Payment for Ecosystem Services' Implementation and Community Livelihood Improvement in Nyamwamba sub-catchment, Kasese District, Uganda

Abstract

Payments for Ecosystem Services (PES) is an innovative, incentive-based approach to natural resource management, where users of ecosystem services compensate landowners who protect, enhance, or restore these services through their land management decisions.The study on PES and livelihood improvement was guided by three objectives. That is, to: assess the implementation mechanisms for PES; determine the effect of PES on livelihood improvement; and explore the relationship between PES implementation and ecosystem improvement. A cross-sectional research design incorporating both quantitative and qualitative methods was used for the study.A total of 207 respondents participated in the research project. Data were collected using a semi-structured questionnaire and interview guides. The information collected were analyzed using a statistical package for social sciences, version 22. The study found that PES implementation mechanisms included reforestation, biodiversity conservation, soil and water conservation measures, agroforestry, and forest landscape restoration. PES improved livelihoods, enabling households to pay school fees for their children, establish better housing facilities, managed food crises, accumulated savings, and covered medical expenses for the household members. A significant relationship was found between PES implementation and ecosystem improvement, with enhancements in community livelihoods at $P<0.001$, flood control and disaster risk reduction at $P=0.001$, soil loss and erosion reduction at $P=0.003$, water resources management at $P=0.003$ and conserved biodiversity at $P=0.005$.The study recommends implementing robust monitoring and evaluation systems to track PES program impacts on livelihoods in the Rwenzori region. It also highlights the need for fostering partnerships between government agencies, NGOs, local communities, and other stakeholders involved in PES initiatives. Training and capacity-building programs should be provided to equip local communities with the skills and knowledge needed to effectively participate in PES schemes. Active involvement of local communities in the design, implementation, and monitoring of PES programs is crucial for the promotion of livelihoods.

Keywords: Payment for Ecosystem Services; Livelihood Improvement; Kasese;Nyamwamba sub-catchment; Uganda

1. Introduction

Payments for Ecosystem Services (PES) is an innovative, incentive-based approach to natural resource management, where users of ecosystem services compensate landowners who protect, enhance, or restore these services through their land management decisions (Engel et al., 2019). According to Jack et al. (2018), PES operates on a straightforward principle: paying individuals or communities to undertake actions that increase levels of desired ecosystem services. Wunder (2020) provides a widely cited definition of PES as a voluntary transaction where a well-defined ecosystem service is bought by at least one buyer from at least one provider, contingent upon the provider ensuring the provision of the service.

Globally, PES has been tested in diverse regions, from Costa Rica's national program initiated in 1997 (Daniels et al., 2020) to water funds in Latin America (Stanton et al., 2010), steep-slope land conversion in China (Zhang et al., 2021), and watershed health initiatives in the United States (Stanton et al., 2020). The increasing focus on PES has sparked a lively debate about its benefits and drawbacks in achieving environmental outcomes. While most PES projects have been implemented recently, limiting long-term data, preliminary evaluations indicate promising potential (Engel et al., 2018).The world is facing unprecedented biodiversity decline due to population growth and economic pressures, which impacts essential ecosystem services (Di Minin et al., 2021). To address this, national and international policies, including PES schemes, are being promoted (Adger et al., 2020). PES schemes can also address issues like biodiversity loss, climate change, and poverty (Pattanayak et al., 2020). For instance, the Paris Climate Accord emphasizes forest and water conservation, with significant funding promised for these efforts (Jindal et al., 2018).

In Sub-Saharan Africa, ecosystems provide essential goods and services, supporting survival and livelihoods (King et al., 2019). However, ecosystem changes threaten the sustainability of areas reliant on these services, such as in Egypt, Nigeria, and South Africa (Egoh et al., 2020). The Millennium Ecological Assessment Report (MEA, 2019) categorizes ecosystem services into

provisioning, regulating, cultural, and supporting services, all vital for human survival and development (Bostia, 2022).

In Africa, PES can play a crucial role in sustainable development by addressing environmental and social objectives, particularly in rural areas (Pagiola et al., 2021). PES schemes in developing countries, which host a significant portion of the world's tropical forests and poor populations, offer a unique opportunity to address both poverty and ecosystem degradation (Pattanayak et al., 2020). In East Africa, studies highlight the economic importance of ecosystem services and advocate for PES to sustain these values (Karangwa, 2021; Nzigidahera, 2014; UNEP, 2012; Malimbwi, 2021; Andrew et al., 2020; Ruhweza and Masiga, 2016).

In Uganda, PES is seen as a promising mechanism for conservation and community benefits (Omondi et al., 2021). However, successful PES implementation requires strong legal frameworks, community involvement, and effective monitoring (Fisher, 2018; Namirembe, 2019; Omondi et al., 2021).In the Rwenzori region, the "Restoration of River Nyamwamba Watershed" project, implemented by Responsibility and Renewable Energy Holding (rAREH) and World-Wide Fund for Nature, Uganda Country Office (WWF-UCO), aims to restore degraded hotspots and improve local livelihoods through PES (Barakagira and de Wit, 2017; WWF-UCO, 2019). This project focuses on controlling runoff, combating soil erosion, and increasing crop productivity through various measures (Fisher, 2018).

Despite the recognized potential of PES programs to enhance ecosystem services and improve community livelihoods (MEA, 2020;Barakagira and de Wit, 2017 & 2019; FAO, 2019), the River Nyamwamba sub-catchment in the Rwenzori region faces significant ecosystem degradation due to human activities and climate change. This degradation has led to a loss of biodiversity and a decline in the effectiveness of ecosystems to provide essential services (WWF Report, 2020; Baguma and Barakagira, 2023; Barakagira and de Wit, 2017; Baguma and Barakagira, 2023). Although PES initiatives have been implemented in this region with the goal of improving both the environment and local livelihoods, there has been limited assessment of their impact (WWF-UCO, 2023). Consequently, this study aims to evaluate how PES contributes to ecosystem restoration and the livelihoods of households in the Nyamwamba sub-catchment, addressing the gap in knowledge regarding the effectiveness of these initiatives. Hence, this study was set out to achieve the following objectives. (i) to determine the implementation mechanisms of PES used in the Nyamwamba sub-catchment; and (ii) to determine the perceived

livelihood improvement as a result of implementing PES to people leaving in the Nyamwamba sub-catchment.

2. Methodology

2.1 Study Design

The study adopted a cross-sectional survey design that utilized qualitative and quantitative approaches for data collection. Cross sectional design is a kind of research design in which the data is collected at a single point in time from a sample posing homogenous characteristics to represent a large population (Mugenda & Mugenda, 2003).Qualitative approaches were used to collect and analyze views and opinions regarding PES approach as a climate change adaptation tool, livelihood improvement of household and the relationship PES has had on the ecosystem using a key informant interview while quantitative approach involved the use of quantifiable methods to capture and analyze quantifiable information generated using a questionnaire on the sampled respondents.

2.2 Study Area

The study was carried out in Rwenzori region, Kasese District with reference to River, Nyamwamba. This river is positioned in western Uganda of the Kasese district and is fed by melting glaciers from Rwenzori Mountains (WWF, 2016). It arises from mountain and flows to Lake George in the Albertine Rift.Kasese District is located along the equator. It is bordered by Kabarole District to the north, Kamwenge District and Kitagwenda District to the east, Rubirizi District to the south, and the Democratic Republic of the Congo to the west as shown in Figure 1.

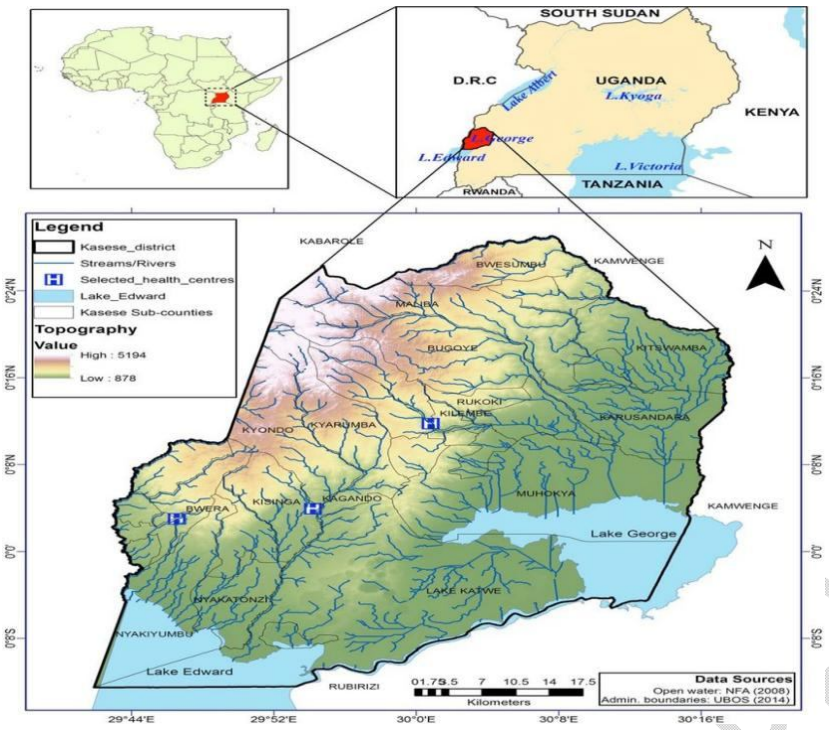

Figure 1. Location of the study area

2.3 Data Collection

The research study targeted three sub-counties around River Nyamwamba water catchment area and these include; Kilembe, Bulembia and Mbunga which all constituted a sampling frame.Both purposive and simple random sampling techniques were used to select the areas of study. The first stage involved a purposive selection of three (3) sub-counties from River Nyamwamba catchment area. The second stage involved a random selection of six (6) parishes from each of the three selected sub-counties making a total of 18 parishes. From each parish two (2) villages were randomly selected making a total sum of thirty-two (32) villages across three sub-counties. The third stage involved a random selection of three (6) major PES actors from each village to meet the target sample of 192 respondents across 32 villages. A list of PES actors was obtained from their respective villages with the help of the agricultural service providers and parish leaders. The fourth stage involved a purposive sampling selection of 15 key informants who were interviewed from their places of work. The key informants were NEMA officials, WWF

officials, and private sector actors like Hima and Serengeti energy officials, parish leaders, agricultural service providers, District local government leaders and community-based organization leaders among others. These were selected due to their key roles they play and having technical information about the study phenomenon.

A questionnaire survey method was used to gather data from the community members since it was cheap, quick and collected data with minimum errors and also allowed the respondents to answer questions at their convenient time (Burns, 2012). In addition, interviews were conducted with key informants where the study participants were subjected to and answered questions which were in line with the study objectives. Direct observation was also employed to gather information. Direct observation was used to acquire nonverbal information that was important in justifying the controversial circumstances (Kothari, 2004). This method was also used to verify the data collected through questionnaires and interviews (Kothari, 2004). A total of 207 respondents participated in the study, providing diverse insights into PES implementation and its effects on livelihoods and ecosystems. The data collected were cleaned, coded and entered into a statistical package for social sciences (SPSS) version 22.0 for analysis. Both descriptive including percentages, mean, standard deviation and inferential statistics including correlation, regression and ANOVA were used to analyze the data to establish the relationships between the variables under study.

3. Results

3.1 Demographic characteristics of respondents

Gender of Respondents

During the survey, the respondents were asked their sex and their responses were captured, analyzed and presented in figure 2 below.

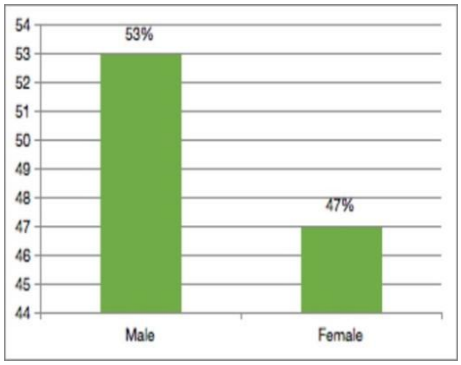

Figure 1: *Gender of Respondents* (*Field data, 2024*)

As shown in figure 2, majority 53% were males and 47% were females. The dominance of males in the study meant that PES activities could easily be done by majority of males since the activities were regarded as hectic in nature. However, the results implied that the study did not suffer from gender bias.

Age of Respondents

The age of the respondents was captured and the responses analyzed to produce Figure 3.

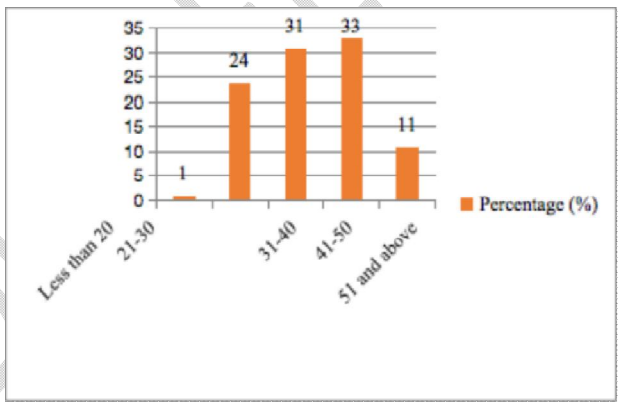

Figure 2: Age of Respondents (Field data, 2024)

According to results in Figure 3, a third of the respondents (33%) were aged 41-50 years, followed by respondents 31% who were aged 31-40 years, and 24% of respondents were aged 21-30 years. The results implied that age could influence access to resources such as land, capital, and education, which are essential for participating in PES initiatives and improving livelihoods. Younger individuals were likely to face barriers related to access to land, limiting their ability to engage in PES activities and benefit from associated payments.

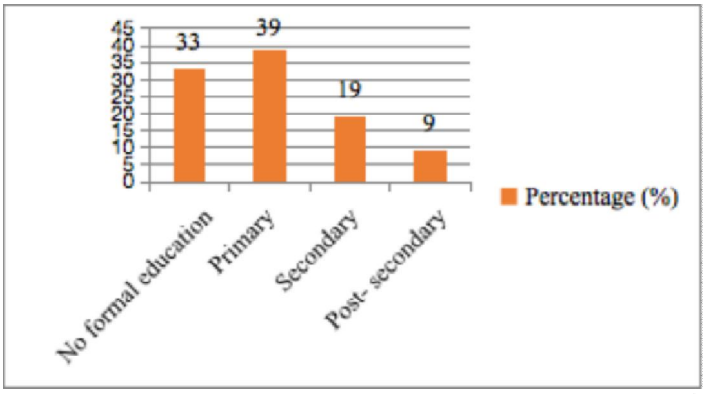

Figure 3: Educational level (Field data, 2024)

The data presented in figure 3 shows that most respondents were aged between 41 and 50 (33%), followed by those aged between 31 and 40 (31%). Respondents aged between 21 and 30 made up 24%, while 11% were aged 51 and above, and only 1% were under 20. The findings suggest that age can affect access to crucial resources like land, capital, and education, which are important for participating in PES programs and enhancing livelihoods. Younger individuals may encounter obstacles that restrict their ability to engage in PES activities and receive the related benefits.

Marital Status of Respondents

Respondents were also asked their marital status and their responses are presented in Figure 5.

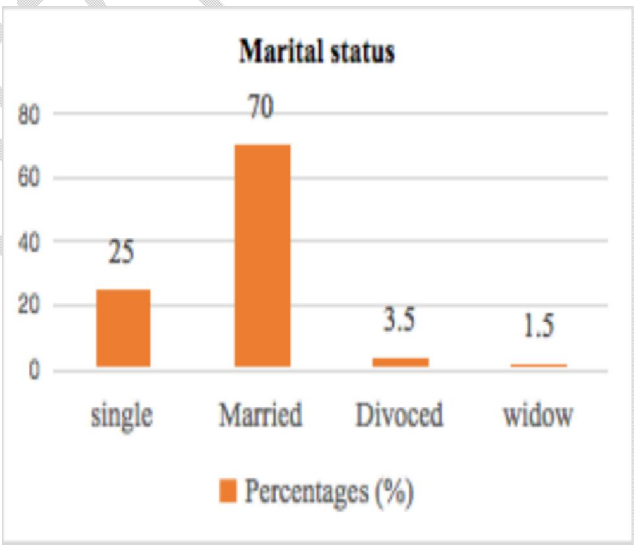

Figure 4: Marital Status of Respondents (Field data, 2024).

The findings depicted in Figure 4 indicate that 70% of respondents were married, 25% were single, 3.5% were divorced, and 1.5% were widowed. These results suggest that marital status influences an individual's decision-making authority within the household. Unmarried individuals, especially women, might have less influence over decisions concerning land use and resource management, potentially affecting their participation in PES programs and livelihood enhancement projects.

According to the results shown in Figure 6, the majority of respondents (75%) rely on farming as their primary source of livelihood, while 25% depend on business activities. The smallest group of respondents rely on salaries for their employment.

3.2 Implementation mechanisms for Payment for Ecosystem Services in Kasese district

Implementation mechanisms for PES in the Rwenzori region, Kasese district were examined through a questionnaire survey. Respondents were asked to identify the participants involved in PES implementation. The responses were analyzed and are presented in Figure 6.

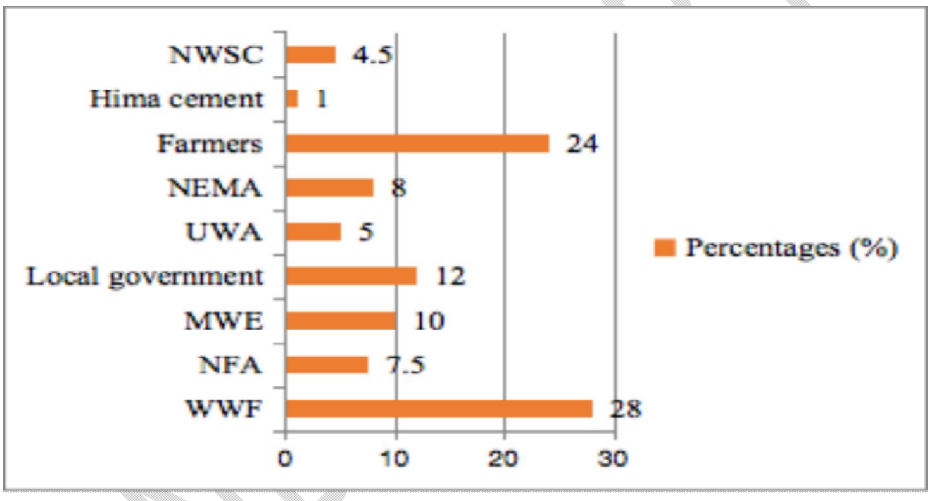

Figure 6: Participants in PES implementation

The study findings indicated that the most of respondents (28%), identified WWF as the primary participant in PES implementation. This was followed by 24% of the participants who identified farmers as key implementers. Local government was mentioned by 12% of respondents, while 10% pointed out MWE. Other participants included NEMA, NFA, UWA, NWSC, and Hima Cement Organization.

Mechanisms for PES Implementation in the Nyamwamba sub-catchment

The study determined various mechanisms for implementing PES in the Nyamwamba sub-catchment and the results are indicated in Table 1.

Table 1: **Mechanisms for PES implementation in Nyamwamba sub-catchment**

Mechanism	Frequency	Percentage (%)	Cumulative Percentage (%)
Biodiversity conservation through reforestation and afforestation, promoting eco-tourism, river bank stabilization with indigenous bamboo	20	14	14
Re-afforestation with indigenous and exotic tree species in RMNP and surrounding areas	60	38	52
Soil and water conservation using techniques like mulching, trenching, and crop rotation	50	36	88
Agroforestry by integrating trees into farm and agricultural landscapes	1	1	89
Water conservation through desilting, pollution prevention, and recycling	8	5	94
Forest landscape restoration with resilient tree species and education on restoration benefits	10	6	100
Total	**158**	**100**	

Re-afforestation was the most frequently cited mechanism (38%), used to implement PES in the study area. This approach involved planting both indigenous and exotic tree species, with notable successes in the Rwenzori Mountains National Park and the surrounding areas.

Soil and Water Conservation as reported by 36% of the respondents was the second most commonly used mechanism for implementation of PES. This category included various techniques such as trenching, crop rotation, and other soil conservation methods aimed at preserving soil integrity and water resources as seen in Plate 1.

Plate 1. A trench dug in the plantain garden to trap water and prevent soil erosion (2024)

Biodiversity Conservation was mentioned by the 14% of the respondents as one of the other mechanisms used to implement PES in the Nyamwaba sub-catchment. The activityfocused onre-afforestation, promoted eco-tourism, and stabilized river banks using bamboo to support diverse ecosystems.

Forest Landscape Restoration (6%) and water conservation through mainly desilting (5%) and agroforestry (1%) were the added mechanisms employed to implement PES in the study area.

During one of the interviews with a key informant working with WWF, he reported that:

“WWF supported pilot PES projects which included river bank stabilization and re-afforestation initiatives, that served as models for broader implementation”.

These projects aimed at balancing environmental conservation with socio-economic development, ensuring sustainable outcomes for both communities and ecosystems.

3.2 Livelihood improvement as a result of implementing PES

Data concerning the perceived livelihood improvement as a result of implementing PES to the communities living in the Nyamwamba sub-catchment was gathered and analysed to generate information in Table 2.

Table 2:Different aspects of livelihood improvements attributed to payments for ecosystem services (Respondent's questionnaire survey, 2024)

Variable	Mean	Std. Deviation	Std. Error Mean
Able to pay children's school fees	.420	.6003	.0455
Able to handle food crisis problems	.879	1.1845	.0898
Establish better housing facilities	.143	.3759	.0285
Able to pay medical bills	.307	.7237	.0549
Able to accumulate savings	.413	.6247	.0474

From Table 2, the standard deviation which is the measure of variation or dispersion in the data-set, a higher value indicates more variability within the data. For instance, handling food crises has a standard deviation of 1.1845, showing a wide range of responses to the variable. Standard error of mean which is an estimate of the variability of the sample mean, indicates the precision of the mean estimate. For example, the standard error mean for paying children's school fees is 0.0455 which indicates high precision.

Paying Children's School Fees: The mean value of 0.420 with a standard error of 0.0455 suggests that on average, participants have experienced moderate improvement in their ability to pay for their children's education due to PES interventions which has enhanced their income.

Handling Food Crisis Problems: With a mean value of 0.879 and a standard error of 0.0898, this aspect shows a relatively high improvement, indicating that PES has significantly helped participants handle food crises and countering hunger amongst household members.

Establishing Better Housing Facilities: The mean value of 0.143 and a standard error of 0.0285 indicates decimal improvement in housing facilities compared to other aspects, suggesting that while PES has had some impact, it is less pronounced in this area.

Paying Medical Bills: The mean value of 0.307 and a standard error of 0.0549 shows moderate improvement, indicating that PES has somewhat helped participants in paying medical bills.

Accumulating Savings: With a mean value of 0.413 and a standard error of 0.0474, this aspect shows a moderate level of improvement, indicating that PES has helped participants accumulate savings especially at the Village Loans and Savings Associations.

A regression was performed to determine the relationship between PES and livelihood improvement and the results are as reflected in Table 3.

Table 3: Regression Model Summaryfor the relationship between PES and livelihood improvement (Respondent's questionnaire survey, 2024)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F-statistic	P-value
1	.614[a]	.432	.312	2.292	18.73	0.000

The results in Table 3 above shows a direct strong correlation between PES and livelihood improvement at P=0.000. The R Square of .432 was an indication that implementation of PES contributed to 43.2% increment in livelihood improvement while an adjusted R Square of .312 implied that application of PES accounted for 31.2% variation in livelihood improvement.

ANOVA test was conducted to find out whether there was a significant difference in the variables that contributed to the perceived effect of PES on the livelihood improvement of the community members and Table 4 was generated.

Table 4: ANOVA results for the perceived effect of PES on livelihood improvement (Respondent's questionnaire survey)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	50.692	2	10.138	1.931	.002[a]
	Residual	11942.922	148	5.251		
	Total	11993.614	150			

Dependent Variable: livelihood improvement

The analysis in Table 4 indicates a significance in the variables that contributed to the perceived effects of PES on the livelihood improvement of the community members at P=0.02. Therefore, various factors (mechanisms) like agroforestry, re-afforestation, water conservation among others are perceived to have promoted PES and hence leading to livelihood improvement to members of the community as shown in the multiple regressions shown in Table 5.

Table 5: Multiple Regression on PES mechanisms and livelihood improvement (Responnt's questionnaire survey, 2024)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.900	.659		10.479	.000
	Agroforestry through integration of tree on farm and agricultural landscapes.	.005	.000	-.073	-1.391	.165
	Re-afforestation through planting of both indigenous and exotic tree species in some areas of Rwenzori Mountains National Park(RMNP) and hills of Kilembe, Bulembia and the down stream of River Nyamwamba.	5.027	.031	.130	2.252	.002
	Soil and water conservation through mulching, trenching, crop rotation, cover cropping, alley cropping, sand bands, stone bands, gabions, terracing, hedge rows, grass strips, trash lines, retention ditches.	9.156	.783	.412	3.223	.000

	Biodiversity conservation through reforestation and afforestation, promoting Eco-tourism, river bank stabilization through planting indigenous and bamboo.	4.003	.201	.137	2.605	.010
	Water conservation to improve water quality through Desilting, pollution prevention, water recycling and re-use, gabions, planting bamboo at the river banks, planting pastures and practising zero grazing.	.000	.001	.036	.689	.491
	Forest Landscape Restoration through planting tree resilient species under Farmer Managed Natural Regeneration, aided regeneration, enrichment planting, education and awareness on benefits of restoration.	5.125	.131	.230	2.785	.001

Dependent Variable: Livelihood Improvement

Table 5 identifies six PES mechanisms as predictors of livelihood improvement, with four showing significant effects. These mechanisms include re-afforestation, soil and water conservation, biodiversity conservation, and forest landscape restoration.

Re-afforestation demonstrated a significant impact at the 5% level, with a coefficient ($\beta = 5.027$, $p = .002$). This mechanism, which involves planting both indigenous and exotic trees in areas like the Rwenzori Mountains National Park and Kilembe, notably improved livelihoods.

Soil and Water Conservation also showed a significant effect at the 5% level ($\beta = 9.156$, $p = .000$). Practices such as mulching and trenching contributed to enhanced agricultural productivity and food reserves, thus improving livelihoods for some households.

Biodiversity Conservation was significant at the 5% level ($\beta = 4.003$, $p = .010$). This mechanism, which includes reforestation, afforestation, and eco-tourism promotion, contributed to increased livelihoods by preserving species and stabilizing riverbanks.

Forest Landscape Restoration had a significant association with livelihood improvement at the 5% level ($\beta = 5.125$, $p = .001$). This approach, which encompasses Farmer Managed Natural Regeneration, aided regeneration, and educational initiatives on restoration, led to increased livelihoods and diversified income through the sale of forested trees.

Interviews further highlight the broader impacts of PES. In Kasese District, Uganda, PES has significantly enhanced livelihoods by encouraging sustainable land management practices, improving agricultural productivity, and diversifying income through eco-tourism, which are believed to have led to the reduction of poverty levels and improved food security.

In the Nyamwamba sub-catchment, PES have positively affected water quality, ecosystem functions, and biodiversity protection as reported by the study participants. The results are as shown in Table 6.

Table 6: Impact of PES Implementation on Ecosystem Improvement in the Rwenzori Region (Respondent's questionnaire survey, 2024)

Responses	Correlation Coefficient (r)	P-value
Flood control	0.45	0.001
Reduction of soil loss and soil erosion	0.40	0.003
Well-functioning ecosystems	0.35	0.008
Water resource management	0.42	0.002
Biodiversity conservation	0.38	0.005

The findings presented in the Table 6 reveal several significant relationships between PES implementation and various aspects of ecosystem improvement in the Rwenzori region.

Flood Control: A moderate positive correlation (r = 0.45) was found between PES and improvements in flood control, with a statistically significant P-value = 0.001. This suggests that PES plays a crucial role in mitigating flood risks and improving disaster resilience. Measures such as bamboo planting for riverbank stabilization have reduced soil erosion and improved water quality in the study area.

Regarding reduction of soil loss and soil erosion, PES was positively correlated (r = 0.40) with the reduction of soil loss and erosion. The relationship is statistically significant at P = 0.003, indicating that PES practices such as terracing and mulching effectively contributed to soil conservation.

In terms of water resource management, a moderate positive correlation (r = 0.42) was observed between PES and improvement of water resource management at P=0.002. This highlights the role of PES in enhancing water management practices and producing clean water to community members.

For biodiversity conservation, PES showed a moderate positive correlation (r = 0.38) with biodiversity conservation efforts, including reforestation, afforestation, and eco-tourism at P=0.005 which confirms that PES supports biodiversity conservation initiatives.

Interviews with officials from government agencies and organizations further illuminate the impact of PES on ecosystem improvement. One official from the National Environment Management Authority (NEMA) stated that NEMA plays a critical role in monitoring and evaluating PES projects, ensuring compliance with environmental standards, and enforcing policies and regulations at the community level, promoting a sustainable land use and conservation effort in the study area. The Uganda Wildlife Authority (UWA) official stated that UWA engages local communities to mitigate human-wildlife conflicts and supports conservation-compatible livelihoods and hence contributing to the successes of PES projects in the study area.

4. Discussion of the study findings

4.1 Implementation Mechanisms for PES in Nyamwamba sub-catchment

The study identified several mechanisms for implementing PES in the Nyamwamba sub-catchment. Notably, forest landscape restoration emerged as a significant mechanism, reported by 6% of respondents. This involves compensating landowners for either avoiding deforestation or re-afforesting degraded lands. This finding aligns with WWF (2016), which documented a substantial reduction in deforestation from 9.1% in control villages to 4.2% in treatment villages through similar PES programs in Uganda.In addition to forest restoration, the study highlighted soil and water conservation practices as critical PES mechanisms. Techniques such as trenching, hedge rows, grass strips, and mulching were noted. These practices not only benefit individual farmers but also contribute to broader environmental goals, including biodiversity conservation, watershed protection, and climate change mitigation. This finding is supported by Barakagira and Ndungo (2023), Zenda Za Begani et al. (2024) and Scherr & McNeely (2018), who emphasized that such conservation practices help mitigate soil erosion and improve water quality, thereby enhancing agricultural sustainability and community well-being.Biodiversity conservation was also identified as a PES mechanism. Respondents reported that PES schemes promoted agroforestry and habitat preservation which enhanced agricultural productivity. This is consistent with Wunder (2015), who noted that PES schemes that compensate communities for ecosystem services like clean water and habitat preservation can offer alternative income sources, thereby reducing poverty and supporting sustainable livelihoods.

4.2 The effect of pes on livelihood improvement

The study found that PES programs have significantly enhanced household livelihoods in the Nyamwamba sub-catchment. Respondents indicated that PES participation has led to increased income, enabling them to pay for children's education, medical bills, and housing improvements. PES schemes provide financial incentives for services such as carbon sequestration and watershed protection, offering alternative income streams beyond traditional agriculture. This finding supports Naidoo & Adamowicz (2015), who found that PES can increase household income and alleviate poverty, particularly in areas with limited livelihood options.

PES also contributes to public health by improving water quality, reducing the risk of waterborne diseases. Respondents highlighted that PES schemes focused on watershed and forest conservation ensure access to clean water, which is crucial for public health. Pagiola et al. (2017)

and Barakagiraand Ndungo (2023) corroborate this, showing that PES can enhance health benefits by stabilizing water sources and supporting environmental sustainability. Furthermore, PES schemes that improve soil fertility and agricultural productivity also help households upgrade their housing conditions. This is consistent with Miteva et al. (2015), who reported that improved environmental conditions through PES can lead to better air quality and reduced healthcare expenses, allowing more resources to be allocated toward housing improvements.

5. Conclusion and recommendations

The study concludes that various PES implementation mechanisms are in place in the Nyamwamba sub-region, including re-afforestation, biodiversity conservation, soil and water conservation, agroforestry, and forest landscape restoration. PES has positively impacted household livelihoods by enabling better education, housing, food security, savings, and medical care. Additionally, PES has been associated with significant improvements in ecosystem health, including flood control, soil conservation, water management, and biodiversity conservation. Therefore, the study recommends that:

- The government of Uganda to strengthen policy frameworks by creating and enforcing policies that support PES initiatives, including guidelines for sustainable land management and conservation practices that promote ecosystem conservation at household level.
- The Ministry of Water and Environment to support capacity-building programs through training and equipping local communities with the skills needed to participate effectively in PES schemes. Training should cover sustainable land management, biodiversity conservation, and financial management to enhance community engagement and program success.
- Local government to share successful PES practices and lessons learned with other organizations and stakeholders involved in similar initiatives, thereby encouraging members of the community to promote and adopt best practices for improvement on the adoption of the PES programmes aimed at promoting their livelihoods and ecosystems conservation.

List of acronyms and abbreviations

MWE – Ministry of Water and Environment

NEMA – National Environment Management Authority

NFA – National Forestry Authority

NWSC – National Water and Sewerage Cooperation

WWF – World Wide Fund for Nature

References

Adger, W. N., Brown, K., & Hulme, M. (2020). Redefining global environmental change. *Global Environmental Change*, 15, 1–4.

African Development Bank (AfDB). (2015). *Payment for environmental services: A promising tool for natural resources management in Africa*. AFDB CIF Knowledge Series. African Development Bank Group.

Andrew, G., &Masozera, M. (2020). Payment for ecosystem services and poverty reduction in Uganda. *Journal of Sustainable Development in Africa*, 12(3), 122–139.

Baguma, C. &Barakagira, A. (2023). Effects of wetland drainage on community livelihoods: A case of Mabengere wetland in Kisita sub-County, Kakumiro district, Uganda. Journal of Global Ecology and Environment. Vol. 19: 1, 1-9, 2023. https://doi.org/10.56557/JOGEE/2023/v19i18396

Barakagira, A., &Kateyo, E. (2008). Impacts of wetland drainage on domestic water supplies and people's livelihoods in Kabale district, Uganda. 12th Biennial Conference of the International Association for the Study of Commons, University of Gloucestershire, UK. http://iasc2008. glos. ac. uk/conference% 20papers/papers/B

Barakagira A., de Wit A. (2019). The role of wetland management agencies within the local community in the conservation of wetlands in Uganda. Environmental and Socio-economic Studies. 7,1:59-74. https://doi.org/10.2478/environ-2019-006

Barakagira A., de Wit A. (2017). Community livelihood activities as key determinants for community-based conservation of wetlands in Uganda. *Environmental and Socio-economic Studies.* 5, 1: 11–24. https://doi.org/10.1515/environ-2017-0002

Barakagira, A and Ndungo, I. (2023). Watershed management and climate change adaptation mechanisms used by people living in dryland areas of Lokere catchment in Karamoja,

Uganda. *Environ. Socio.-econ. stud.*, 2023, 11, 1: 45-57. https://doi.org/10.2478/environ-2023-0004

Biryahwaho, B., Agasha, A., Omondi, H. M., Okwousa, E., & Mogaka, H. (2021). Policy, legislation and institutional frameworks governing payment for ecosystem services in Uganda. In H. Mogaka, J. Okeyo-Owuor, & A. Kipkoech (Eds.), *Case studies from Eastern and Central Africa* (pp. [pages]). Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).

Bostian, M., & Lundgren, T. (2022). Valuing ecosystem services for agricultural total factor productivity: A review of best practices, challenges, and recommendations. *Sustainability*, 14, 3035.

Bracer, C., Scherr, S., Ochieng, B. O., &Sriskanthan, G. (2017). Organization and governance for fostering pro-poor compensation for environmental services: CES Scoping Study Issue Paper, 4. World Agroforestry Centre ICRAF, Working Paper, 39.

Brouwer, R., Tesfaye, A., & Pauw, P. (2011). Meta-analysis of institutional-economic factors explaining the environmental performance of payments for watershed services. *Environmental Conservation*, 38(4), 380–392.

Carroll, N., & Jenkins, M. (2018). The matrix: Mapping ecosystem service markets. In *Ecosystem Marketplace. Integrated Solutions: Water Biodiversity and the Clean Development Mechanism*. EM Market Insights: Beyond Carbon. Trends and Ecosystem Marketplace (pp. 1–40).

Carroll, N., & Jenkins, M. (2020). The matrix: Mapping ecosystem service markets. In *Ecosystem Marketplace. Integrated Solutions: Water Biodiversity and the Clean Development Mechanism*. EM Market Insights: Beyond Carbon. The Katoomba Group, Forest Trends and Ecosystem Marketplace (pp. 1–40).

Daniels, A., Bagstad, K., Esposito, V., Moulaert, A., & Rodriguez, C. (2020). Understanding the impacts of Costa Rica's PES: Are we asking the right questions? *Ecological Economics*, 69, 2116–2126.

Daw, T., Brown, K., Rosendo, S., & Pomeroy, R. (2021). Applying the ecosystem services concept to poverty alleviation: The need to disaggregate human well-being. *Environmental Conservation*, 38, 370–379.

Di Minin, E., Soutullo, A., Bartesaghi, L., Rios, M., &Szephegy, M. N. (2021). Integrating biodiversity, ecosystem services and socio-economic data to identify priority areas and landowners for conservation actions at the national scale. *Biological Conservation*, 206, 56–64.

Egoh, B. N., O'Farrell, P. J., Charef, A., Gurney, L. J., & Koellner, D. (2020). An African account of ecosystem service provision: Use, threats and policy options for sustainable livelihoods. *Ecosystem Services*, 2, 71–81.

Engel, S., Pagiola, S., & Wunder, S. (2018). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, 65, 663–674.

Ferraro, P., & Kiss, A. (2020). Direct payments for biodiversity conservation. *Science*, 298, 17–18.

Ferraro, P., & Simpson, R. (2020). The cost-effectiveness of conservation payments. *Land Economics*, 78, 339–353.

Fisher, B., Lewis, S. L., Burgess, N. D., &Malimbwi, R. E. (2021). Implementation and opportunity costs of reducing deforestation and forest degradation in Tanzania. *Nature Climate Change*, 1, 161–164.

Fisher, J. A. (2018). Reprint of 'Ecosystem services concepts and approaches in conservation: Just a rhetorical tool?'. *Ecological Economics*, 117, 261–269.

Folke, C. (2022). The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, 16, 253–267.

Goldman, R., Thompson, B., & Daily, G. (2017). Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics*, 64, 333–343.

Guo, Z. W., Xiao, X. M., Gan, Y. L., & Zheng, Y. J. (2016). Ecosystem functions, services, and their values: A case study in Xingshan County of China. *Ecological Economics*, 38, 141–154.

Hamilton, K., Sjardin, M., Peters-Stanley, M., & Marcello, T. (2020). Building bridges: State of the voluntary carbon markets 2010. Ecosystem Marketplace and Bloomberg New Energy Finance Report.

Hooper, D. U. (2015). Effects of biodiversity on ecosystem functioning and ecosystem theoretical framework development: A consensus of current knowledge. *Ecological Monographs*, 75, 3–35.

Ingram, J. C., Wilkie, D., Clements, T., & McNab, R. B. (2014). Evidence of payments for ecosystem services as a mechanism for supporting biodiversity conservation and rural livelihoods. *Ecosystem Services*, 7, 10–21.

Jindal, R., Swallow, B., & Kerr, J. (2018). Forestry-based carbon sequestration projects in Africa: Potential benefits and challenges. *Natural Resources Forum*, 32, 116–130.

Johnson, C. N., Balmford, A., Brook, B. W., Buettel, J. C., & Wilmshurst, J. M. (2017). Biodiversity losses and conservation responses in the Anthropocene. *Science*, 356, 270–275.

Kaplan-Hallam, M., & Bennett, N. J. (2018). Adaptive social impact management for conservation and environmental management. *Conservation Biology*, 32, 304–314.

Karangwa, C. (2021). Payment for ecosystem services for social welfare enhancement at the community level: The case of Rwanda and Uganda. In H. Mogaka, J. Okeyo-Owuor, & A. Kipkoech (Eds.), *Case studies from Eastern and Central Africa* (pp. [pages]). Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA).

King, E., Nelson, D., & McGreevy, J. (2019). Advancing the integration of ecosystem services and livelihood adaptation. *Environmental Research Letters*, 14, 124057.

Kosoy, N., Corbera, E., & Brown, K. (2018). Participation in payments for ecosystem services: Case studies from the Lacandon rainforest, Mexico. *Geoforum*, 39, 2073–2083.

Kosoy, N., Martinez-Tuna, M., Muradian, R., & Martinez-Alier, J. (2017). Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America. *Ecological Economics*, 61, 446–455.

Lele, S. (2021). Watershed services of tropical forests: From hydrology to economic valuation to integrated analysis. *Current Opinion in Environmental Sustainability*, 1, 148–155.

Medd, W., & Marvin, S. (2020). Strategic intermediation: Between regional strategy and local practice. *Sustainable Development*, 15(5), 318–327.

Merger, E., Dutschke, M., &Verchot, L. (2016). Options for REDD+ voluntary certification to ensure net GHG benefits, poverty alleviation, sustainable management of forests and biodiversity conservation. *Forests*, 2, 550–577.

Millennium Ecosystem Assessment. (2020). *Ecosystems and human well-being*. Island Press.

Millennium Ecosystem Assessment (MEA). (2019). *Ecosystems and human well-being: Synthesis*. World Resources Institute.

Muradian, R., Arsel, M., Pellegrini, L., & Adaman, F. (2015). Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation Letters*, 6, 274–279.

Mussa, K., &Mwakaje, A. (2019). The impact of equitable payment for watershed services scheme on livelihoods in Tanzania: The case of Uluguru Mountains. *International Journal of Development and Sustainability*, 2(2), 1031–1051.

Namirembe, S., Mwangi, J., &Gathenya, J. (2019). *Case studies on Remuneration of Positive Externalities (R4o mini.

Zenda Za Begani, A. N., Orach-Meza, F. L., & Barakagira, A. (2024). The contribution of subsistence agriculture to the livelihoods of the smallholder farmers in south Kivu

province, Democratic Republic of Congo. *Qeios*. Pp. 1-9. https://doi.org/10.32388/JE9WZW

Data availability:

The data presented in the manuscript is available on request.