Protection of Urban Poor from Ecosystem Disservices for Attaining Sustainable Development Goals: Status and Determinants in a Coastal Metropolis in Bangladesh†

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1. Introduction

This paper has twofold objective. First to examine how the urban poor are affected by various ecosystem services and disservices and second to identify the factors that determine the urban poor's adoption of ecosystem services and disservices in a coastal metropolis in Bangladesh. Ecosystem provides varieties of services and disservices. The Millennium Ecosystem Assessment (MEA) report identified four broad categories of ecosystem services. These are provisioning, regulating, supporting and cultural services (MEA 2005). When these services negatively affect the wellbeing of urban poor they could be termed as disservices. Among these four broad types of ecosystem services provisioning and regulating services are the most services that urban poor count the most for their wellbeing. The services are often categorised as green ecosystem services and blue ecosystem services. Green ecosystem services include green-parks, playgrounds, urban forests, street scape etc. and the blue ecosystem services includes river, canal, water bodies, water front, storm water etc. These ecosystem services and disservices affect the wellbeing of urban poor as the urban poor's livelihood, security, and comfort are largely determined by the functioning of these ecosystem services and disservices.

After the publication of MEA report the need for addressing the urban ecosystem services has been appeared as an important component of liveable city planning and design. Over the decades although enormous growth of literature on ecosystem services are observed yet overwhelming majority of these are written in the rural or regional context. Most of them have exclusive focus on forests or wetland services (Nicholls et al 1999; Faruque and Ali 2005). Only scanty of them are written in the context of urban ecosystem services. Again

those examples are drawn from highly urbanized developed countries. Bangladesh being a poor and low income country, the wellbeing of both urban and rural poor largely depend on the functioning of the ecosystem services and disservices (Adger et al 2003; Saroar and Routray 2010). The coastal metropolis Khulna is located in a unique setting that offer varieties of ecosystem services for its urbanites. Despite increased use of ecosystem services by the urban poor their roles are often unaccounted for. The urban poor make use of many of the ecosystem services for their wellbeing; conversely they try to cope with the disservices to ensure their wellbeing. Although there is general assertion that poor people are benefitted from urban ecosystem services but they are adversely affected by the ecosystem disservices (ADB 2010). Unless we are able to protect the urban poor from the negative impacts of ecosystem disservices the attainment of at least two sustainable development goals (SDGs) would be very difficult. The SDGs that would be hampered due to urban poor's exposure to ecosystem disservices include: healthy lives and well-being (Goal 3) and access to safe water and sanitation (Goal 6). In fact, in the post Paris Agreement the issue of protecting the poor from ecosystem disservices has been appeared as an important consideration if we are to attain SDGs in an inclusive manner. This study in addition to identifying the current status of urban poor of a coastal metropolis in Bangladesh as regards impacts of ecosystem services and disservices, is aimed to identify various factors that determine the urban poor's adoption of ecosystem services and disservices. The findings will have good policy implication as this would help in urban planners, policy makers and the practitioners to determine strategies first to enhance urban poor's access to ecosystem services and the second to protect the urban poor's wellbeing from the adverse effects of ecosystem disservices. Both of these would contribute to the attainment of several goals of SDGs.

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2. Materials and Methods

2.1 Study area, sample and the survey procedures

Coastal metropolis Khulna is located at the south-west edge of Bangladesh. Although Khulna is the third largest Metropolis in Bangladesh after Dhaka, the capital city of Bangladesh, Khulna has been appeared as an expanding metropolis due to increased investment in shrimp farms, processing industries and tourism. In fact over the last two decades or so to support the export oriented shrimp industry more than five hundred processing plants and packaging farms have been developed (Orda 2008). These normally attract poor people from the neighbouring cities and settlements. Especially the coastal people affected by various natural calamities such as cyclones, surges, river erosion, salinity intrusion, coastal flooding often find their ways to coastal metropolis Khulna. Therefore in

Khulna city about 520 slums have been developed within an area of 50 sq km where about one-fifth million people live (Islam et al 2008). Among these slums 10 to 15 slums are very big in size; each accommodates about two thousand families. Rupsha slum located along the river Rupsha is one of the oldest and largest slum in Khulna city. This slum attract the most because of its proximity to shrimp processing farms and its supporting enterprises located along the river Rupsha (Manoj et al. 2012, 2013). Another cause of attraction is its ease of transport and communication. As the study site the Rupsha slum was selected. All the families are included in the sample frame. As the survey instrument mostly a semi-structured questionnaire was used to collect data and information. A total of 215 respondents were selected randomly for taking interview. The survey was conducted during August to September in 2014. Interviews were done through administering Bengali version of semi-structured questionnaires. Three focused group discussions were conducted; these are male group, female group and mixed group. Each group were comprised of 10-12 members.

2.2 Theoretical underpinning of indicators of ecosystem services and disservices

From review of global literature on ecosystem services and disservices, the list of ecosystem services and disservices that fit with the coastal metropolis of Bangladesh are developed considering the coastal urban morphology, hydrology, and other socio-ecological system. The following table presents the list of ecosystem services and disservices that affect the urban poor in Khulna. Although ecosystem services affect the wellbeing in various ways, yet attempt was taken to make a comprehensive list of ecosystem services and disservices that affect urban poor's wellbeing by impacting livelihood, security, and comfort. Respondents were asked to rate each of the services/disservice in a 5-point Likert scale (Very rarely benefited/affected = 1 to Very often benefited/affected = 5).

2.3 Major dimensions of ecosystem services/disservices: A Factor Analysis

For reduction of a large number of variables related to the urban ecosystem services and disservices into a meaningful and manageable category all 25 statements/questions were entered in a factor analysis. Principal component analysis (PCA) method is employed to bring these 25 statements/questions under few factors that construct various major dimensions of utilities that urban poor derive from urban ecosystem service. Following the Kaiser criterion, i.e. only factors/components having Eigenvalue >1, four factors were extracted using varimax rotation. The first factor could be named as livelihood, the second factors could be termed as comfort, the third factor could be termed as health and the fourth factors could be named as recreation. All these four together determine the well-being of

urban poor. Details of the ecosystem services/utilities that are grouped under each of these four major categories are shown in the expanded full paper.

It is to be noted here that as the value of determinant of correlation matrix was found greater than 0, the Kaiser-Meyer-Olkin value for sampling adequacy was 0.82, the Bartlett's test of sphericity was significant at $p<0.0001$ and the average communality was >0.500 the factor analysis is considered statistically valid (Field 2005; George and Mallery 2006, Hair et al. 2006).

2.4 Determination of looser and gainer from ecosystem services and disservices

First, by employing simple arithmetic mean, the mean score of each surveyed household for each of the four dimensions of ecosystem utilities, e.g. livelihood, comfort, health, recreation are computed. Second, based on the sample mean of each ecosystem utility, each surveyed households are classified as either gainer (if scores more than sample mean) or looser (if scores less than or equal to sample mean). In this way the gainer and looser of urban ecosystem services and disservices are identified.

2.5 Characterizing the gainer and the looser from ecosystem services: Application of Logit model

It was hypothesized that various urban morphological, hydrological, ecological, socio-economic, demographic, behavioral, and institutional factors are the determinants whether a family would be gainer or looser from urban ecosystem services or disservices. From literature review about two dozens of such factors are identified and data and information about these variables were collected from the household surveyed. These variables are used as independent variable. As dependent variable each of the three dimensions of urban ecosystem utilities e.g. livelihood, comfort, health and recreation are used in Logit model. Here the Logit model is built because the dependent variables are nominal type. For instance, Gainer vs. Looser from urban ecosystem services and disservices. Four Logit models, one for each of "Livelihood", "Comfort", "Health" and "Recreation" are developed. In the result section the results of the four Logit models are summarized.

Before running the Logit model bivariate correlation is performed and due to strong colinearity ($r > 0.80$) among few independent variables three of them are eventually excluded from the Logit model. Similarly, cross-tabulation for each categorical/binary

independent variable with each of the three dependent variables is performed. The independent variables which have zero count/frequency or count/frequency less than 5 in any cell of cross-table (matrix) were excluded from the model to ensure robustness of the model output. Finally, after running the model, factors that significantly explain the variations in respondent's status (e.g. gainer or looser) as regards derived utilities from urban ecosystem services are identified and their influences are assessed quantitatively. These outputs are analysed to identify policy suggestion for increased adoption of urban ecosystem services by the urban poor in a coastal setting.

3. Result and Discussion

3.1 Gainer and looser from urban ecosystem services and disservices

In the study area greater variability is observed among the respondent as regards their access to ecosystem services and disservices. They make use of various green and blue ecosystem services. Among the green ecosystem services most respondents get benefit from urban green parks, play rounds, street scape and urban forests. The benefit that they derive from these green ecosystem services includes fresh air, shedding, natural cooling, biomass fuel, earning wage etc. Among the blue ecosystem services, most commonly used are river, canal, water bodies, (artificial) water front etc. Although many of these blue ecosystem services are beneficial to most of the respondents, yet many respondents have acknowledged that they are affected by many of the ecosystem disservices. Ecosystem disservices that affect the respondent are storm water over flow, rainfall induced water logging and flooding. The most common negative utilities that they get from ecosystem disservices includes decomposed wastes and bad smell, ugly view, water-born diseases, air born insect, prevalence of malaria mosquito, falling of tree-branch on the roof etc.

Multiple responses shows that among the green urban ecosystem components, 28% HH benefited or impacted by green-park. In the same way 22% and 21% HH benefited or impacted by Green urban streetscape and urban forest. Only 13% of the HH benefited or impacted by community/family garden.

Table 1. Respondent's adoption of green ecosystem components.

Green Ecosystem Component[a]	N	% of cases
Urban Forest	60	38.0%
Green Park	79	50.0%
Community/Family Garden	39	24.7%

Urban Street scape	62	39.2%
Playground	42	26.6%
Total (a. Multiple response question.)	282	178.5%

Multiple responses shows that among the blue urban ecosystem components, 29% HH benefited or impacted by impounding (pond/ditch) of water around their place of living. However 25% and 24% HH benefited or impacted by rainwater or canal water.

Table 2. Respondent's adoption of blue ecosystem components.

Blue Ecosystem Component[a]	N	% of cases
Rain water	61	42.4%
Pond/Ditch	71	49.3%
Natural Drainage	21	14.6%
Canal	60	41.7%
River	34	23.6%
Total (a. Multiple response question.)	247	171.5%

The PCA:

To reduce 25 ecosystem services and disservices into meaningful utilities, PCA is done. This offers ultimately four utilities. These are:

- 1st component- Livelihood security;
- 2nd component- Personal comfort;
- 3rd component- Health security; and
- 4th components- Recreation

Therefore, the PCA shows that the broad utilities that most respondent's family derive from urban ecosystem are related to livelihood, comfort, health and recreation.

Table 3. The PCA and the explanatory power of the components

Component	**No. of Variables**	**Explain-**
1st component : Livelihood Security	**9 variables**	**21.11% variance**
2nd component: Personal Comfort	6 variables	15.49% variance
3rd component: Health	5 variables	14.47% variance

Security		
4th component: Recreation	4 variables	7.78% variance
	24*	59% variance

Most of the variables grouped under personal comfort and health security are related to Ecosystem Disservice. But most of the variables grouped under livelihood security and recreation are related to Ecosystem Services.

Table 4. Descriptive Statistics of Ecosystem Services and Disservices Index

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ecosystem Service Index	215	1.53	3.67	2.6602	.40318
Ecosystem Disservice Index	215	1.20	4.20	2.8056	.56126

3.2 Binomial logit model: who cares for gain & loss from ecosystem service & disservice?

Based on mid value of two Index of Concern for Ecosystem Services & Disservices, the gainer & losers are identified. This offer the opportunity to use Binomial Logistic Regression model to characterize the low income people/slum residents would gain or loss from ecosystem services & disservices. Two separate models are developed.

- Ecosystem Services Model: The model summary shows that Pseudo (Nagelkerke) R Square:.43 But, Hosmer and Lemeshow Test shows model validity is poor (Chi-square = 6.784; Sig.=.56).
- Ecosystem Disservices Model: The model summary shows that Pseudo (Nagelkerke) R Square:.36 But, Hosmer and Lemeshow Test shows model validity is poor (Chi-square = 6.094; Sig.=.64).

Whether a HH would care for gain or loss from ecosystem services are significantly associated with 7 factors:

- If the HH has fear of eviction;
- If the HH maintain connection with local polity
- If the HH has adapted with city's work culture
- If the HHH (the respondent) is educated or not
- If the HH own the dwelling unit or not
- If the HHH is self employed or not
- If the HH is associated with any social group

Whether a HH would care for gain or loss from ecosystem disservices are significantly associated with three factors:

- If the HH was exposed to water related disaster in the past;
- If the HH own the dwelling unit or not
- If the HH is associated with any social group

Table 4. Binomial Logit model: determinants of adoption of ecosystem services and disservices

Influencing factors	Ecosystem Service Model					Ecosystem Disservice Model			
	B	Exp B	SE	Sig		B	Exp B	SE	Sig
Fear of eviction	-1.144	.318	.450	.011					
Connection with local polity	-.969	.380	.426	.023					
Past exposure to water related disasters						-.165	.191	.419	.000
Adapted to city's work culture	-.168	.186	.407	.000					
Education	-.920	.398	.558	.099					
Tenure of housing	-1.136	.321	.553	.040		.843	2.32	.516	.102
Occupation of HH	1.123	3.074	.454	.013					
Member of social group	-.621	.537	.379	.101		1.169	3.219	.363	.001

Furthermore to determine the factors that affect the gain (both positive and negative) from urban ecosystem services/disservices in the dimension of "Health security", "Personal comfort" and "Livelihood security" three separate Logit are developed. The first Logit model predicts the influence of factors on slum household's probability to be gainer or looser from urban ecosystem services/disservices in the dimension of Health security. The second and third Logit models predict the influence of factors on slum household's probability to be gainer or looser from urban ecosystem services/disservices in the dimension of personal comfort and livelihood security respectively.

Models output are presented in some details in the expanded full paper. Gain from ecosystem service related to livelihood security are mostly affected by socio-economic and demographic variables while gain from personal comfort/recreation related services are determined by resource governance related and spatial factors. The Binomial Logistic Regression analysis unveils that gain from personal comfort/recreation related ecosystem services are significantly determined by gender, family income, distance from house, access fees etc. as well. On the other hand gain from livelihood security related ecosystem services are significantly determined by level of education, fear for eviction, tenure of housing, length

of stay in the city, perception about intrinsic benefit. On the contrary loss from ecosystem disservices that relate to health security are determined by risk perception, season of a year, tenure of housing, fear of eviction, and past adaptation behaviour. However, other factors such as occupation, age, access to information do not have significant influence in this respect.

4. Concluding Remarks

Finally it can be concluded that most dominant factors that determine whether a family would benefit from or affected by urban ecosystem services are tenure of housing, fear of eviction, connection of local polity, adaptation with city's work culture, education, occupation and membership of social group. Similarly, the most dominant factors that determine whether a family would benefit from or affected by urban ecosystem disservices are past exposure to disasters, tenure of housing and membership status of social group. The policy implication of the findings is, this would help designing separate sets of intervention for enhancing urban poor's access to ecosystem services and to protect them from ecosystem disservices for better livelihood, comfort, health and recreation particularly in the changing context of climate. Therefore, this finding would give synergies to ongoing efforts of building resilient city in an urbanizing world.

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