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Factors of Demand and Supply for Improved Watershed Services in a PES Intervention in the Blue Nile Basin, Ethiopia

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Abstract: The Blue Nile Basin is harshly degraded mainly due to human intervention, which is characterized by high run-off, soil erosion, salinity, water quality/quantity deterioration, heavy floods, sediment deposition etc. Alternative watershed management interventions need to be implemented on the upperpart of the Basin to maintain supply of sustainable watershed services. However, implementation of such intervention might be determined by demand/WTP and supply/WTA of the services. Accordingly, demand and supply of the services need to be investigated prior to implementation of PES intervention. The main purpose of this study is to investigate factor of demand and supply for improved watershed services to design better PES intervention. Data was collected from secondary and primary sources, 601 respondents were interviewed from (300) downstream and (3001) upstream stratum. Choice experiments, nested logit model and descriptive statistic were employed. Policy implications for a better watershed management in PES intervention are made based on the results.

Key words: choice experiments; demand for improved watershed services (willingness-to-pay); improved watershed management; supply of watershed services (willingness-to-accept); policy

JEL code: Q5

1. Introduction

Blue Nile Basin has a number of indispensable watersheds, which provide watershed services for upstream and downstream communities. However, the watersheds are harshly degraded mainly due to human intervention (Alemayehu et al., 2008; Legesse, 2009; Ashagre, 2009) such as high run-off, soil erosion, salinity, soil acidity, decline in soil structure, decline in water-holding capacity, deterioration in water quality, fluctuation in water quantity, heavy floods and sediment deposition on irrigation canals etc. As a solution, improved watershed management measures need to be implemented. The measures might include enclosing degraded areas, construction of stone terraces, tree plantation, crop residue management etc. Such measures are expected to be implemented by upstream land users through modifying their land use practices. As a matter of fact, improved watershed management interventions have been implemented for a couple of decades in the study area but not successful might be due to high investment costs, measures might not be invented in accordance with farmers'

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preferences, might have negative impact on land users' livelihood through decreasing farm size and production amount, etc. Hence, it is worthwhile to implement alternative watershed management intervention in the Basin to revert the degradation.

It is believed that payments for ecosystem services (PES) considered as an alternative voluntary policy instrument to preserve ecosystem services worldwide (see Figure 1 to figure out logic of PES). Voluntary nature of PES approach might be influenced by demand/willingness-to-pay (WTP) and supply/willingness-to-accept (WTA) of improved watershed services. Demand and supply of improved watershed services might raise issue of understanding socio-economic, institutional and policy factors that influences land users to participate in such interventions. With the above background and justifications, the general objective of this paper is to investigate determinants of landholders' choice behavior towards PES intervention. Specifically, this paper aims to investigate determinants of supply/WTA of improved watershed services and demand/WTP for improved watershed services. The study stratified the watershed into upstream and downstream stratum based on agro-ecological classification of the study area.

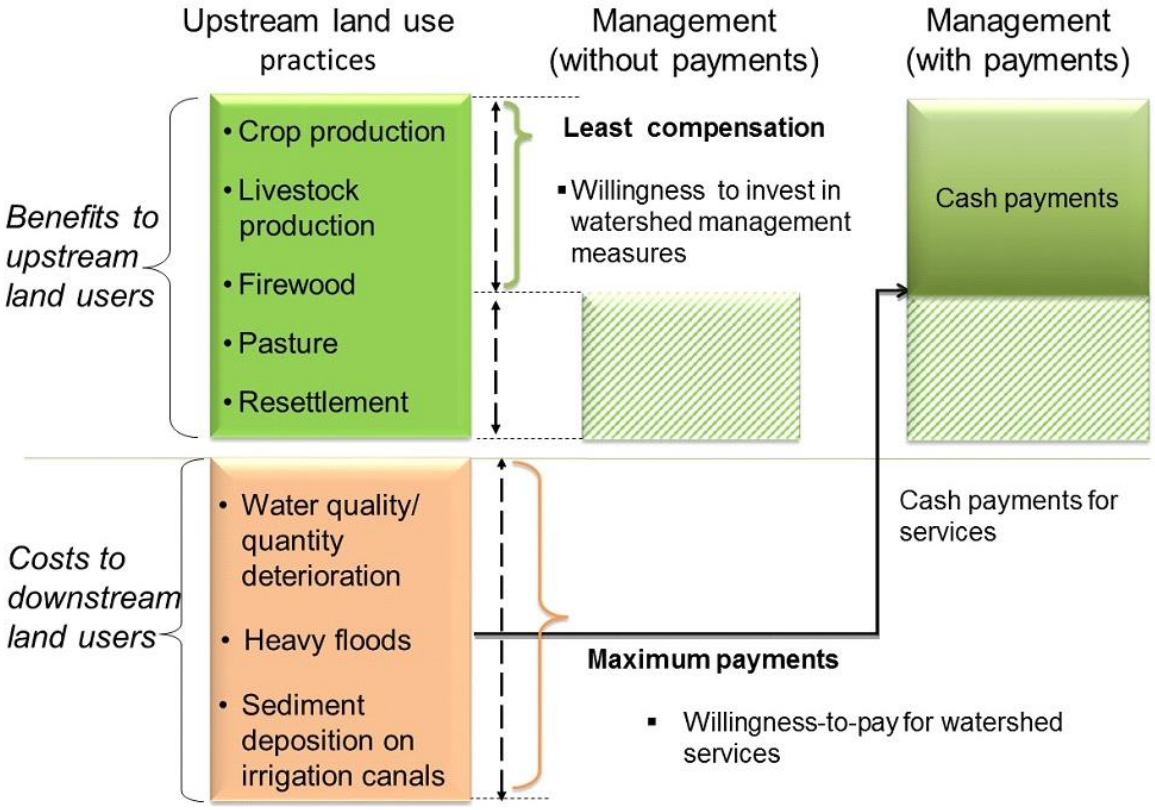

Figure 1 Logic of PES

Source: Adapted from Engel et al., 2008

2. Method

2.1 The Study Area

This study was done in Koga watershed of the Blue Nile Basin, which is one of the important watersheds in the Basin. Koga watershed is located in the Amhara National Regional State of Ethiopia. Koga watershed encompasses the headwater source called Koga River, which serves as means of livelihood for upstream and

downstream communities. The study area is located between 11°8' North to 11°25' North latitude and 37°2' East to 37°20' East longitude and has a drainage area of 299 km^2 (Bitew & Gebremichael, 2011). Its elevation ranges between 1,800 to 3,200 meters above sea level with an average annual rainfall of 1,560 mm and an average daily temperature between 16°C to 20°C (Alemie, 2009; Kassahun, 2009). The watershed is characterized by high rainfall during July to September and the highest mean monthly rainfall is recorded in July while the highest likely evapotranspiration is recorded in May (Alemayehu *et al*., 2008). About 43 percent of the watershed encompasses lowland (which is lower than 1,800 meters above sea-level.) and the remaining 19 and 38 percent are midland (which ranges between 1,800 to 2,250 meters above sea-level) and highland (which is higher than 2,250 meters above sea-level) respectively (MOA, 2012) (see Figure 2).

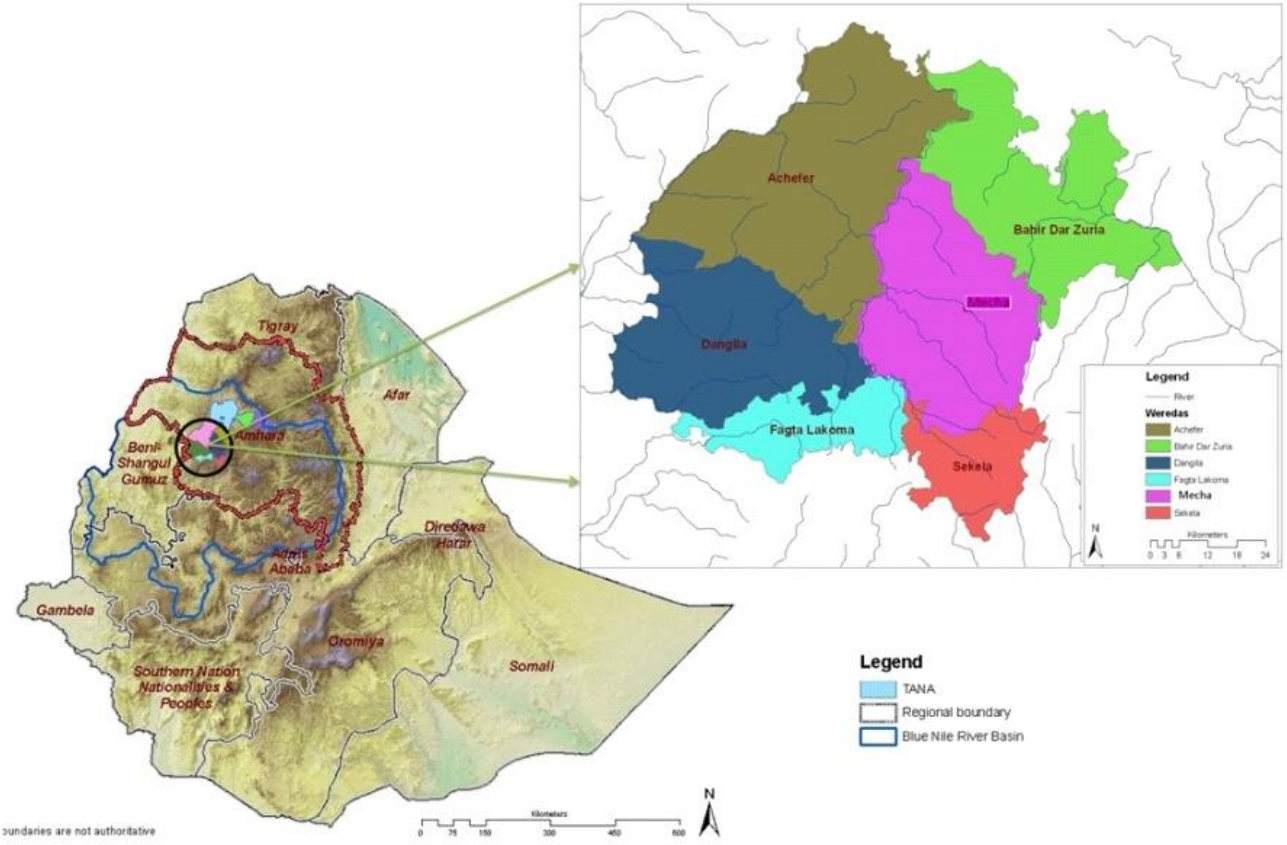

Figure 2 Map of the Study Area

Source: ILRI-IPMS GIS Unit, 2012

2.2 Analytical Procedures

The study used choice experiments (CE) method to elicit WTA and WTP values based on combination of different levels of attributes (Hanley et al., 1998; Ryan et al., 2008a; Street et al., 2008; Amaya et al., 2008; Kwak et al., 2009). Respondents were presented with eight different choice cards in which each card had two better alternatives and a status quo alternative and asked them to choose their most preferred alternative in each card (Louviere et al., 2007; Ryan et al., 2008a; Xu et al., 2007). This method has ability to estimate marginal WTP (marginal demand)/WTA (marginal supply) values for change in attributes through permitting trade-offs between attributes (Adamowicz et al., 1998; Hanley et al., 1998; Christie et al., 2006; Mogas et al., 2006; Torres et al., 2009; Hoyos, 2010; Hensher, 2010; Louviere et al., 2007; Ortega et al., 2011).

The study employed nested logit model (NLM) to made empirical analysis of choice sets (Greene, 2002; Hensher et al., 2005; Train, 2009), it does not correlate across branches, has a natural tree decision structure (Hensher et al., 2005; Silberhorn et al., 2007; Ryan et al., 2008b; Das et al., 2012) and relaxes multinomial/conditional logit model strong proportional substitution assumption via considering more general substitution patterns (Guadagni & Little, 1998; Silberhorn et al., 2007; Train, 2009; Ortuzar & Willumsen, 2011). In addition, NLM is straightforward and fast compared to multinomial probit and mixed logit models (Heiss, 2002; Hensher & Greene, 2002). The mathematical form of the nested logit model is given as follows (Hensher & Greene, 2002; Greene, 2002; Hensher et al., 2005; Train, 2009).

$$P(J,L) = P(L) \times P(J/L) \tag{6}$$

$$P(J,L) = \left(\frac{\exp(\lambda \left(\ln \sum_{J \in L} \exp(\beta_j \chi_i / L) \right)_L)}{\sum_{L=1}^{n} \exp \lambda (\ln \sum_{J \in L} \exp(\beta_j \chi_i / L))} \right) \left(\frac{\exp(\beta_j \chi_i / L)}{\sum_{J \in L} \exp(\beta_j \chi_i / L)} \right) \tag{7}$$

Where: $P(J,L)$ is the probability of an individual choosing J alternative in sub group L,

$P(J/L)$ is the conditional probability of an individual to choose J,

X_i is a vector of measuring attributes of alternatives and

β_j is a vector of coefficients to be estimated.

$P(L)$, is the probability of an individual belonging to group L,

λ is coefficient of the inclusive value of the group L.

If the value of λ is equal to 1 then the nested logit model might be multinomial model and IIA assumption holds, otherwise IIA assumption fails.

The study used LIMDEP-10/NLOGIT-5 software to run nested logit analysis and DOE++ software to run orthogonal main effect fractional factorial to design the choice cards. In this study, downstream and upstream land users were said to be willing to participate in PES intervention, if they deliberately WTP and WTA cash in PES intervention respectively (examples of choice cards used in this study are shown in Figure 3).

Downstream land users' demand/WTP for improved watershed services was the first dependent choice variable. This variable took the value 1 if downstream land users choose one of the improved watershed services alternatives and 0 otherwise. Upstream land users' supply/WTA cash compensation to invest in improved watershed management measures was the second dependent choice variable. This variable took the value 1 if upstream land users choose one of the improved watershed management measure alternatives and 0 otherwise. Socio-economic, institutional, demographic and cultural factors were hypothesized as an independent variables, which might influence downstream land users' demand/WTP choice behavior and upstream land users' supply/WTA choice behaviors.

2.3 Data Collection and Sampling Techniques

Primary data was collected through choice cards and structured questionnaires to examine determinates of WTP (demand side) and WTA (supply side) of improved watershed services. Choice cards and questionnaires were pre-tested before actual survey to modify some of the questions, which were either irrelevant or out of context. In addition, published and unpublished works in the study area were considered as secondary sources of information. The study employed multi-stage sampling techniques to select sample respondents. In the first stage, Koga watershed was purposively selected. In the second stage, ten *Kebeles* (the lower local administrative region next to district) were selected based on simple random sampling procedure. In the third stage, *Gottes* (the lower

local administrative region next to *Kebele*) were selected based on proportional random sampling procedure. Finally, the sample respondents were selected from the sampling frame by using systematic random sampling procedure. The list of farmers (sampling frame) were obtained from development centers and administrative offices of the respective *Kebeles*. A total of 601 farmers were selected, at the rate of 301 respondents from the upstream and 300 respondent from the downstream users.

Attributes	Alternative 1	Alternative 2	Alternative 3 (Status quo option)
Planting of trees	Cover a "Temade" (0.25 ha) of your land by fodder trees 	Cover a "Temade" (0.25 ha) of your land by fruit trees 	Current poor condition 
Construction of stone terraces	Construct wide-base/ broad-based stone terraces (>6m) 	Construct medium-base stone terraces (3m to 6m) 	Current poor condition 
Crop residue management	Mulch crop residual 	Mulch crop residual 	Current poor condition 
Compensation in cash / year	603 ETB	836 ETB	0
Choose only one			

(a) Example of choice card used to elicit upstream users WTA

Attributes	Alternative 1	Alternative 2	Alternative 3 (Status quo option)
Water quality	Washing purpose (once a month/200 liter container) 	Drinking and cooking(once a month/600 liter container) 	Current poor water quality condition 
Flood damage on property and life	No flood damage 	Low flood damage property 	Current high flood damage on property and life condition 
Suspended load on irrigation canals	Low suspended load on irrigation canals 	No suspended load on irrigation canals 	Current high suspended load on irrigation canals 
Payment in cash	35 Eth Birr/ month	86 Eth Birr/ month	0
Choose only one option			

(b) Example of choice card used to elicit downstream users WTP

Figure 3 Example of Choice Card Used to Elicit WTA and WTP

3. Results

The study shows that only 59 percent of downstream land users are found to be willing-to-pay an average annual cash payment of 25.43 USD/household/year for improved watershed services. Likewise, 74 percent of upstream land users are found to be willing-to-accept an average annual cash compensation of 50.46 USD/household/year to invest in improved watershed management measures. This implies that majority of the respondents are found to be willing to participate in PES intervention.

3.1 Factors of demand for improved watershed services

This part of the paper investigates factors of demand/willingness-to-pay for improved watershed services. To do this, four major improved watershed services attributes were considered based on the services users' priority, literature review, experts experience and the researcher's experience. This study focuses on certain improved watershed services attributes, which used to elicit WTP value. These are water quality/quantity, level of flood damage, suspended load on irrigation canals and monthly cash payments.

Eight continues and eight discrete explanatory variables were considered to investigate factors of demand/willingness-to-pay for improved watershed services in PES intervention. The hypothesized explanatory variables were checked for incidence of multicollinearity and degree of association prior to the model estimation. Following, Variance Inflation Factor (VIF) and Contingency Coefficients (CC) techniques were employed. Researchers recommend to omit variables with a VIF value ≥ 10 and CC value with ≥ 0.75 from the analysis to avoid serious multicollinearity problem (Healy, 1984; Alemayehu et al., 2010; Beshir et al., 2012; Beshir, 2014). VIF and CC analyses indicated absence of series association among variables. The study employed maximum likelihood estimation method to estimate parameters of the model following multicollinearity assessment.

The dependent variable in this analysis was demand for improved watershed services also called downstream land users' willingness-to-pay cash for improved watershed services (WTP *CHOICE*). Researchers suggest to interact socio-economic and institutional factors with alternative specific constants (ASC) or interact them with attributes (Hensher et al., 2005). In this analysis, the model was estimated through interacting socio-economic and institutional factors with ASC. The hypothesized explanatory variables were found to be significant at less or equal to 5% probability level (Table 1). Socio-economic and institutional explanatory variables used in this analysis were age (*AGE*), education (*EDUCA*), total farm size (*FARSZ*), land tenure security (*LSECR*), size of farm land covered by eucalyptus tree (*ECTRE*), average plot distance from homestead (*PDIST*), total farm income (*FINCM*), total off-farm income (*OINCM*), tropical livestock unit (*TLU*); access to agricultural credit in cash (*CCASH*), access to agricultural credit in kind (*CKIND*), access to agricultural extension services (*EXTN*), membership in local traditional institutions (*INFR*), voluntary participation in community based activities (*PART*), membership in cooperative (*COOP*), average walking distance to nearest central market (*MAKDS*).

As shown in Table 1, *EXTN* is found to be significant at $P < 0.01$ probability with a positive influences on demand for improved watershed services in PES intervention. This implies that downstream land users might be tended to choose PES intervention instead of current poor state (status-quo alternative) as they obtain more access to agricultural extension services. TLU is significant at $P \leq 0.05$ probability and has a positives influences on downstream land users' choice behavior. AGE has a negative influences on downstream land users' choice behavior and found to be significant at $P < 0.01$ probability, which implies that demand might decline as AGE increase by a single unit. The reason is that downstream land users might have short planning horizon and be risk averse to pay cash for improved watershed services in PES as AGE increase by a single unit. *FARSZ* has a

significant positive influences at $P \leq 0.05$ probability level, which shows that downstream land users' demand for improved watershed services increases as this variable increase by one unit because their livelihood depends on size of arable land.

Table 1 Model Estimates for Factors of Demand/WTP for Improved Watershed Services

Explanatory Variables	Alternative 1			Alternative 2		
	Coefficient	95 % CI		Coefficient	95 % CI	
CONST	-2.43419***	-3.26755	-1.60082	-2.10043***	-2.88963	-1.31123
AGE	-0.02613***	-0.04337	-0.00890	-0.03204***	-0.04887	-0.01521
EDUCA	0.05313	-0.28991	0.39618	0.25473	-0.07457	0.58404
FARSZ	0.33852**	0.04208	0.63495	0.28310*	-0.00965	0.57585
LSECR	0.03481	-0.07584	0.14546	0.05721	-0.04964	0.16406
ECTRE	-0.1111	-0.31403	0.09190	-0.08	-0.27739	0.11739
PDIST	-0.30370***	-0.46472	-0.14268	-0.23294***	-0.38222	-0.08365
CCASH	0.45333	-0.47724	1.38390	0.377	-0.53568	1.28968
CKIND	0.27532	-0.30358	0.85422	0.27506	-0.27814	0.82826
EXTN	1.55666***	1.14698	1.96635	1.13972***	0.76641	1.51304
INFR	0 .56343***	0.17093	0.95592	0.66347***	0.28651	1.04042
PART	1.20576***	0.77648	1.63503	1.44038***	1.02483	1.85594
COOP	0.94551**	0.17507	1.71595	0 .69274*	-0.07576	1.46124
MAKDS	-0.0385	-0.09402	0.01710	-0.0198	-0.07179	0.03220
FINCM	0.00080**	0.00014	0.00145	0.00082**	0.00018	0.00146
OINCM	-0.00046**	-0.00088	-0.00004	-0.00059**	-0.00106	-0.00011
TLU	0.10794***	0.02958	0.18630	0.09500**	0.01900	0.17101

***, **, * shows significance at 1%, 5%, 10% probability levels

Dependent variable			WTP CHOICE
Log likelihood function			-1118.24161
R^2 = 1-LogL/LogL*	Log-L fncn	R-sqrd	R^2Adj
Constants only	-1305.2996	0.1433	0.1310
Chi-squared [32]			= 374.11595

Source: Model analysis, 2018

According to the Federal Democratic Republic of Ethiopia Rural Land Administration and Land Use Proclamation, Page 3133 (unpublished data), land tenure security correlate positively with demand for improved watershed services though land is property of the government in which farmers do not have ownership right (Table 1). *PDIST* is significant at $P < 0.01$ probability level and correlates negatively with demand for improved watershed services in PES intervention. This underscores that downstream land users' choice most likely decline to demand the services as a plot distance increases from homestead. *CCASH and CKIND* correlate positively with demand for improved watershed services in PES intervention. Similarly, *INFR* has significant positive impact at $P < 0.01$ probability on demand/willingness-to-pay for improved watershed services in PES intervention. This implies key role of local traditional institutions on downstream land users' choice behavior.

Table 1 shows that eucalyptus (*ECTRE*) correlate negatively with demand for improved watershed services. This shows out that downstream land users' are most likely not willing to pay cash for improved watershed services in PES intervention as this variable increases. The reason is that they might generate more income from

eucalyptus through not paying enough attention for watershed services improvement. *PART* is found to be significant at $P < 0.01$ probability, which associates positively with demand for improved watershed services in PES intervention. This might be due to the fact that downstream land users' develop sense of ownership and belongingness as they voluntary participate in the intervention. *COOP* has positive significant correlation at least at $P < 0.05$ probability because cooperative might improve land users' access to information, and bargain power as well as it might empower them in decision marketing processes. *MAKDS* correlate negatively as downstream land users might obtain less/no information and less return through offering their produce for sale at a lower possible price when they locate faraway from central market. *EDUCA* has a positive influences because education improves land users' awareness and knowledge concerning management, protection and sustainable use of watershed services in PES intervention. *FINCM* has a positive significant correlation at $P < 0.05$ probability since land users' capacity to pay cash in PES might dependent on farm income. However, *OINCM* has significant negative correlation at $P < 0.05$ probability for the reason that land users might give less attention to farm activities as they generate large amount of off farm income.

Researchers pointed out that a unit change in one variable with respect to a given choice has direct and cross marginal effects on the choice probabilities of competing alternatives.

Direct marginal effects represent change in the choice probability for an alternative with respect to a 1 unit change in a variable in which the variable is belonging to the same alternative, ceteris paribus. Cross marginal effects represent the impact of a 1 unit change in one variable on the choice probability of competing alternatives in which that variable does not belong to the same alternative, ceteris paribus (David et al., 2005). Table 2 shows that probability of demand/WTP for improved watershed services will increase by 0.006849 as *EXTN* increases by one additional unit in the first PES alternative, ceteris paribus. However, the probability for the second competing PES alternative might decrease by 0.003684 as *EXTN* increases by one unit in the first PES alternative, ceteris paribus. See Table 2 to understand direct and cross marginal effects of a unit change of other variables on demand/WTP for improved watershed services in PES intervention.

3.2 Determinants of Supply of Improved Watershed Services

Upstream land users are supposed to be suppliers of improved watershed services through investing in improved watershed management measures in PES intervention. Upstream land users were considered to be the services provider if they were willing-to-accept cash compensation to invest in PES intervention. This study considers the following foremost recommended improved management measures as improved measures: tree plantation, construction of stone terraces, crop residues management and cash compensation. The dependent variable is supply/upstream land users' choice (WTA *CHOICE*) towards improved watershed management measures. This variable took the value 1, if upstream land users choose one of PES alternatives and 0 otherwise.

Seven continues and ten discrete explanatory variables were considered to investigate factors of supply/WTA to invest in improved watershed services. Explanatory variables were checked for incidence of multicollinearity and degree of association prior to NLM estimation. These variables were age (*AGE*), education (*EDUCA*), total farm size (*FARSZ*), plot slope (*PSLP*), land tenure security (*LSECR*), chemical fertilizer (*FERT*), plot distance from homestead (*PDIST*), past landscape memory (*RMBRN*), access to credit in cash (*CCASH*), access to credit in kind (*CKIND*), extension services (*EXTN*), membership in local traditional institutions (*INFR*), voluntary participation in community based activities (*PART*), total farm income (*FINCM*), total off-farm income (*OINCM*), tropical livestock unit (*TLU*), family size in man equivalent (*MANEQ*). Of these, nine explanatory variables were found to be significant at less or equal to 10% probability levels.

Table 2 Marginal Effects of A Unit Change in Explanatory Variables on Demand/WTP Choice

Explanatory Variables	Alternative 1			Alternative 2		
		Marginal Effect			Marginal Effect	
	Coefficient	Choice 1 ♦	Choice 2	Coefficient	Choice 1	Choice 2♦
CONST	-2.43419***			-2.10043***		
AGE	-0.02613***	-0.8027	0.3212	-0.03204***	0.4456	-0.9322
EDUCA	0.05313	0.0212	-0.0088	0.25473	-0.0524	0.0911
FARSZ	0.33852**	0.4033	-0.1803	0.28310*	-0.1706	0.3174
LSECR	0.03481	0.0912	-0.0402	0.05721	-0.0754	0.1406
ECTRE	-0.11110	-0.0349	0.0151	-0.08000	0.0121	-0.0239
PDIST	-0.30370***	-0.1902	0.0765	-0.23294***	0.0730	-0.1316
CCASH	0.45333	0.0189	-0.0144	0.37700	-0.0116	0.0160
CKIND	0.27532	0.0289	-0.0161	0.27506	-0.0174	0.0275
EXTN	1.55666***	0.6849	-0.3684	1.13972***	-0.2916	0.4796
INFR	0 .56343***	0.1146	-0.0620	0.66347***	-0.0802	0.1277
PART	1.20576***	0.6039	-0.2884	1.44038***	-0.4021	0.6638
COOP	0.94551**	0.0520	-0.0457	0 .69274*	-0.0306	0.0410
MAKDS	-0.03850	-0.1354	0.0478	-0.01980	0.0296	-0.0647
FINCM	0.00080**	0.2001	-0.0921	0.00082**	-0.1069	0.1920
OINCM	-0.00046**	-0.0191	0.0089	-0.00059**	0.0101	-0.0258
TLU	0.10794***	0.3593	-0.1608	0.09500**	-0.1603	0.2974
Dependent variable						WTP CHOICE
Log likelihood function						-1118.24161
$R^2 = 1 – LogL / LogL *$	Log - L		R-sqrd			R^2Adj
Constants only	-1305.2996		0.1433			0.1310
Chi-squared						= 374.11595

Source: Model analysis, 2018.

***, **, * shows significance at 1%, 5%, 10% probability levels

♦ = Direct marginal effect of the explanatory variables

As presented in Table 3, *EDUCA* correlate positively with supply/WTA because *EDUCA* boost upstream land users' knowledge towards improved watershed management measures in PES. *FARSZ* has a significant positive association with supply of improved watershed services at $P < 0.05$ probability. This implies that upstream land users might most likely incline to be willing-to-accept cash compensation to invest in the measures for a unit improvement in *FARSZ*. *LSECR* is found to be significant at least at $P < 0.01$ probability and associate positively with supply of the services. This underscores that upstream land users are most likely incline to invest in the measures as their sense of land tenure security improve/develop confidence to use their parcel. Therefore, it is worthwhile to consider farmers' sense of land tenure security to design sustainable watershed management policy. This result underscores importance of land ownership right in watershed management interventions since farmers demanded secured land ownership right. However, *AGE* has significant negative correlation at least at $P < 0.1$ probability. Similarly, *PDIST* correlate negatively with supply of the services because upstream land users' might prefer to invest in nearby plots as remote plots need extra resources.

Table 3 Model Estimates for Factors of Supply/WTA for Improved Watershed Management

Variables	Alternative 1			Alternative 2		
	Coefficient	95% CI		Coefficient	95% CI	
CONST	-5.32672***	-6.68000	-3.97350	-4.81972***	-5.95390	-3.68550
AGE	-0.02069*	-0.04390	0.00248	-0.02898***	-0.05090	-0.00710
EDUCA	0.21338	-0.23580	0.66252	0.16419	-0.24920	0.57758
FARSZ	0.65600**	0.03942	1.27257	0.72661**	0.15025	1.30298
PSLOP	2.21995***	1.74865	2.69124	2.46589***	2.03357	2.89821
LSECR	0.21438	-0.27930	0.70803	0.70004***	0.24912	1.15096
FERT	1.13919***	0.38259	1.89580	1.10736***	0.37599	1.83873
PDIST	-0.0032	-0.06320	0.05689	-0.02790	-0.09290	0.03715
RMBRN	2.42618***	1.38405	3.46831	2.03638***	1.24424	2.82853
CCASH	1.00292***	0.39897	1.60686	0.86842***	0.33281	1.40403
CKIND	-0.1827	-0.77930	0.41395	-0.34300	-0.90310	0.21716
EXTN	1.26546***	0.65589	1.87502	0.95364***	0.37927	1.52801
INFR	0.41685	-0.17590	1.00961	1.01003***	0.46631	1.55375
PART	0.39617	-0.15590	0.94819	0.66470***	0.16170	1.16770
FINCM	0.00092	-0.00040	0.00221	0.00137**	0.00017	0.00256
OINCM	-0.00160	-0.00430	0.00107	-0.00243*	-0.00490	0.00006
TLU	-0.08821*	-0.18380	0.00739	-0.05890	-0.14550	0.02770
MANEQ	0.20445*	-0.00160	0.41047	0.24829**	0.05721	0.43937

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

Dependent variable			WTA CHOICE
Log likelihood function			-942.25646
R^2 = 1 – LogL / LogL * Log - L		fncn R-sqrd	R^2Adj
Constants only	-1261.5546	0.2531	0.2418
Chi-squared [34]			638.59634

Source: Model analysis, 2018

RMBRN has a significant positive correlation with supply of the services at P < 0.01 probability (Table 3). This implies that upstream land users who have knowledge about an old time natural resource condition most probably incline to invest in the measures. The reason is that past landscape memory might motivate them to restore the current poor natural resource condition. *CCASH* is found to be significant at most at P < 0.01 probability level and correlate positively with supply of the services. This shows that upstream land users are most likely invested in the measures as their financial shortage relaxes. However, *CKIND* correlate negatively with supply of improved watershed services, which might shows that credit in cash is more preferable than credit in kind in the upstream stratum due to nonvolatile nature of credit in kind. *EXTN* is significant at P < 0.01 probability and correlates positively. *INFR* has a significant positive correlation at most at P < 0.01 probability with supply of the services. *PART* is significant at most at P < 0.01 probability and correlate positively because participation in community based schemes at all levels empower land users to own the intervention. *FINCM* has significant positive association at most at P < 0.05 probability in which land users might pay attention to invest in improved watershed management measures as long as they generate sufficient income from farm activities. *OINCM* is significant at most at P < 0.1 probability and correlate negatively with supply of the services. The possible

explanation is that upstream land users might discourage to accept cash compensation to invest in improved watershed management measures as they generate more off-farm income. *TLU* has a significant negative correlation at least at P < 0.1 probability. This implies that supply of the services decline as this variable increase by additional unit. The reason might be that free grazing is main source of feed in the upstream part and land users oblige to feed their livestock from every possible options regardless of conserving the watershed so as to keep more animals. In this study, the total family size of household is converted into common unit of numeraire called man equivalent in order to bring different age groups into a common unit of measurement called man equivalent (MANEQ). *MANEQ* has significant positive impact at least at P < 0.5 probability because family is main source of labour. *PSLOP* is found to be significant at P < 0.01 probability with positive impacts on supply of the services. This is due to the fact that steep slope plots are demonstrated by high runoff, which might affect productivity of arable land. *FERT* found to be significant at most at P < 0.01 probability and correlates positively with supply of the services. A unit change in each independent variable has a direct and cross marginal effects, ceteris paribus. The direct and cross marginal effect of a unit change in each explanatory variables are presented in Table 4.

Table 4 Marginal Effects of a Unit Change in Explanatory Variables on WTA Choice

Variables	Alternative 1			Alternative 2		
	Coefficients	Marginal Effect		Coefficients	Marginal Effect	
		Choice1♦	Choice 2		Choice 1	Choice2♦
CONST	-5.32672***			-4.81972***		
AGE	-0.02069*	-0.6317	0.2108	-0.02898***	0.5734	-0.6068
EDUCA	0.21338	0.0987	-0.0374	0.16419	-0.0566	0.0481
FARSZ	0.65600**	0.3644	-0.1231	0.72661**	-0.2726	0.2674
PSLOP	2.21995***	1.1542	-0.4610	2.46589***	-1.0179	0.7762
LSECR	0.21438	0.1034	-0.0404	0.70004***	-0.2715	0.1983
FERT	1.13919***	0.1627	-0.0833	1.10736***	-0.1472	0.0920
PDIST	-0.00320	-0.0011	0.0010	-0.02790	0.0083	-0.0105
RMBRN	2.42618***	1.5758	-0.5924	2.03638***	-0.9708	0.8491
CCASH	1.00292***	0.5848	-0.2249	0.86842***	-0.3772	0.3239
CKIND	-0.18270	-0.0557	0.0262	-0.34300	0.0897	-0.0641
EXTN	1.26546***	0.3237	-0.1598	0.95364***	-0.2202	0.1442
INFR	0.41685	0.0654	-0.0177	1.01003***	-0.1351	0.0663
PART	0.39617	0.2191	-0.0862	0.66470***	-0.2904	0.2219
FINCM	0.00092	0.1027	-0.0335	0.00137**	-0.1171	0.0859
OINCM	-0.00160	-0.0427	0.0129	-0.00243*	0.0363	-0.0476
TLU	-0.08821*	-0.2831	0.0958	-0.05890	0.1287	-0.1243
MANEQ	0.20445*	0.4563	-0.1523	0.24829**	-0.3741	0.3650
Dependent variable						WTA CHOICE
Log likelihood function						-942.25646
$R^2 = 1 – LogL / LogL *$		Log - L		fncn R-sqrd		R^2Adj
Constants only		-0.2531		1261.5546		0.2418
Chi-squared [34]						638.59634

Source: Model analysis, 2018, Note: ***, **, * Significance at 1%, 5%, 10% probability levels,
♦ = Direct marginal effect of explanatory variables

4. Discussions

Provision of watershed services in the Basin is harshly threatened due to degradation, economic activities and other human interactions. Hence, an alternative watershed management approaches need to be implemented. In this regard, PES intervention is considered as an alternative ecosystem protection approach worldwide. The main purpose of this study is to investigate factors of demand and supply of improved watershed services. The study employed choice experiments to elicit willingness-to-pay (demand side) and willingness-to-accept (supply side) values. Upstream and downstream respondents were presented with different choice cards based on two different choice experiment methods. Nested logit model employed to analyze the discrete choice outcomes. Respondents were selected based on multistage sampling procedure. A total of 301 and 300 respondents were selected from upstream and downstream stratum respectively.

The study found out that past landscape memory has a positive significant impact on the supply side so that the intervention needs to develop awareness creation mechanisms towards old times' natural resource conditions. To this end, it is advisable to educate and train farmers on the bases of adult-education methods such as audiovisual instruments, seminar, workshop, farmers-to-farmers discussion, experience sharing etc. Land tenure security has a significant positive correlation, hence, this study strongly suggests to provide ownership right to farmers to design sustainable watershed management interventions. Livestock size correlate negatively with upstream land users' choice behavior, hence, a PES intervention better encourages zero grazing instead of free grazing. The study suggests to target upstream land users who have relatively hilly land due to positive impact of plot slope. Agricultural extension services, access to credit, inorganic fertilizers and farm size are associated positively but off-farm income correlate negatively with supply of the services. This implies an intervention has to improve farming activities through boosting farm income based on improved production systems. Therefore, credit institutions need to be strengthened, enhance inorganic fertilizer and improve agricultural extension services to boost farm production and productivity. Community based local traditional institutions and cooperative units have high level of trust, acceptance and recognition by local communities. Therefore, technical support need to be provided to local institutions through encouraging farmers' participation at all levels. In addition, the intervention should improve extension services, provision of farm inputs and veterinary services so that downstream land users' might be empowered financially to pay cash for improved watershed services. In general, it is necessary to establish networking, collaboration and integration among institutions. These networking might make PES intervention attractive in such a way to PES might be alternative policy instrument for better provision of watershed services.

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