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Business model for preventing Iranian ecosystem by community based financial participation

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Abstract
The preservation of nature has long been a formidable challenge, as human activities have continuously diminished the ecological processes and functions of the natural environment. These processes and functions, collectively known as ecosystem services (ES), provide immense benefits to both humans and their communities. ES encompass the various advantages that people derive from natural ecosystems. To safeguard these services, numerous policy measures, including legal and voluntary protections, have been implemented. However, the escalating threats to the natural environment necessitate the adoption of additional policy instruments to achieve environmental protection and sustainability goals. Land degradation, desertification, flooding, water scarcity, and climate change are all on the rise, primarily due to the decline in ES. The predicament lies in the fact that ES are often perceived as free resources, making their preservation challenging. Despite the use of tax policies to incentivize payment for ES, their supply continues to dwindle. This can be attributed to social dilemmas such as differing preferences, free riders, and the "tragedy of the commons" issues that commonly arise in resource distribution. Consequently, tax systems alone may not effectively ensure the substantial preservation of ES. The use of utility theories and market-based instruments has been debated as a means of achieving policy targets for nature protection. However, in order for the market for ecosystem services (MES) to thrive, incentive and motivation schemes are necessary to encourage interaction among multiple actors. This study utilizes socio-economic and ecological concepts to advocate for MES and presents a business modeling framework using Petri net. This framework incorporates multi-actor interaction for the demand and supply of ecosystem services, which are modeled to estimate their distribution across a landscape in support of policy targets based on market structures. Additionally, a future scenario is modeled to achieve environmental balance and a management framework is provided for MES. The UNESCO Golestan biosphere reserve in northern Iran serves as an experimental area for testing the concepts and models developed in this research. The results demonstrate that MES has the potential to contribute to nature protection by helping achieve targets for preserving ecosystem services. This conclusion is supported by data sampling, analytical schemes, and management support systems integrated into the simulation framework of this research.
Keywords: *Biosphere reserve, Ecosystem services, Golestan national park, Petri nets.*

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I. INTRODUCTION

Human societies are constantly grappling with the uncertainty surrounding the future changes in the environment, primarily caused by the escalating activities that deplete ecosystem services (ES) (Tebboth et al., 2020). Despite the growing number of environmental studies, campaigns, literature, workshops, conferences, policies, and programs dedicated to raising awareness about environmental issues, the comprehension of ES and its crucial role in sustaining and harmonizing environmental processes remains limited in most regions across the globe (Arenas-Wong et al., 2023). Consequently, the global supply of ES is dwindling, despite certain areas managing to maintain a balanced or positive state.

The ongoing threat of ES decline persists, particularly with the growing global population. As the world population increases, so does the demand for ES, placing greater pressure on it (Arkema et al., 2024; Jayalath et al., 2021). Unfortunately, there is a prevailing misconception that ES is both free and limitless, which has led to the destructive exploitation of natural resources. Consequently, ecosystems have been destroyed, and ES has declined in various regions worldwide (Pynegar et al., 2018). Overfishing has depleted water resources, pests and diseases have spread beyond expectations, and deforestation has hindered flood control in human settlements, resulting in the loss of both lives and property (Feio et al., 2021).

Conservation and preservation of ecosystem services necessitate the recognition of their intrinsic value, although it is commonly assumed that nature provides them for free (Zarandian et al., 2017). However, the well-being of the environment relies on its conservation, and the ongoing impact of human activities on landscapes has resulted in escalated land degradation. For instance, the intensification of agriculture without adequate management and control measures for community sewerage systems will inevitably lead to land degradation (Berry et al., 2020). Numerous governments and international organizations believe that protected areas are the solution to issues like land degradation, which has consequently led to the establishment of numerous protected areas worldwide (Ochieng et al., 2024). This has also prompted the creation of various Biosphere Reserves, such as the UNESCO human and biosphere program (MAB), aimed at enhancing biodiversity and conserving landscapes (Sultana et al., 2023). The UNESCO Biosphere Reserve (BR) concept comprises three distinct levels of restricted areas: the core zone, where the most fragile flora and fauna thrive in ecosystems that are generally undisturbed; the buffer zone, where economic activities, environmental education, training, and recreational pursuits can take place; and the transition areas, where people typically reside within a BR, with the objective of safeguarding and ensuring the rational utilization of natural resources (D'Ottavio et a., 2016; Hassen et al., 2023).

Economists and environmental scientists have started discussing the potential value that can be added to specific environmental standards. They utilize political and economic arguments to support the European commission (Pérez-Sánchez et al., 2021). This is because payment systems for ecosystem services can serve as innovative tools for managing natural resources, which are of interest to various stakeholders in the ecosystem community. However, the willingness to pay (on the demand side) poses a significant challenge for these systems, both in terms of supply and demand (Van der Biest et al., 2020). This challenge primarily arises from the normative perspective or logic (known as the free rider effect) associated with utilizing public goods and services. The effects of normative behavior or free participation have demonstrated that citizens are more likely to engage in environmental protection and mitigation of ecosystem damage when they can share in the benefits resulting from environmental improvements (Guan et al., 2022). This advantage is not merely functional, but also financial. Consequently, market-based instruments have been considered to ensure compliance with environmental and social standards. These instruments generate financial resources, direct funds towards environmentally friendly technologies, create incentives for investment, and enhance the involvement of the private sector in environmental protection (Obeng et al., 2019). Therefore, recognizing the necessity for market-based environmental instruments can play a crucial role in implementing multilateral environmental agreements, fostering sustainable development, and reducing poverty, particularly in many developing regions.

The main objective of this study is to contribute to nature conservation by understanding and describing the relationship between ES's multifaceted interactions, conservation, payment for them, and markets.

II. MATERIALS AND METHODS

2.1 PETRI NET MODEL FRAMEWORK

The light ends produced by cracking reaction are removed in the stripper column. The off -gas from the stripper is sent to the fuel gas, but flared if it is under high pressure[3]. And the paraffins and olefins in the column bottom stream are fed to the linear alkyl benzene alkylation unit. In order to recover enough heat from the bottom stream, it is necessary by passing where the paraffin stream is heated [3].

This approach involves the utilization of Petri nets as a means of design and modeling. It has been devised as a computer-based model for evaluating the environmental impact of business development, serving as a tool for landscape-level management with potential climate protection outcomes. The model is characterized by its multi-agent framework, encompassing various actors and ecosystem services within a specific location and environment, all aimed at supporting business development strategies that sustain ecosystem services. These actors and services are represented as objects through image-based mathematical modeling utilizing Petri nets. The entire process is meticulously designed in a step-by-step manner, taking into account the activities of numerous actors in the landscape who either require or provide ecosystem services, along with the corresponding service units and service delivery units (Liu et al., 2022).

A Petri net is both a graphical and mathematical instrument. It serves as a versatile tool for measuring continuous, discrete, rapid, and cumulative processes, while also accommodating random effects. The specific type of Petri net discussed here is a uniform-colored Petri net, specifically designed for event simulation. It consists of points, transitions, and connecting curves (Byeon et al, 2023).

2.1.1 Conceptual model of construction with petri net

A flow system is incorporated in the model to calculate the quantity of ES available after a particular transportation occurrence. Modes in the MES model is service unit for ES, stock for ES and ES as flow. The structure of the network is such that when multiple transfer destinations are implemented, the token is removed from the "MES" location and placed at the "Server for ES" location. Depending on the flow order you need to choose, you can also go back in the opposite direction.

The model consists of two active components: flow ES and stock ES. Changes in site conditions are considered active flows. It is the flow of increase in ES (supply of ES) and decrease in ES (demand for ES) that determines their stock. Therefore, when developing the model, a standard ES service center (ES service unit) is created to study the interaction behavior of multiple manufacturers in ES supply and demand. ES provides the opportunity to evaluate market-oriented strategies that can lead to the growth of their business. Within Petri net modeling, the emphasis is on creating a set of cause-and-effect relationships between problems and computations that work sequentially (different approaches) to correct solutions (Prilandita et al., 2016). Upon investigating whether the sequence's limit maintains specific characteristics of its elements, we encounter the following model specification: a landscape type (L) is denoted as terrestrial ecosystems (ECOS) consisting of 8 ecosystem types, which can be further categorized under the subsequent ECOS:

i. Agricultural (ECOS1)
ii. Forestry (ECOS2)
iii. Water (ECOS3)
iv. Plants including green plants (ECOS4)
v. Urban (ECOS5)
vi. Rural (ECOS6)

Each ECOS is then classified into three components (Comp) consisting of tokens: land surface (Comp1), water surface (Comp2), biodiversity (Comp3) and ES (tokens). The interaction of many different actors with these components is explored by modeling changes based on the actions of each actor. ES is a token that is classified into five types: provision (ES1), regulation (ES2), support (ES3), protection (ES4), and culture (ES5). Representative ES flow servers are then defined as locations whose inputs and outputs (ES stock inputs) are identified by markers. The supply and demand of MES, ES stock and ES modules are distributed based on 5 different ES types based on color (pure Petri color) (Rova et al., 2019).

2.1.2 Petri net relations

In general, a symbol is a natural number Nm = {0, 1, 2, ..., m} a function of letters between them. If we have n letters in place of S, then we can say that S contains n letters. If n = ni and i = (1, 2, 3, 4), the Petri net contains comp tokens for MES positions, supply/demand units and ES shares. Where n1-4 = strong token is set to cross by tokens (ES). That is, n1 is the input in the MES area, n2 is the input in the ES supply unit area, n3 is the input in the ES demand unit area, and n4 is the input in the ES warehouse area. Input is defined as follows:

$$Comp = \{Comp_1, Comp_2, Comp_3\} \tag{1a}$$

$$ES = \{ES1, ES2, \dots, ES5\} \tag{1b}$$

$$Comp_1 = \{ES1, ES2, \dots, ES5\} \tag{1c}$$

$$Comp_2 = \{ES1, ES2, \dots, ES5\} \tag{1d}$$

$$Comp_3 = \{ES1, ES2, \dots, ES5\} \tag{1e}$$

Therefore, the color sets can be defined:

$$Colors = \begin{pmatrix} Comp1ES1\ Comp1ES2 \dots Comp1ES5 \\ Comp2ES1\ Comp2ES2 \dots Comp2ES5 \\ Comp3ES1\ Comp3ES2 \dots Comp3ES5 \end{pmatrix} \tag{2}$$

So, color set for MS is defined:

$$Colors = (MSMS_1 MSMS_2 MSMS_3) \tag{3}$$

2.1.3 Set up and deploy petri nets using snoopy software

A Petri networks like a mathematical graph made up of random objects like Snoopy. The Snoopy 2.0 software package is used to implement and describe Petri nets. Snoopy possesses a graphical editor that enables the creation of Petri nets, with its syntax being governed by Backus-Normal-Form (BNF). The BNF formalism serves as a distinctive notation for specifying expressions, functions, expressions, and their corresponding values, operators, and parameters (Byeon et al., 2023). Various color combinations defined to evaluate ES flow in Snoopy are implemented using this dynamic specification-based formalism. Table 1 shows the set of software-defined colors for the implementation. These are colors for ES application flows, Finance, Management application flows and various color groups such as "production" and "union" mixed color groups.

Table 1: Definition of color sets for implementing petri nets

Name	Type	Colors
Dot	dot	dot
Compset	enum	C_1, C_2, C_3
ES	emun	ES_1, ES_2, ES_3, ES_4, ES_5
Fin	enum	a, b
MS	enum	MS_1, MS_2, MS_3
PP	Product	Compset, ES
Market	Union	PP, MS, Fin
Management	Union	PP, MS

2.2 USE OF THE MODEL IN THE GOLESTAN UNESCO BIOSPHERE RESERVE

The methodology applies the Petri net modelling framework and the data sampling strategy to the UNESCO Golestan biosphere reserve. Golestan biosphere reserve is situated in Golestan province of Iran at the border to Turkmenistan. It belongs to the Caucaso-Iranian highlands and is situated in-between the sub-humid and semi-arid Caspian regions. The biosphere reserve represents three biomes: temperate rain forest, cold (continental) winter and semi-deserts and mixed mountain and highland systems. A vast variety of habitats can be found, such as closed forests, open woodlands and shrubs, mountain meadows, steppes, halophytic, hygrophilous and aquatic communities. Golestan is also designated as a national park. Golestan offers a great ethnic diversity. The 26,000 inhabitants of the biosphere reserve are Turk, Persian and Kurdish. Their main activities consist in agriculture, animal husbandry, horticulture, industry, silk production and tourism. Adverse effects on the transition area come from traffic, overgrazing of rangelands and deforestation.

Figure 1 illustrates a map showcasing the UNESCO Golestan biosphere reserve, highlighting the primary data collection regions and the distinct protection zones along with their respective statuses. The map visually represents the varying levels of protection through the use of different colors for each zone.

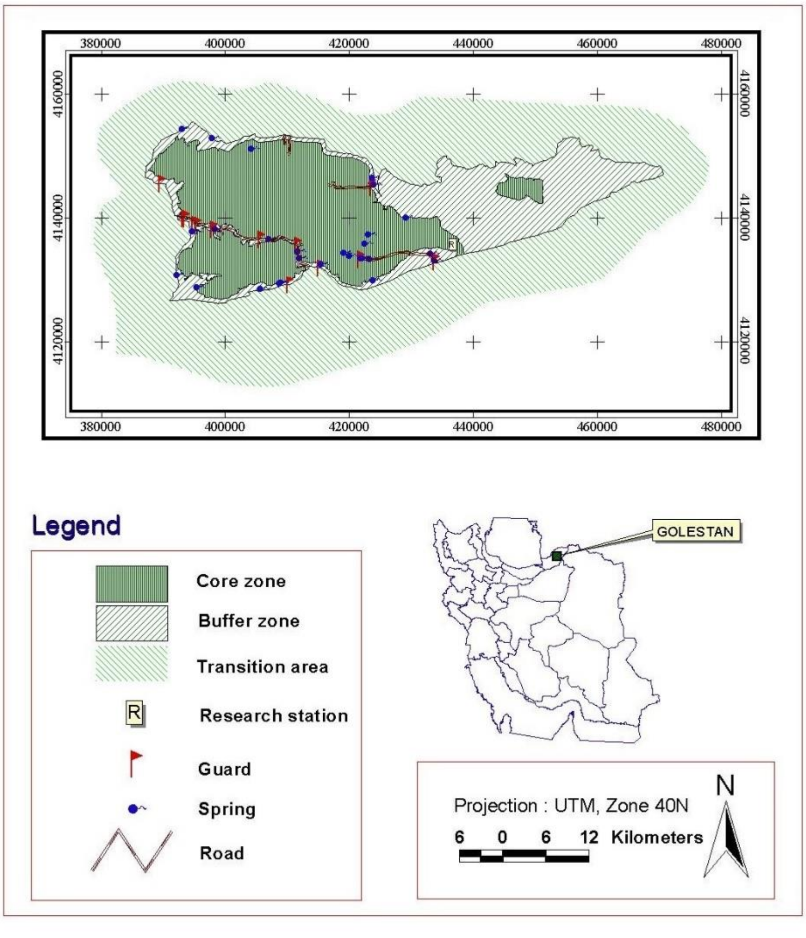

Figure 1: Map of UNESCO Golestan biosphere reserve with zones of protection

2.2.1 Nature's masterpiece

Golestan national park, established in 1957, spans over 900,000 hectares, making it one of the largest national parks in Iran. Located in the Golestan Province, it encompasses a rich tapestry of landscapes. Recognizing its ecological significance, Golestan national park was designated as a UNESCO biosphere reserve in 1976, underscoring its role in the conservation of biodiversity.

2.2.2 Biodiversity hotspot: flora and fauna

Golestan biosphere reserve boasts an astonishing diversity of ecosystems, including temperate broadleaf and mixed forests, alpine meadows, and vast steppes. Each zone harbors a unique array of plant and animal species. Golestan biosphere reserve is a refuge for several rare and endangered species, including the Persian leopard, Goitered gazelle, and the wild goat species, the Bezoar ibex.

The park's lush forests are dominated by deciduous and coniferous trees, creating a picturesque landscape. Oak, beech, and hornbeam trees are prevalent, while conifers such as fir and spruce add to the green canopy. As elevation increases, alpine meadows come into play, displaying a vibrant tapestry of wildflowers. These meadows are essential for the park's herbivores and contribute to the overall biodiversity.

Golestan biosphere reserve is a stronghold for the Persian leopard, a critically endangered subspecies. Conservation efforts aim to protect and increase the population of these elusive big cats. The Golestan biosphere reserve serves as a vital stopover for migratory birds, with numerous species traversing its skies during their journeys. This has elevated the park's status as a crucial bird-watching destination.

2.2.3 Human interaction and conservation

Golestan biosphere reserve is home to several indigenous communities whose traditional practices coexist harmoniously with conservation efforts. Their sustainable lifestyles contribute to the park's preservation. While the park has made strides in preserving its biodiversity, challenges such as poaching and habitat degradation persist. Ongoing conservation initiatives strive to address these challenges and ensure the park's longevity.

III. RESULTS AND DISCUSSIONS

3.1 ECOSYSTEM SERVICES ASSESSMENT RESULTS

Land area, biodiversity and water were used as key landscape components and then combined to estimate ES in the UNESCO Golestan biosphere reserve. Figure 2 shows the assessment of different ES species in the UNESCO Golestan biosphere reserve with different lines representing different species.

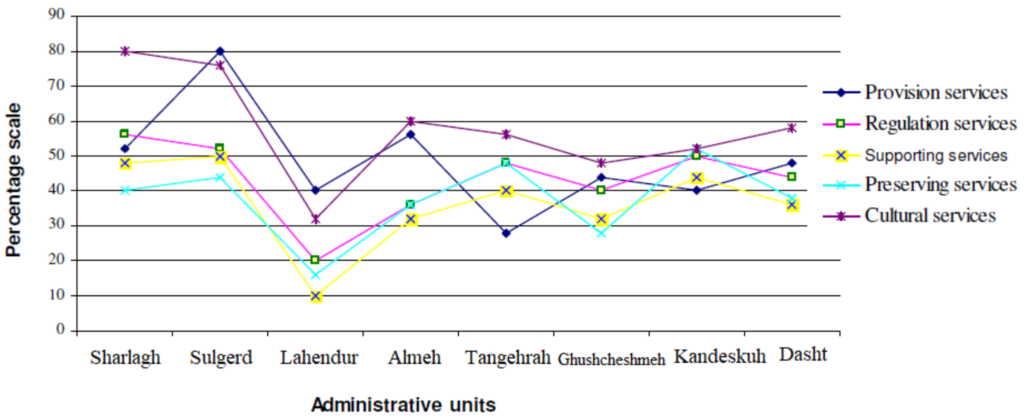

Figure 2: Ecosystem services estimation in UNESCO Golestan biosphere reserve

The x-axis denotes distinct administrative units, whereas the y-axis fluctuates in percentage to portray the altered data values. By juxtaposing data parameters with points corresponding to percentage values on the y-axis and administrative units on the x-axis, one can exhibit the data. However, it is important to note that perfect lines do not necessarily indicate trends (Imdad). Delivery service is 80% (highest effective capacity) in Sulgerd and 40% (lowest effective capacity) in Lahendur. This indicates that delivery services in Sulgerd are at maximum capacity. Sulgerd has enough water, green spaces and plants for cosmetics, large agricultural activities, fiber optic and wind energy parks. In the Strait, there is an area of Tangehrah that suffers from lack of water, poor soil and little agriculture or green land and plants. But other areas have more water for recreation than for agriculture or other service activities. On the other hand, cultural services are better in Sharlagh and almost as good in Sulgerd. Sulgerd is top attraction in UNESCO's Golestan biosphere reserve for high-quality recreation, local traditions, park conservation and significant investment in tourism facilities. Due to the very low capacity of other services, cultural services are at the lowest level of adequate capacity in Lahendur. Lahendur is limited in development and recreational activities due to increased landscape destruction, attracting fewer tourists and thus less investment in tourism centers. Although the people preserved their traditions, it was not enough because they did not appreciate the beauty of the environment.

Hence, the allocation towards alternative cultural amenities remains minimal while the populace upholding these customs continues to grow trips outside this administrative area (Anbleyth-Evans et al., 2020). Other administrative and organizational units of the Golestan UNESCO biosphere reserve present very low-capacity services. The UNESCO Golestan biosphere reserve exhibits varying levels of potential across its units, with some units showing high potential while others show low potential. However, the overall results indicate that most units within the reserve possess potential. Consequently, the presence of an environmental crisis in the region can be attributed to the challenges faced by ES. They are considered an important component of the landscape depending on nature and human activities, which can make it shrink or expand on the geological level (Stamatiadou, et al., 2023). Potential business services that are included are carbon sequestration, biodiversity, and water resources like MES. Data on demand and supply-driven activities in the UNESCO Golestan biosphere reserve were collected and evaluated by different administrative units. Figure 3 shows the potential demand and supply of carbon sequestration in different management units in the UNESCO Golestan biosphere reserve. This MES shows that the needs and benefits of carbon sequestration are not adequately addressed in the Golestan UNESCO biosphere reserves, Sulgerd, Tangehrah, Almeh, Ghushcheshmeh and Kandeskuh. Sharlagh has the lowest capacity and lowest demand in Lahendur. It also shows the characteristics of the land and the inherent green space, forests and carbon-sequestering biological species that apples need.

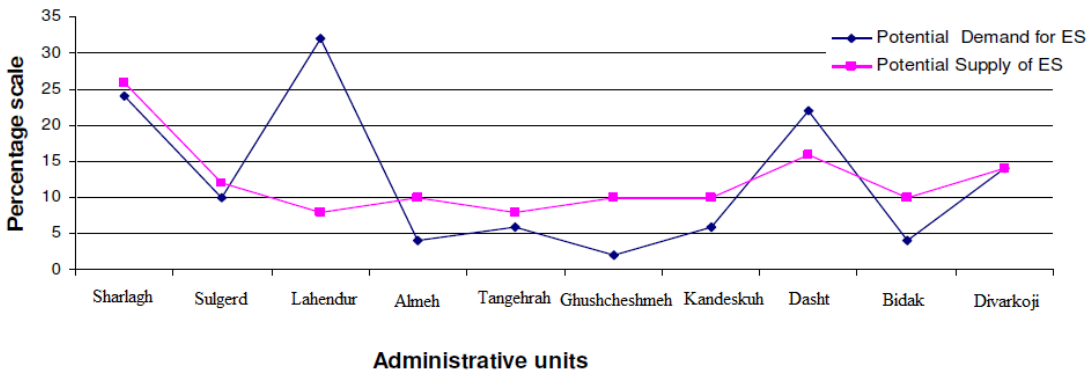

Figure 3: Demand and supply of potential carbon sequestration ecosystem services

But there are many types of economic activities that require it, such as tertiary services, agricultural machinery and public services. Therefore, ES stocks for carbon sequestration activities should be ≥0 for goals or policy actions aimed at achieving balanced supply and demand scenarios for carbon sequestration in the UNESCO Golestan biosphere reserve. The width should be equal to or greater than zero, in other words (Page et al., 2015).

But for policy measures or green balance goals carbon sequestration must achieve neutral capacity. Therefore, carbon sequestration arrangements must exceed demand with neutral capacity to achieve environmental protection objectives (Del Rossi et al., 2021). Information on demand and supply of organisms is collected. Figure 4 illustrates the prospective demand and supply of biodiversity within the administrative sector of Golestan UNESCO biosphere reserve. The biological source of the MES shows that all administrative units and offices lack energy, except Sharlagh, which has a low-level capacity. Golestan UNESCO biosphere reserve is a degraded natural area that protects degraded biodiversity with minimal investment in rehabilitation activities. Relying on natural dynamics (UNESCO's landscape conservation concept) for biodiversity, some areas such as Sharrlagh are recovering very slowly. While, the demand in Lahendur shows a corresponding medium potential and a relatively low potential in Golestan UNESCO biosphere reserve. Overall, Sharlagh and Sulgerd have less significant abilities. Areas with poor soil conditions and biological resources need more biodiversity populations to reduce genetic resources, biotic refugees, soil acquisition by insects and microbes, bee pollination and soil fragmentation (Palsaniya et al., 2022). Therefore, as in the case of carbon sequestration, to achieve ecosystem balance, the supply of biodiversity must exceed the demand in relation to the average relative capacity.

However, in Lahendur's case, the supply must be greater to balance the demand. Data on the supply and demand for water resources were also collected. Figure 5 shows the potential requirement and supply of water resources in the various management places of the Golestan UNESCO biosphere reserve.

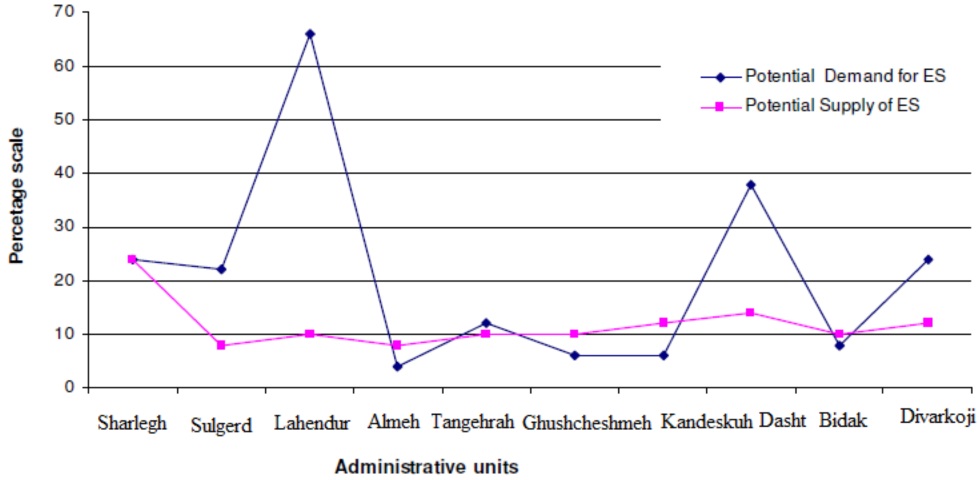

Figure 4: Potential requirement and provision of ecosystem services for biodiversity

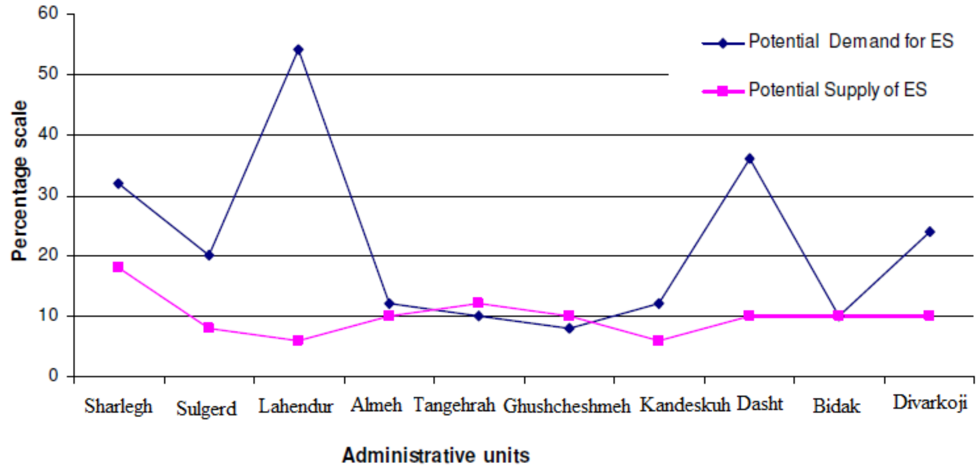

Figure 5: Potential requirement and supply of ecosystem services for water resource

This depicts that the supply of water resources of the administrative units is not enough in any administrative unit and all departments except the Sharlagh region with a very good capacity. Streams are incapable of offering a diverse array of hydrological services, including the regulation of eutrophication (water quality), the management of seasonal flow (water quantity), and the prevention of water erosion. While the demand in Lahendur shows the average matching capacity and very matching capacity in all areas of BR and Sharlagh. Lehendur is a dry land where there is not enough water and when it rains all the water falls because there is no living soil. They can also be found in communities in areas that are resistant to water resources due to the presence of reservoirs (Flood et al., 2024). Therefore, as in the case of carbon sequestration and biodiversity, to achieve an ecological balance of water resources, the supply must exceed the level of demand to meet the relevant average capacity (Sangha et al., 2024). But in Lahendur, supply must be plentiful to keep up with demand. Data was additionally gathered on action-focused endeavors, which strive to depict various participants in the Petri net. Activities such as the use, distribution, development, production and promotion of ES and tourism work are considered. Examples: deforestation for increased agricultural use, development of irrigated land, canals, agricultural production, land distribution, military action, green trees for migrants, etc. Data were collected using the same methods of classification and grouping, but their separation was based on frequency of activity. The value is then converted to a percentage. Table 2 displays the percentage of demand and supply for ES across various agencies. It provides insights into the supply and demand levels of ES for different agencies, which also reflect the supply and demand outcomes for MES in UNESCO Biosphere Reserves within the sector. This can be attributed to the low visibility and low ES feed.

Table 2: The demand rate and supply of ecosystem services based on multi-agents

Actions-oriented	Rate of demand of ES (%)	Rate of supply for ES (%)
Consumption	25	-
Supplying	-	27
Developing	11	5
Producing	19	14
Antagonizing	29	-
Tourist impacts (migrants)	17	-

3.2 IMPLICATIONS OF MODELING AND SIMULATION FOR THE MANAGEMENT OF ECOSYSTEM SERVICES

Data is encoded into Petri nets defined for modeling and simulating demand, supply and stocks in ES. It's about understanding long-term trends in data behavior in order to design, monitor and manage future ES protection scenarios. Therefore, any high or low BR or ES can be specifically considered or assembled for simulation. Simply define the corresponding color combination and then encode the corresponding data in the studied administrative unit or specific EC type (general model) (Byeon et al., 2023). However, here the model is adapted for the specified case of UNESCO's Golestan biosphere reserve, by identifying and encoding ES estimation data in a Petri grid. Table 3 presents a summary of the data sets coded in selected Petri net locations. The raw data shows the locations in the Petri grid as aggregates. So, 1500 were identified and coded at various locations in the Petri net. The data for applications with dual scenarios is also displayed. For the starting point, "ES demand unit" is obtained by averaging the findings of 3 MES determined for Golestan UNESCO biosphere reserve. It is 14, 24, 24, which gives us approximately 20. For the initial energy unit value ES is also obtained from 3 MES. That is, the numbers 14, 10 and 12 are mentioned respectively. While, for ES stocks, it is taken from the average of all ES produced in UNESCO. They are 48 (Providing Services), 44 (Maintaining ES), 36 (Support Services), 38 (Protection Services) and 58 (Cultural Services) which provide 45. The UNESCO Golestan biosphere reserve is coded by ES. Distance box #1500 is the imaginary location "MES" and is the constant value (approximate level) of the most uniform ES power in the area.

Table 3: Summary of dataset encoded in the selected places of a petri net

Places in Petri net	Initial data (mean value in %)	Aggregated data (1500)	Modelled data scenario 1 by increase in supply (%)	Modelled data scenario 2 by higher increase in supply (%)
MES	-	1500	100	100
Demand unit for ES	19	300	20	200
Supply unit for ES	13	180	20	100
Stock of ES	44	1500	100	100

The value of ES shares be not able determined since it is determined over a period of time without knowing the initial value (Liu et al., 2022). However, we found the value of 1500 to be a sufficient measure for empirical studies of value changes. The ES space supply units are listed as 180 with a value of 1500 which corresponds to the maximum amount of ES that can be provided when the ES space requires closed units with a value of 300. The "MES" area is the ES stock logic. It may be "market or other place" considering that it is a myth. This points that ES supply must come from one place and ES demand must come from another place (natural or market) motivated and determined by actions (things). This alteration also demonstrates the activity's capture rate in the Petri net, although it can solely be displayed in the backdrop while simulating the model. It includes events related to the potential supply and demand of some ES products. Data generated by multiple supply and demand ratios are fed into ES in various variables. Weights are then determined on the edges (arrows) and applied to the signal flow (color set amplitude) where the messenger is evaluated according to the chosen motor rule (TRUE-flow or FALSE-no flow) (Prilandita et al., 2016). Simulation results are generated based on an optimization step to remove lines in the matrix of events and probabilities according to Gillespie processing (stochastic simulation in Snoopy software). This is used to create a simulation counter where 100 or more runs can be made for each level (sector). For a fixed system, the matrix "Ax = b", where "A" is the indicator matrix (Ai), "x" is the vector (p1, p2, p3, p4) and "b" is the result. vector. The lines (b1, b2, b3, b4) on the page are found by Gaussian elimination. If we assume that the random probability function (Gillespie) is assigned to the transmission level T (t1, t2, ..., t8), ώ:

$$\omega A_i x = b \tag{4a}$$

$$\omega \begin{pmatrix} 0\ 0\ -1\ 1 \\ 0\ 0-1\ 1 \\ 1\ 0-1\ 0 \\ 1\ 0-1\ 0 \\ -1\ 0\ 0\ 1 \\ -1\ 0\ 0\ 1 \\ 0-1\ 1\ 0 \\ 0\ 1\ 0-1 \end{pmatrix} (p1\ p2\ p3\ p4) = (b1b2b3b4) \tag{4b}$$

$$\omega \begin{pmatrix} 0\ 0\ -1\ 1 \\ 0\ 0-1\ 1 \\ 1\ 0-1\ 0 \\ 1\ 0-1\ 0 \\ -1\ 0\ 0\ 1 \\ -1\ 0\ 0\ 1 \\ 0-1\ 1\ 0 \\ 0\ 1\ 0-1 \end{pmatrix} (1500\ 300\ 180\ 1500) = (b1b2b3b4) \tag{4c}$$

The total initial value data for the vector "x" represents the number of tokens in the corresponding area in the Petri grid. After assuming v (Snoopy in build) as the conversion rate, all initial set steps are utilized to conduct 100 simulations in order to obtain "b". "B" refers to the solution simulation in MES (b1), the demand unit for ES (b2), the supply unit for ES (b3), and the Stock of ES (b4) using Petri net. Table 4 presents a summary of the simulation results, specifically focusing on b2, b3, and b4, as they are the only ones of interest. These results are based on ES data obtained from UNESCO's Golestan biosphere reserve.

Table 4: Summary of simulation results using ES data from the UNESCO Golestan biosphere reserve

Simulation counts	Demand unit for ES	Supply unit for ES	Stock for ES
0	302	179	1505
1	419	105	1393
2	650	69	1061
3	843	86	759
4	1039	52	487
5	1114	78	314
. . .	. . .	. . .	. . .
10	1021	67	52
15	576	51	46
. . .	. . .	. . .	. . .
100	72	30	49

It offers an overview of the outcomes produced. Initially, it encompasses the initial stage (0), followed by the initial five simulation calculations, then ten, fifteen, and one hundred calculations of the necessary ES unit, the ES supply unit, and the ES stock. However, the outcomes are graphed for the fifth comparison to illustrate the ES behavior in UNESCO's Golestan biosphere reserve BRS. Figure 6 describes the simulation results of the network learning process of ES in Golestan biosphere reserve of UNESCO. The average cumulative value of ES is on the y-axis, while the statistical comparison reading is on the x-axis which is considered as the monitoring period during the long period of ES in the UNESCO Golestan biosphere reserve.

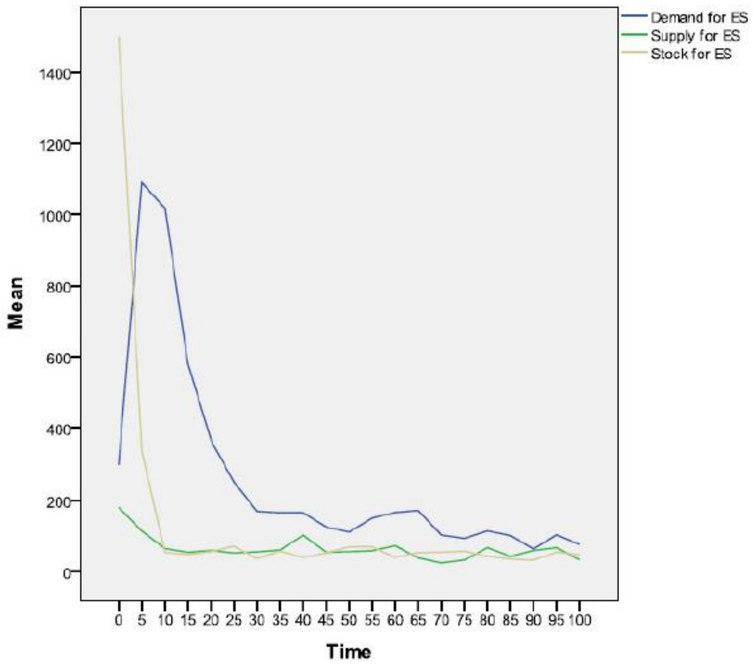

Figure 6: Trend of ecosystem services at the UNESCO Golestan biosphere reserve

This depicts that the capacity of the very suitable ES stock in the area considered in the data will decrease significantly if the requirement for ES increases overly, while the supply does not have the appropriate capacity (deficit balance). If the demand for ES increases rapidly to near ideal capacity, it will decrease rapidly as there is no relevant supply replenishment left without relevant capacity during the trend (Bruno et al., 2023). Consequently, the high ES stock will rapidly drop to its inappropriate capacity and remain at that level throughout the trend. The reduced demand for ES will also reach inappropriate capacity (Rey-Valette et al., 2024). As a result, all of them will remain without relevant capacity during other trends. This indicates a typical scenario trend for a high level of landscape degradation, which poses a significant vulnerability to the people in the area. It could serve as an early warning sign for the necessity of implementing ES mitigation, rehabilitation, and restoration measures in the Golestan UNESCO biosphere reserve. Therefore, alternative scenarios are being modeled to examine different variables that can be targeted to assess the potential for achieving environmental improvement and sustainability.

Input variables data are transformed into the generated Petri net (Table 3) to determine the actual conditions for environmental improvement (data mining). Figure 7 illustrates the pattern in the ES management model, indicating a marginal rise in the allocation of ES from a negligible level of capacity (experiencing a minimal increase in efficiency capacity- use: modelled data scenario 1 by increase in supply). The y-axis and x-axis retain the same meaning as depicted in Figure 6. Consequently, it can be inferred that the trend of ES shares closely aligns with the official outcomes.

Although. EC requirement is slightly higher than the corresponding higher capacity, the excess supply is falling more than the official result, and again much faster. Their supply capacity is not important for satisfying the demand for products and services, which behave more like official results. ES supply was further studied by increasing it to a level equal to the high estimated ES supply (test: model data scenario 2 with high supply increase). In Figure 8, a common pattern is depicted where the power supply gradually rises from a state with no connected capacitance to a significantly higher level of connected capacitance. The accompanying Figure 6 illustrates the y-axis and x-axis. This suggests that very high EC supply capacity is quickly reverting to a lack of relevant capacity, while EC stocks are growing rapidly. But it will also come back strong in any relevant capacity. ES demand will increase beyond the corresponding very high capacity due to excess supply due to high demand.

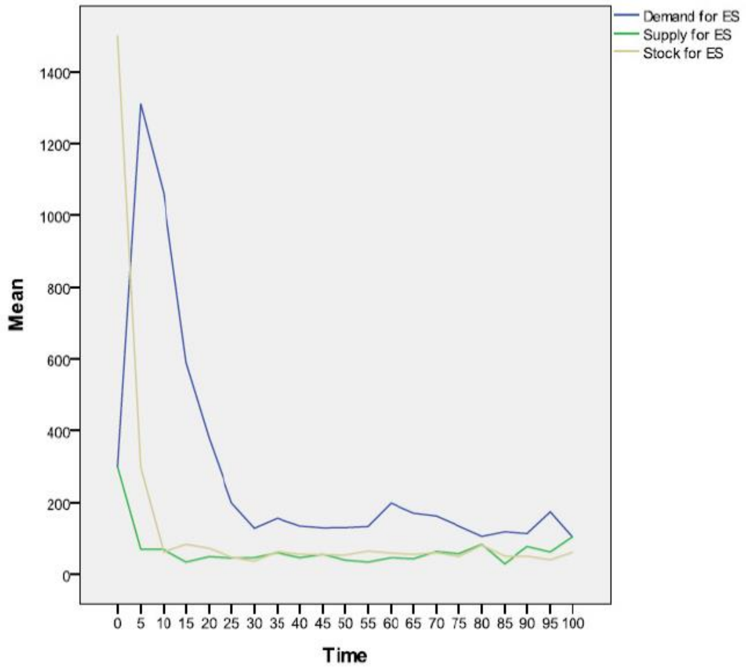

Figure 7: The modelling trend of ecosystem services with slight increase in supply

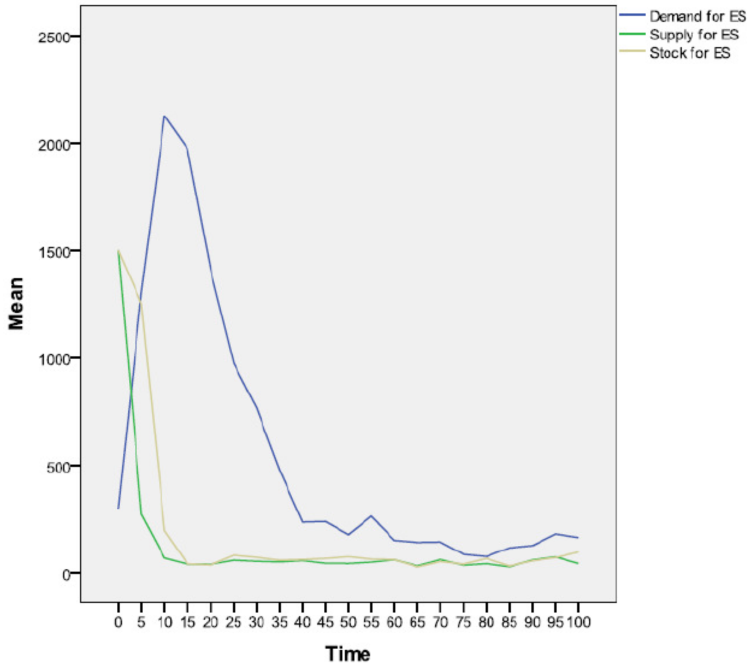

Figure 8: The modelling trend of ecosystem services based on a higher supply level

It subsequently swiftly reverts to a suitable energy and in nearly all circumstances, it consistently maintains that level due to the absence of any response from its source to replenish it. This indicates that measures to improve the environment by increasing food production will not have a significant impact. But it is not reasonable to model the demand for ES because the relationships between them are interconnected, so the supply and demand for ES are determined by the actions of many actors who use their values in the variables. This was to analyze, based on the sample, whether control for various factors could have influenced the results. The buying and selling values of ES are then multiplied by a factor of 100. Figure 9 shows the proposed scenario of ES with a marginal increase in the value of several actors' activities to produce/demand ES from the lower level. The y-axis and x-axis both exhibit a minimal amplitude impact, which is equivalent to what is illustrated in Figure 6. This signifies a noteworthy alteration in ES reserves and ES production, both of which are currently operating at their standard capacity and well surpassing it.

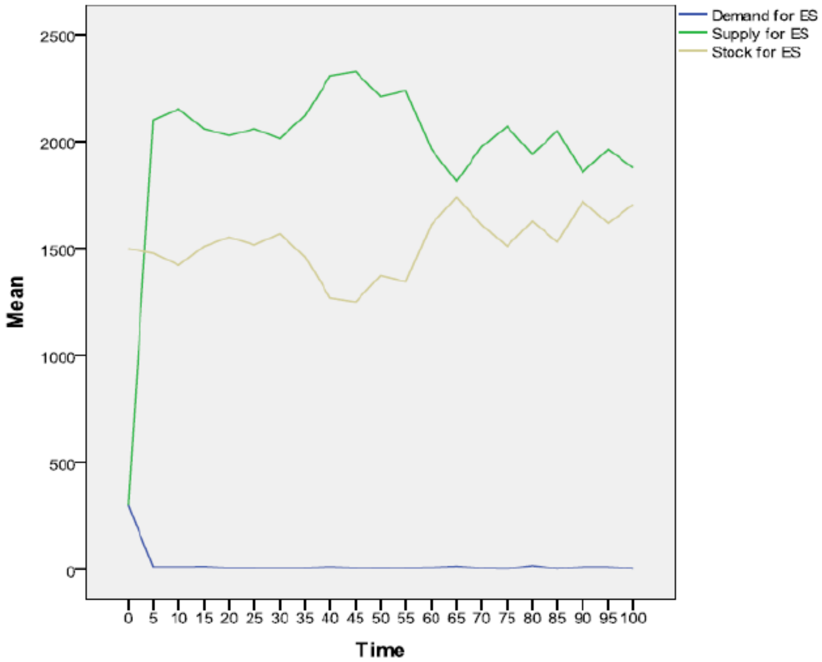

Figure 9: The actions of multiple actors reveal the trend of ecosystem services

This implies that as the activities of different actors in relation to the supply or demand rate of the ES in the Petri net change, the value also changes. Consequently, the supply of the ES experiences a rapid and significant increase, reaching a remarkably high available capacity. This means that the amplitude of the ES will increase from the corresponding very low amplitude to a level much higher than the corresponding very high amplitude. Nevertheless, the ES stocks will surge in reaction to an exceedingly abundant ES supply and persist at comparable elevated levels for the duration of the prevailing trend. Nonetheless, the ES supply will revert back to its corresponding average capacity and endure within the range of medium to high capacities.

However, the demand for ES experiences an abrupt decrease from extremely low power to an adequate power level, and subsequently remains consistent throughout the entire process. It can be explained like this; If environmental improvement occurs, most participants have little or no related opportunities due to simple landscape concerns. This points that water, soil, and the surface conditions are good as a result of the implementation of good conservation measures and the positive response of many stakeholders. Hence, it is imperative to develop a simulation model that can offer a cooperative strategy for multi-player markets, aiding the EU in attaining environmental enhancement scenarios. Developing, maintaining, and sustaining the EU through market-based strategies are approaches to attain such a favorable circumstance. Business development is to create a business platform for potential demand and supply to support the MES, strengthen monitoring and analysis (Prilandita et al., 2017). The MES is already in place, along with other new and innovative elements that can be added to the EU conservation and landscape management plan for the Golestan region. Therefore, a simulation model is used to manage the MES in a landscape created in the UNESCO Golestan biosphere reserve.

The estimated value of ES in Golestan UNESCO biosphere reserve was not used as ES stock value in the comparison to estimate ES (Table 3), which was 45% (675 when converted to 1500). The data entered in the model was considered only for one event (period from 03 September 2023 to 29 November 2023). This transition period before reaching the value of ES cannot be treated as zero, but the evaluated value of ES can increase or decrease. Therefore, in order to estimate the long-term performance of ES and other investment strategies (Table 3-4), the highest value of the ES 1500 stock (the top three) was calculated. The estimation was also conducted for the potential factors that could contribute to the demand and supply of ES during a specific time (change event). So, the characteristic is valid only for the monitoring event, which is used to follow the ES process for a long period of time in order to understand its changes. In ES ecological systems, there are also intersections, where activities affecting ES density or their ES benefits (values) may not be immediately apparent. This is due to problems that can only be understood through observational studies and long-term observational studies. Only demand and supply-based activities can be found in the landscape of Golestan UNESCO biosphere reserve.

The number of tasks (multitasking) requiring ES was similar to the number of tasks provided, but there was a disparity in the rates (Table 2). The findings (Figures 5-8) of ES using the specific conditions of ES

(Figures 2-4) and their measurements can provide important information that methods of keeping ES should not rely on increasing ES. This can be rationalized by the similar findings of a slight increase in the value of ES in the upper part (Figure 7) and in the upper part (Figure 8). There has been no notable alteration in the pertinent outcomes as previously observed (Figure 6). But with the increase in supply and demand and service-based services (Figure 9), a significant increase in supply and demand for natural products and services is observed. Despite the decline in demand for ES or the absence of any notable alteration. This makes sense because as the supply of EC increases, so does the supply of EC. However, the importance of ECs should be underestimated because of the small tasks that ECs have to perform in the development of the environment. Therefore, management strategies for balancing ES at the landscape should implement control measures to impact on multi-action-oriented activities by multi-actors.

IV. CONCLUSION

The results of this study, especially regarding the Golestan biosphere reserve, which includes UNESCO, can be cited, that the establishment of UNESCO protected areas should not be the only way to fight against the destruction of the earth. This is because the regenerative power of ES watersheds is weak. For example, if natural conditions such as climate change (heavy rain or drought) threaten, the level of destruction will increase and become dangerous for people. Therefore, mitigation strategies such as restoring or rehabilitating degraded areas should be the first step. Then use conservation measures to promote ecosystem sustainability.

REFERENCES

[1]. Anbleyth-Evans, J., Lacy, S. N., Aguirre-Muñoz, C., & Tredinnick-Rowe, J. (2020). Port dumping and participation in England: Developing an ecosystem approach through local ecological knowledge.

[2]. Arenas-Wong, R. A., Robles-Morúa, A., Bojórquez, A., Martínez-Yrízar, A., Yépez, E. A., & Álvarez-Yépiz, J. C. (2023). Climate-induced changes to provisioning ecosystem services in rural socioecosystems in Mexico. Weather and Climate Extremes, 100583.

[3]. Arkema, K. K., Cunningham, S. K., Delevaux, J. M., Celina, B. G., Klain, S., Lamb, J. B., ... & Sutton-Grier, A. (2024). Beneficiaries, Equity, and Trade-Offs in Estuarine and Coastal Ecosystem Services.

[4]. Berry, Z. C., Jones, K. W., Aguilar, L. R. G., Congalton, R. G., Holwerda, F., Kolka, R., ... & Asbjornsen, H. (2020). Evaluating ecosystem service trade-offs along a land-use intensification gradient in central Veracruz, Mexico. Ecosystem Services, 45, 101181.

[5]. Bruno, E., Falco, E., Shahab, S., & Geneletti, D. (2023). Integrating ecosystem services in transfer of development rights: a literature review. Land Use Policy, 131, 106694.

[6]. Byeon, H., Thingom, C., Keshta, I., Soni, M., Hannan, S. A., & Surbakti, H. (2023). A logic Petri net model for dynamic multi-agent game decision-making. Decision Analytics Journal, 9, 100320.

[7]. Del Rossi, G., Hecht, J. S., & Zia, A. (2021). A mixed-methods analysis for improving farmer participation in agri-environmental payments for ecosystem services in Vermont, USA. Ecosystem Services, 47, 101223.

[8]. D'Ottavio, P., Francioni, M., Trozzo, L., Sedic, E., Budimir, K., Avanzolini, P., ... & Toderi, M. (2016). Methods and approaches used for assessing ecosystem services provided by grazing systems. OPTIONS, 51.

[9]. Feio, M. J., Ranta, E., & Odume, O. N. (2021). Contribution of Citizens to Preserving Local Freshwater Ecosystems. In Clean Water and Sanitation (pp. 1-11). Cham: Springer International Publishing.

[10]. Flood, K., Mahon, M., & McDonagh, J. (2024). A process perspective of conceptual innovation: Integrating equity in applications of the ecosystem services concept in Ireland. Ecosystem Services, 65, 101582.

[11]. Guan, Y., Bai, J., Tian, X., Wang, X., Wang, C., Zhang, Y., ... & Liu, G. (2022). Social network analysis and application for ecosystem service perceptions by stakeholders for coastal wetland conservation. Journal of Cleaner Production, 371, 133596.

[12]. Hassen, A., Zander, K. K., Manes, S., & Meragiaw, M. (2023). Local People's perception of forest ecosystem services, traditional conservation, and management approaches in North Wollo, Ethiopia. Journal of Environmental Management, 330, 117118.

[13]. Imdad, K., Sahana, M., Ravetz, J., Areendran, G., Gautam, O., Dwivedi, S., ... & Sajjad, H. (2023). A sustainable solution to manage ecosystem health of wetlands in urban and peri-urban areas of Lucknow district, India using geospatial techniques and community based pragmatic approach. Journal of Cleaner Production, 414, 137646.

[14]. Jayalath, T. A., Grala, R. K., Grado, S. C., & Evans, D. L. (2021). Increasing provision of ecosystem services through participation in a conservation program. Ecosystem Services, 50, 101303.

[15]. Liu, X., Zhao, M., Wei, Z., & Lu, M. (2022). The energy management and economic optimization scheduling of microgrid based on Colored Petri net and Quantum-PSO algorithm. Sustainable Energy Technologies and Assessments, 53, 102670.

[16]. Obeng, E. A., Oduro, K. A., Obiri, B. D., Abukari, H., Guuroh, R. T., Djagbletey, G. D., ... & Appiah, M. (2019). Impact of illegal mining activities on forest ecosystem services: local communities' attitudes and willingness to participate in restoration activities in Ghana. Heliyon, 5(10).

[17]. Ochieng, C. N., Thenya, T., Mwaura, F., & Owuor, M. A. (2024). Awareness and perceptions of coral reef ecosystem use and management in 'pseudo community'and government-managed marine protected areas in Kwale county, Kenya. Ocean & Coastal Management, 248, 106949.

[18]. Page, G., & Bellotti, B. (2015). Farmers value on-farm ecosystem services as important, but what are the impediments to participation in PES schemes?. Science of the total environment, 515, 12-19.

[19]. Palsaniya, D. R., Kumar, S., Das, M. M., Kumar, T. K., Chaudhary, M., Chand, K., ... & Sahay, C. S. (2022). Ecosystem services from smallholder dairy based integrated farming system vis-a-vis double cropping. Agroecology and Sustainable Food Systems, 46(10), 1456-1481.

[20]. Pérez-Sánchez, D., Montes, M., Cardona-Almeida, C., Vargas-Marín, L. A., Enríquez-Acevedo, T., & Suarez, A. (2021). Keeping people in the loop: Socioeconomic valuation of dry forest ecosystem services in the Colombian Caribbean region. Journal of Arid Environments, 188, 104446.

[21]. Prilandita, N., McLellan, B., & Tezuka, T. (2016). Modeling Autonomous Decision-Making on Energy and Environmental Management Using Petri-Net: The Case Study of a Community in Bandung, Indonesia. Challenges, 7(1), 9.

[22]. Prilandita, N., McLellan, B., & Tezuka, T. (2017). Evaluation method for autonomous decision-making performance in energy and environmental innovations: A case study of an Indonesian community. Sustainability, 9(1), 80.
[23]. Pynegar, E. L., Jones, J. P., Gibbons, J. M., & Asquith, N. M. (2018). The effectiveness of payments for ecosystem services at delivering improvements in water quality: Lessons for experiments at the landscape scale. PeerJ, 6, e5753.
[24]. Rey-Valette, H., Salles, J. M., & Blayac, T. (2024). Perceptions of ecosystem services and bonds with nature: the case of fish-farming ponds in France. Ecological Economics, 217, 108049.
[25]. Rova, S., Meire, P., Müller, F., Simeoni, M., & Pranovi, F. (2019). A Petri net modeling approach to explore the temporal dynamics of the provision of multiple ecosystem services. Science of the total environment, 655, 1047-1061.
[26]. Rova, S., Stocco, A., & Pranovi, F. (2023). Sustainability threshold for multiple ecosystem services in the Venice lagoon, Italy. Ecosystem Services, 64, 101568.
[27]. Sangha, K. K., Ahammad, R., Russell-Smith, J., & Costanza, R. (2024). Payments for Ecosystem Services opportunities for emerging Nature-based Solutions: Integrating Indigenous perspectives from Australia. Ecosystem Services, 66, 101600.
[28]. Stamatiadou, V., Mazaris, A., Mallios, Z., & Katsanevakis, S. (2023). Valuation and mapping of the recreational diving ecosystem service of the Aegean Sea. Ecosystem Services, 64, 101569.
[29]. Sultana, R., Irfanullah, H. M., Selim, S. A., & Budrudzaman, M. (2023). Vulnerability and ecosystem-based adaptation in the farming communities of droughtprone Northwest Bangladesh. Environmental Challenges, 11, 100707.
[30]. Tebboth, M. G. L., Few, R., Assen, M., & Degefu, M. A. (2020). Valuing local perspectives on invasive species management: Moving beyond the ecosystem service-disservice dichotomy. Ecosystem services, 42, 101068.
[31]. Van der Biest, K., Meire, P., Schellekens, T., D'hondt, B., Bonte, D., Vanagt, T., & Ysebaert, T. (2020). Aligning biodiversity conservation and ecosystem services in spatial planning: Focus on ecosystem processes. Science of the Total Environment, 712, 136350.
[32]. Zarandian, A., Baral, H., Stork, N. E., Ling, M. A., Yavari, A. R., Jafari, H. R., & Amirnejad, H. (2017). Modeling of ecosystem services informs spatial planning in lands adjacent to the Sarvelat and Javaherdasht protected area in northern Iran. Land Use Policy, 61, 487-500.