

RESEARCH PAPER

## Is provisioning services assessment a tool for forest dependency estimation in Coastal Bangladesh?

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### ABSTRACT

Coastal community of Bangladesh tremendously depends on the provisioning services such as food, timber, wood etc. from the forest. The objective of this study is to evaluate the potentials of provisioning services assessment as a tool for the estimation of forest dependency in coastal Bangladesh. A literature review was conducted to identify the coastal forest ecosystem services which were validated by a checklist survey. Moreover, face to face questionnaire interview was conducted among 105 randomly selected coastal community respondents in Dhulasar union (three villages i.e. Char Gongamoti, Char Chapli, and Char Kauwa) of Patuakhali, Bangladesh. This study then identified all of the ecosystem services provided by the coastal forest of this area. Furthermore, the average monthly resource extraction potential from the coastal forest i.e. monetary value of provisioning services was calculated around 4000 tk month<sup>-1</sup> person<sup>-1</sup>. The study reveals that average monthly average income per household of the community was almost close to the calculated monthly average provisioning services from the forest. For instance; around 15% respondents' monthly income was 2000 to 5000 tk person<sup>-1</sup> and around 45% respondents' monthly income was 5500 to 8000 tk person<sup>-1</sup>. Hence, monetary value of the provisioning services estimates defined the level of dependency of the coastal people on forest. Consequently, the study showed that, the accurate assessment of the provisioning services might be a tool to determine the forest dependency in the coastal community. Therefore, this study provides a policy tool to the decision makers for determining the forest dependency estimates through ecosystem services assessment.

**Key words:** Coastal community, ecosystem services, forest dependency.

### Introduction

Coastal forest resources potentials are inevitable for the coastal community of Bangladesh. Coastal forests of Bangladesh perceived to have coastal protection, livelihood development and aesthetic potential. In addition, these forests have lot of benefits in terms of ecosystem services. Ecosystem services are the benefits people obtain from ecosystem processes (Ahmed & Gotoh, 2006; Alcamo et al., 2005; Chiesura, 2004; De Groot, Wilson, & Boumans, 2002; Loomis, Kent, Strange, Fausch, & Covich, 2000; Vihervaara, Kumpula, Tanskanen, & Burkhard, 2010; Wallace, 2007). The direct benefits, those are extracted from ecosystem processes termed as provisional services e.g. food, timber, woods etc.(Adamowicz, Boxall, Williams & Louviere, 1998; Ahmed & Gotoh, 2006; Costanza et al.,

1997; Dahdouh-Guebas & Koedam, 2008; Dwyer, McPherson, Schroeder, & Rowntree, 1992). The coastal forest provides different direct ecosystem services to the coastal community. The monetary value estimation of these direct services could be done by the coastal forest ecosystem services assessment (Groot, Wilson, & Boumans, 2002). In reality, coastal community depends on the forest resources for their livelihood. Most of the cases, the resources extracted from the forest are the main sources of income for the adjacent local community. The monetary value of the direct ecosystem service i.e. provisioning services assessment might represent the forest dependency of the coastal community. Therefore, the objective of this study is to assess the provisioning services of the coastal forest and to establish the potentials of it as a tool of forest dependency estimation.

## Methodology

### Study area

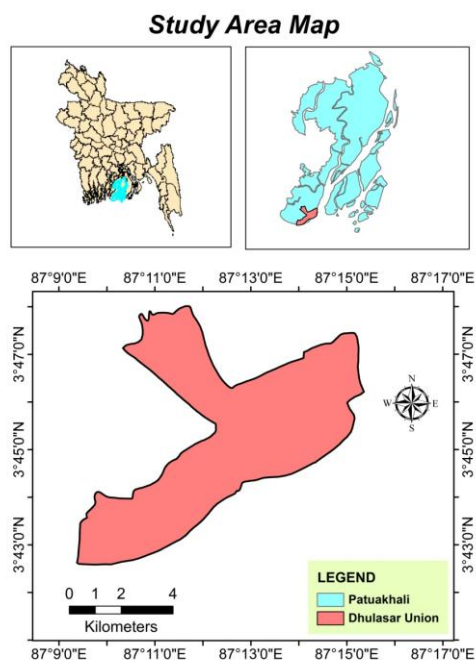
As this study is considering the coastal forests to estimate forest dependency, so three coastal villages viz. Char Gongamoti, Char Chapli, Char Kauwa, Kalapara, Patuakhali district were selected as the study area. This study area is located between 21.98° N and 90.24° E (BBS, 2011). The total population of these three villages is 3,544 where male is 1836 & female is 1708 (BBS, 2011).

### Ecosystem services assessment

Extensive literature review was conducted to assess the existing ecosystem services of the coastal forests. A check list of the existing ecosystem services of the coastal forest was prepared on the basis of the literature review. Then the theoretical findings about the existing ecosystem services were checked and validated by the prepared checklist through field visit in the study area.

### Analysis of the ecosystem services

To analyze the ecosystem services and estimate the monetary value of it, 105 face to face questionnaire interviews were conducted among the coastal people of selected three villages. The amounts of different provisioning services collected by the local people were estimated on the basis of responses. For example, the total amounts of collected furniture wood were estimated on the basis of gross collection of the selected interviewee. To get the monetary value of the identified services, local market prices of those services were evaluated. Regarding this way other provisioning services such as cooking fuel, cattle grass fishes, honey, boar etc. were also estimated. The following were the ways to estimate the monetary value of different provisioning services:



**Figure 1.** Study area covering the three villages of Dhulasar union in Patuakhali, Bangladesh. Sources: The administrative boundaries are from Global administrative areas (GADM, 2012).

### Market price of furniture wood

General people of the coastal locality don't know the accurate measurement of the furniture wood. They gave an approximate measurement of furniture wood. The woods were collected as pieces or as whole of the trees from the forest. The local market was surveyed through discussion with the furniture wood tradesman to know the accurate measurement and prices of the furniture wood. According to the tradesman, if any piece of wood is 12 inch wide, 1 inch thick and 12 inch long then it is called 1 cubic feet (cft) wood. Considering these factors, the woods collected from the forest per year were randomly measured and calculated during the survey. The following formula was used to measure the total monetary value:

$$V_{fw} = U_{t_{fw}} \times P_{fw} \dots \dots \dots \text{(Equation- I)}$$

$V_{fw}$  = Monetary value of furniture wood (In taka)

$U_{t_{fw}}$  = Total forest wood used for furniture (cft yr<sup>-1</sup>)

$P_{fw}$  = Price of furniture wood (per cft)

### Market price of cooking fuel

Only wood was considered as the cooking fuel in this study. The fuel wood was measured in MON (1 MON = 36 kg). The respondents gave approximate prices of fuel woods. Nevertheless, to ensure the exact monetary value of it, the local fuel wood market was surveyed. Then the total market price was measured by following formula:

$$V_{cf} = U_{t_{cf}} \times P_{cf} \dots \dots \dots \text{(Equation- II)}$$

$V_{cf}$  = Monetary value of wood used for fuel (In taka)

$U_{t_{cf}}$  = Total forest wood used for fuel (MON yr<sup>-1</sup>)

$P_{cf}$  = Price of fuel wood (per MON)

### Market price of cattle grass

Respondents also gave approximate idea about the price of cattle grass during the study. On the basis of the responses, the following formula was used to estimate the cattle grass price:

$$V_{fo} = U_{t_{fo}} \times P_{fo} \dots \dots \dots \text{(Equation- III)}$$

$V_{fo}$  = Monetary value of cattle grass (In taka)

$U_{t_{fo}}$  = Total cattle grass collected (kg yr<sup>-1</sup>)

$P_{fo}$  = Price of cattle grass (per kg)

### Market price of fish

Different fish have different market prices. The average market price of the fishes from the local market was considered in this study. Then the following formula was used to calculate the total fish price.

$$V_{fi} = U_{t_{fi}} \times P_{fi} \dots \dots \dots \text{(Equation- IV)}$$

$V_{fi}$  = Monetary value of fish (In taka)

$U_{t_{fi}}$  = Total fish catch (kg yr<sup>-1</sup>)

$P_{fi}$  = Price of fish (per kg)

### Market price of honey

Most of the respondents knew the actual price of the honey in their local market. Therefore, following formula was used to calculate the price of honey:

$$V_{ho} = U_{t_{ho}} \times P_{ho} \dots \dots \dots \text{(Equation- V)}$$

$V_{ho}$  = Monetary value of honey (In Taka)

$U_{t_{ho}}$  = Total honey collected (kg yr<sup>-1</sup>)

$P_{ho}$  = Price of honey (per kg)

### Market price of Boar

Generally these animals are not sold in the local market. The meat of the animals is only used by the tribal of that locality. The average price of the meat was estimated

comparing with goat price of the local market. Then total monetary value of boar counted by the following formula:

$$V_{Bo} = Ut_{Bo} \times P_{Bo} \dots \dots \dots \text{(Equation- VI)}$$

$V_{Bo}$  = Monetary value of Boar (In taka)  
 $Ut_{Bo}$  = Total boar hunted (piece  $yr^{-1}$ )  
 $P_{Bo}$  = Price of Boar (per piece)

### Market price of hunted birds

Different types of birds were found in this locality. According to the respondents the birds were hunted seasonally and different birds' prices are different. An average price was settled for each single bird through the survey. Moreover, to get the validation of this price, the bird prices of local market were investigated by interviewing the local tradesmen. Then following formula was used to estimate the values of birds:

$$V_{Bi} = Ut_{Bi} \times P_{Bi} \dots \dots \dots \text{(Equation- VII)}$$

$V_{Bi}$  = Monetary value of birds (In taka)  
 $Ut_{Bi}$  = Total birds hunted (piece  $yr^{-1}$ )  
 $P_{Bi}$  = Price of piece of birds

### Market price of palm leaf

The local measurement unit of palm leaf is pon (1pon= 80 pieces). The price of the palm leaf was determined through discussion with the tradesman. Then following formula was used to estimate the monetary value of the palm leaves:

$$V_{lf} = Ut_{lf} \times P_{lf} \dots \dots \dots \text{(Equation-VIII)}$$

$V_{lf}$  = Monetary value of palm leaves (In taka)  
 $Ut_{lf}$  = Total palm leaves collected (pon  $yr^{-1}$ )  
 $P_{lf}$  = Price of palm leaf (per pon)

### Total monetary benefits

Generalized formulas were used to calculate the total monetary value of the provisioning services provided by the forest in the study area. The formulas were:

$$\sum V_{tm} = V_{fw} + V_{cf} + V_{fo} + V_{fi} + V_{ho} + V_{bi} + V_{bo} + V_{lf} \dots \dots \dots \text{(Equation - IX)}$$

Here,

$\sum V_{tm}$  = Total Monetary benefit obtained from provisioning service (per person per year)

For other parameters see the previous equations.

$$T_m = \frac{\sum V_{tm}}{T_h} \dots \dots \dots \text{(Equation - X)}$$

Where,

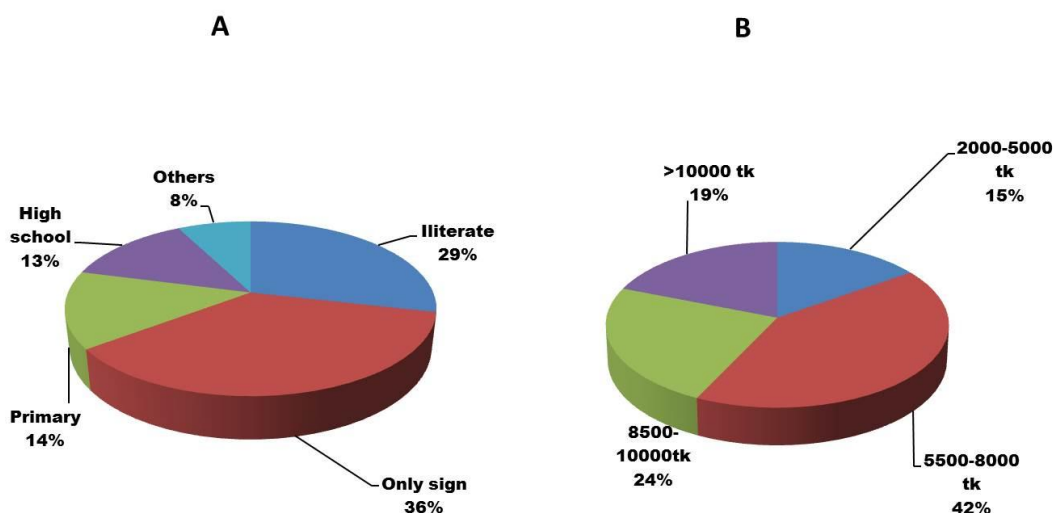
$T_m$  = Average monetary benefit obtained from provisioning service (per person per year)

$T_h$  = Total respondent surveyed

## Results

### Demographic characteristics

Among 105 interviewed respondents 76% was male and 24% was female. The average household size of the respondents included 6 members. We assume that in each household, only one person is the earning member. In this study around 65% was illiterate, more than 25% of the respondents had school education and more than 10% of the respondents had higher education (Figure 2A). Among the respondents more than 80% of them are young aged (18 to 49 years) and around 15% are old aged (50 to 60 years).



**Figure 2.** Demographic characteristic of the respondents A) Education level B) Income level (tk month<sup>-1</sup>)

Here, 18 to 49 years aged group was recognized as the working group of the study area. The highest income level of the respondents was more than 10000 tk (around 20%) and the lowest level of income was around 2000-5000 tk (15%). The highest number of respondents income level was around 8500-10000 tk (25%) (Figure 2B).

Chi-square analysis demonstrated that all socio-economic factors of the samples (respondents) were not significantly different from the whole population ( $p = 0.002$ ), which validated the representativeness of the randomly chosen samples. It would be statistically acceptable to aggregate estimates of mean income from the forest resources of the samples to the target population (Chen & Jim, 2008).

**Table 1.** Enhanced Ecosystem Services in the study area

Provisional Services	Regulating Services	Cultural Services
Furniture Wood	Climatic regulation	Spiritual and religious value
Fuel wood	Disaster risk reduction (Strom surges, Cyclone etc.)	Tourism and recreation
Timber and leaves	Increased soil fertility	Scientific and education perspectives
Cattle grass	Carbon sequestration Habitat for wild life	
Birds	Pest control in the crop filed due to presence of buffer zone.	
Fish	Pest control in the crop filed due to presence of buffer zone. (homestead garden)	
Boar	Reduced river bank erosion	

**Ecosystem services**

The ecosystem services identified in the study areas include provisional, regulating and cultural services. The ecosystem services from those areas are provided in table 1.

**Provisioning services estimates from the coastal forest**

Provisioning services are the products or services, directly obtained from the ecosystems such as food, fresh water, wood, fiber, genetic resources and medicines (Shiue, 2015). The processes of estimating the monetary value of provisioning services of the study area were discussed in section 2.3.

**Furniture**

Furniture wood was collected all the year round from the forest in this area. It was estimated from the responses that, 521 cft furniture wood were extracted from this coastal forest per year. Then the equation (I) from section 2.3.1 was used to estimate the total monetary benefits from furniture wood. The estimated monetary value of the furniture wood was 693001tk yr<sup>-1</sup> (Table 2).

**Cooking fuel**

More than 90% people of this area are directly dependent on the coastal forest for the cooking fuel. The amount of extracted fuel from the forest was 5604 MON yr<sup>-1</sup>. The equation (II) in section 2.3.2 was used to estimate the price of cooking fuel extracted from the forest. The estimated monetary benefit was 684702 tk yr<sup>-1</sup> (Table 2).

**Fish**

A large amount of different types of fishes such as Ilish, Koral, Toposhi, Poma, Aair, Boal, Carp and Shrimp etc. were collected from the forest canals. Substantial number of people depends on fishing in the studied area. The amount of collected fishes was 557 MON yr<sup>-1</sup> (Table 2). Using the equation (IV) in section 2.3.4 the estimated value of the amount of fishes was 3068003 tk yr<sup>-1</sup>.

**Cattle grass**

The forest in that locality is a big source of cattle feeds. According to the respondents, every year they need minimum 3811 kg of cattle grass (Table 2) for their domestic animal. Interestingly, they can get it from the neighboring forest. Therefore, using the equation (III) in section 2.3.3, the total monetary benefit acquired from this forest was 37702 tk yr<sup>-1</sup>.

**Boar**

“Rakhainpolli” a tribal community hunts boar for eating purposes. The information collection about the boar hunting was very difficult as most of the people want to keep it secret for violating the hunting law of the country. It was possible to collect such information only from 5 respondents. According to their responses, every year up to twelve to fifteen boars were hunted from the neighboring coastal forest. The equation (VI) in the section 2.3.6 was used to measure the total monetary benefit of Boar. The total monetary value of boar from the coastal forest was calculated as 40000 tk yr<sup>-1</sup> (Table 2).

**Table 2.** Monetary value of the provisioning services from the coastal forest

Provisioning service	Quantity of collected resources (per year)	Amount of resources (tk yr <sup>-1</sup> )
Furniture	521 Cft	693001
Cooking fuel	224141 kg	684702
Fodder	3811 kg	37702
Fish	22257 kg	3068003
Honey	226 kg	97653
Boar	13 Piece	40000
Birds	372 Piece	39083
Taal Leaf	200 Pon	60000
Total		4720144

## Birds

Birds are the adornment of this forest ecosystem. Different types of local birds and seasonally different migratory birds were found in this area. 20 respondents told that, they were engaged with hunting. Main hunting season of birds is winter (December- January). The birds are hunted 2/3 times in a season. According to the respondents, 372 birds (Table 2) were hunted in a year. The monetary values of the birds were estimated using the equation (VI) in the section 2.3.7 (Table 2).

## Honey

Many people are engaged with the collection of honey from this forest. The honey was collected at end of February to the end of May. According to the respondents, five to six MON honey was collected from this forest per year. Equation (V) in section 2.3.7 was used to estimate the total monetary benefit from the honey (Table 2).

## Palm leaf

The determined price of each pon of palm leaf was 300 tk and total leaf collected from the forest was around 200 pon yr<sup>-1</sup>. Using the equation (VIII) from the section 2.3.8 the monetary value of palm leaf was calculated as 60000 tk yr<sup>-1</sup> (Table 2).

## Total provisioning services

The value of the total provisioning services was estimated summing all the measured value from different direct services in the study area. The equation (IX) and (X) were used to calculate the monetary values of the provisioning services. According to the equation (IX), the total value of the provisioning services provided by the coastal forest was estimated as 4720144 tk yr<sup>-1</sup> person<sup>-1</sup> (Table 2). Similarly, using the equation (X), the average value of the provisioning services provided by the coastal forest was calculated around 4000 tk month<sup>-1</sup> person<sup>-1</sup>.

## Analysis of the forest dependency

The provisioning services analysis showed the forest dependency of the coastal community by estimating the monetary value of the direct services provided by the forest ecosystem. The provisioning services provided by the coastal forest were estimated around 4000 tk month<sup>-1</sup> person<sup>-1</sup>. Interestingly, the major income group of the respondents lies into the income level of 5000 to 8000 tk month<sup>-1</sup> person<sup>-1</sup> (more than 40%). Besides, 15% of the respondents' income level was 2000 to 5000 tk month<sup>-1</sup> person<sup>-1</sup>. Around 40% respondents' monthly income was more than 8000 tk person<sup>-1</sup> (Figure 2B). Thus, we see that, majority of the coastal communities' income bear a resemblance to the calculated value of the provisioning services from the coastal forest. Furthermore, around 40% of the respondents' half of the monthly income was similar to the estimated provisioning services of the coastal forest (Figure 2B). It is clear from the study that, the livelihood dependency of the coastal communities enormously depends on the income from the provisioning services of the coastal forest. Therefore, provisioning services assessment

might be a realistic tool for the forest dependency estimation for the coastal community of Bangladesh.

## Discussion

The concept of ecosystem services assessment is a relatively new methodological approach providing different possible approaches for natural resources dependency estimates and management (Vihervaara et al., 2010; Wallace, 2007). Our study assessed the monetary value of the provisioning services and resembles the proximity of it with the monthly average income of the household. For example, the calculated monetary value of the provisioning services provided by the studied coastal forest ecosystem was around 4000 taka per month and monthly income of the community was below 8000 tk (about 60%, Figure 2B).

All information of this study was collected directly from the field survey. As a result, this study reflects the actual condition of the study area regarding the surveyed parameters. For example, the study provides actual monetary value of the provisioning services through the local community response and local market judgments. In addition, this monetary value induced income generation from the forest resources was compared with the income level of the community to measure the forest dependency perceptions. Thus these direct responses of the community about the forest resource dependency depicted the real community level picture of the forest dependency estimates in the coastal area.

As the responders could not provide standard units for measuring the quantity of any specific forest resources that they collect from the forest, therefore, the local units of measurement were considered. After that the local units of resource quantity measurement was converted to the standard unit consulting with the local tradesman, which ensures the possibility of no data distortion.

This study emphasized only the provisioning services of the forest. However, regulating and cultural services are also apart of ecosystem service assessment to determine the forest dependency perspective which was ignored in this study. The determination of the monetary value might have some non-conformity because of considering different species as same species. For example, all the fish species are considered as the same price commodity which is not true in real sense. In spite of these limitations, the study can be validated by considering the factor of education level of the coastal community. For instance, determining the monetary value of regulating and cultural services requires rationale judgment of the actual value of the ecosystem processes. Considering the factor education level (around 70% illiterate and 14% primary level, see Figure 2A) the perceived valuation of the regulating and cultural services could be over and under estimated (Adamowicz et al., 1998; Chen & Jim, 2008). This study provides the techniques to determine the direct ecosystem services assessment of the forest by the

local people. In addition, it shows the way to use the ecosystem service assessment as a tool for forest dependency estimates. Thus, this study could serve as a determining factor for coastal forest destruction by the local people through estimating the forest dependency of them. Moreover, this study may be a ladder for the policy makers of the developing country to take proper initiatives for the reduction of coastal forest destruction.

## Conclusion

This study analyzed the factors of the ecosystem services assessment potentials for forest dependency estimate of the coastal community. From the analysis it is clear that provisioning services assessment can be used as a tool for the measurement of coastal forest dependency. Provisioning services assessment tool also help to calculate the amount of forest resource extraction of the community and its monetary value. The estimated income from the forest resources calculated around 4000 tk month<sup>-1</sup> person<sup>-1</sup> by using the provisioning services assessment tool. Monthly income level of the surveyed respondents was similar to estimated income from the direct ecosystem service of the forest. Thus, it reflects the level of dependency on the coastal forest resources of the local people. Apart from this result, we believe that estimating the regulating and cultural services of the coastal forest can showcase the more realistic picture of the forest dependency estimates. However, this process may require more effective ecosystem service assessment procedure for the developing countries.

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