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Economic Assessment of Best Management Practices in the Mara River Basin: Toward Implementing Payment for Watershed Services

George Atisa · Mahadev G. Bhat · Michael E. McClain

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Abstract The Mara River in East Africa is currently experiencing poor water quality and increased fluctuations in seasonal flow. Improved water quality will require upstream farmers and foresters to adopt Best Management Practices (BMPs), which might cost them considerably. This study proposes a Payment for Watershed Services (PWS) mechanism. This is a market-based approach, whereby downstream water users would pay upstream watershed service providers towards the costs of BMPs implementation. This study analyzes the technical feasibility and economic viability of adapting selected BMPs and provides cost estimates of a PWS program. Using three criteria of water quality improvement, economic feasibility, and technical suitability, a detailed economic opportunity cost analysis revealed that farmers would indeed incur economic losses for all BMPs except no-till farming. We also developed a multi-criteria (demographic and environmental) methodology for identifying land areas to be placed under BMPs. More than 122,000 ha of land would require BMPs, including a moratorium on agriculture inside the Mau Forest Complex. The initial per hectare opportunity costs across the five highest ranked BMPs ranged from US$ 272 to US$ 926. Using these cost estimates, the paper draws some valuable policy and management insights on how to finance BMP implementation.

Keywords Water quality · Payment for watershed services · Best management practices · Opportunity costs

1 Introduction

The demand for watershed services in many river basins around the world far exceeds the supply in terms of quantity and quality as a result of population growth, agricultural intensity

G. Atisa
Department of Public Administration, Florida International University, Miami, FL, USA

M. G. Bhat (✉)
Department of Earth and Environment, Florida International University, Miami, FL, USA
e-mail: bhatm@fiu.edu

M. E. McClain
UNESCO-IHE Institute of Water Education, Delft, The Netherlands

and overall development (Antle and Valdivia 2005; Bollinger et al. 2005; Hoffman et al. 2011; Wunder and Southgate 2007; UNEP 2012). Watershed services are public goods in nature and therefore are easily accessible without making appropriate payment for them. Such services often end up being undersupplied or abused. The Mara River in East Africa is a good example of a basin where there is rising water demand due to rising population and agricultural expansion thus leading to increased fluctuations in seasonal river flow (Nyangena and Kohlin 2008; Hoffman et al. 2011; Kenya Forests Working Group 2006; WWF 2005). Population growth in the headwaters of the Mara River Basin (MRB) has not been matched by commensurate development of sustainable land use and agricultural practices due to poverty and lack of investment by resource users (Kenya Forest Working Group 2004, 2005).

The downstream section of the MRB in Kenya is home to Maasai Mara National Reserve, large-scale irrigation wheat farmers and Maasai pastoralists in Kenya, and Serengeti National Park in Tanzania. Majority of farmers living in the upstream section of the basin are poor, practice small scale subsistence farming, and care more for short-term survival needs than long-term environmental quality sustainability (WWF 2005; Hoffman et al. 2011; Mati et al. 2005). Globally existing water management initiatives have not been effectively applied in Kenya to manage the cumulative effects of land use and agricultural practices to protect water quality and quantity in watersheds. This study is important as it introduces Best Management Practices (BMPs) and explains how economic incentives could be used in the protection of the MRB watershed.

There is a growing attention to the declining water resources and quality degradation in the MRB because of the importance of the Maasai Mara National Reserve in Kenya, the Serengeti National Park in Tanzania and all communities that live downstream and rely on water from this river. A number of BMPs that will allow farmers in the headwaters of the Basin to continue to use land resources without degrading the environment were examined in this study. The BMPs that meet specific adoption criterion would have to be negotiated and costs of their implementation agreed to by all communities living in the basin.

This study had two primary objectives. First objective was to identify various agronomic, economic and physical factors that influenced the opportunity costs of making changes from conventional farming and watershed protection practices to the use of BMPs. Second objective was to develop a methodology based on multiple environmental and demographic criteria for identifying and prioritizing areas needing BMP implementation. Estimating the costs and areas of BMPs would be a necessary precursor to developing PWS programs. The methodology we developed for these two variables was based on direct stakeholders' inputs that we gathered through a household survey and from key informants. These estimates provide valuable policy insights for designing a feasible Payment for Watershed Services in the basin.

Although there have been many studies done on watersheds management, we have not come across one that has used the costs of implementing BMPs and associated opportunity costs as a way of developing Payment for Watershed Services (PWS) schemes. Studies such as those done by (Artita et al. 2013; Tuppad et al. 2010; Rocha et al. 2012) have examined watershed-scale BMP alternatives to determine long-term impact on sediment control without establishing opportunity costs of implementing such BMPs. Other studies (Sun et al. 2013; Bryan and Kandulu 2010; Zaag 2007) have analyzed mixed policies and targeting of instruments alongside institutional arrangement needed to ensure equitable distribution of water resources without going into actual opportunity costs of implementing these policy instruments. None of the above studies looked into the socio-economic feasibility of practices from the stakeholders' perspective.

Adoption of BMPs so as to reduce environmental degradation and move towards sustainable agriculture can reverse the declining water quality trends (Clint et al. 2002). There are many economic and practical reasons why farmers may be hesitant or slow to adapt environmentally sustainable practices. These include perceptions on costs of implementation and expected yields (UNFAO 2008). In addition, UNFAO (2008) argues that key attributes that matter the most are the comparative advantage of a specific BMP in terms of higher yields, improved soils, adoption cost, and improvement of the general environment (UNFAO 2008). Secondly, compatibility with previous and current practices is a major attribute as this requires more investments and land to turn around an old practice to a totally new one. Thirdly, good BMPs must be simple, should be easy to pre-test, and its impact should be obvious and convincing. Finally, it should not pose any technical difficulties and misunderstanding to the farmers.

Despite the many appealing aspects that BMPs might have for natural resources managers and farmers, their adoption rate remains low in Kenya because of high initial adoption costs (Swinkels et al. 1996). Land owners do incur economic costs as they transition from conventional to environmentally sustainable practices. Adoption of these practices requires extra labor, land and capital, and therefore often leads to reduced short-term profits for the farmers (UNFAO 2008). Although the use of BMPs can lead to increased profitability and production efficiency, most small scale farmers rarely view adoption of BMPs in these terms due to high initial opportunity costs (Hilliard et al. 2002; Bollinger et al. 2005). We argue that factoring economic opportunity costs into designing the Payment for Watershed Services (PWS) schemes is central to its success as a mechanism for paying upstream communities to implement BMPs. Such scheme would not only improve overall environmental resources in their settings (Zaag 2007; Wunder 2005; WWF 2006), but also would be economically viable and socially Equitable. A mandatory policy for implementing BMPs is an approach often used by governments but this is viewed as denying communities the use of natural resources for improving their socio-economic wellbeing (Wunder 2005; Wunder and Southgate 2007).

2 Methodology

2.1 Study Area

Mara River Basin is shared between Kenya and Tanzania (Fig. 1) and is formed by the confluence of the Amala and Nyangores Rivers, which have their source in the Mau Forest Complex (MFC). About 40 % of the study area was under MFC. The MFC is one of the five water towers in Kenya forming the headwaters of many major rivers such as Sondu and Nyando to the west, Ewaso Ngiro to the South and Njoro to the North. The current study concentrated on the headwaters of the Mara River Basin including the section of the Mau Forest Complex and parts of Bomet District that falls within the basin extending south to the confluence of Nyangores and Amala rivers. The exact area of study is shaded grey in Fig. 1 and it covered 245,688 ha.

2.2 Data Collection

We conducted a structured interview of farmers in the summer of 2008 for 4 weeks. Farmers interviewed represented a wide range of age groups, and educational levels, but gender was heavily skewed towards men. Most women refused to be interviewed on matters regarding land because culturally in this region, land belongs to men. A total of 220 farmers were interviewed but only 155 questionnaires were retuned at the end of the survey, yielding a 70 % response rate. About 67 % of the farmers interviewed said they had high school education and above while a mere 2.6 % had not been to school.

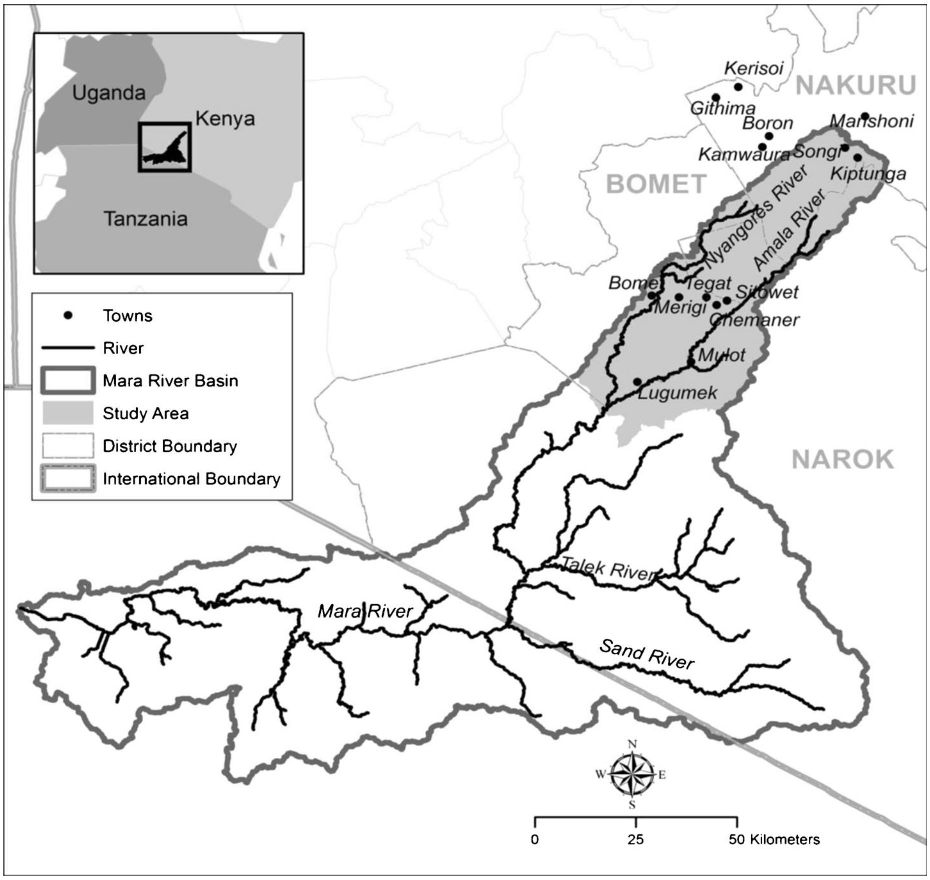

Fig. 1 Map. Location of the study area. The *grey* (study) area is upper section of the Mara River Basin. The remaining part to the south is the lower Mara River Basin

2.3 Delineation of the Study BMPs and Assessment Criteria

Table 1 presents a brief description of BMPs that farmers had a chance to review for assessment. These practices were identified from Karin et al. 2008; Tenge et al. 2005; Cunningham 2003; Nicholson 2001; Ekboir et al. 2002. Some of the BMPs such as bench terraces, grass strips, cut-off drains, infiltration ditches and agroforestry had local names which made the survey a lot more interesting.

According to Cunningham (2003), BMPs must meet three criteria to successfully stop natural resources degradation. First, they must be economically and socially beneficial in order for farmers to adopt them. Secondly, BMPs must be easily acceptable and adoptable. Finally, practices chosen must be environmentally effective. Otherwise, even with compulsory implementation, water quality and quantity improvement will not be achieved.

Using the five point Likert scale, where one represented “I strongly disagree” and 5 “I strongly agree,” farmers identified those BMPs that were suitable to their farms under the three criteria of water quality improvement, economic feasibility and technical suitability. They also provided us with the estimate of what each BMP would cost on their own farms.

Table 1 Brief description of best management practices

Best management practice	Brief description
No till farming	This requires farmers to do their farming with minimum disturbance on the soil surface soil
Contour farming or grass Strips	Developing ridges across a slope to change the direction of runoff from directly flowing down the slope to around the hill slope
Contour strip cropping or bench terraces	A systematic practice of growing crops alternating with vegetation or grass cover.
Strip cropping	This is a practice where different crops are grown in different strips across the field so that crops that hold the soil together are alternated with those that do not
Ecoagriculture	These are land use systems that are designed to produce food for communities and ecosystem services for biodiversity without degrading the landscape
Do no farming	This is a practice where farmers are required to stop completely any form of active farming.
Construction of erosion controls—*Fanya Juu*	This is the use of barriers to slow soil erosion
Streamside management Zones	These are strips of land adjacent to rivers, streams or any body of water that help to protect water quality by stopping soils from entering the rivers.
Irrigation water management—Infiltration ditches	These are practices aimed at improving the efficient use of water that goes to irrigated agriculture
Mixed farming or agro-Forestry	Growing different crops and animals in one farm such that wastes from one type of farming can be used as inputs for other farming practice.
Crop nutrient management	This is a practice allows for reduced external application of nutrient use through good timing and placement match of plant growth.
Conservation tillage	This is a practice that uses crop residues to cover farms to reduce surface runoff.
Run-off management systems or Cut off strips	This practice helps to control excess runoff that often come as a result of land use changes or land disturbances

Source: Hilliard et al. 2002; Ekboir et al. 2002; Swinkels et al. 1996; Clint et al. 2002

2.4 Opportunity Cost of Best Management Practices

There are two criteria for determining how much should watershed service providers receive for implementing BMPs (Reis et al. 2007): (a) the actual opportunity costs of adopting BMPs by upstream watershed service providers; and (b) willingness to pay of downstream service users. We assumed that farmers would experience the following types of changes and/or opportunity costs when they adopt a particular land management practice: (a) new costs of making permanent change in the structure of land and other natural resources that include labor and cost of inputs; (b) changes in the annual costs of cultivation; (c) going from high value crops to low value crops; (d) changes in crop yields; and (e) changes in certain income-earning opportunities. Therefore, the "true" opportunity costs of making desirable land-use changes will be equal to a reduction in the net profits from farming, due to all the factors listed above. Some BMPs may result in increased crop yield and decreased costs.

What follows is the method we employed for capturing the effects of all the above five factors on the total opportunity costs of implementing BMPs. Let h denote the number of hectares that a farmer owns before the implementation of a BMP. Assume that the farmer would lose a fraction α (0<α<1) of the cultivable land due to implementation of a specific BMP. Therefore, the actual area of land planted crops after implementing a BMP is only (1-α)*h*. Let subscript *pre* and *pos* denote pre-BMP and post-BMP scenarios. The per hectare cost of production and revenue are *c* ($/ha) and *r* ($/ha), respectively. The total farm-level costs and revenue are *TC* ($/ha) and *TR* ($/ha), respectively.

The total net farm income (π_{pre}) before the implementation of a given BMP (π_{pre}) is,

$$\pi_{pre} = \left(r_{pre} - c_{pre}\right) \cdot h \tag{1}$$

Similarly, the expected net farm income after the implementation of that BMP (π_{pro}) is,

$$\pi_{pos} = \left(r_{pos} - c_{pos}\right) \cdot (1-\alpha)h \tag{2}$$

The above two identities reflect that per hectare crop yield, and therefore, the total per hectare revenue may change as a result of implementing a BMP. Also, the unit costs of production and the total available farm area for cultivation may change. Finally, the annual opportunity cost of BMP implementation (C_t) on average is the difference between the net farm income before the implementation and the net farm income after the implementation. Formally,

$$C_t = \pi_{pos} - \pi_{pre} \tag{3}$$

where *t* is the year. If the outcome in Eq. (3) is negative, farmers gain when they implement BMPs and therefore may not require compensation unless the initial capital costs of implementation are beyond their reach. If Eq. (3) is positive, they lose and therefore would require to be compensated.

The BMP cost information provided by farmers was supplemented with other costs such as area and yield losses with certain practices, in order to produce overall opportunity costs of various BMPs (C_t) over a ten year period. The annual costs and revenues were discounted at 10 %. The 10 % percent discount rate reflects the real opportunity costs of risk free investment and falls within the range used for developing countries (Pattanayak 2004). The total net present value opportunity costs (*NPVC*) was computed as follows:

$$NPVC = \sum_{t=0}^{10} \frac{C_t}{(1+r)^t} \tag{4}$$

Although we initially asked farmers to assess 13 different BMPs, some of the practices were found to be part of larger farm-wide BMP systems. Therefore, in the final analysis we considered six systems of BMPs that were ranked highest by farmers across the three criteria of water quality improvement, technical suitability and economic feasibility. Grass strips and bench terraces were grouped into one because they were found very similar in many respects including cost estimates. They were: (a) bench terraces, (b) grass strips, (b) agro-forestry, (c) streamside management zone, (d) do-no-farming and (e) no-till farming. For brevity, specific economic and physical parameters and steps used in the cost estimation are in Table 4 and its footnotes.

2.5 Estimation of Land That Needs to be Placed Under BMPs

Estimating the areas to be placed under BMPs is the next logical step in determining the total payment for watershed services. Five different demographic and environmental criteria were chosen for determining the extent of the land needed to be placed under BMPs in the study area. The five land categories based on the above criteria are:

Category (a): portion of the land under cultivation, settled within the last 10 years inside of MFC

Category (b): portion of the land under cultivation, settled for more than 10 years within MFC which is under cultivation

Category (c): portion of the land under cultivation which was highly erodible and settled for more than 10 years outside of MFC excluding that next to the rivers

Category (d): area of land outside MFC where farmers said they needed crop nutrient practices

Category (e): area of land under cultivation that bordered rivers.

The following literature was used to compliment the survey in the estimates of land that would be put under different BMPs. Atela et al. (2012) estimated an area of land converted to farming in the last 10 years under land category (a). Gereta (2004) reported a total settled area for longer than 10 years under land category (b). The total farmland (136,108 ha) outside of MFC but within the Kenyan Mara basin was obtained from the Kenya Geographic Information Systems Maps. We then multiplied this total farm land area by the percent (48 %) sample farmers who said their land was prone to soil erosion. The resulting total erosion-prone farmland area was further converted to actual cultivated area by the sample ratio of average cultivated area (3.1 ha) to average farm size (5.1 ha). This yielded a total land area (c) of 39,712 ha. We assumed that remaining farmland area outside of MFC of 70,776 ha (=136,108–65,332 ha) would fall under category (d), which needed some crop nutrient BMPs. The total hectares that needed streamside management zones (SMZ) was estimated from GIS data with Global Water for Sustainability (GLOWS) at Florida International University, and the literature on the minimum allowed land strips along the river (Li et al. 2006). The total number and length of all rivers was multiplied by the minimum allowed land strips on both sides of the rivers to obtain total hectares needed for SMZ (e). By applying the ratios of sample mean cultivated area to sample mean settled area to each of the above areas of total settled lands, we obtained the proposed area of BMP under each land category.

The choice of BMPs on each of the above land categories was determined based on the improvement necessary for each land category. The five highest ranked BMPs across the three criteria were selected for adoption under different land conditions. These BMPs were do-no-farming, no-till farming, erosion control practices, crop nutrient management, and streamside management zones for land categories (a), (b), (c), (d) and (e), respectively.

The final total estimate of costs of BMPs was determined based on three main factors: (a) the type of BMP suitable to each land type, location and situation; (b) the area under each practice; and (c) the opportunity cost of each practice.

3 Results

3.1 Sample Characteristics and Perceptions

Table 2 shows the descriptive statistics of the sample households, including the respondent's perceptions on the PWS program. Majority of the respondents were in the age group of 31 to 40 years and 41 to 50 years. About 33.8 % of the farmers were natives of the study area while majority of the households either purchased (47 %) or leased (12.6 %) lands in the study area.

Table 2 Sample characteristics and perception on PWS program

Description	Categories and values					
Age in years	under 30	31 to 40	41 to 50	51 to 60	61 to 70	Over 71
Percent	19.1	31.2	32.6	12.1	2.8	2.1
Composition of farmers	Indigenous	Purchased	Leased	Squatter	Other	Owner
Percent	33.8	47.0	12.6	0.7	5.3	0.7
Length of stay in the basin in years	Less than 5	5–10	10–15	Over 15		
Percent	1.3	11.7	11	76		
Farmer Characteristics	Subsistence farmer	Small-Scale & large commercial farmer	Other			
Percent	47	52.3	0.7			
Farm Sizes in hectares	Less than 1	1–3	3–5	over 5		
Percent	44.6	38.3	14.3	2.8		
BMPs Adoption	Understanding PWS	Understanding of BMPs	Willing to implement BMPs	Not investing in water quality		
Farmers Percent	58.6	88.3	87.4	78		
Farmer's farm conditions	Erodible lands	Bordering rivers	Use of fertilizers			
Percent	48	55	92			
Preferred source of funding	Government	Downstream People	International Organizations	Self		
Percent	30	14.7	42	13		

Source: Own survey data

About 76 % of the farmers had lived in the study area over 15 years. Majority of the farmers (82 %) owned or cultivated less than 3 ha.

Farmers understood that deforestation was the major cause of soil erosion, which led to water quality problems in the basin. A majority of the sampled farmers had a positive attitude towards protecting natural resources, with 87.4 % of them willing to implement some BMPs. They also knew that they were not investing on soil and water conservation measures (78 %).

3.2 Ranking of BMPs

The BMPs presented for assessment by the farmers for water quality improvement, economic feasibility and technical suitability for potential adoption were ranked based on the number of farmers who viewed them as most applicable on their farms. The underlying assumption was that while ranking practices based on the three criteria farmers made rational decisions that reflected both their concern for water resources protection and their perception of socioeconomic needs. Those practices that were good for water quality improvement have been ranked very high but when socioeconomic considerations were taken into account, some of them have been ranked very low. Table 3 shows the percentage of farmers that responded positively to each BMP across the three criteria and the rank in order of popularity of each BMP.

About 83.6 % of the farmers rated construction of erosion control as the number one practice in terms of contributing to water quality improvement, 73.6 % of the farmers rated mixed farming as the most economically feasible practice, and 67.7 % graded both contour farming and runoff management system as the most technically suitable practice to their farms. Practices that received ranks above number seven with respect to all three criteria included construction of erosion control systems, runoff management systems, contour farming and streamside management zones. Practices that ranked the lowest and therefore least acceptable from an economic point of view included do-no farming, no-till farming, conservation tillage

Table 3 Ranking of the suitability of BMPs based on the three criteria

BMPs	Water quality improvement		Economic feasibility		Technical suitability	
	Percent[a]	Rank	Percent[a]	Rank	Percent[a]	Rank
No till farming	82.1	2	12.6	12	45.5	9
Contour farming	73.5	6	66.7	2	67.7	1
Contour strip cropping	70.0	7	45.0	9	57.9	6
Strip cropping	41.7	13	45.4	8	54.7	8
Ecoagriculture	66.9	8	41.2	11	55.9	7
Do no farming	81.4	3	10.7	13	44.5	10
Construction of erosion control	83.6	1	66.4	3	63.4	4
Streamside management zones	81.0	4	51.2	7	61.4	5
Irrigation water management	54.9	11	54.0	5	65.0	3
Mixed farming	45.8	12	73.6	1	66.7	2
Crop nutrient management	61.1	10	58.2	4	55.9	7
Conservation tillage	68.8	9	42.9	10	54.4	9
Runoff management system	76.0	5	52.8	6	67.7	1

Source: Estimated from own data analysis

[a] Percent is the percentage of sample farmers that agreed that a given practice met the subject criteria. The ranks are in the same order as percentages

and strip cropping. Although these practices received very low ratings economically, they have been analyzed further because of their high rating in the water quality improvement criteria.

A rank correlation (ρ) between the three criterion was estimated to establish how strongly one criterion would influence another. The coefficient of correlation between water quality improvement criteria and economic feasibility was $\rho=-0.264$ ($p=0.384$) and statistically insignificant. The relationship between water quality and technical suitability of BMPs was $\rho=-0.110$ ($p=0.720$). Economic and technical suitability criteria showed a strong relationship of $\rho=0.818$ ($p=0.001$), which was statistically significant.

3.3 Opportunity Costs of Selected BMPs

Table 4 presents the annual and total opportunity costs of top six ranked practices over a period of 10 years discounted at 10 %. These estimates were calculated based on net incomes obtained from the survey data on farm incomes and costs. The sample average opportunity cost of bench terraces was US$ 336 per hectare during the adoption year, US$ 160 per hectare in year 1 and US$ 103 per hectare annually between year two and ten. The Net Present Value (NPV) cost was US$ 1022 per hectare. Similarly, the net present value total opportunity costs over 10 years were US$ 832, US$ 603, US$ 482, US$ 2888, and US$ -776 for grass strips, agroforestry, SMZ, do-no-farming, and no-till farming, respectively. In terms of opportunity costs, grass strips practice had the lowest in the first 3 years, agroforestry though expensive initially turned into lower opportunity costs over the years. No-till-farming resulted to negative opportunity cost over a 10 year period, meaning that farmers would actually benefit.

3.4 Total Amount of Land to be Placed Under BMPs

Recall that this study had established five criteria for determining the total number of hectares that could be placed under BMPs. Table 5 shows the estimated cultivated area under each land category. The total study area was estimated to be 190,826 ha. About 64 % (122,486 ha) of this land will need some form of BMPs. The land category (d) or area outside of MFC needing some crop nutrient management of 43,021 ha, followed by the land category (c) of 39,712 ha, land category (a) of 23,786 ha, and land category (b) of 15,743 ha. A small area of 224 ha will need stream-side zone management. A total area of close to 40,000 ha inside MFC will require either do-no-farming or no-till farming while a total area of more than 83,000 ha outside MFC will need some BMPs.

4 Discussion

This study was a first attempt to provide useful cost estimates that would aid Payment for Watershed Service (PWS) program design and implementation. PWS provides a structure to trade watershed services so that upstream communities receive equitable compensation in order to both protect and sustainably use natural resources. Theoretically speaking, the monetary compensation may fall somewhere between the costs of the service [i.e., the minimum amount that the provider is willing to accept (WTA)], *or* the benefit of the service [i.e., the maximum amount that the buyer is willing to pay (WTP)]. Thus, WTA and WTP serve as lower bound and upper bound of the actual compensation for watershed services, respectively. This study developed cost-based WTA estimates, which have two practical advantages. First, from a political point of view, a conservative estimate is more likely to receive people's attention and get people to the negotiation table. Extremely large estimates of

Table 4 Opportunity costs and net present value of adoption of top six ranked best management practices ($/hectare)

	Bench terraces					Grass strips					Agro-forestry					SMZs					Do-no farming					No-till farming				
Years	0	1	2	…	10	0	1	2	…	10	0	1	2	…	10	0	1	2	…	10	0	1	2	…	10	0	1	2	…	10
Pre-adoption[a]																														
Gross income	0	943	943	…	943	0	943	943	…	943	0	943	943	…	943	0	943	943	…	943	0	943	943	…	943	0	943	943	…	943
Total cost of farming	0	679	679	…	679	0	679	679	…	679	0	679	679	…	679	0	679	679	…	679	0	679	679	…	679	0	679	679	…	679
(A) Net Income	0	264	264	…	264	0	264	264	…	264	0	264	264	…	264	0	264	264	…	264	0	264	264	…	264	0	264	264	…	264
Post-BMP adoption[b]																														
Gross income	0	717	774	…	774	0	868	868	…	868	0	660	660	…	849	0	915	915	…	915	0	38	38	…	38	0	472	547	…	1094
New income from BMP	0	100	100	…	100	0	27	27	…	27	0	66	66		85	0	14	14	…	14	0	0	0	…	0	0	0	0	…	0
Total income	0	816	874	…	874	0	895	895	…	895	0	726	726	…	934	0	929	929	…	929	0	38	38	…	38	0	472	547	…	1094
Cost of farming	0	679	679	…	679	0	679	679	…	679	0	577	577	…	577	0	659	659	…	659	0	0	0	…	0	272	475	475	…	475
Post-BMP costs	336	34	34	…	34	332	33	33	…	33	320	80	80	…	80	322	32	32	…	32	926	93	93	…	93	0	0	0	…	0
Total costs	336	713	713	…	713	332	712	712	…	712	320	657	657	….	657	322	691	691	…	691	926	93	93	…	93	272	475	475	…	475
(B) Net income	−336	104	161	…	161	−332	183	183	….	183	−320	69	69	…	277	−322	238	238	…	238	−926	−55	−55	…	−55	−272	4	72	….	619
Annual Opportunity costs [A-B]	336	160	103	…	103	332	81	81	….	81	320	195	195	…	−13	322	26	26	…	26	926	319	319	…	319	272	260	192	…	−355
Present Value[c]	336	146	85	…	40	332	74	67	….	31	320	177	161	…	−5	322	24	21	…	10	926					272	244	159	…	−137
Total Net Present Value	1022					832					603					482					2887					−776				

[a] Pre-adoption cost and income numbers are sample averages from our survey. For each BMP, farmers are assumed will incur the full initial cost of BMP adoption in year zero

[b] Post-adoption income are estimated as follows: (a) Land/income available for cultivation reduced by 24 % under bench terraces and 8 % grass strips (Tenge et al. 2005; Ekboir et al. 2002). (b) Reduction of land/income available for cultivation by 30 % under agro-forestry (Tamubula and Sinden 1999). (c) The area/income affected by streamside management zones was reduced by 3 %, this was based the land average 4 m of buffer next to the river bank and length of the rivers (Li et al. 2006). (d) Do-no-farming leads to complete loss of farm incomes as land is removed from active ploughing (e) Adoption of no-till farming reduced incomes by 50 %, incomes go up by 16 % in the second year and reach maximum in the fourth year. Cost of farming was reduced by 30 % (Ekboir et al. 2002)

Post-adoption incomes from BMPs results from fast growing grass or trees used as BMPs. Initial costs of establishing these BMPs were based on our survey results

[c] Present values are computed using 10 % discount rate

compensation may discourage stakeholders early on during the PWS negotiations. Second, there is a large degree of uncertainties about the timing, scale and nature of the downstream benefits of BMPs. Therefore, benefit-based WTP estimates are vague at best if not unknown. The lower bound estimates of PWS developed in this study are equitable in that they cover the full opportunity costs of providing a service. Any upward adjustments to these lower bound estimates could happen during the negotiation depending on the information and interest that various stakeholders bring to the table.

Previous studies such as Spash et al. (2005) have described estimation methods of watershed services on the basis of their welfare impacts and environmental degradation. These methods are more theoretical in nature, are difficult to explain, and often face serious implementation challenges. Obviously, the cost-based WTA estimates in this study are location-specific, yet the methodology would be relevant to other parts of the world.

4.1 Financial Implications of Watershed Services Protection

The total programmatic costs of PWS in MRB would be based on two primary factors: (a) the unit opportunity cost of change from conventional to improved practices, and (b) the total area to be placed in BMPs in any given point in time. Initial unit net present value PWS estimates ranged from US$ 272 to US$ 926 per hectare (Table 4). While these unit costs were conservative estimates or the minimum WTA of farmers, there exists a need for placing a large area under BMPs (Table 5). The BMP implementation in the basin therefore is going to place a huge financial burden on downstream users and agencies. The PWS promoters therefore will have to exercise extreme caution in prioritizing lands for implementation and seek measures to reduce the costs of implementation.

The above cost estimates suggest that farmers would actually incur income losses as a result of cropping area being taken up by BMPs across all practices. The initial year costs of all BMPs but do-no-farming were in the range of per hectare amounts of US$ 272 to US$ 336 (Table 4). Do-no-farming practice costs farmers three times ($926) as much in the very initial

Table 5 Total number of hectares that need to be placed under BMPs

Land category	Inside or outside of MFC	Length of settlement or land condition[a]	Settled area (ha)	Average land ownership (ha)[a]	Average under cultivation (ha)[a]	Total area under cultivation (ha)[b]	BMPs recommended
(a)	Inside	10 years or recent	28,594	11.3	9.4	23,786	Do-no-farming
(b)	Inside	past 10 years	25,900	5.1	3.1	15,743	No-till farming
(c)	Outside	highly erodible	65,332	5.1	3.1	39,712	Erosion controls (bench terraces)
(d)	Outside	Nutrient deficient	70,776	5.1	3.1	43,021	Crop nutrient management (agroforestry)
(e)	Outside	River bank	224	NA	NA	224	Stream-side zones
Total			190,826		Total	122,486	

Source: Own data analysis

[a] Computed from own sample data

[b] Area under cultivation is computed by multiplying the total settled area and the sample ratio of the farm cultivated area to settled area

period. However, the total area needed to be placed under this practice was less than 20 % (23,786 ha) of the total area (122,486 ha). In addition to these large initial costs, four of the six BMPs would result in income losses in perpetuity.

Because of the huge financial burden as stated above, the PWS promoters will face certain implementation challenges in the study area. It is unlikely that BMPs will be implemented in the entire area at once. That begs the question how one would prioritize different land categories needing watershed protection (Table 5). There are a few ways to guide this process. One approach is to start with the least economically expensive or most beneficial BMP (e.g., no-till farming), and gradually choose other BMPs at an increasing order of per unit PWS cost. Accordingly, in the study area, do-no-farming will be the last BMP to come on board. The second approach will be to prioritize land areas that are highly erodible (39,712 ha) and that are nutrient deficient (43,021 ha). Discussions with stakeholders during our survey indicated that these land types were in critical need for watershed service protection. Finally, the prioritization could also be based on the recency of tenancy. Those farmers who have recently colonized or acquired lands (in less than past 10 years) in the basin may be encouraged to enroll in the PWS schemes first so that they have a better chance of adapting to the new land management systems.

4.2 Equitable Compensation and Watershed Services Protection

The PWS program may not come to fruition if one fails to consider the socio-economic considerations of the people and biophysical characteristics of the area appropriately. According to the Kenya Bureau of statistics guidelines (2009), the poverty line in Kenya's rural communities based on expenditure method is US$ 186 per person. Per our survey, the average farm size in the upper MRB is 2.4 ha, and 55 % of the farmers earn less than US$ 150 per hectare per year. On average, more than 55 % of all farmers upstream in the MRB are living below the poverty line. Paying upstream farmers at rates equivalent to just the opportunity costs of respective BMPs may not significantly alter their lifestyles. It is therefore important to note that great gains in achieving environmentally sustainable livelihoods can be expected through more equitable and above poverty line compensation. This means that the estimated opportunity costs in this study should only be viewed as an estimate of floor level compensation and still may not necessarily bring about the desired changes among more than 50 % of the farmers.

Some BMPs are expected to result in crop yield increase but this may take several years. Farmers may not have the financial wherewithal to wait for several years before they reap positive benefits of the BMPs. Second, certain BMPs involve taking land out of crop production partially or fully. For instance, bench terraces for erosion control would reduce the total cultivated land by up to 24 %. Do-no-farming would require complete replacement of crops. Full or partial PWS would be necessary in the above circumstances.

4.3 Institutional and Financial Mechanisms for PWS

Through the Water Act of 2002, the Kenya government has provided for decentralizing water management decision making from the central government to the local levels. This has led to the establishment of the Water Resources Management Authority (WRMA), a body responsible for water management. Although PWS can be implemented successfully in the absence of land titles or formal legal requirements (Wunder 2008), there must be strong policy and institutional support from the government and the community. Strengthening the WRMA would be a primary factor towards building a structure that links both downstream and upstream communities. In addition, there is a need to strengthen the Mara River Watershed Advisory Committee (MRWAC) that would bring together all upstream communities to agree on specified agendas that are in the interest of all the people living in the basin.

Next logical question is how to raise funds for PWS. Our survey results showed that 42 % of the upstream farmers were of the opinion that international NGOs were the most sustainable source of funding towards implementation of PWS. Only 30 % felt that government funding was the most sustainable source. About 14 % said it was downstream communities and about 12 % said self-financing was the most sustainable option. Further research in sustainable source of funding towards PWS is however needed for all the downstream sectors that benefit from the Mara River. This will establish both the capacity and their level of consumption so that each will be made to pay appropriately.

5 Conclusion and Recommendations

This paper presented a methodology for developing economic cost and area estimates that would be necessary for instituting a market-based Payment for Watershed Services in the Mara River Basin. While the actual estimates may not be readily transferrable to other parts of the world, the methodology is. The Kenyan government continues to rely on command and control policies mainly in the form of evictions to protect the headwaters of the Mara River but this has not stopped people from acquiring forest lands and converting them to farmlands. The watershed remains under intense pressure from illegal settlements, forest loggers and families who rely on the forest as a source of energy and firewood (Mati et al. 2005).

What has been learned in the course of this research is that improved water resources management practices cannot be achieved if the community is simply left out of decision making, *and* if socio-economic considerations of the people and biophysical characteristics of the area are not considered appropriately. For the best watershed conservation results, adoption of BMPs should be seen as ways to improve farm incomes while protecting all the fragile lands in the watershed. Introduction of BMPs for watershed protection under the fabric of economic incentives ensures full participation of farmers, government institutions and all other stakeholders.

Adoption of certain BMPs by upstream farmers has great potential for contributing towards increased farm yields and incomes in addition to alleviating water resources problems. As can be seen from Table 5, No-till farming as well as Agro-forestry practices generate farm profits from the second year of BMPs adoption. This is a finding that farmers should be made to understand as it will improve adoption potential. We find that some of the initial costs are extremely high and therefore would require PWS planers to really prioritize certain land areas and/or BMPs for implementation. The prioritization could be strictly based on the costs of various BMPs (lowest to highest per unit costs), watershed service protection needs (highest to lowest needs), or receny of land tenancy (i.e., first in – first implement).

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