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Valuation of Provisioning Ecosystem Services and Utilization in Three Rural Communities of Ghana

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Abstract: Benefits to ecosystem services may be identified and achieved through their quantification and valuation. The objectives of this study were to map the provisioning ecosystem services and determine the values of these services to the local community members. The study took place at Ejisu-Juaben district of Ghana which is endowed with forests, water bodies, minerals, plants and animals. The study used Participatory Geographic information systems (PGIS) as a tool in valuing ecosystem services in Ejisu-Juaben districts of Ghana. The valuation was carried out based on the construction preference method that sought to assign values to ecosystem services and places where they collect these services. It was indicated that forest holds lots of the key ecosystem services followed by fallow, farmland and grass. The most important ecosystem services listed by both low and high income groups in all study communities were mushroom, medicinal plants, bush meat, snails, honey, food (fruits), fuel wood, water and cane. Low income group use the ecosystem services more for commercial purposes and less for domestic usage across the study communities in contrast to the high income group, who use more for domestic purposes than for commercial purposes. The results mean that the low income groups' livelihoods depend more on income generated from selling the ecosystem services whilst the high income group may have other alternative sources of income in addition to the ecosystem services provision.

Keywords: Ecosystem Services, Participatory GIS, Valuation, Communities

1. Introduction

Ecosystem services are made up of benefits people derive from the ecosystem including provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling and carbon that ensures that favourable conditions are created for the maintenance of life on Earth [1].

Today, natural ecosystems have come under severe pressure from growing demands arising out of increased population which has translated into converting natural ecosystems into agriculture, industrial and residential use [2]. It has been estimated that nearly 60% of ecosystem services obtained are being degraded or not put to sustainable use [3]. The last decade of the 20th century has seen much attention been drawn to global-scale degradation of natural habitats and threats to potentially millions of species [4]. [5] remarked that the lack of efficient systems of valuing environmental services has led to the progressive loss of natural resources. There has also been an information gap in respect of limited information on values of ecosystem services to all segments of society [6]. Valuation of ecosystem services forms the basis of determining the worth of nature and the amount of benefits that are derived from the ecosystem at any given time [7]. Several methods to valuate ecosystem services have been developed by researchers including [8], [9], [10], [11], [6] and the [1]. However, there exists certain insufficiency in these methods regarding the supply of valid information by local communities because they are not directly involved in the process. Therefore, [12] remarked that, the suitability of the stated preference or contingent valuation method is questionable because stakeholders are not deeply involved and lack sufficient familiarity with ecosystem functions to make meaningful

preference statements. In addition, there are variations in the values to ecosystem services by local people. The objectives of this study were to map the provisioning ecosystem services and determine the values of these services to the local community members.

2. Materials and Methods

2.1. Study Area

The Ejisu-Juaben district is located in the central part of the Ashanti Region in Ghana and lies within latitude 1.15°N and 1.45°N and longitude 6.15°W and 7.00°W. The district stretches over an area of 637.2 km^2 and lies within the semi deciduous forest zone. The economy of the districts is based on agriculture employing 68.2% of the people. The main cash crops grown in the area are cocoa (*Theobroma cacao*), oil palm (*Eleais guinensis*) and citrus (Citrus spp.) while other crops such as cassava (*Manihott utilissima*), maize (*Zea mays*), cocoyam (*Colocasia esculenta*) and tomatoes (*Solanum cycopersium*) are grown on subsistence basis. Activities such as slash and burn agriculture, stone quarrying and chain saw operations have resulted in degradation of the natural vegetation cover into secondary forest [13]. These can consequently affect the livelihood of local communities who depends more on the forest ecosystem [14]. Figure 1 is a map showing the study area. The topography is flat undulating, with altitude ranging from 240 m to 300 m above sea level. The soil types resulted from pre-cambrian rocks of the Birimian and Tarkwaian formations. The rainfall pattern is bi-modal with the major rainy season lasting from March to July and minor rainy season from September to November. The mean annual rainfall is 1200 mm and mean temperatures normally ranges between 20°C in August and 32°C in March resulting in moderate relative humidity [15]. The district is basically rural with a population of 144,272, showing an increase in population compared to previous years and the youth forming 64% of the population [13].

The three study communities were selected based on (1) their dependence on provisioning ecosystem services and (2) their pronounced land use/cover transformations that were fast reducing and depleting their sources of livelihoods. The communities were Bomfa, Apemso and Kotey.

2.2. Method

2.2.1. Determination of Income Levels

A preliminary questionnaire was administered to determine the income level of the respondents. Each respondent's information relating to quantity of harvestable ESS and yield from other sources of income were elicited and used to determine his/her income. In Ghana, income levels are defined based on the minimum daily wage as set by the Ghana Statistical Service. Low income is defined as people whose income fall below the daily minimum wage of $ 2.40 US and high income refers to those whose income is above the daily minimum wage of $2.40 US [16]. The daily income of the respondents was compared with the daily minimum wage set by the Ghana Statistical Service. Income levels that fell below the minimum daily wage was classified as low income and those that fell above the minimum daily wage was categorised as high income. An exchange rate of GH 1.90 cedis to US $ 1 was used in the calculation [17].

2.2.2. Participatory Mapping and Valuation

The information in this study was collected through a focus group discussion and interviews together with mapping exercise. In this study 8-10 people from different income levels (categories of rich/poor men and rich/poor women) were selected randomly from each of the 3 villages for the community mapping exercise. They were then asked to identify through ranking, the key ecosystem services in a pebble game to indicate how much value they attach to each ecosystem service [18]. Again valuation was done using the construction preference method that sought to assign values to ecosystem services and places they collect these services in order of importance [19]. In the participatory mapping exercise, the groups were asked to locate and describe places of value by arranging pebbles on a 1:1,200 scale A1 (600 x 1060 mm) size high resolution image of the study area. They were free to move the pebbles until they were satisfied. The group also had access to a true colour Landsat ETM+ 2010 image of a bigger scale than the high resolution image to show areas they collect ecosystem services outside the range (scale) of the high resolution image.

In order to create value, the groups were given 100 pebbles to assign values to each ecosystem services they identified and collected. In a similar fashion, the groups were given 100 pebbles to assign values to the various land cover classes that provide them most of the identifiable ecosystem services. They were asked why the places they value were important to them. Each of the land covers was assigned values for multiple ecosystem services [20]. During the mapping exercise the groups sketched the polygons describing the spatial extent and location of specific values on A1 tracing paper placed on the high resolution image during the mapping exercise.

2.3. Preparation of Ecosystem Services Map

After the participatory mapping exercise, places of values were digitised as multi-pack polygon in ArcGIS 9.3. Digitised polygons ranged in size from very small (e.g. < 1 ha) to very large (e.g. some tracts of farmlands & forested areas). The spatial data structure included many overlapping areas of value. Each polygon value was the sum of all values of ecosystem services assigned by the groups [21]. The attribute information associated with each value area was entered in a database using a unique identifier to enable linking with other spatial data layers. Each value area formed a row in the attribute database coded with the relevant ecosystem services. A series of spatial layers were created summarising values for elements of ecosystem services. For

example, a layer summarising the spatial distribution of value were created by summing relevant individual values assigned to each ecosystem services. The data structure provided the ease to retrieve data for specific uses and purposes because the database was linked to the spatial value information and queries were built to retrieve specific information.

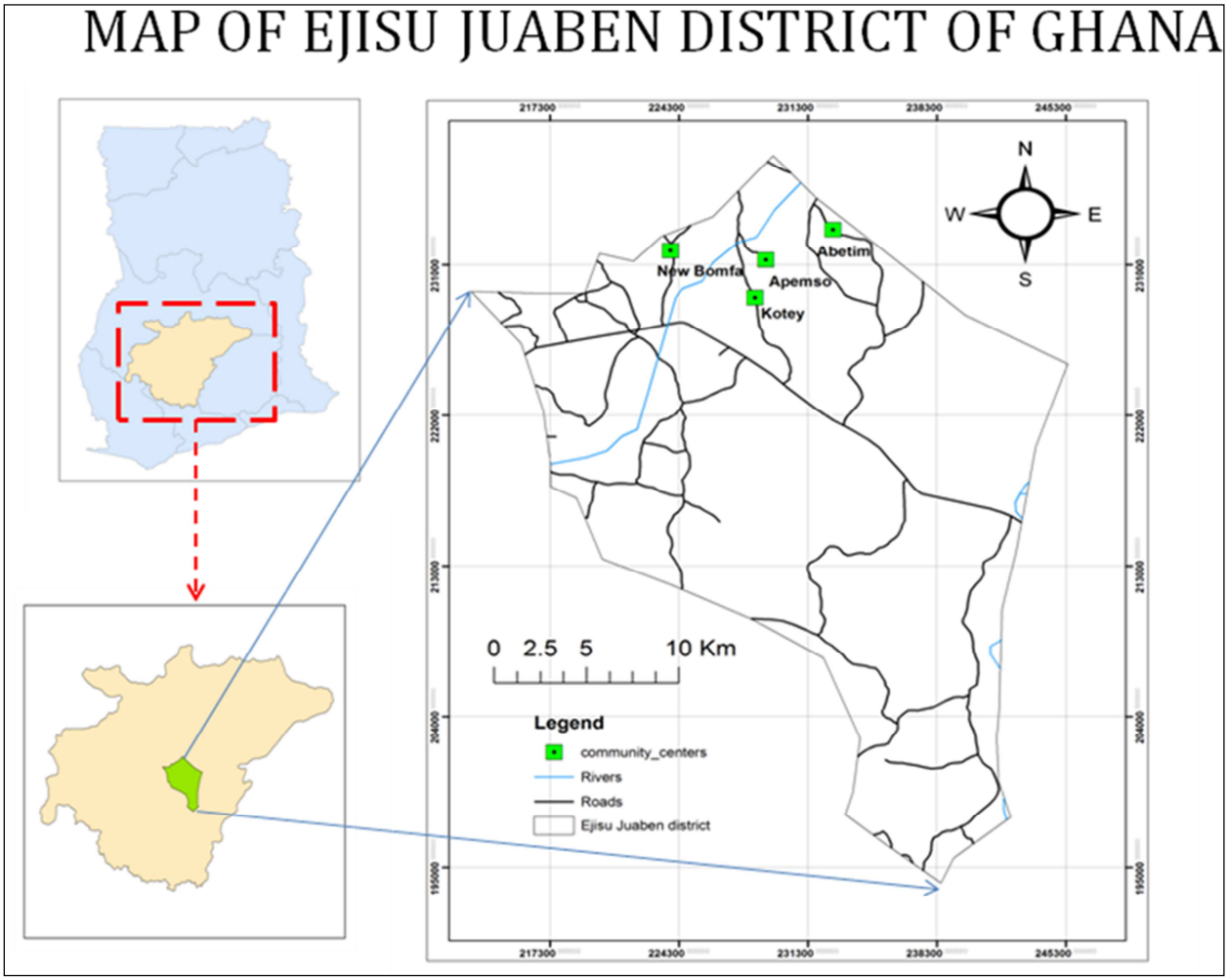


Figure 1. *Regional map of Ghana showing the location of Ashanti region and Ejisu-Juaben district with the study communities.*

3. Results

3.1. Assessment of Ecosystem Services

3.1.1. Respondents Characteristics

Out of 73 local respondents interviewed, 37 were males and 36 were females, the average age of male respondents was 47, and that of female respondents was 42 years old. 43 of the respondents fell in the low income group and 30 respondents fell in the high income group. Table 1 shows the number of participants based on their income status and average age distribution. All respondents had lived in the study area all their life (i.e. over 10 years) and are engaged in various forms of occupation (Table 2). Majority of the respondents were farmers whilst the rest were involved in occupations such as hunting, palm wine tapping and trading. Table 2 shows the occupational status for the various income groups in the study area. In Table 3, 61 were literates (i.e. respondents who have had at least 6 years of formal education), 12 are illiterates (respondents with no formal education), 34 males and 27 females have had formal education up to secondary level, whilst none of the respondents have had post-secondary education (i.e. tertiary education).

Table 1. *Number of participants per income group in the focus group discussion.*

Communities	Income status	No. of respondents			Average age of respondents	
		Total	Male	Female	Male	Female
Apemso	Low income	11	6	5	45	42
	High income	8	4	4	48	44
Kotey	Low income	17	9	8	52	47
	High income	9	4	5	46	38
New Bomfa	Low income	15	7	8	49	43
	High income	13	7	6	44	40

Table 2. *Respondent characteristics (Occupation).*

Study communities		
New Bomfa	**Low income group (%)**	**High income group (%)**
Farmers	57.1	51.7
Hunters	28.1	14.3
Palm wine tapper	14.3	0
Trader	0	28.6
Apemso township	Low income group	High income group
Farmers	50	50
Hunters	16.7	0
Traders	33.3	50
Kotey township	Low income group	High income group
Farmers	55.6	75
Hunters	33.3	25
Palm wine tapper	11.1	0

Table 3. *Respondents' level of education.*

Gender	Illiterate	Literate			
		Primary	J. H. S	Secondary	Tertiary
Male	3	10	17	7	0
Female	9	14	12	1	0

3.1.2. Key Ecosystem Services

Two (2) income groups (i.e. low income & high income) from three (3) communities were identified and involved in a focus group discussion to list the key ecosystem services. The main ecosystem services found in these communities are presented in Table 4. The respondents provided the purpose of collecting the ecosystem services. Generally, across the 3 communities the results showed that the low income groups use greater proportion of the ecosystem services for commercial purposes whilst the high income group use greater proportion for domestic purposes as shown in Table 5.

Table 4. *List of Ecosystem services in three communities.*

Ecosystem services in study communities	
New Bomfa township	
Mushroom	Fuel wood
Snails	Water
Bush meat	
Medicinal plants	
Apemso township	
Mushroom	Honey
Cane	Food (Fruits)
Bush meat	Water
Medicinal plants	
Kotey township	
Mushroom	Honey
Snails	Food (Fruits)
Bush meat	
Medicinal plants	

Table 5. *Purpose of collection of ecosystem services.*

Communities	Family use (%)		Commercial use (%)	
	Low income	High income	Low income	High income
New Bomfa	10	70	90	30
Apemso	20	60	80	40
Kotey	15	55	75	45

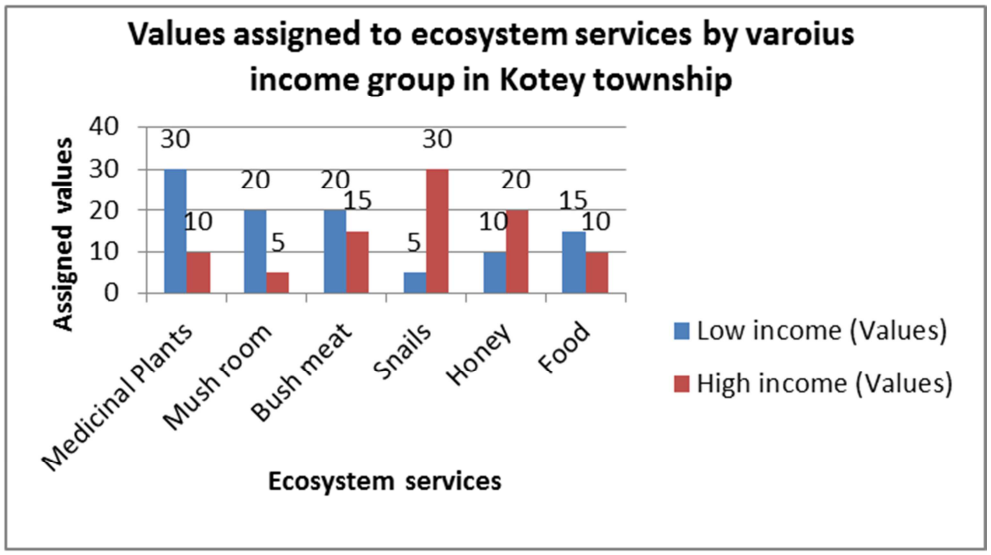
3.2. Spatial Variations of Ecosystem Services Values

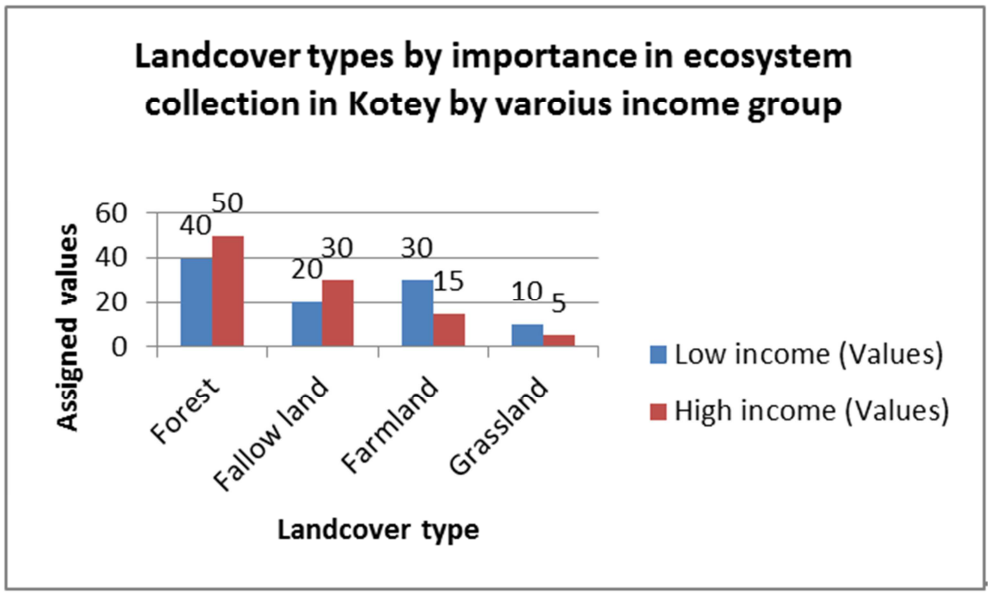
The bar chart in Figure 2 showed the total values allocated to each ecosystem service and the corresponding land cover types. In general, the groups assigned weights according to the ecosystem services they collect more in their respective communities. For instance, in Apemso area, the low income group valued services such as medicinal plants (25 pebbles) and mushroom (30 pebbles) higher than values placed by high income group on the same services (medicinal plants= 15 pebbles), mushroom=5 pebbles). Ecosystems services such as water (10 pebbles), food (10 pebbles), and bush meat (15 pebbles) were moderately valued whilst honey (5 pebbles) and cane (5 pebbles) were less valued by the low income groups respectively. Similarly, ecosystems services such as water (15 pebbles), food (10 pebbles), honey (12 pebbles), and bush meat (10 pebbles) were moderately valued whilst cane (2 pebbles) was less valued by the high income groups. The t-test conducted to evaluate the relationship between low income and high income group in relation to the values they place on the ecosystem services Indicated no significant difference ($t=1.09$, $p=0.16$).

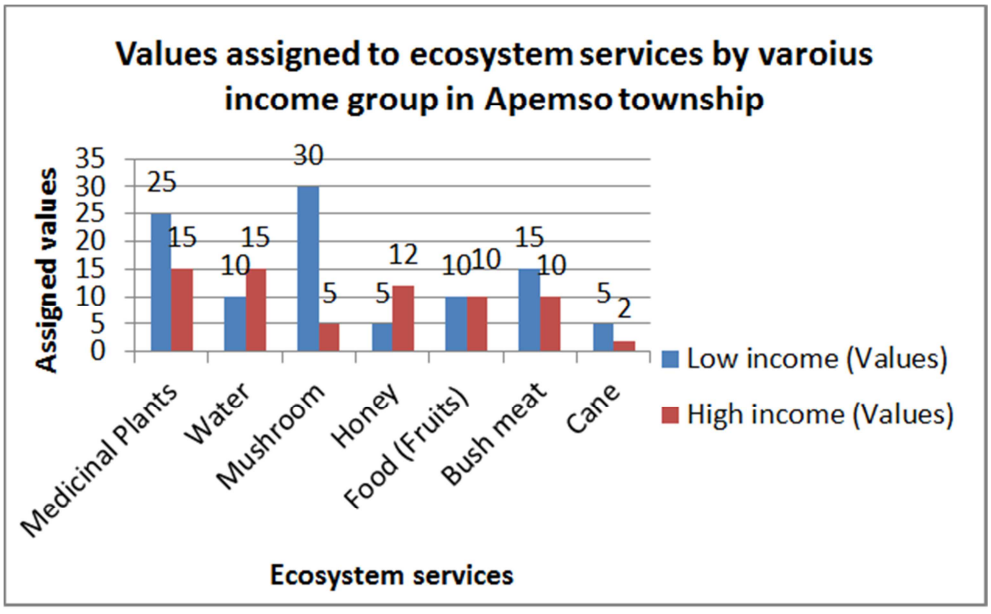
The trend is not different for Bomfa area for both income groups as shown in Figure 2. Low income groups tend to place more value on mushroom (30 pebbles) and water (20 pebbles) than high group (Water=10 pebbles, mushroom =12 pebbles). Also, ecosystems services such as fuel wood (10 pebbles), snails (16 pebbles), bush meat (14 pebbles), medicinal plants (10 pebbles) were moderately valued for low income group contrary to bush meat (25 pebbles) and medicinal plants (20 pebbles) for high income group. However, high income groups placed moderate values on snails (10 pebbles), mushroom (10 pebbles), water (15 pebbles) and less value on fuel wood (5 pebbles). Again, the t-test indicated no significance difference ($t= -0.48$, $p=0.32$).

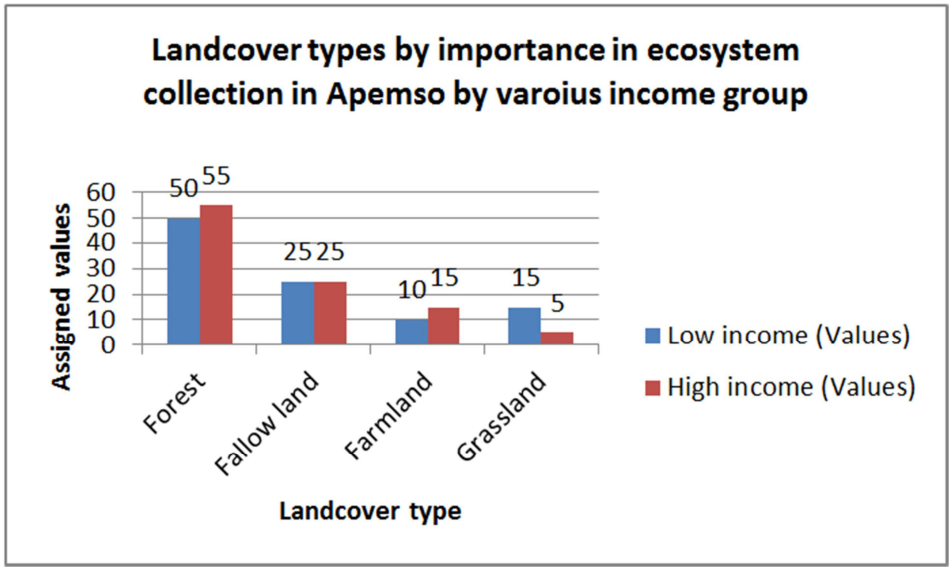
In Kotey township, only snails services (5 pebbles) showed less value for low income group but highly valued (30 pebbles) by high income group. All other ESS were valued the same ($t=0.25$, $p=0.407$).

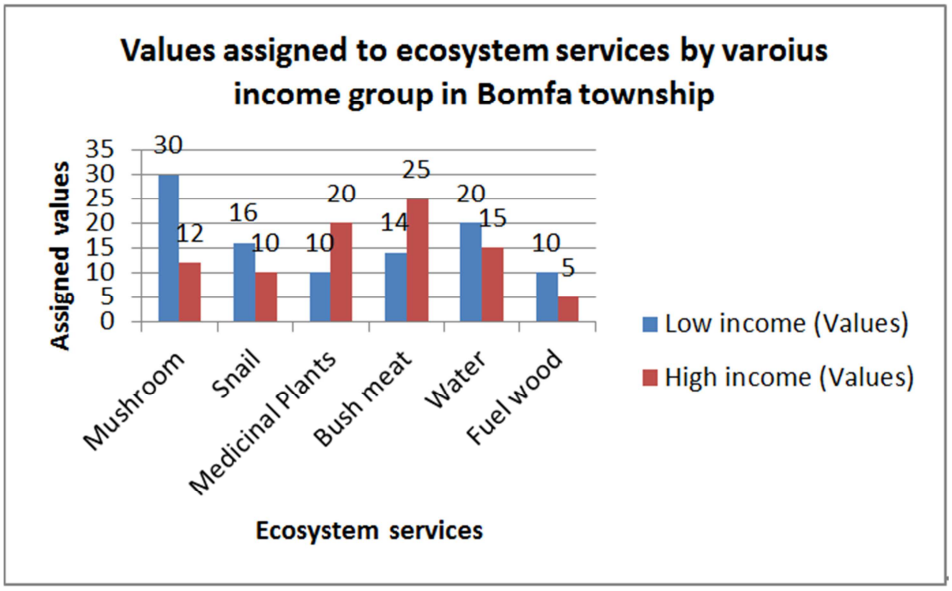
The ecosystem services were found to vary in spatial distribution across the various land cover types in all study communities (Figure 3) and this is in line with related studies conducted by [18] and [19]. From Figure 3 the spatial distribution of ecosystem services and values depicts that, high values areas are places the participants attach more importance due to the large quantity of ecosystem services they collect per land cover. Likewise, low values areas are places that provide least quantity of ecosystem services per cover type.


Values assigned to ecosystem services by varoius income group in Kotey township
Assigned values
40
30
20
10
0
30
10
20
5
20
15
5
30
10
20
15
10
Medicinal Plants
Mush room
Bush meat
Snails
Honey
Food
Low income (Values)
High income (Values)
Ecosystem services


Landcover types by importance in ecosystem collection in Kotey by varoius income group
Assigned values
60
40
20
0
40
50
20
30
30
15
10
5
Forest
Fallow land
Farmland
Grassland
Low income (Values)
High income (Values)
Landcover type


Values assigned to ecosystem services by varoius income group in Apemso township
Assigned values
35
30
25
20
15
10
5
0
25
15
10
15
30
5
5
12
10
10
15
10
5
2
Medicinal Plants
Water
Mushroom
Honey
Food (Fruits)
Bush meat
Cane
Low income (Values)
High income (Values)
Ecosystem services





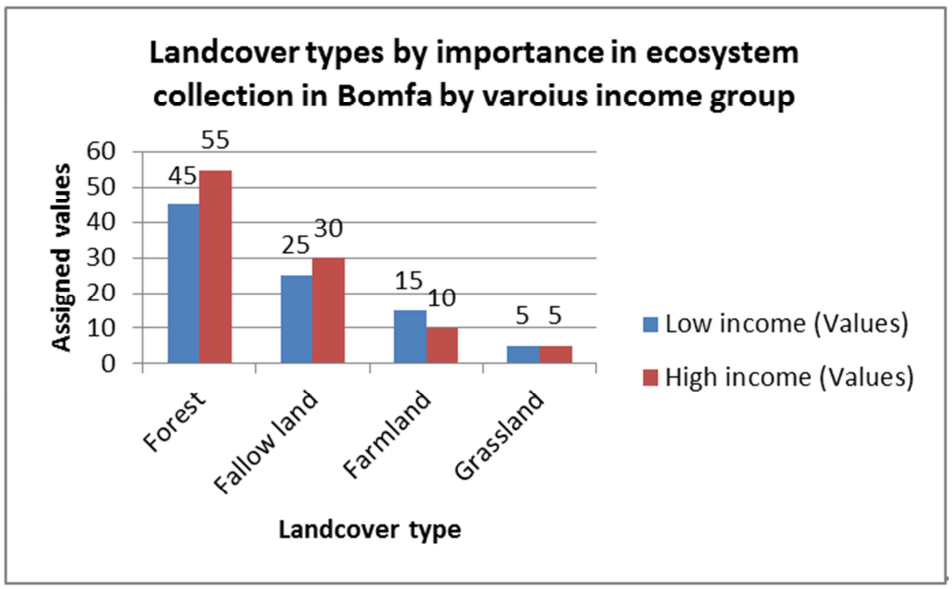


Figure 2. *Key ecosystem services identification and valuation per income group in the 3 communities.*

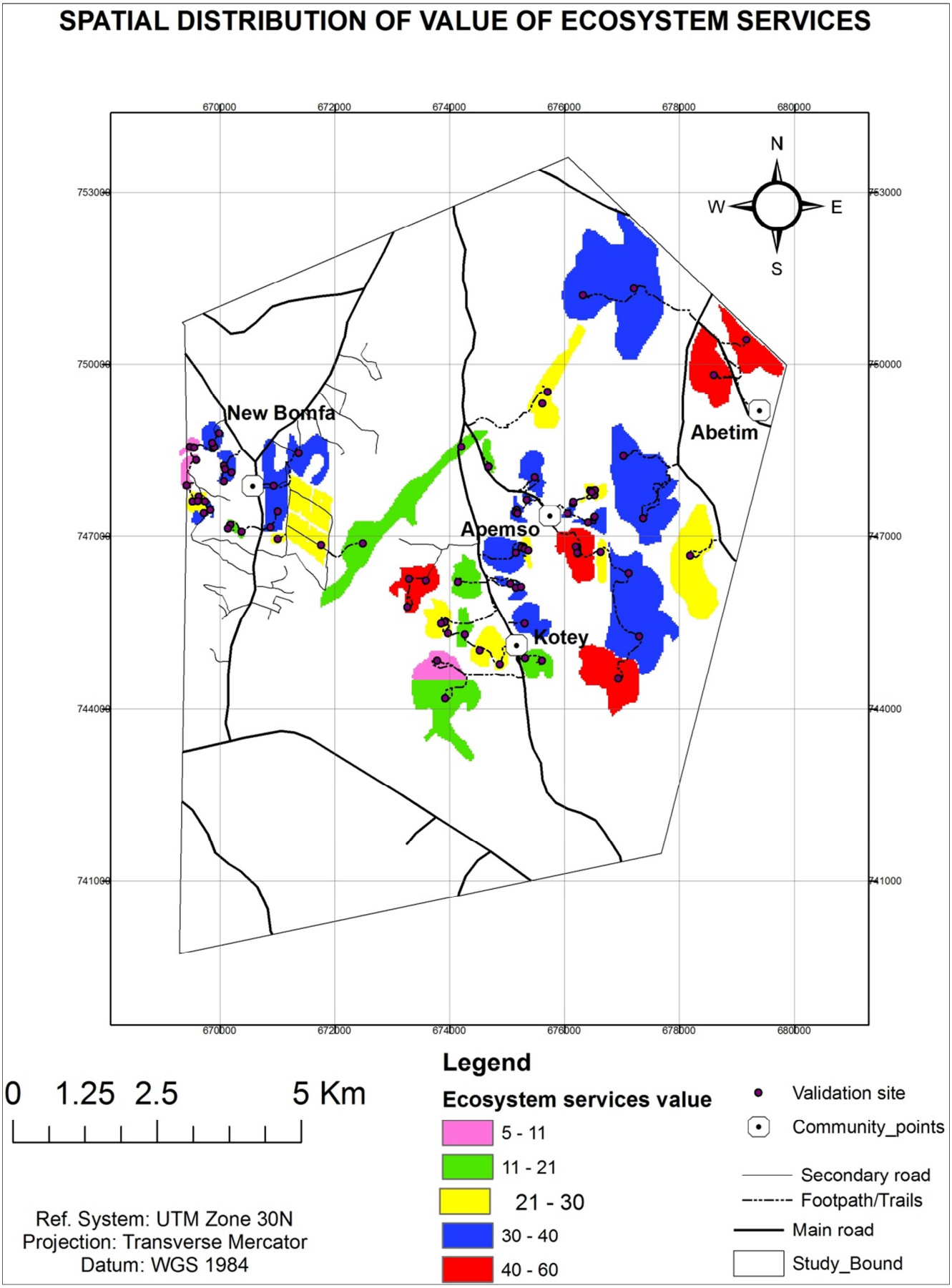


Figure 3. *Spatial distribution of value for ecosystem services.*

4. Discussions

Socio-demographic characteristics in the study area indicated that majority of the participants were slightly educated (up to secondary education). All participants have lived/stayed for more than 10 years in the study area. The level of education, average age of respondents and length of stay in the communities shows that the local people have reasonable knowledge of the natural resource around them. This was reflected in the participatory mapping because the groups were able to identify and map specific area with ecosystem services they collect. Applying participatory tools to map ecosystem services and places they collect them have contributed to knowledge and provided understanding of the links between human interactions with their environment.

For example, based on the construction preference method, values assigned to ecosystem services in order of importance revealed that the participants valued the key ecosystem services in Kotey, New Bomfa and Apemso for several reasons. The locations of the communities showed different patterns with respect to values assigned to the various ecosystem services and important places which provide most of the ecosystem services.

Since income levels affect the value local people put on ecosystem services, the participants were grouped into low and high income levels for the valuation exercise. Ecosystem services such as Mushroom, Medicinal plants, Bush meat, Snails, Honey, Food (Fruits) and Cane were identified and associated with forest, fallow, farmland and grass. This is consistent with previous studies by [18] and [22]. The ecosystem services were found and collected mainly from forested areas which tend to hold most of such services in all study communities [23] and perceived to be more useful to their livelihood [24] that determines their quality of life [25];[26]. This is consistent with studies done by [27] that forestry is known to contribute to poverty reduction and this had been shown through its multiple uses or benefits of forest resources [28].

Fallow lands also hold considerable amount of ecosystem services such as bush meat, honey and fruits. Farmland especially oil palm fields prominent in the study area holds more mushrooms and snails due to the favourable conditions it provide for such ecosystems services.

The results from Table 5 shows that the low income group use the ecosystem services more for commercial purposes and less for domestic usage across the 3 study communities in contrast to the high income groups, who use more for domestic purposes than commercial purpose. The results means that the low income groups' livelihoods depend more on income they gain from selling the ecosystem services whilst the high income groups may have other alternative sources of income in addition to the ecosystem services provision.

Furthermore, the use of GIS and Remote sensing application here allows for spatial representation of ecosystem services, access to these resources locations and its effects on land cover patterns. The integration of the two technologies provides good data analysis and presentation of results for the study

The variations found in spatial distribution of the ecosystem services across the various land cover types in all study communities may attest to the level of importance the local people attach to such services. High values areas tend to provide large quantity of ecosystem services they collect and low values areas provide least quantity of ecosystem services (Figure 3). The lower usefulness and values the locals attached to certain less accessible areas may be attributed to the some physical barriers (i.e. rivers or water logged areas, high slope areas) within the study communities [25].

5. Conclusion

The objectives of this study were to map the provisioning ecosystem services and determine the values of these services to the local community members. This has been demonstrated through the use of remote sensing and GIS technology. The following are the study conclusions.

Firstly, six provisioning ecosystem services were identified in Kotey community (Medicinal plants, Mushroom, Bush meat, Snails, Honey and Food (fruits)). Seven (7) provisioning ecosystem services were identified in Apemso community (Medicinal plants, Mushroom, Honey, Food (fruits), Water, Bush meat and Cane) and six (6) provisioning ecosystem services were collected in New Bomfa community (Medicinal plants, Mushroom, Bush meat, Snails, Water and Fuel wood). The overall ecosystem services listed in all 3 study communities were Mushroom, Medicinal plants, Bush meat, Snails, Honey, Food (Fruits) and Cane.

Secondly, in all 3 study communities, the low income groups use greater proportion of the ecosystem services for commercial purposes (82%) than for domestic purposes (15%). The high income group use greater proportion for domestic purposes (62%) than for commercial purpose (38%). This means that the low income groups' livelihoods depend more on income they gain from selling the ecosystem services whilst the high income groups might have other alternative sources of income in addition to the ecosystem services provision.

Thirdly, the spatial distribution of communities showed different patterns with respect to values assigned to the various ecosystem services and viewed these ecosystem services as crucial to their livelihood. The spatial distribution of ecosystem services and values depicts that, high values areas were places the participants attach more importance due to the large quantity of ecosystem services they collect and low value areas are places that provide least quantity of ecosystem services. Forest provides the highest ecosystem services followed by fallow land, farmland and grassland respectively.

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