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MAPPING AND VALUATION OF BLUE ECOSYSTEM SERVICE IN AN URBAN AREA: A CASE STUDY ON WARD 30 IN KHULNA CITY, BANGLADESH

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ABSTRACT

Cities are getting increasingly dependent on the ecosystem servicers that generate both within and outside the city limit. While the city dwellers enjoys numerous benefits from ecosystem services, particularly from blue ecosystem services, they also cause degradation of these services in several ways. Therefore, the flows of a particular ecosystem services in a city is dynamic, and ofnine follow a particular trend. Knowing this dynamical nature of flows of an ecosystem service is a prerequisite to assess the benefit and the value of such benefits derived from healthy ecosystem. The paper is first, aimed to map out the blue ecosystem services available in a ward of Khulna city. Second it assesed the benefits that the local residents derive from these blue ecosystem components. Finally, some policy suggestions are given to conserve the ecosystems for ensuring sustained flow of ecosystem services in the study area of Khulna city. The study was conducted through the following steps. First all the blue ecosystem components located in the study site of the city is mapped out in GIS environment from Satellite images.The ecosystem service types, and the number of population using them and other attribute data will be collected from both field survey and secondary sources. These attribute data is linked to spatial data (ecosystem flow) in a GIS environment to assess the service areas and to quantify the value of such services. The research is underway and it is expected that the research outcome would help designing a strategy to enhance the local residents' access to sustained flow of ecosystem services.

Keywords: *Ecosystem; Blue ecosystem services; Urban ecology; Khulna city*

1. INTRODUCTION

An aquatic ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems. (Alexander,1999). Ecosystem services are defined as the benefits that people obtain from ecosystems (MEA, 2005), and the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010).The concept of ecosystem services is relevant for connecting people to nature. It makes visible the key role of ecosystem functioning and biodiversity to support multiple benefits to humans. Understanding the linkages between the natural and socio-economic systems can lead to improved and more sustain-able management of ecosystems (Guerry et al., 2015).

In the coming decades population growth and changes in diet will increase the global food demand and consequently the water demand for agricultural production (Devi et al., 2014). Water, food and energy are at the core of human needs and there is a boundless complex cycle among these three elements which has been recently referred to as the water–food–energy nexus (Zhang, 2002) To produce food, water and energy are needed; while to produce energy, water is required; and to access water, energy is almost always needed (i.e. to run pumps). Due to the complexity of relationships among these three elements, there is a need for them to be considered simultaneously. According to (Costanza, 2014) ecosystem services contribute at least 125–145 trillion US $ per year to the global economy and to the livelihood of more than a billion poor people in the world. Due to the value of ecosystem services to humans, governments around the world are beginning to recognize the importance of investing in safeguarding ecosystems as opposed to industrialized solutions to their problems.

The paper is first, aimed to map out the blue ecosystem services available in a ward of Khulna city. Second it will assess the benefits that the local residents derive from these blue ecosystem components. Finally, it will put some policy suggestions to conserve the ecosystems for ensuring sustained flow of ecosystem services in the study area of Khulna city. Develop a practical methodology for assessing and valuing ecosystem services relevant for water resource management, considering the links between pressures, ecological status and ecosystem services.

Major limitations of this research are the blue ecosystems (water body) having the area greater than 0.0024 square km only considered for the research, for calculating Habitat Suitability Index only 9 variables were taken and as it is a preliminary research only two blue ecosystem services were analyzed.

The paper is structured as follows. The first part describes the methodological approach adopted in the study. The second part presents the results of our analysis in the form of a practical approach for assessing and valuing ecosystem services relevant for water resource. The third part discusses the challenges in valuing ecosystem services and integrating biophysical and economic assessments.

2. THEORETICAL FRAMEWORK

An ecosystem is defined as a structural and functional unit of biosphere consisting of community of living beings and physical environment, both interacting and exchanging materials between them. Ecosystem is a self-contained, dynamic system composed of a natural community along with its physical environment. It is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. An ecosystem is also defined as a functional and structural unit of Ecology (Priscila et al.) This implies that each ecosystem has a definite structure and components and that each component part of the system has a definite role to play in the functioning of the ecosystem (Devi et al., 2014). Ecosystems have two 'parts': The living (**Biotic**) components like plants and animals; and the nonliving (**Abiotic**) components like water, air, nutrients and solar energy. These two parts of the ecosystem do not stand in isolation, rather they continuously interact with one another. In fact, they are so closely linked to each.

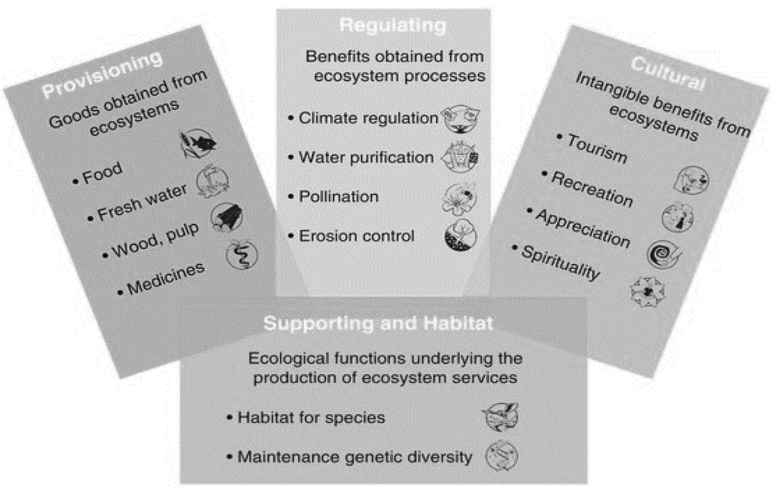

Figure 1: Classification of ecosystem services, The Economics of Ecosystem and Biodiversity (TEEB)

2.1 Ecosystem Service Values:

Valuation of ecosystem services involves dealing with multiple, and ofnine conflicting value dimensions (Oldham, 2000). In this section, we broaden the traditional focus of the ecosystem services literature on biophysical measurement and monetary values to explore a range of value domains, including biophysical, monetary, socio-cultural, health, and insurance values, and discuss concepts and methods through which they may be measured and captured.

2.2 Habitat Suitability Index (HSI) for fishes:

HSI scoring systems were originally developed by the US Fish and Wildlife Service as a means of evaluating habitat quality and quantity. An HSI is a numerical index, between 0 and 1. 0 indicates unsuitable habitat, 1 represents optimal habitat.HSI evaluates (pond) habitat quality. (Oldham, 2000).

How to collect data and calculate HIS

The HSI is a geometric mean of nine suitability indices:

HSI = (SI1 x SI2 x SI3 x SI4 x SI5 x SI6 x SI7 x SI8 x SI9 x SI10) ^1/9

- The nine Suitability Indices are scored for a pond, in the field and from map work.
- The nine field scores are then converted to SI scores, on a scale from 0.01 to 1 (0.01 is used as the bottom end of the range instead of 0, because multiplying by 0 reduces all other SI scores to 0).
- The nine SI scores are then multiplied together.
- The ninth root of this number is then calculated (X)ˆ1/9 the calculated HSI for a pond should score between 0 and 1.

HSI	Pond suitability
<0.5	Poor
0.5- 0.59	Below average
0.6- 0.69	Average
0.7- 0.79	Good
>0.8	Excellent

Suitable Criteria:

a)Geographic Location (SI-1)
b) Pond Area (SI-2)
c)Pond Drying (SI-3)

Field score	SI	Criteria
Never	0.9	Never dries
Rarely	1	Dries no more than two years in nine or only in drought
Sometimes	0.5	Dries between three years in nine to most years
Annually	0.1	Dries annually

d) Water Quality (SI-4)

Category	SI	Criteria
Good	1.0	Abundant & diverse communities Netting = diverse inverts including may fly larvae & water shrimps
Moderate	0.67	Moderate invert diversity
Poor	0.33	Low invert diversity (e.g. Species such as midge and mosquito larvae), few submerged plants
Bad	0.01	Clearly polluted, only pollution tolerant species (rat-tailed maggots), no submerged plants

e)Water Depth (SI-5)

Category	SI	Criteria
Good	1.0	More depth (more than 3 m)
Moderate	0.67	Moderate depth (2-3 m)
Poor	0.33	Low depth (about 1 m)

f) Phytoplankton (SI 6)

Category	SI
Adequate	1
Possible	0.67
Minor	0.33

g) Waste dumping (SI 7)

Category	SI
Absent	1
Possible	0.67
Minor	0.33
Major	0.01

h) Adjacent ground cover (SI 8)

Category	SI
Adequate	1
Minor	0.50
Absent	0.01

i) Presence of water hyacinths (SI 9)

Category	SI
Adequate	0.01
Minor	0.33
Absent	1

3. STUDY AREA AND METHODOLOGY

3.1 Study Area

The geographic area of Khulna city is bounded by Jessore, Narail districts to the north, The Bay of Bengal to the south, Bagerhat district to the east, Satkhira district to the west. Total area is 4394.45 Sq Km. There are 31 wards in Khulna city corporation. The selected study area is ward 30 (Figure 2) that it has a population of 18719 male and 17108 female where the literacy rate is 74.2% . It is in 24.47'N and 89.35'E. There is a salient feature of the study area that Rupsha river flows beside the ward and a huge number of water body also available there.

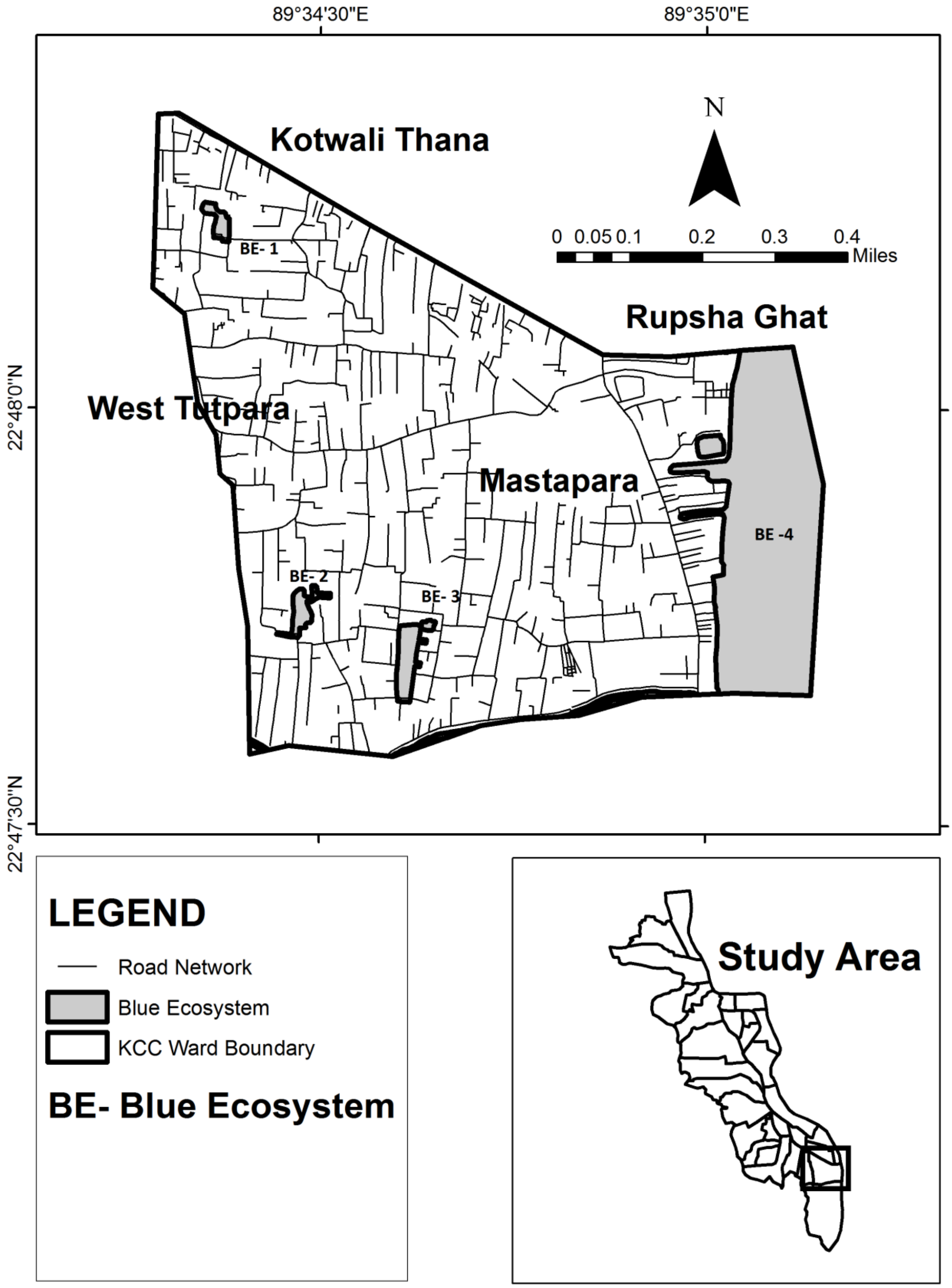

Figure 2: Ward 30 (Study Area), Author 2017

3.2 Methods

After the fixation of the study area, preliminary data was collected through the desktop research and reconnaissance survey were done. Then conceptualization of the problem completed by reviewing a huge number of literature about the blue ecosystem and the valuation. Questionnaire survey was done for finding the user's perception and the relationship between the variables. Collected data was inputted in SPSS, Excel and GIS specially used here to analyze the problem. Statistical analysis, satisfactory level analysis and Habitat Suitability index were the focused issue in this research. Habitat suitability index was analyzed for assessing the habitability condition of fishes in the ponds of Ward 30. Satisfaction level also identified through these analyses. The results of the analysis were interpreted and at last some findings were mentioned on the basis of the overall analysis. Index is analyzed for certain service such pond which is given below: Evaluates (pond) habitat quality. Factors are scored for the pond convert to SI scores ranging from 0.01- 1. The calculated habitat suitability index should be between 1 and close to 0.

Table 1: Habitat Suitability Index

HSI	**Pond Suitability**
<0.5	Poor
0.5- 0.59	Below average
0.6- 0.69	Average
0.7- 0.79	Good
>0.8	Excellent

On the basis of the findings and the present condition of the low-income people and the impacts of the various issues of ecosystem services and disservices of the study area, some recommendations were provided. The recommendations were provided in such a way that they may help to improve the ecosystem services and reduce the ecosystem disservices.

4. PRELIMINARY FINDINGS

4.1 Basic information

There are different types of people for maintain the ecological balance. Among them maximum people have only Secondary education and their family member also large. The demographic table also shows the composition of the population structure.

Table 2: Demographic information

		Family member			**Total**
		2	**3-5**	**>5**	
Education	Illiterate	0	2	0	2
	Primary	0	2	0	2
	Secondary	3	8	2	13
	Higher Secondary	0	4	0	4
	Degree and Above	0	2	0	2
	Technical Education	0	2	0	2

(Field Survey, 2017)

Table 3 shows the dependency relationship among the different ecosystem services in the locality. Blue ecosystem services mainly served as supporting and provisioning services which is shown in the table that the Sig. value between them is quite satisfactory than others.

Table 3: Sig. value of different types of services

	Cultural	**Provisioning**	**Supporting**	**Regulating**
Cultural	1	.220	.728	.599
Provisioning	.220	1	.019	.226
Supporting	.728	.019	1	.381
Regulating	.599	.226	.381	1

(Field Survey, 2017)

4.2 Social Value

In the locality people satisfaction level was judged by the survey and the result shown in figure 2 that about 39% food is generated from the blue ecosystem services. People really relied on this part of service facility and the willingness to pay for protecting this service is very high than other services. The social value of the service is measure from the checklist which shows that the value of the blue ecosystem is higher than the other parts.

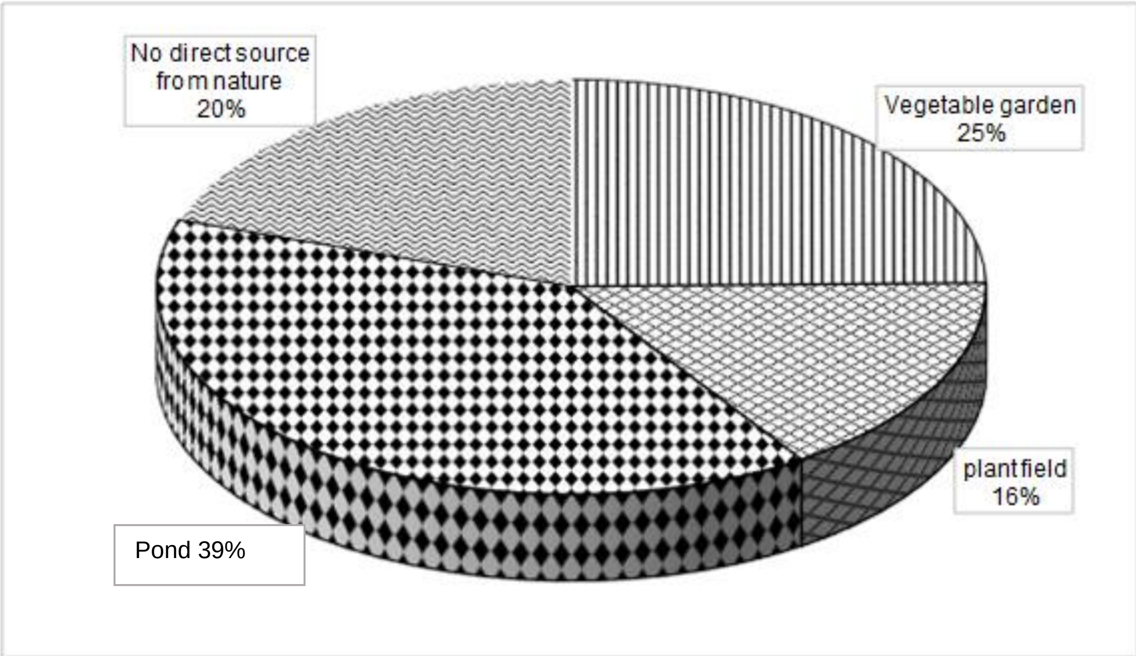

Figure 3: Direct source of food from nature (Field Survey, 2017)

From the survey data it was observed (Figure 3) that there exists 8 ponds in Ward 30 and the linear regression equation about the different ecosystem services is **$y = -1.2x + 6$ and $R^2 = 0.3495$**. The result indicates that there is no well-balanced combination among the ecosystem services. The model is moderately acceptable.

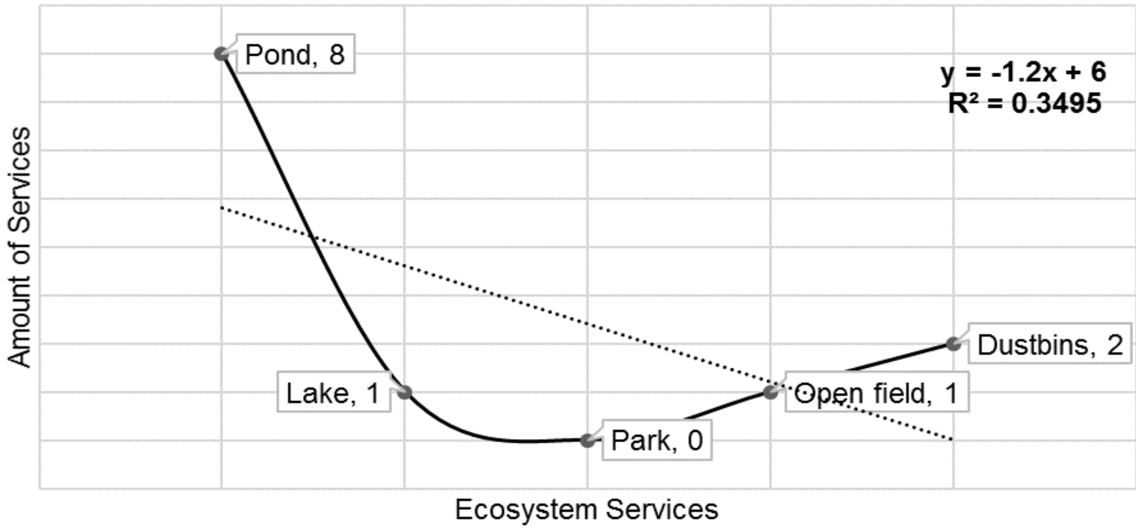

Figure 4: Different Ecosystem services of study area (Field Survey, 2017)

4.3 Habitat Suitability Index

Blue Ecosystem - 1

Location:
Latitude:22°48'15.1"N
Longitude: 89°33'40.5"E

Criteria	SI
a) Geographic Location (SI-1)	0.8
b) Pond Area (SI-2)	0.8
c) Pond Drying (SI-3)	0.5
d) Water Quality (SI-4)	0.33
e) Water Depth (SI-5)	0.33
f) Phytoplankton (SI- 6)	0.67
g) Waste dumping (SI- 7)	0.01
h) Adjacent ground cover (SI- 8)	0.50
i) Presence of water hyacinths (SI- 9)	0.01

(Author, 2017)

HSI = [1.167*10^ (-6)] ^ (1/19)
=**0.22**

As, Habitat Suitability Indices (HSI) value is less than 0.5, this pond is unsuitable for fishes and it has poor condition.

Blue Ecosystem - 2

Location:
Latitude:22°47'04.1"N
Longitude: 89°34'00.3"E

Criteria	SI
a) Geographic Location (SI-1)	0.9
b) Pond Area (SI-2)	0.9
c) Pond Drying (SI-3)	0.9
d) Water Quality (SI-4)	0.67
e) Water Depth (SI-5)	0.67
f) Phytoplankton (SI 6)	1

g) Waste dumping (SI 7)	1
h) Adjacent ground cover (SI 8)	0.50
i) Presence of water hyacinths (SI 9)	0.33

(Author, 2017)

HSI = 0.054^ (1/9) = **0.72** As, Habitat Suitability Indices (HSI) value ranges from (0.70-0.79), this pond is suitable for fishes.

5. CONCLUSIONS

Blue Ecosystems and the services they deliver underpin and enable our exisninece. For producing food, regulating water supplies and climate, and breaking down waste products ecosystem is very essential. We also value them in less obvious ways: contact with nature gives pleasure, provides recreation, has aesthetic appeal and is known to have a positive impact on long term health and happiness.

From the study, it has been found that 39% food is generated from the blue ecosystem services in ward 30 so that people are greatly depends on it. Here the value of R^2 is 0.3495. The result indicates that there is no well-balanced combination among the ecosystem services as the value of R^2 is very higher than .005 at 5% sig. level. From the suitability index it can be said that the living condition of fishes may certainly depends on 9 criterias. The value of the first BE shows that it is 0.22 and it stands for unsuitable situation where it puts negative impact on environment. Second observation may describe it is good for the fishes. So, this procedure may apply for further research to know the scenerio of blue ecosystem services and the consequences.

Now it is important to think about why they are important in terms of governance and policy making. European and international state governments and organizations have recognized that economic value can be gained by including ecosystem service assessment in policies and decision making. By understanding these considerations from the start, it is possible to avoid significant costs and risks to policy objectives, and help to increase long–term resilience of policies. Also, to reduce risks to our policy objectives from failing natural systems and to reduce public costs from degraded natural services.

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