (Hettiarachchi *et al.,* 2014). Land-use pressure on surrounding watersheds often threatens the sustainable functioning of urban wetland ecosystems(Han *et al.* 2019; Xie *et al.,* 2014; Robert *et al.,*1993). However, people's knowledge improvement can understand that wetlands are among the most valuable and vulnerable environments in the world on which various plants, animals, and human societies depend (Schuyt 2005). The wetland functions, for example, recreation, protection of shoreline erosion, reduction of the flood peak, timber harvesting, peat harvesting, shellfish harvesting, carbon cycle, methane cycle, historical, archaeological protection, hay harvesting, hydrological cycle, livestock watering, sulfur cycle, water quality improvement, internal value, external value, functions, productivity, biodiversity, hydrology, velocity reduction, atmospheric processes, interaction with groundwater/surface water, habitat, support for plants and animals, soil formation, sediment trapping, biochemical function, and water quality, vary (Maltby *et al.,* 2011). Wetland degradation is the loss of the qualitative and quantitative value of wetlands that can be identified through patterns of land-use change (Xie *et al.,* 2010). The environment is defined as the complex of physical, chemical, and biotic factors such as climate, soil, and living beings that act on an organism or an ecological society and ultimately determine its form and survival (Tansley 2013). Marshes are important habitats for breeding a wide variety of wildlife in the wetland environment (Gibbons 2003). Freshwater marshes are the most productive ecosystem on land (Schedlbauer *et al.,* 2012). Marshes also recharge groundwater supply, moderate stream flow, mitigate floods by slowing and storing floodwaters, and purify water by removing sediment and other pollutants (Fretwell 1996; Baron 2008).Marshes provide many social benefits, which are food and habitat for fish and wildlife, including endangered species, water quality improvement, flood storage, shoreline erosion control, economically beneficial natural products for humans, opportunities for recreation, education, and research (Woodward and Wui 2001; Adame *et al.,* 2019). In this case, the Colombo marshland constitutes three interconnected marshes that form a unique environment in the metropolitan area of Colombo. Wetlands are significant for flood detention in Colombo city. The total land extent of the Colombo Flood Detention area is approximately 400 acres. In addition, considerable marshlands have been found around 214.3 hectares in Kolonnawa, 97.4 hectares in Kotte, and 87.7 hectares in Heen-ela in Colombo (Dir. Natl. Wetl Sri Lanka 2006). Most of Sri Lanka's wetlands face various threats from harmful human activities. The Kotte marshland is also considered a significant marsh in the Colombo flood catchment area. Thus, the Kottemarsh has chosen to study ecosystem services and marshland changes. Therefore, this study aims to explore the wetland ecosystem services and the loss of marshes in the Kotte marshland area from 2004 to 2021 using geospatial technology.

MATERIALS AND METHODS

The study area

The Kotte marshland is located in Sri JayewardenepuraKotte, the western part of Sri Lanka (see Fig. 1). Colombo metropolitan can be

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considered a city built on and around wetlands in Sri Lanka (Perera *et al.,* 2012). The growth of Sri JayewardenepuraKotte from 1981 to 1994 has influenced land prices. Most of the existing developed land is subdivided to cover housing and significant roads for commercial development due to no vacant plots. The adjacent areas of the municipality, such as Battaramulla, Talawatugoda, Udahamulla, and Nawinna have accommodated the expansion of Sri JayewardenepuraKotte, especially in residential use due to the lack of land within the city limits. Low-lying areas are also filled to meet the demand for land (Weerakoon 2016; Ranaweera and Ratnayake 2017). The total land area is 1704 hectares covered by Sri Jayewardenepura Municipal Council; of these, Kotte covered the marshland around 97.4 hectares.74% of the municipal council area was developed in 1992, and the rest consisted mainly of water bodies and marshlands. Therefore, this study is a significant aspect that should be addressed by the Sri JayewardenepuraKotte municipal council, since the development of the city with an increase in population and the need for land can lead to loss of this natural resource with severe consequences (Wijayapala 2003).

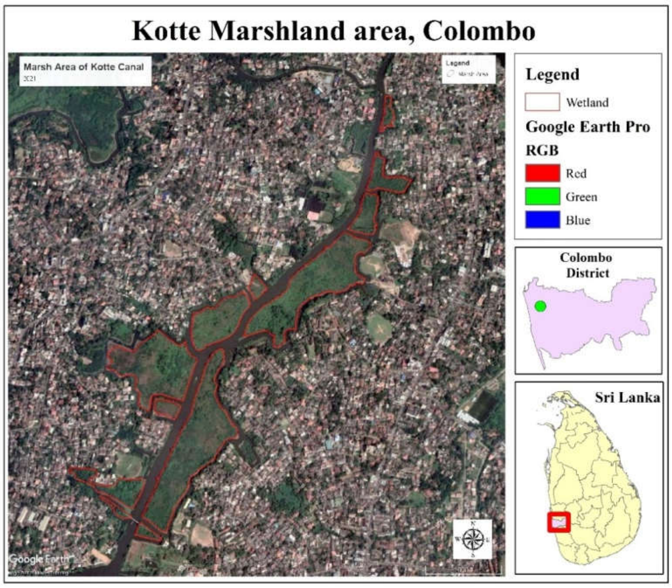


Fig. 1. The Study Area - Kotte Marshland

Rapid Assessment of Wetland Ecosystem Services (RAWES) Approach

Rapid assessment of wetland ecosystem services is the method used to identify the ecosystem services provided by the Kotte marshland. A field visit is a primary method of evaluating the RAWES approach. RAWES includes 37 ecosystem services into four groups (see Table 1), which are provisioning services, regulating services, cultural services, and supporting services (Adapted from McInnes and Everard 2017).

Table 1. The list of provisioning ecosystem services considered on the RAWES approach

Provisioning services	
Ecosystem service	Description
Provision of freshwater	Availability of fresh water and the level of usage of available water in the wetland. Ex: domestic, drinking, irrigation, and livestock.
Provision of food	Availability of food, fruits, and fish for both humans and animals.
Provision of fiber	Possibility to obtain wood, fiber for human needs. Ex: Building, wool, and clothing.
Provision of fuel	Availability of fuel for domestic and other purposes. Ex: Fuelwood& peat
Provision of genetic resources	Availability of native or rare strains of plants and animals, wild and domesticated, could contribute to genetic diversity for human uses. Ex: Rare breeds used for crop/stock breeding.
Provision of natural medicines and pharmaceuticals	Availability of plants, animals, or their parts as traditional medicines
Provision of ornamental resources	Availability of plants, animals, or parts at wetland collected and used/sold as ornamental properties. Ex: A collection of shells & flowers
Clay, mineral, aggregate harvesting	Extractable substances for construction and other human uses. Ex: Sand and gravel extracted for building use; clay removed for brick making.
Waste disposal	Availability of any location as a waste dumpsite in the wetland. Ex: Dumping of solid waste, discharge of wastewater.
Energy harvesting from natural air and water flows	Possibilities to use wetland air or water flow for energy formation. Ex: water wheels, wind turbines.
	Regulating services
Ecosystem service	**Description**
Air quality regulation	Availability of any sources in the wetland for airborne pollutants and role of wetland to settle airborne pollution. Ex: Removal of airborne particles from the exhaust of cars, chimneys of industry, dust from agricultural land
Local climate regulation	Role of wetland to control air temperature and evapotranspiration to influence the climate of the area Ex: Through shading, regulation of the local microclimate, reducing air temperature
Global climate regulation	Role of wetland to control green-house gas. Ex: Regulation of global climate and the sequestration of carbon
Water regulation	The capacity of a wetland to store water during high rainfall/ discharge with its topography, permeability, and roughness of wetland and recharge groundwater.
Flood hazard regulation	The capability of wetland to regulate, store and retain floodwaters to minimize or maximize flood hazard. Ex: Regulation and floodwater storage and intense rainfall events.
Storm hazard regulation	Role of wetland in the regulation of tidal or storm and extreme wind.
Pest regulation	The capability of wetland to control pest organism or the wetland act as a source of pests.
Regulation of human diseases	The capability of wetland to control human diseases or the wetland act as a source of human illnesses. Ex: Presence of species that control the vectors that transmit human diseases such as malaria, and dengue fever
Regulation of diseases affecting livestock	The capability of wetland to control or spread vectors for diseases in livestock. Ex: Presence of species that control the vectors that transmit human diseases.
Erosion regulation	Role of wetland to protect from soil erosion. Ex: Presence of dense vegetation protecting soils
Water purification	The capability of wetland to purify polluted water flowing through the marsh.
	Cultural services
Ecosystem service	**Description**
Cultural heritage	Importance of the wetland for historical or archaeological value. Ex: Traditional uses or management practices, as a cultural landscape

Recreation and tourism	Role of wetland as recreational purposes such as fishing, water sports, swimming, and tourism destination.
Aesthetic value	Role of wetland for aesthetic value as natural beauty.
Spiritual and religious value	Role of wetland for spiritual and cultural value to people
Inspirational value	Presence of myths or stories about the wetland. Role of wetland to inspire people for the creative mind. Ex: Presence of local stories relating to the wetland, traditional oral or written histories about the wetland.
Social relations	Role of wetland for fishing, cropping, walking, jogging, bird watching, and photography in and around the wetland. Ex: Presence of fishing, grazing, or cropping communities developed within and around the wetland.
Educational and research	Role of wetland for educational purposes for schools and universities and awareness programs. Ex: Use of the wetland by school children, site of long-term research, site visited by study tours
	Supporting services
Ecosystem service	**Description**
Soil formation	Role of wetland in soil formation. Ex: Deposition of sediment, accumulation of organic matter.
Primary production	Role of wetland in photosynthetic processes and organic matter and store energy in biochemical form. Ex: Presence of primary producers such as plants, algae.
Nutrient cycling	Role of wetland in nitrification/denitrification, decomposition of organic matter. Ex: Source of nutrients present from inputs from agricultural land, internal cycling of plant material, inputs of nutrients from floodwaters, presence of fauna to recycling nutrients
Water recycling	Role of wetland in water recycling (discharge or recharge of groundwater) Ex: Presence of wetland vegetation and open water result in evapotranspiration.
Provision of habitat	Role of wetland to protect and provide habitat and conserve locally essential species.

Four sites were selected for thorough observation and public opinion on the benefits of the marshland (see Fig. 2). In addition, Google Earth Pro and Open Street maps were used to understand the land-use patterns of the study area.

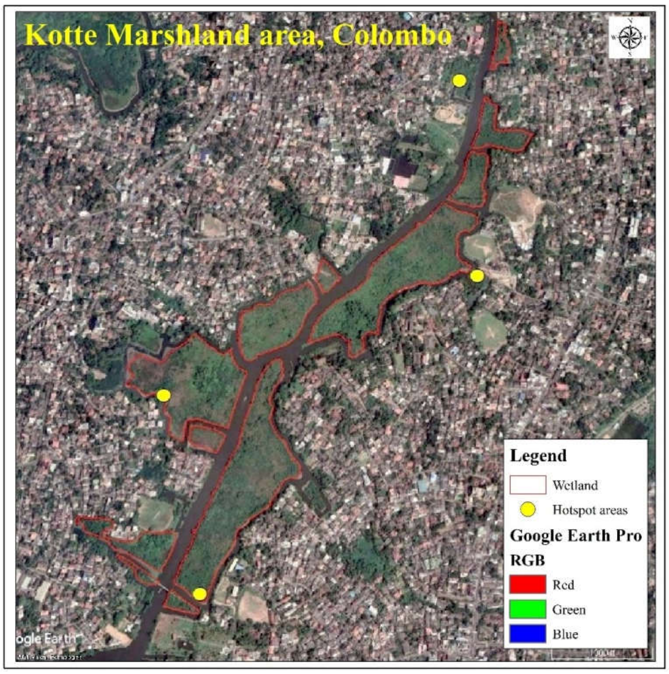


Fig. 2. Hotspot areas of marshland in Kotte

RESULTS AND DISCUSSION

The information collected through the RAWES approach was loaded into the Excel sheet and transformed into quantitative data to display the results and facilitate understanding. The relative scale used to assess 37 ecosystem services and values is shown in Table 2.

Table 2. Ecosystem Services provides by Kotte marshland and the benefit scale of the ecosystem services.

Ecosystem service	Location 01				Location 02				Location 03				Location 04				AveVA	AveSB
	H	VA	SB	V	H	VA	SB	V	H	VA	SB	V	H	VA	SB	V		
Freshwater	0	3			0	3			0	3			0	3			3	
Food	+	4	L	1	0	3			+	4			0	3			3.5	0.5
Genetic resources	?				?				0	3			?					
Biochemical, natural medicines, pharmaceuticals	+	4	L	1	+	4	L	1	+	4	L	1	+	4	L	1	4	1
Ornamental resources	0	3			0	3			0	3			0	3			3	
Clay, mineral, aggregate harvesting	0	3			0	3			0	3			0	3			3	
Waste disposal	0	3			0	3			0	3			0	3			3	
Energy harvesting from natural	0	3			0	3			0	3			0	3			3	
Air quality regulation	++	5	R	3	++	5	C	2	++	5	R	3	++	5	R	3	5	2.3
Climate regulation-local	++	5	R	3	++	5	C	2	++	5	R	3	++	5	R	3	5	2.5
Climate regulation-global	0	3			0	3			0	3			0	3			3	
Water regulation	++	5	R	3	+	4	L	1	++	5	C	2	++	5	C	2	4.8	2
Natural hazard regulation	++	5	R	3	++	5	R	3	++	5	R	3	++	5	R	3	5	2.8
Pest regulation	++	5	C	2	+	4	L	1	+	4	C	2	++	5	C	2	4.5	1.8
Disease regulation – human	++	5	C	2	+	4	L	1	+	4	C	2	+	4	C	2	4.3	1.8
Disease regulation – stock	0	3			0	3			0	3			0	3			3	
Erosion regulation	+	4	L	1	+	4	C	2	+	4	L	1	+	4	L	1	4	1.5
Water purification and waste treatment	++	5	C	2	+	4	L	1	++	5	C	2	++	5	C	2	4.8	1.5
Pollination	+	4	C	2	++	5	C	2	++	5	C	2	++	5	C	2	4.8	1.8

Salinity regulation, fire regulation	0	3			0	3			0	3			0	3			3	
Noise and visual buffering	+	4	L	1	++	5	L	1	++	5	C	2	++	5	C	2	4.8	1.3
Cultural heritage	++	5	R	3	0	3			+	4	N	4	+	4	N	4	4	2.8
Recreational and tourism	+	4	C	2	++	5	R	3	+	4	C	2	+	4	C	2	4.3	2
Aesthetic value	++	5	C	2	++	5	C	2	+	4	L	1	++	5	L	1	4.8	1.5
Spiritual and religious value	0	3			0	3			0	3			0	3			3	
Inspiration of art, folklore, architecture, etc.	0	3			?	_			+	4			0	3			2.5	
Social relations	+	4	R	3	++	5	L	1	+	4	L	1	+	4	L	1	4.3	1.5
Educational and research	++	5	R	3	++	5	R	3	+	4	C	2	+	4	C	2	4.5	2.3
Soil formation	++	5	R	3	+	4	C	2	+	4	C	2	++	5	C	2	4.5	1.8
Primary production	++	5	R	3	++	5	C	2	+	4	C	2	++	5	C	2	4.8	2
Nutrient cycling	++	5	R	3	++	5	C	2	+	4	C	2	++	5	C	2	4.8	2
Water recycling	++	5	R	3	++	5	C	2	++	5	C	2	+	4	C	2	4.8	2.3
Provision of habitat	++	5	N	3	++	5	C	2	++	5	C	2	++	5	C	2	5	2.3

HI – How important, VA – Value assigned, SB - Scale of Benefit, V – Value,

Ave. VA – Average value assigned, Ave. SB –Average Scale of Benefit,

L – Local, R – Regional, C – City, N – National

Table 3. The level of assessment and assigned values of shorthand notations used in Table 2

Score	Assessment of ecosystem services	Values assigned
++	Potential significant positive contribution	5
+	Potential positive contribution	4
0	Negligible contribution	3
-	Potential negative contribution	2
--	The potential significant negative contribution	1
?	Gaps in evidence	No value assigned

The result revealed that four services, namely provisioning services, regulating services, cultural services, and support services, positively contribute to the ecosystem. All supportive services provided by the study site have positive contributions with significant importance from a few services. However, 21 ecosystem services were only showed substantial contributions in the RAWES approach in the Kotte marshland, which are listed below.

- Provisioning services: biochemical, natural medicines, pharmaceuticals, air quality regulation, climate regulation (both local and global), water regulation, natural hazard regulation, and pest regulation.
- Regulating services: disease regulation – human, erosion regulation, water purification and waste treatment, pollination, noise and visual buffering, cultural heritage, recreational and tourism, and aesthetic value.
- Cultural services: social relations, education and research, soil formation, and primary production.
- Supporting services: nutrient cycling, water recycling, and provision of habitat.

Ecosystem services include freshwater, food, ornamental resources, clay, mineral, aggregate harvesting, waste disposal, energy harvesting from nature, climate regulation - global, disease regulation-stock, salinity regulation, fire regulation, spiritual and religious values negligible in the Kotte marsh area. None of the services was provided with a negative contribution of ecosystem services. Freshwater service is negligible in the study area because there is a canal around the marsh, but it cannot be used for human purposes and used by birds, animals, and plants. Marshland resources are mainly used as food for animals that are not used for human purposes. Kotte marshland does not rely heavily on harvesting biochemical, natural medicines, pharmaceuticals, ornamental resources, clays, minerals, and aggregates, but some people use them for their primary needs. The Kotte marsh is not used for dumping waste. This marshland has significant importance on air quality regulation, local and global climate regulation, water regulation. It is one of the most crucial marshlands centered in highly developed cities such as Rajagiriya, Nawala, Battaramulla, Nugegoda, and Thalawathugoda in Sri Lanka.

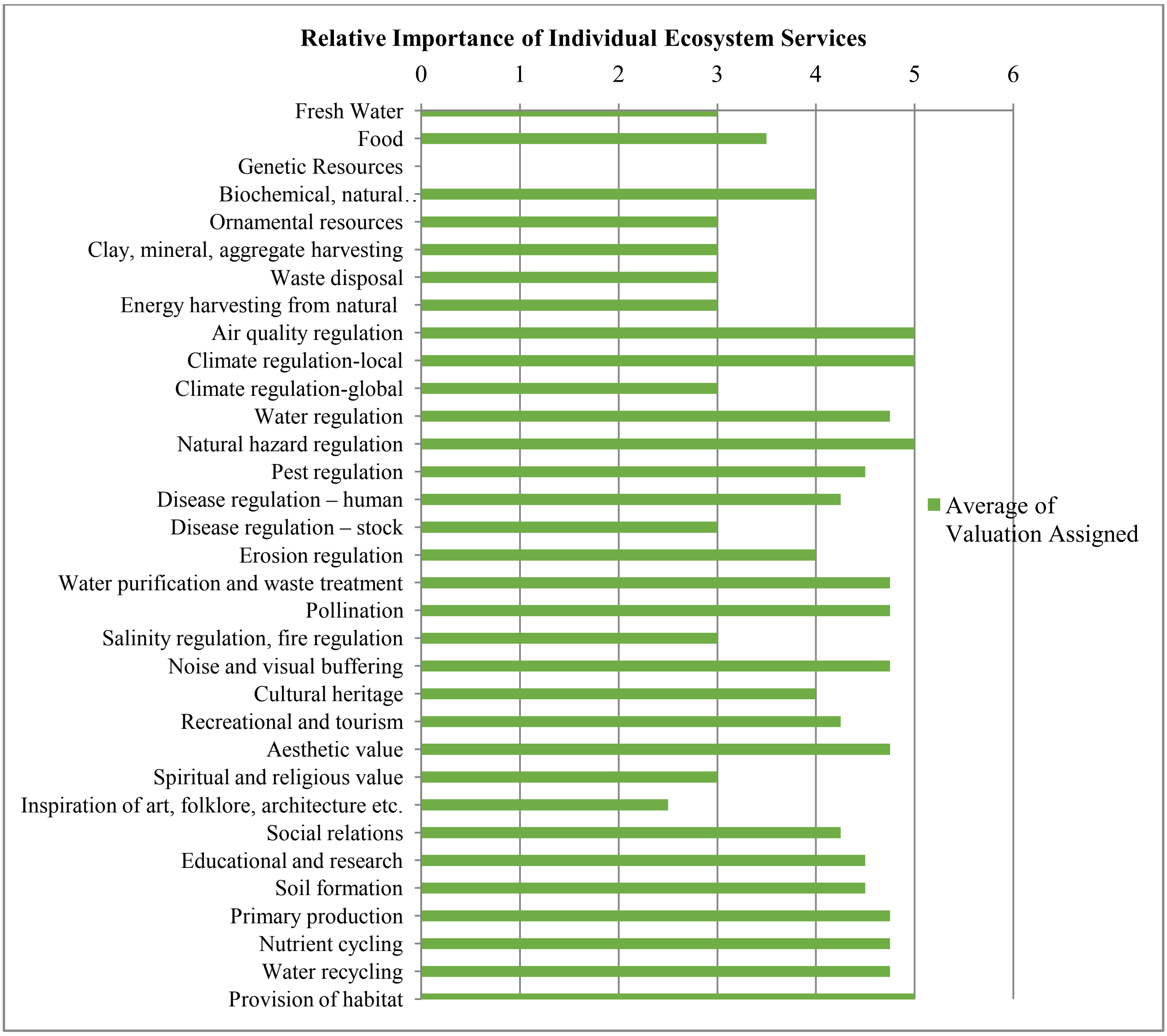


Fig. 3. The relative importance of individual ecosystem services in the study area

In addition, this marshland has played an essential role in regulating the natural hazards of the surrounding urban cities. Flood hazard is one of the significant natural hazards affecting Colombo city. The marshland protects the environment and the public from flood hazards. Further, the grasslands and reed beds are used for water purification and waste management. The Kotte marshland is a cultural heritage in Colombo city. This land is located in Sri JayawardanapuraKotte, which is the capital of King Parakramabahu VI in 1412. Thus, this land should be carefully protected to save the cultural heritage in Colombo city.

Benefit scale

The RAWES approach uses a benefit scale to estimate the benefits to people who can get from the marshland. The benefits are classified into five levels: local, urban, regional, national, and global, and the assigned numerical values are 1, 2, 3, 4, and 5, respectively. The results of the benefit scale are shown in Table 2, and the proportion of benefits obtained from each scale is illustrated in Fig. 4.

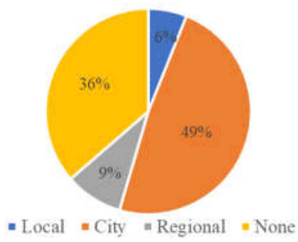


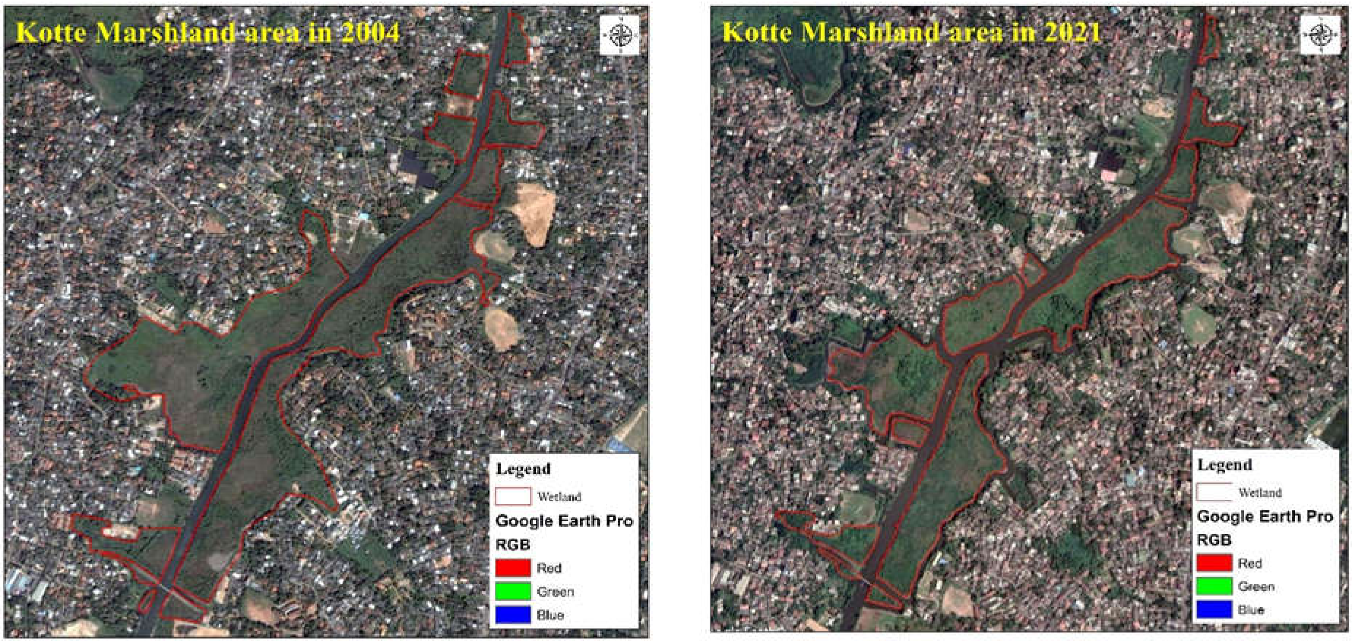
Fig. 4. Benefit scale of Kotte marshland

The Kotte marshland benefits 6.06% of the environment and humans locally. The environment is surrounded by the marshland and gets public use. Biochemical is good for society and nature at the local level. Ecosystem services such as air quality regulation, water regulation, pest regulation, human disease regulation, erosion regulation, water purification and waste treatment, pollination, recreation and tourism, aesthetic value, social relations, education and research, soil formation, primary production, food cycling, water recycling, and habitat are received benefits in the city level. City-level is the developed urban cities surrounded by Kotte marshland in Colombo, for example, Rajagiriya, Nawala, Nugegoda, Battaramulla, and Thalawathugoda. These areas are highly developed with a colossal infrastructure and densely populated city. These places play the leading role in land degradation, air pollution, and water pollution.

However, the marshland has taken a role in purifying naturally polluted air and water to these areas. The Kotte marshland is the only colossal vegetation cover that can be used as a habitat for animals. The maximum vegetation cover areas were destroyed and turned into industrial areas due to the demand for land in the city. Since it is the natural source used for flood control, it should be protected for sustainable use.

Loss of Kotte marshland

The Kotte marshland varies over time, has relatively cheaper land and a pleasant environment that has attracted middle-income groups in recent decades. Then this area began to develop as a residential area, and during these years, the area instigated to improve, and people started to crawl through the marshes.



(a) (b)

Fig. 5. The pattern of Kotte marshland in (a) 2004 and (b) 2021.

The pattern of the Kotte marshland is shown in Fig. 5 indicates the extent of the Kotte marshland decreased with the function of years. The extent of the wetland in 2004 and 2021 is 57.21 hectares and 45.07 hectares, respectively. According to the data, the extent of the marshland was reduced by 12.14 hectares in the last seventeen years. Urbanization is a significant cause of wetland degradation in the Sri JayewardenepuraKotte area. It has exerted a significant influence on the structure and function of wetlands. Filling the marshland to expand the industrial land is an important cause for the loss of marshland. Domestic water discharges into the marshland, and the surrounding water bodies cause water pollution. Even freshwater must be purified to drink in these areas. The Kotte marshland faces various threats from harmful human activities. This study demonstrated an impact on the environment through changes in the Kotte marshland and changes in the environment as they are; deterioration and degradation of the quality of wetlands. Reclamation, water pollution, waste management around the marshland, and water regulation are the most crucial degradation factors that affect wetlands. Organic pollution, other chemical effluents, and wastewater disposal affect the water. Garbage management in some areas involves eutrophication and the spread of harmful diseases. Degradation leads to a reduced population of target birds and mammals, fish, and aquatic plants due to habitat loss. Many years ago, the marshland was a habitat for fishing cats, but today, it is challenging to find the animal in the marshland. The degradation of the Kottemarshland causes a flood hazard in Sri Jayewardenepura Kotte. The Kotte marshes decreased by the expansion of the industrial area and institutional structure in Sri Jayewardenepura Kotte. Through the landfill, the marshland was converted into highland and for construction. The Kottemarshland loses the ability to control flooding because it lost the reed bed through the filling process, which acts as a sponge to absorb water. The comparison of the ecosystem services currently offered by Kotte marshland reduced its size than before. Water bodies in the Kotte marshland have been used for human purposes before urban expansion, but the highly residential area has been polluted in the nearby periods.

CONCLUSION

The Kotte marshland was destroyed by human activity. When the area of the marshland is reduced, the quality and quantity of the ecosystem services provided by the marshland are also reduced. It affects the environment and people in the area. Kotte marshland is the main vegetation patch for urban areas such as Rajagiriya, Nawala, Nugegoda, Battaramulla, and Thalawathugoda. Currently, the marshland provides several ecosystem services at local, urban, and regional levels. The continuous degradation of wetlands can cause several disadvantages, such as air pollution, reduced provision of water resources, food, fuel, genetic aids, natural medicine, and pharmaceutical. Wetland loss affects the local climate regulation, water regulation, hazard regulation, pest regulation, human disease regulation, and erosion regulation. The loss of trees from wetlands and tall reeds affects urban areas' absorption and buffering noise. Human activities are a threat to future generations by using the resources. Finally, this study primarily contributes to Ramsar strategic plan goal 1, which focuses on addressing wetland loss and degradation drivers to achieve the sustainable development goals.

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