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# Scope for introducing payments for ecosystem services as a strategy to reduce deforestation in the Kilombero wetlands catchment area

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ABSTRACT

Payment for Environmental or Ecosystem Services (PES) is among the tools for managing degraded ecosystems and their associated ecological and economic services. Wetlands are an important type of ecosystem, which are highly degradable and accordingly PES become relevant for the sustainable management of wetlands. In Tanzania deforestation in catchment forests has affected many wetlands so much that they cannot adequately contribute to quantity and quality supply of water throughout the year. This study uses consumption surveys and choice modelling to examine the values attached by communities in and around Kilombero Valley to the conservation of catchment trees as compared to the market price value of wood used for timber products in the wetlands. Results show that although conservation preference is generally positive among both rural and urban communities for the trees, the Willingness to Pay (WTP) for the rural dwellers is in proportion to approximately less than 1% of what they receive from the market. Again, the WTP for the rural communities is three times lower than that of the urban communities. These findings are important to policy makers and conservationists in making informed economic decisions on how PES schemes can be used to enhance sustainable management of wetlands.



## 1. Introduction

Payments for Ecosystem Services (PES) are a tool for managing ecosystems and their associated ecological or environmental and economic services (Ferraro, 2001). Examples of these Environmental Services (ES) include climate regulation, water quantity and quality regulation, food and fibre provision, soil fertility enhancement and biodiversity preservation (De Marco and Coelho, 2004). Since wetlands are one the ecosystems that can perform such vital roles in the environment, PES schemes become a relevant instrument for their sustainable management (Milon and Scrogin, 2006; Engel et al., 2008).

While the theoretical background of PES dates back to the 1960s, its implementation using market-based instruments for natural resources management is a recent phenomenon. Currently the Scandinavians (the pioneers) plus a number of developing countries in Latin America namely; Nicaragua, Honduras and Costa Rica, already have such schemes (Kosoy et al., 2007). In Africa, the concept has only recently been introduced and Tanzania for example has such some schemes in the framework of the Reducing Emissions from Deforestation and forest Degradation (REDD+) programme. The REDD+ schemes are mainly geared at carbon sequestration for the purposes of climate regulation. In watershed and wetlands management there are no established schemes despite the provision for it in the Environmental and Management Act — EMA (MNRT, 2010). This situation gives relevance to the reported study.

Theoretical foundations for PES schemes are grounded in welfare economic theory where externalities need to be internalised through

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various pricing mechanisms. PES schemes stem from the fact that natural or human-managed ecosystems provide positive environmental externalities, which are often not considered in economic decisions (Pagiola et al., 2002; Pattanayak, 2004). The term "ES" refers to the provision of these positive externalities (Kosoy et al., 2007). Under PES schemes to those whose economic or social activities interfere with the ecological functions of the ecosystems hence making them fail to provide their services as expected, receive compensation in return for not undertaking these activities (Compose and Caparros, 2006; Azqueta and Sotelsek, 2007).

In Tanzania, the anthropogenic activities of the communities living in and around the Kilombero Valley, which is listed as Ramsar site,[7] have resulted in degradation of these important wetlands (Kangalawe and Liwenga, 2005). The extraction of timber and fuel wood from the catchment areas of the Kilombero Valley Wetlands and the surrounding forests is leading to a high rate of deforestation. The wood fuel consumption in the study area, for example, is estimated to be causing a net deforestation ranging between 3.37 and 21.59 ha day$^{-1}$(Mombo et al., 2011). The most recent statistics (Butler, 2007; FAO, 2009) put deforestation rate in Tanzania at an estimated rate of 410,000 ha year$-^{1}$. Between 1990 and 2010 Tanzania lost a total of 19.4%, or around 8,067,000 ha, of its forest cover (FAO, 2009).

Deforestation and poor agricultural practises are reported to be responsible for reducing the flow in many rivers; Some permanent rivers have become seasonal ones. Moreover, these activities have resulted in the drying up of a number of swamps and have caused the reduction in size of some others (Mombo et al., 2011). Research has shown that communities prefer to improve vegetation cover in the catchment areas in order to ensure constant flow of water throughout the year (Mombo et al., 2011). While the consumers of timber products from the catchment benefit from the products, the urban dwellers incur costs through the loss of clean and ample water. The deforestation of the catchment areas impairs the capacity of the wetlands to fully provide their ecological services to water users. Similarly, communities in Kilombero also depend on the timber products for their livelihoods (MNRT, 2007; Kajembe et al., 2008; Munishi and Mbeyale, 2009). Prohibiting the rural communities from harvesting the trees would therefore have a negative effect on the livelihood of these people.

An external cost (dis-economy/negative externality) exists if an activity by one agent causes a loss of welfare to another agent. If this is not compensated it creates an external cost to another agent; but when this cost is compensated it is said to be internalised (Pearce and Tunner, 1990). Determination of the size of externalities is possible through stated preference techniques and the choice experiments are said to be one of the best methods for this (Hanley et al., 2001). In this respect the WTP for those who are willing to buy ES from the Ecosystem Managers can be determined. PES schemes can therefore enhance transactions between the upstream communities (rural dwellers) and the downstream communities (urban dwellers). The rural dwellers, together with institutions concerned with conservation activities, will be further referred to as catchment tree managers.

This study seeks *first to* examine the values attached to the conservation of the catchment forest cover[8] as opposed to the market value of the trees when used for energy and timber within the Kilombero Valley Wetlands.[9] From this it is possible to determine the benefits of conserving trees for ecological services (constant and quality water flow throughout the year) as opposed to the market value of extracting them. *Second*, the study seeks to determine the difference in WTP for the conservation of the tree cover between the upstream (rural dwellers) and the downstream (urban dwellers) communities of the Kilombero Valley Wetlands. This information on WTP would determine the possibilities of these two groups to trade on their preferences through buying and selling of ES. This would result in internalising the existing externalities and creating sustainable wetlands management.

### *1.1. Conceptual framework*

Wetland ecosystems provide both marketed (goods) and non-marketed (services) resources for mankind. However, the over exploitation of goods such as timber resources has an impact on the ecological functions of the wetlands ecosystems in terms of their potential in the provision of water services as per the required quantities and quality. On one hand this creates externalities to the urban populations who are normally the downstream dwellers and on the other hand the livelihood of the rural population is directly linked to the exploitation of the ecosystem goods. This is linked in such a way that any intervention that would constrain their access to these goods would impose high cost to these upstream dwellers. The rural dwellers depend also on ecological services of the wetlands for their daily living. Therefore these externalities affect the various groups differently in both urban and rural areas.

There are various ways in which externalities of such kind can be internalised. Most scholars (e.g. Ferraro, 2001; Rosa et al., 2004; Kosoy, 2007) suggest that economic instruments such as PES are a viable solution (Fig. 1). The establishment of such schemes should not be generalised but should consider the diverse nature of these resources in terms of their geographic locations as well as the socio-economic characteristics of the affected populations.

## 2. Methods

### *2.1. The study area and background*

The Kilombero Wetlands area under the current study is in the Southern part of Tanzania. The wetlands are listed as a Ramsar site and therefore managed by the Ministry of Natural Resources and Tourism through stipulated rules and regulations following the Ramsar convention (Ramsar, 1971). They are located between the Udzungwa Mountains and the Mahenge escarpment which is part of the Eastern Arc Mountains. The valley is divided by the Kilombero River and is found within two districts — Kilombero and Ulanga in Morogoro Region (Fig. 2). The wetlands area covers an estimated 7967 km$^2$ with a catchment area of about 40,000 km$^2$. All the catchment areas fall under government reserved forests, where according to the law it is prohibited to cut trees. Forest tenure in Tanzania falls into five major entities namely; central government forest reserves, local government forest reserves, private forests, village forest reserves, and general land forest — non reserved (URT, 1998). Many rivers, permanent and seasonal, feed the floodplains. These streams and rivers pour their water into the main Kilombero River, which pours its water to the Rufiji River. The Rufiji River forms a Rufiji basin, the biggest of all in the country. Kilombero Valley Wetlands, which forms a part of Rufiji basin contributes greatly to the provision of industrial and domestic water to the big cities and towns of Mbeya, Morogoro, Iringa, Dodoma, Singida Coast, Ruvuma and Lindi regions. The Kilombero Valley Wetlands area is characterised by sub-humid tropical climate with relative humidity ranging between 70 and 80% and an annual rainfall of about 1200–1400 mm. It has two rainy seasons: long rains from March to May and short rains from October to December. Temperatures normally vary between 20 °C and 30 °C (MNRT, 2007).

[7] Although Kilombero Valley is listed as a Ramsar site under the Wildlife Department in the Ministry of Natural resources, the surrounding catchment forests are managed under other departments in the same Ministry. Forest tenure in Tanzania falls into five major entities namely, central government forest reserves; local government forest reserves; private forests; village forest reserves and general land forest — non reserved (URT, 1998). Catchment forests fall under government forest reserves. No extraction is allowed in all reserved forests.

[8] The rural communities' Willingness To Pay for increased vegetation cover in the catchment areas of the wetlands regarded to as their perceived value.

[9] The rural communities revealed or market value of catchment trees.

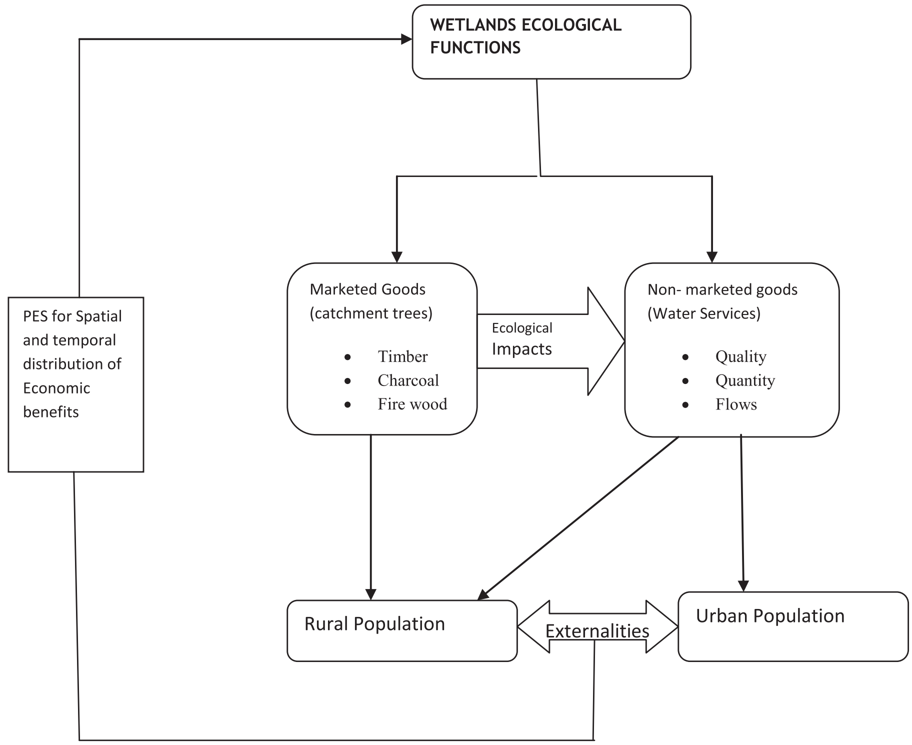


**Fig. 1.** The integrated Wetlands flow of ecological and economical values (Authors' construct).

## 2.2. Data collection methods

Primary and secondary data were collected for this study. The primary data were obtained through a Participatory Rural Appraisal (PRA), which is a standard tool for capturing social survey data. The data were also collected through questionnaire surveys and direct measurement of the biomass energy uses at household level. The secondary data sources included electronic resources, scientific papers and documents from NGOs and Government departments.

### 2.2.1. Direct measurement of household fuels

Direct measurements were conducted to quantify the fuels consumed by the households (HHs). The fuels directly measured were firewood and charcoal as these are the main sources of biomass energy used in the study area and are claimed to greatly contribute to the deforestation of vegetation in catchment areas of the wetlands. The sampled HHs were visited in the morning before the start of their cooking activities and measurements were taken of the available fuels and recorded in the measurement (data) sheet. The same HHs were re-visited the following

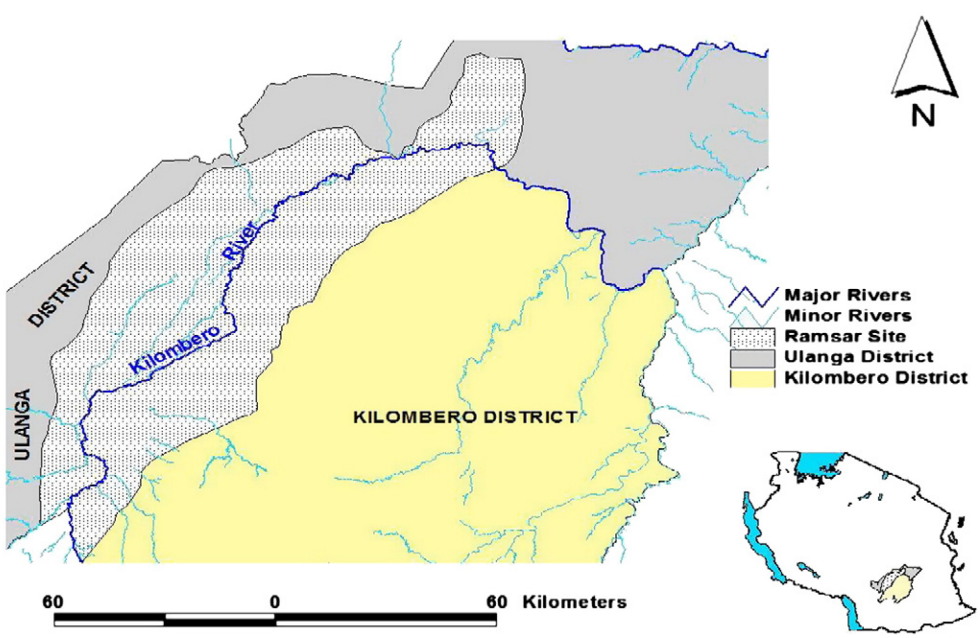


**Fig. 2.** Map of Tanzania showing the Location of the Kilombero Valley Ramsar site (KVRSP, 2009).

day (at the same time as the previous day) and measurement of the remaining fuels was taken and recorded. The difference in measurements, i.e. measurement on the first day *minus* the measurement on the second day was taken as the *household daily fuel consumption intensity*. The main instruments used for fuel measurement was a *spring balance*.

#### 2.2.2. Key informant interviews

Before conducting formal consumption surveys and WTP surveys interviews with key informants were conducted with the aim of understanding some useful and important aspects of energy and timber use in the study area. The main key informants were District Forest Officers, wood fuel vendors, well-known and influential elders, and village environmental committee members.

#### 2.2.3. Households sampling and surveys on consumption and WTP

The sample consisted of individuals with various socio-economic characteristics. The sample for the consumption surveys consisted of 100% of rural HHs from the communities of Kilombero and Ulanga districts. For the WTP determination, both rural and urban population were sampled. In this respect 50% of the respondents were urban dwellers from Morogoro Municipality and the remaining 50% were from Kilombero and Ulanga districts thereby representing rural dwellers.

Consumption surveys were carried out in 204 randomly sampled HHs in Kilombero and Ulanga districts to determine the frequencies and intensities of energy and timber used by HHs in the wetland area. The structured HH questionnaires were administered and used to solicit information that was used to estimate the consumption/demand for biomass energy and timber of each HH. Additionally WTP for increased vegetation cover in catchment areas was determined through a choice experiment in which a sample of 408 HHs were randomly selected using village and street registers from purposively selected villages in Kilombero, Ulanga and selected streets in Morogoro Municipal. The Kilombero and Ulanga districts represented rural population and the Morogoro Municipal represented the urban population.

### 2.3. Analysis

#### 2.3.1. Determining aggregate benefits for rural population

HH consumption was determined using the SPSS software whereby the proportion (%) of HHs using specific biomass energy was determined. For the timber, since it was difficult to determine the consumption from the HH level except for the percentage of the HHs using timber, data from the District Forest Office were used to estimate the supply based on the information on the permits issued during 2010/11. Excel software was then used to compute the amount of wood used for energy and timber per kg and/or $M^3$ units using the conversion factors presented in Table 1. The units were later used to determine the price per each use and to estimate the total amount received as revenue by the identified HHs involved in such economic activities.

This study has made use of various conversion factors during data analysis. *First*, to compute *wood fuel* ($m^3$ of round wood) consumption it was necessary to convert the weight of firewood consumed (kg) and that of charcoal (kg) to their round wood equivalent volumes ($m^3$ of round wood). Table 1 shows how these conversions were carried out.

**Table 1**
Conversion factors for firewood and charcoal into wood volume.

| Fuel wood | Unit | Conversion into wood volume | Source |
|---|---|---|---|
| Firewood | kg | 1 $m^3$ of wood = 725 kg of firewood | ▪ Kaale (2005) |
| Charcoal | kg | 1 $m^3$ of wood = 165 kg of charcoal | ▪ Amous (1999) |
| | | | ▪ Amous (1999) |

Therefore demand for charcoal and firewood was estimated using the following equation:

$$\text{Total Demand(kg)/Month} = [(\text{Number of HH Using}) * (\text{consumption/HH/day}) * (\text{Number of days/month})]. \quad (1)$$

The cost per unit on energy and timber resources was determined based on the average price. This was done in order to see how much of the revenue (in aggregate) is gained by individuals who are involved in the business based on what is demanded in the market. This value was then used to compare with that of the aggregate WTP for the conservation of trees for ecological services.

#### 2.3.2. Determining benefits of non-marketed services

The values of the WTP for wetlands attributes were determined through a choice experiment (Adamowicz et al., 1994; Hanley et al., 2001; Westerberg et al., 2010) investigating the following three biodiversity attributes of Kilombero Valley: tree cover in the catchment areas; area under grazing; and area of undisturbed flood plains, together with a price attribute which was proposed as the percent increase in the water dues. As the intention of this study is not in the choice experiment but rather to determine the WTP based on preferences and socio-economic characteristics for conserving catchment trees the focus has therefore been made on the value attached to tree cover increase in catchment areas. Subsequently the average value for the entire sample was calculated to estimate the average WTP for both rural and urban populations. Additionally a specific average WTP for improved tree cover for either rural or urban population was later estimated. A random parameter model was used to calculate the coefficients which, through Wald's procedure, calculated the WTP (Wattage and Mardle, 2005).

The choice experiment method is consistent with utility maximisation and demand theory (Louviere et al., 2000) and therefore, for the linear utility index, the marginal value of changes in wetland management programmes can be calculated as a ratio of coefficients (Ref Eq. (2)):

$$\text{WTP} = -\left(\beta_{\text{wetland attribute}}/\beta_{\text{monetary attribute}}\right). \quad (2)$$

## 3. Results

### 3.1. Socio-economic characteristics of the respondents in the study area

The urban area consisted of people from diverse economic activities such as businessmen, formal employees, small business vendors and farmers. In the rural areas most of the respondents directly depend on goods and services from wetlands for their livelihoods. Most respondents (60%) had at least primary education, only 4% completed adult education and 20% secondary education. The remaining 26% had a higher education degree i.e. bachelor and some doctoral degrees. The HHs with an income of less than 100,000 TSHS[10] per annum were only 24.4% while those with an income of between 100,000 and 1 TSHS Million (M) per annum made 52% of all respondents. Moreover, those with an income of above 1 M and less than 10 M TSHS made 18.6% of the sample. Few HHs (i.e. 5.1%) had an annual income above 10 M TSHS. Gender distribution was nearly even with male respondents constituting 58% of the sample. The respondent age ranged from 17 to 81 years.

[10] TSHS Tanzanian shilling, at time of data collection the exchange rate was 1 US $ = 1450 TSHS.

**Table 2**
Wood sustainable growth and extraction from Kilombero Valley wetlands forests and their aggregate revenues.

| Item measured | | Round wood volume ($M^3$/year) | Price per unit volume (TSHS[b]/$M^3$) | Aggregated revenue (TSHS/year) | Source |
|---|---|---|---|---|---|
| Sustainable growth[a] | | 416,318.9 | – | – | MNRT, 2005 |
| Extraction | Firewood | −215,746.72 | 0 | 0 | Field surveys 2009/11 |
| | Charcoal | −319,587.40 | 305.9701 | 16,134,391,903 | |
| | Timber | −139.38 | 486,000 | 67,740,923.08 | |
| Total | | −119,154.60 | – | 16,202,132,826.06 | |

[a] Sustainable growth is based on an average value of: 2.35 $m^3$ $ha^{-1}$ $yr^{-1}$ (Malimbwi et al., 2001), 2–4 $m^3$ $ha^{-1}$ $yr^{-1}$ (Malimbwi et al., 1994) and 4.35 $m^3$ $ha^{-1}$ $yr^{-1}$ (Luoga et al., 2002).
[b] 1 $ (USD) was equivalent to 1450 Tanzania shillings (TSHS) in 2009/2010.

### *3.2. The timber extraction and energy demand in the area and their implication in ecological functioning of wetlands ecosystems*

Tree extraction for either timber production or energy use is not allowed in all forests managed for the protection of water catchment and biodiversity conservation although illegal practises are often reported (Mugasha, 2001). In the production forest reserves (mainly under Miombo woodlands) controlled harvesting is allowed. According to MNRT (2005) and inventory data of 11 districts in Tanzania are practising the illegal harvesting of timber and biomass extraction. Timber harvesting is done haphazardly without any prior knowledge of the authorities and is leading to unsustainable management of forest resources. The status of the forests and the human impact in both Kilombero and Ulanga districts, where Kilombero Ramsar site is situated, is summarised in the MNRT (2005) inventory report.

Forests and woodlands cover about 11% of the total land of Kilombero Valley Wetlands Ramsar site of which 4000 ha is protected. According to the National Forest Policy management plans need to be formulated for the management of forest reserves (URT, 1998). Recent data from an inventory of 11 districts, including Kilombero and Ulanga, show that communities are illegally harvesting resources in the catchment areas. The consumption survey shows that communities in Kilombero Ramsar Site extract timber and biomass energy for their various uses from the protected forest through formal and informal (normally illegal) ways. This finding is in line with what Malimbwi (2000) and MNRT (2005) also found in their studies.

The majority (91.4%) of the HHs in Kilombero Valley Wetlands depends mainly on firewood and charcoal for cooking and most HHs (77%) cook three times a day. The sample data revealed that on average the HHs in Kilombero Valley Wetlands use 5.5 kg of firewood and 3 kg of charcoal per day. If this is extrapolated to the entire population the aggregate use would be 156,416,370 kg/year and 52,731,915 kg/year of firewood and charcoal respectively. Using the above reported conversion factor this is equivalent to total sum of 528,000.7 $M^3$/year of round wood. In terms of timber resources the sample HHs are estimated to be using an average of 0.00184 $M^3$ of round wood per year. For the entire population in the study area this would sum up to 139.3846 $M^3$/year (Ref. Eq. (1) and Table 2).

Although, according to Tanzanian forest tenure policy, the largest part of the forests and woodlands in Kilombero Valley Wetlands fall under reserve, deforestation through illegal harvest is still evident in these places (MNRT, 2005). This is thought to be the case since communities are entirely dependent on the forests for their energy and timber needs. From the findings it is clear that the use of biomass energy and timber wood has contributed to the deforestation of the catchment area of the wetlands. There is no evidence of replacement through tree planting in those areas (Kajembe et al., 2008; Munishi and Mbeyale, 2009). Although forests have natural annual yields, when the trees harvested are not replaced, the rate of harvest becomes greater than the annual growth or yield of the forests. For this reason extraction is unsustainable. In this study the current use is therefore compared with the annual allowable cut (annual yield) of these forests. For this purpose it was necessary to determine the rate at which these forests are growing. The summary of sustainable growth of all forests in Kilombero and Ulanga is given in Table 2.

The conservatively calculated (see Table 2) sustainable growth of these forests shows that the current use of the trees for fuel and timber exceeds the allowable cut per year. The findings indicate that the amount of trees extracted annually exceeds the quantity which the entire forests in the Kilombero and Ulanga districts can produce by 119,154.60 $M^3$ per year.[11] These findings suggest that even when management plans are used to guide harvesting, and the harvest is evenly distributed throughout the entire forested land, without replanting the actual forest resource use is not sustainable. Additionally, there is some evidence showing that deforestation is not only caused by fuel wood extraction but also for other reasons, such as the conversion of land for agricultural use or grazing (Misana et al., 2003; Butler, 2007; Monela and Abdallah, 2007). From this, we can see how the forests in the Kilombero Valley wetlands are unable to meet community demand and need for forest resources.

**Table 3**
The prices of timber and fuel wood in the Kilombero and Ulanga market.

| Items | Price in the remote/forest | Price in the market/consumption places |
|---|---|---|
| Firewood | They collect themselves | 10,000/$m^3$ |
| Charcoal | 6000/per bags | 18,000/23,000/(per bags = 67 kg)<br>1000/@ 10 l bucket<br>500/@ 4 l (Kopo) |
| Timber 2″ × 6″ × 12 | 6000/@ 1 Piece | 18,000/@ 1 piece |

### *3.3. Aggregate value of wood extraction at market prices*

In order to understand the pull factor (demand) for extracted wood from the wetland catchment forests it was important to determine the market value of these goods from the wetlands and compare this with the conservation value. The calculations of the market value of the wood is based on the consumption surveys for both timber and energy uses in the HHs in rural area (Kilombero and Ulanga districts). Morogoro urban dwellers were excluded because they get their energy and timber products from other districts like Kilosa and nearby coastal region forests. The estimated consumption per HH was thereafter used to calculate the aggregate amount of the entire rural population spending based on the market prices per unit of the consumed wood for timber and energy uses. The details are elaborated in the chapter on methodology. The official prices for charcoal, firewood and timber (both in remote places and at the market) are given in Table 3.

For those who sell timber (most preferred species) illegally the price at the primary market ranges from 13,500 to 15,000 TSHS[12] per 2″ × 6″ × 12 piece of timber. In this respect, since illegal business is the one which is most responsible for the degradation of wetlands and because this degradation does not follow management plans, we would consider the price resulting from this kind of business to determine the average revenue received through these transactions. For our calculations we took a conservative price of 13,500 TSHS.

With regard to the consumption survey the aggregate amount received from the timber harvest collected as revenue is 67,740,

[11] This assumes only the rural area is consuming, which is not the case.
[12] 1 $ (USD) was equivalent to 1450 Tanzania shillings (TSHS) in 2009/2010.

923.08 TSHS per year (Table 2). This estimated amount is considered to be lower than what is thought to be the exact amount. The figure is based on information regarding registered timber dealers. Although these people have permits, in the key informant interviews it was revealed that these timber dealers use the permits to shield their illegal deals. As there is also some evidence of this (e.g. aerial surveys by KVRS, 2008/09) we therefore believe that much of the timber in the market is illegally extracted from reserved forests. However only approximately 0.1% of HHs in the study area was officially registered as timber dealers. These HHs dealing with timber production receive a gross average of 486,000 TSHS/M$^3$ and the collection of revenue of approximately 1,354,818 TSHS/year. It is important to note that the HHs involved in charcoal business are most of the time not involved in timber business.

Charcoal burning is prohibited in Kilombero District in which part of Kilombero Valley catchment forests falls. However, illegal burning is claimed by the respondents to be practised in the area. This finding is supported by the recent conducted aerial survey which spotted a number of kilns in the catchment forests of Kilombero Valley Wetlands located in Kilombero District (KVRSP, 2009). In Ulanga District, unlike Kilombero District where charcoal burning is prohibited, there are forests in public land where charcoal burning is allowed. For trees in these forests to be extracted for charcoal burning a vendor needs to be registered at the Catchment Forest Office in the district where he/she is given a one-year permit. It was reported by the respondents that due to the hilly geographical nature of Ulanga District, access to some of these allowed forests for charcoal burning is difficult. Furthermore due to over-exploitation of charcoal burning there are almost no trees left to extract. Consequently, illegal charcoal burning is being carried out in the catchment forests in Ulanga District just as it is done in Kilombero District. The villages that are highly involved in charcoal burning in Ulanga and Kilombero districts are those near the market where the demand for charcoal is high.

In general, a HH involved in charcoal business gets an average price of about 306 TSHS/M$^3$. The aggregate amount collected as revenue on charcoal sales is 16,134,391,903 TSHS per year. This amount is only for charcoal sales since most of the HHs in the rural area freely collects firewood from the forests. This means that if we consider a conservative percentage of 10% (the estimated proportion based on focused group discussion of the HHs involved in the business) each HH collects approximately an average gross revenue of 1,461,700 TSHS/year.

### 3.4. Aggregate value of the WTP for tree conservation

The WTP for increased vegetation cover in the catchment areas was determined through a choice experiment. Firstly, the WTP for the entire sample, which consisted of HHs in both rural and urban areas, was determined. Later, the WTP of a HH based on location was determined. These unit average payments were then used to calculate the aggregate WTP for the entire population in both urban and rural areas. Thereafter, the aggregate WTP based on location was calculated for each group. The aggregate WTP for the entire population in both urban and rural areas, to conserve trees for ecological services such as water quality improvement and flow enhancement throughout the year, is 294,755,038 TZS (Ref. Eq. (2)). The aggregate WTP for HHs in Kilombero (i.e. rural dwellers/upstream population considered as tree managers for improving vegetation cover) is 103,804, 800 TSHS/year. The aggregate WTP for HHs in Morogoro (i.e. urban population/downstream) is 304,674,000 TSHS/year.

This study indicates that the estimated aggregated WTP for conservation, without specifying for location, is proportional to only 2% of what a rural population obtains from total charcoal revenue. This comparison is made based on what the rural communities (i.e. within the wetlands areas) receive from market sales of charcoal and timber. This information is used to value the goods extracted from the forests in the Kilombero Valley wetlands. Once again the information reveals the aggregated WTP for the rural communities is almost three times lower than that for urban communities. The figures give an indication of the temptation which rural HHs face with regard to extracting trees for market sales, compared to conserving them for ecological benefits. From this perspective, we believe that prohibiting local communities from extracting catchment trees costs them a great deal. In order for the illegal practise to be stopped a management scheme that considers such realities would be a viable solution. According to the findings from most literature on ecosystems conservation, PES schemes might provide a viable solutions. The establishment of such schemes would need to adhere to particular principles (Ferraro and Kiss, 2002; Kosoy et al., 2007) and some of these finer points are therefore outlined in the following section.

### 3.5. Determination of the compensation schemes in Kilombero Valley wetlands

There are various means of compensation depending on the nature and objectives for the watershed management scheme (Pagiola, 2005; Engel et al., 2008). According to Ferraro (2001) and Rosa et al. (2004), rural communities are highly dependent on natural resources for their survival. These authors therefore suggest that, in terms of compensation, PES schemes should focus on three levels of need. The first level should take into account the need for these communities to meet their basic needs for things such as fibre, energy, water and spiritual well-being. Not all local community HHs extract resources directly from the ecosystems. Internal relations within the communities are linked to the second level, where transactions are based on their basic needs. On the third level the transaction is between the upstream communities (where the resource is located) and the downstream communities. The upstream population are referred to as resource managers and the downstream population are referred to as secondary resource users (Ferraro, 2001; Kosoy et al., 2007). At this level, the upstream and downstream communities are transacting ecosystem goods and services, such as the provision of a constant and quality flow of water throughout the year when this is inferred to river basins. It should, however, be noted that the compensation cited by most research on PES is not that of a one to one ratio. There are many issues to be considered for PES schemes' compensation to produce an impact (Sierra and Russman, 2005; Engel et al., 2008).

The Kilombero Valley wetlands' stakeholders fit well within the structure of the communities described in the work of Ferraro (2001) and EFTEC (2005). This is because the wetlands are important to both the local population, where more than 80% of them reside in the valley and are entirely dependent on the catchment trees for energy and construction use, and to secondary users who are dependent on these wetlands for ecological goods and services such as water. The water is important for domestic, commercial, urban and agricultural uses, and industrial uses such as power generation. Currently, 70% of the hydro electricity in the country is produced within the Kilombero Valley wetlands.

While the primary users are directly dependent on the wetlands for timber products and to obtain sufficient, quality water, the downstream dwellers' needs are specifically linked to the demand for sufficient quality water. This is therefore correlated to the third level of transactions described in Rosa et al. (2004) and EFTEC's (2005) works. In this regard, if the pressing needs of the local communities for energy and timber were not considered, the demand for catchment trees would increase. As a result, the market price for the trees would remain high. Consequently, the trees from the catchment forests would continue to be extracted illegally, as the local charcoal and timber dealers would have an incentive for doing so. This would negatively impact on the ecological functioning of the wetlands and therefore impair their capacity to provide a constant and quality water flow to meet the needs of both communities. In this respect, the impact on urban dwellers would be considerable. Consequently, it is for this reason we believe the WTP for increased vegetation cover in the catchment areas and to have sufficient quality water is higher among urban communities than it is among rural communities.

On the other hand, some of the communities (an estimated 1% and 10% of all HHs) in the rural areas depend on the sales of timber and charcoal for cash income. In addition, more than 90% of the total rural HHs depend on biomass energy for their cooking and lighting. In order to achieve a respite in the illegal extraction of trees, it is important for the disadvantaged to be compensated through a properly designed incentive mechanism. The compensation (not necessarily direct payment) would reduce the temptations for individuals residing in the rural areas (primary users and upstream dwellers) to focus on the economic value of the catchment trees. Otherwise, as things stand, the high value that can be earned by felling trees for timber and energy is an incentive to continue felling, instead of conserving the tree cover for the provision of ecological or environmental services. The illegal actions of those felling trees pose high management costs for the government and the downstream population (i.e. the cost for cleaning polluted water and water with sediments, increase in the water price per unit due to scarcity and increase in the unit price of hydro-electricity used for domestic and industrial purposes due to the siltation of dams). Furthermore, they lead to further degradation of the ecosystems in general. These costs constitute externalities.

PES schemes could induce a change in behaviour among economic agents by internalising environmental externalities. PES can also internalise a depletion cost, which these agents face through a change to the incentives structure. The use of economic instruments/policies (used in PES schemes) has several advantages, including imposing less social costs than command and control mechanisms. They are also less susceptible to rent-seeking behaviour. They can be used to generate revenues that could then be utilised to motivate the beneficiaries of ecosystems degradation to change their behaviour, and to defray the administrative costs of enforcing environmental policies (Pearce and Tunner, 1990; Ferraro, 2001; Engel et al., 2008). In the case of the Kilombero wetlands this could include the planting of trees in open public land, improvements to the underdeveloped rural infrastructure which encourages the free-riding characteristics of the users, and enhancing land-use plans through surveys and entitlement. The literature indicates that the difference between economic instruments and traditional regulatory measures is that, whilst the former use market forces the latter use enforcement to induce behavioural change. Several studies have shown that economic instruments, such as PES, can be more flexible, stimulate innovations and lower the costs for consumers and companies who want to green the way in which they do business (Sierra and Russman, 2005; Engel et al., 2008).

Evidence from this study demonstrates that deforestation within the catchment areas is very much linked to the illegal practises of some HHs in rural areas and the lack of enforcement. If PES schemes can first consider the HHs whose livelihoods depend entirely on the sales of timber and biomass energy, these schemes could well bring about a respite from the illegal harvesting of timber and biomass energy (Ferraro, 2001; Rosa et al., 2004). One of the ways to achieve this could be through the creation of alternative income generation activities, such as beekeeping, ecotourism and cultural tourism with its associated economic activities such as hotels, lodges, camping sites and tour guiding. These alternatives would offer these HHs returns similar to those obtained from the sale of timber and charcoal, which is currently the most lucrative business in the area.

Further to the above, an intervention that would meet the demands for energy and timber for the communities living inside and around the valley should also be considered. Such interventions could involve tree-planting programmes in areas that are not linked to the water catchment: such as public/private (village farms)/village forest areas; provision of energy-saving stoves at an affordable price; and subsidies on technological innovations for alternative energy sources. The results in this study also demonstrate that, in the Kilombero Valley catchment forests, the harvest of timber resources exceeds requirements, leading to a significant amount of deforestation in these forests (Table 2). It is therefore important for PES schemes to consider subsidising public institutions concerned with the sustainable management of the ecosystems (e.g. the newly established Tanzania Forest Service) to ensure their proper function. Revenue collected from locals through the use of environmental economic instruments (for example, by taxing the regulatory and supply bodies for water and electricity — the choice experiment used to determine the WTP is based on a percentage increase in water bills) if directed to these conservation bodies, already has the potential to make a big difference.

Besides, environmental education about the importance of conserving catchment forests would improve the conservation preference, which would later raise the value of the forest cover in the catchment areas. The conservation preference would improve because the valuation of non-market goods is based on the perceptions and preferences of the individuals. Therefore, information on conservation will also increase the interest of the communities in the conservation process through participatory approaches. These interventions would help to reduce the pressure on the wetlands by lowering the price of the trees and by changing the attitude of the rural communities making them conservation partners, instead of illegal catchment tree extractors as they are now. A change of attitude and preferences in future years would help to maintain the catchment forest for the Kilombero Valley wetlands to provide the communities with water resources. The incentive mechanism established could be financed from revenues collected through ES sales and purchases. Since the WTP for both urban and rural communities is positive, the unit prices of the sales of ES could be based on the estimate made by this study. *Action research* could be used to determine the constraints on such flows of economic benefits to the identified groups of the disadvantaged, and the beneficiaries can be analysed. Apart from the local scheme, which by itself can significantly improve the management of wetlands and their associated catchment forests, it is an area where international PES schemes could also play a significant role. Programmes linked to REDD+ which are now implemented in the country could be connected to the proposed local schemes. If these results could be used to improve the strategies employed by international communities to establish PES schemes in Tanzania, and elsewhere, the schemes can be expected to be successful.

Several challenges related to the functioning of PES are thus far reported for developing countries including some in Latin America and India (Kosoy et al., 2007; Porras et al., 2008). In most of these countries PES schemes for water shed management were based on land use proxy, leading to challenges in measuring and attributing changes in the provisioning of water services. Beside most of the initiatives in India and Latin America were based on donor funded projects. The situation in Tanzania is different from that in these countries, because the degradation considered is mainly linked to deforestation and considers payments from urban water users to the rural communities who are regarded as catchment forest cover managers. It is therefore expected that a reduction in the illegal harvesting of catchment trees caused by a PES scheme following the recommendation provided in this study, would significantly improve the water quality and increase the quantity of the flows.

It should be noted that PES alone cannot eradicate the problems of ecosystem degradation (Turner and Daily, 2008; Engel et al., 2008). Pagiola (2003) further claims that reasons for ecosystem mismanagement are many and that PES cannot solve them all. According to Ostrom (2005) the suitable response in this case would be to ensure that local ecosystem managers have appropriate property rights. This study did not focus on matters pertaining to wetlands ecosystem property rights in Tanzania. Moreover the problems of the existing land tenure in rural areas of Tanzania are well explained in the works of various authors, including Lane (1994); Walsh (2008); Goldman (2011) and Komu (2012). In this literature, the authors explain how the property rights of the holder are insecure under the country's customary law. In view of the diverse reasons for ecosystem mismanagement, Engel et al. (2008) proposes that PES should be part of a mix of policies in order to achieve the expected results.

## 4. Conclusion and recommendations

From the study findings, it can be concluded that the capacity of the forests in Kilombero Valley Wetlands (private Forests are not included) are not able to cater for the entire population found in Kilombero and Ulanga districts for their pressing timber and energy needs. Also, deforestation is not only attributable to the uses analysed in our study but also to issues of converting forest lands for crops and livestock farming and this situation requires urgent intervention. Because of the high demand for trees in the market caused by the pressing needs of the local communities, the value attached to such trees by the rural communities is bigger than the value obtained when the trees are left or conserved for environmental services purposes. In our case, we considered the wetlands ecosystems/environmental services for constant and quality water supply to both urban and rural populations.

Further to this, the externalities created by these diverse socio-economic groups of wetland users, where each has its own costs and benefits, can be internalised through PES schemes. The tree resource exploiters in this respect disrupt the ecological function of the wetlands and therefore impair the capacity of ecosystems from delivering enough quality water to the people downstream. It follows that the urban dwellers and the rural communities can negotiate their preferences through PES schemes since the former attach higher values to the conservation of the vegetation cover in the catchment areas than the latter. These PES schemes are regarded by the scholars as the management tool that could help to change the environmental destructive behaviours of economic agents on the ecosystems through compensating their losses and enhancing the conservation attitudes. The benefits accrued through buying and selling of ES between the two groups can therefore be used to compensate those whose livelihoods are dependent on tree resources. PES can also help to collect revenues which could be used to fund development interventions that would reduce the demands and needs on the ecosystem goods. Such development could be on replanting of trees after extraction; the establishment of management plans based on sustainable harvests; improvement of stove efficiency and supplying of the same at affordable prices; and environmental education on the causes of degradation with viable solutions to both elite persons and the local community. This in turn would reduce the demand for the marketed trees for the provision of energy and timber and instead let them be conserved in the catchment forests. For the schemes to be viable the establishment of PES must consider the particular needs of the communities based on their socio-economic preferences; nature of the managed resource and the type and levels of the transactions existing among and between the communities found on local, national and global scale.

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