Kasetsart Journal of Social Sciences 41 (2020) 83–90

Kasetsart Journal of Social Sciences

journal homepage: http://kjss.kasetsart.org

# Implementation effects of incentive policies on Tanzanian wetland ecosystems

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**Article Info**

*Article history:*
Received 2 September 2017
Revised 27 February 2018
Accepted 19 May 2018
Available online 19 June 2018

**Keywords:**
TEMPLATE,
TREND,
*vinyungu*,
wetlands friendly investments,
wildfires

**Abstract**

Incentive conservation policies are acknowledged to reduce the degradation of natural resources for improved ecosystem services worldwide. However, there have been few studies conducted on the contribution of development programs using such policies in wetlands of local importance. This paper examined the implementation effects of an incentive-based Wetlands Friendly Investments (WFI) strategy in the Ndembera Valley, Tanzania. Data were collected using a survey of 208 households and in-depth interviews, supplemented by Landsat 8 imagery and topographical maps. ERDAS Imagine 15 was used to process land cover changes and water flow using the TREND software. The results indicated: (i) all major wetlands areas had declined; (ii) the differences in land cover ($t = -.418$, $df = 8$, $p = .687$) and water flow ($t = -.418$, $df = 8$, $p = .9$) before and after introduction of the strategy were not significant; (iii) weak correlation was observed between rainfall and water flow ($r = .37$); and (iv) land conversion was the main driver for the decline in cover. These findings represent a failure of the WFI incentives to improve the ecological effects of wetland cover and water flow. This suggests that application of the strategy alone was not sufficient for substantial improvement of the desired short-term cover and flow effect. Integrating land use and livelihood into incentive policies can improve WFI incentive implementation practices for sustainable land conservation in the study area. The multi-method approach used minimized human behavior-response limitations, therefore it can be replicated elsewhere.



## Introduction

Wetland ecosystems support food production, water supply, climate regulation, and culture (Gray, Hagy, Nyman, & Stafford, 2013). In Tanzania, wetland ecosystems exist in various forms including lakes, swamps, rivers, mangroves, and grassland plains (Mwakaje, 2009). These ecosystems are estimated to cover 10 percent of Tanzania's total land area although no full inventory has been conducted to establish the actual coverage (Mombo, Speelman, Huylenbroeck, Hella, & Moe, 2011). Wetlands have long supported a range of services including provision of water, control floods, fishing, dry season grazing areas, agriculture, and wildlife habitats (Kangalawe & Liwenga, 2005). In Iringa district and the Ndembera Valley in particular, wetland ecosystems have potential for bottom valley cultivation, locally known as *vinyungu* (Magembe, 2007). Given this socio-ecological importance of wetlands, Magembe (2007) found that any sign of degradation can be a sufficient reason to seek different ways to address the problem.

Expansion of agriculture, overfishing, overgrazing, overuse of water in irrigation, sedimentation, and climate

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Peer review under responsibility of Kasetsart University.
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https://doi.org/10.1016/j.kjss.2018.05.016
2452-3151/

change coupled with the community attitude in Tanzania which regards wetlands as a common pool resource (CPR), has led to wetlands degradation (Mwakaje, 2009). Wetland, livelihoods and sustainability studies by Mombo et al. (2011), Mwakajes (2009), and Ntongani, Munishi, More, and Kashaigili (2014) show that the loss of services caused by degradation of wetlands is a potential socio-environmental problem in Tanzania. In addition, most of the previous attempts to address the problem, such as eviction and policing of wetlands, have shown some limitations including violation of rights of the adjacent wetland dwellers (Nindi, Maliti, Bakari, Kija, & Machoke, 2014).

Example of policies which provided incentives to improve wetland ecosystem services are many and include: conservation programs which paid farmers to reduce soil erosion and improve water quality in the USA (Polasky, 2011); Paddy Land-to-Dry Land (PLDL) program in Miyun wetland of China (Zheng et al., 2013); and payments to landowners to protect the quality of water and biodiversity in Costa Rica (Polasky, 2011).

In the light of the positive outcomes of incentive policies elsewhere and the increasing concern over the loss of water and food security caused by the degradation of wetlands, a strategy called Wetlands Friendly Investments (WFI) based on incentive policies was introduced by the Government of Tanzania and ran for nine years from 2003 to 2012. The WFI strategy was part of the Sustainable Wetlands Management Programme (SWMP). The program was financed by the Danish International Development Agency (DANIDA) in partnership with the Government of Tanzania (Ministry of Natural Resources and Tourism and Ministry of Foreign Affairs Denmark, 2003).

The main theoretical concept that underpinned the strategy was that by providing incentives, communities would engage in the strategy-supported activities, reduce over-dependency on wetland resources, restore degradation, and therefore improve wetland cover and water flow services and community livelihoods in the study area.

However, little is known regarding the effects of the implementation of this strategy in the Tanzanian wetlands (Ernst & Young, 2010). This study aimed to fill this gap using the Ndembera River Valley in Iringa district as a case study. It intended to provide information on the implication of this strategy on swamps, floodplains, and open waters cover/use and its effect on water flow, and to investigate the main drivers. Wetland area cover and water flow were the key ecological indicators for the WFI incentive policy; therefore this was the basis for their selection for further investigation. The research was guided by a null hypothesis: *the implementation of the Wetland Friendly Investment strategy had no effect on wetland cover and water flow.*

## Methods

### *Study Area*

This study was conducted between 2015 and 2017 in the Ndembera River Valley also called the Lyandembela sub-catchment. The valley covers an area of about 1,834 km$^2$ in southern highland Tanzania (Magembe, 2007) as shown in Figure 1. The area has a population of 32,693 people. The choice of this area was determined by its hydro-ecological potential contributing 15 percent of the average annual water flow to the Great Ruaha River (Rufiji Basin Water Board, 2015).

In relation to the WFI strategy, tree planting, bee keeping, fish farming, and animal husbandry were implemented in all intervention villages of the study area. *Syzigium* tree species were planted for water conservation purposes. *Prunus persica* and *Persea americana* for fruits,

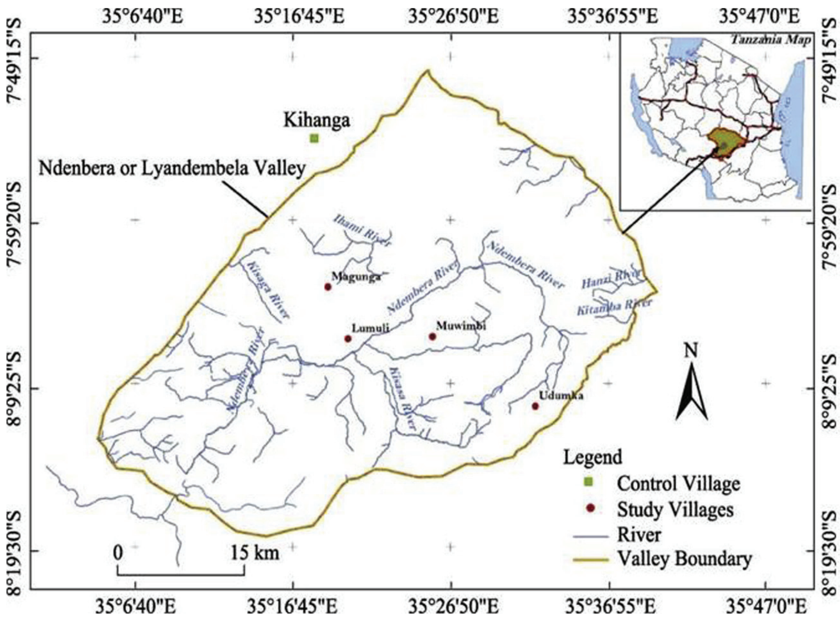


**Figure 1** Map of the study area in Iringa, Tanzania (inset).
Source: Ngowi and Mwakaje (2017).

while *Pinus* sp and *Eucalyptus* spp. were planted for timber. Bee keeping was introduced in forests and woodlands dominated by *Uapaca* tree species. Fish farming (mainly *Tilapia* spp.) was introduced in the fishponds located in the upper catchments where water was available. Animal husbandry (rabbit, chicken, pig, goat, and cattle) was also encouraged. It was anticipated that the valley could offer the best lessons learned on the implementation of the WFI strategy.

Five villages were purposively selected on the basis of the objectives of the study and the status of WFI strategy implementation. This maximized variability of the distance from the major wetlands and implementation of the strategy. Out of the five villages, Udumka, Muwimbi, Magunga and Lumuli were from the intervention area while Kihanga was used as the control. The area was accessible during the dry weather but for villages like Udumka it was difficult in the rainy season. This impacted the strategy implementation as well as utilization of wetland resources in the area.

*Participants*

The in-depth interviews involved 15 key informants with special and broad knowledge of the strategy. They were divided into three equal groups: 1) staff aged between 30 and 50 years working in the Wildlife Division, Worldwide Fund for Nature (WWF), and in regional and district councils; 2) elected village chairpersons aged 50 years and older; and 3) village elders aged 70 years and older. The researchers' personal observations supplemented the information collected in the areas where the strategy was implemented.

*Data Collection*

*Determination of Wetland Area Cover, Their Drivers and its Effect on Water Flow*

In this study, a mixed methods design was used to collect quantitative and qualitative data (Creswell & Clark, 2007). The researchers started with secondary data which were collected through a literature review of previous studies on the subject. This was important in establishing the gaps in the primary information. The source of information was reports, journals, books, policy documents, and web resources.

The sample size was calculated from 309 households which implemented the strategy using the formula by Israel (1992) $n = 309/1 + 309\ (.05)^2 = 174$. Ten percent of the 336 households which had not participated in the strategy formed the control group. The final sample size was $n = 174 + 34 = 208$ households. A simple random sampling technique was used to select heads of households. In this case, every tenth name on the list of the households in the study villages was selected. This technique allowed all heads of households to have an equal chance of being selected and to represent the entire population.

A questionnaire survey was administered to these 208 heads of households. The questions among other things aimed to collect data on: key drivers for wetland area/cover use change over time for swamps, floodplains and open waters, and water flow. For instance, participants were asked: 1. What are the main drivers of wetland cover change and water flow today compared to the last 9 years? and 2. What are main activities that have been impacting wetlands cover in the area in the last 9 years?

Landsat 8 imagery acquired in 1995, and scenes for 2003 and 2012 were used (Seto et al., 2002) to supplement the data collected through questionnaires. The images downloaded from http://glovis.usgs.gov/had a resolution of 30 by 30 m. The images were taken in the dry season (between June and October) for ease of vegetation contrast. The topographical maps of the district at a scale of 1:50,000 and secondary data were used to complement the information in the images from 1995 during image classification. The swamps, floodplains, and open water coverages were delineated from the other major land cover types.

The mean annual water flow ($m^3/s$) for the 9 years before and after the strategy was used. The 34 years of rainfall data spanning 1981 to 2015 were complemented by other information from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data (Funk et al., 2015) and the Tanzania Meteorological Agency (TMA) to determine the correlation between water flow and rainfall.

*Data Analysis*

The analysis of the area cover was interpreted based on the Iringa topographic maps and Landsat 8 imagery from 1995 (Seto et al., 2002). Household survey data were analyzed using cross tabulation and chi-square with the SPSS ver. 20 software. The TREND software (Chiew & Siriwardena, 2005) was used to analyze water flow. The TEMPLATE method (Brooks & King, 2014) was used in the analysis of data collected through interviews and personal observation. A $p$ value of .05 was used as the cut off for statistical significance.

## Results and Discussion

*Wetland Area Cover/Use and its Effect on Water Flow*

The results (Table 1) show that the study area cover change for the major wetland types from 1995 to 2003 was swamps (−1,643 ha or −7.1%), floodplains (−598 ha or −41.9%) and open waters (−324 ha or −97%). However, the rates of change from 2003 to 2012 showed a slow decline for both swamps and floodplains of −2,417 ha (−11.3%) and −69 ha (−8.3%), respectively. The area in open waters increased slightly by +1.0 ha (+10%) during the same period. The results of the paired samples t-test showed that the differences in means of −8.011 and −1.111 in land cover/land use change for the nine land types from 1995 to 2003 and 2003 to 2012 were not significant ($p = .687$).

It was observed that although a decline in coverage occurred in all major wetland types, most of the decline happened before (1995−2003) rather than post strategy (2003−2012). This can be explained by the fact that

**Table 1**
Land use land cover changes in the Ndembera valley between 1995 and 2012

| Land use types | 1995 | 2003 | 2012 | 1995–2003[a] | | 2003–2012[b] | | 1995–2012[c] | |
|---|---|---|---|---|---|---|---|---|---|
| | ha | ha | ha | ha | % | ha | % | ha | % |
| Bush land | 25,297 | 17,990 | 15,885 | −7,307 | −28.9 | −2,105 | −11.7 | −9,412 | −37.2 |
| Cultivated land | 25,889 | 52,696 | 66,403 | +26,807 | +103.5 | +13,707 | +26.0 | +40,514 | +156.5 |
| Grassland | 54,058 | 36,763 | 32,587 | −17,295 | −32.0 | −4,176 | −11.4 | −21,471 | −39.7 |
| Swamp | 23,120 | 21,477 | 19,060 | −1,643 | −7.1 | −2,417 | −11.3 | −4,060 | −17.6 |
| Floodplains | 1,428 | 830 | 761 | −598 | −41.9 | −69 | −8.3 | −667 | −46.7 |
| Open Waters | 334 | 10 | 11 | −324 | −97.0 | +1 | +10.0 | −323 | −96.7 |
| Forests | 1,688 | 1,634 | 1,551 | −54 | −3.2 | −83 | −5.1 | −137 | −8.1 |
| Settlements | 1,501 | 2,064 | 2,279 | +563 | +37.5 | +215 | +10.4 | +778 | +51.8 |
| Woodland | 59.465 | 59,316 | 54,243 | −149 | −.3 | −5073 | −8.6 | −5,222 | −8.8 |
| Total | 192.780 | 192,780 | 192,780 | | | | | | |

Key: a/before strategy, b/after strategy, c/18 year data, +/− denotes increases in area/declines in area cover, ha denotes hectares and %, percentage
Source: calculated and interpretation based on Iringa topographic map (scale: 1:50,000) and landsat 8 Imageries 1995 as well as Google earth maps for 2003 and 2012 as well as field survey

**Table 2**
Paired samples test for land use land cover change between 1995 and 2012

| Variables | Mean | N | Std. Dev. | Std. Error Mean | T −test statistics |
|---|---|---|---|---|---|
| Land use land cover type 1995–2003 | −8.011 | 9 | 55.4914 | 18.4971 | t = −.418, df = 8, |
| Land use land cover type 2003–2012 | −1.111 | 9 | 13.3999 | 4.4666 | p = .687 (NS)** |

Key: t = t value; df. = degree of freedom; N = number of observation; NS** = not significant at p = .05
Source: calculated and interpretation based on Iringa topographic map (scale: 1:50,000) and landsat 8 Imageries 1995 as well as Google earth maps for 2003 and 2012 as well as field survey

before the strategy, there were no access ban and local communities could access all areas for resources, hence increasing the pressure on the wetlands beyond their capacity to sustain exploitation therefore increasing the rate of cover decline. The opposite occurred in the period after (2003–2012) when the WFI strategy introduced an access ban to the wetlands. This led to the control of resource demand within the capacity of the wetlands to sustain exploitation and therefore reduced the decline in cover.

There were also post strategy declines in other forms of land use: bushland (−2,105 ha or −11.7%), grassland (−4,176 ha or −11.4%), forests (−83 ha or −5.1%), and woodland (−5,073 ha or −8.6%). Other areas of cover increased: cultivated land (+13,707 ha or +26%), settlements (+215 ha or +10.4%) and open waters (+1.0 ha or +10%). This implies that there were more land use changes caused by land conversion from grassland and bushland to cultivated land and settlements than to the declining area in swamp and floodplains. These findings were different from those of Ouyang et al. (2016) which showed that the Natural Forest Conservation and the Sloping Land Conservation Programs in China improved the area cover between 2000 and 2010. For instance, Ouyang et al. (2016) showed that while habitat for biodiversity had declined by 3.1 percent, food production, carbon storage, soil retention, flood control, sandstone prevention, and water retention increased by 38.5 percent, 23.4 percent, 12.9 percent, 12.7 percent, 6.1 percent, and 3.6 percent, respectively.

The results of water flow (Table 3) showed that the mean between the two periods remained almost similar with the annual mean flow before and after intervention being 6.3 $m^3/s$ and 4.7 $m^3/s$, respectively. However, this difference was not significant ($p = .9$).

The results of the correlation between the flow and rainfall before and after the intervention (Figure 2) revealed a regression fit of mean flow: $Y = .77 + .0526\ X$ with $p = .149$ and $r = .37$ respectively. This suggests that the correlation between the flow and rainfall was not significant ($p = .149$), with a weak correlation (.20–.39) according to the five classifications of correlation (Evans, 1996). This implies that rainfall had little impact on water flow. The influence of rainfall on flow was supported by meteorological data shown in Figure 3 which indicated that some deviations existed, where the period with the highest rainfall might not experience the highest flow and vice versa. This suggests that the flow might have been accounted for by other factors, such as human activities, besides the rainfall.

Generally, the results in Figure 4 show that the water flow was worsening after the strategy was introduced compared to the pre-strategy period. This could have been caused by several factors, including: the methods of raised camber beds used in wetland cropping which was observed to have blocked the flow of water held between

**Table 3**
The annual mean water flow between 1995 and 2012

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Before strategy 1995–2003 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Mean annual flow in $m^3/s$ | 4.113 | 4.856 | 3.569 | 22.294 | 3.059 | 7.273 | 5.720 | 2.468 | 3.351 |
| After strategy 2003–2012 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| Mean annual flow in $m^3/s$ | 4.811 | 2.541 | 6.475 | 6.731 | 5.742 | 5.840 | 2.482 | 3.200 | 4.415 |

**Source**: Field survey

**Table 4**
The statistic results of the mean water flow between 1995 and 2012

| Variables | Mean | N | T −test statistics |
|---|---|---|---|
| Water flow 1995−2003 | 6.3 | 9 | t = −.418, |
| Water flow 2003−2012 | 4.7 | 9 | df = 8, |
| | | | p = .9** (NS) |

Key: t = t value; df. = degree of freedom; N = number of observation; NS** = not significant at p = .05
**Source**: calculated based on field survey

the furrows from returning to the main stream; and upland clearance which caused erosion and therefore siltation down slope wetlands (Figure 5). These results were similar to those of the studies by Magembe (2007) and Dixon and Carrie (2016). In 2007 Magembe's study of wetlands showed that the techniques used in wetland cropping reduced water flow in the Iringa and Mufindi districts. Dixon and Carrie (2016) showed that over-utilization of *dambo* reduced water flow in Malawi. However, these results were contrary to the findings of a study by Zheng et al. (2013) which showed that the Paddy Land-to-Dry Land (PLDL) program had increased the water quantity in the Miyun wetland, China between 2000 and 2009.

### *Drivers for the Wetland Area Cover/Use Changes*

Respondents were asked what were the main drivers of wetland cover change and water flow today compared to the last 9 years. The results showed that 54.8 percent of respondents pointed out that the growing demand for land for food and income was the key driver for changes in wetland area cover/use. This was followed by 10.6 percent of respondents who identified land demand for private forests, agriculture, and grazing. Only 7.7 percent of the respondents mentioned rainfall variability, while 5.3 percent of respondents associated it with the establishment of new settlements and 4.3 percent reported that wildfires affected most of the wetlands studied. Very few (1.1%) of respondents considered that new infrastructure such as earth roads contributed to changes in the area cover. As observed in the water flow, long-term rainfall variability affected most of the wetlands as supported by the meteorological data.

When asked what were the main activities impacting wetlands cover in the area in the last 9 years, a significant number (55.3%) of respondents, of whom 62.1 percent had implemented the strategy and 20.6 percent had not, considered that farming was a leading activity in degradation. The use of wildfires in farm preparation, harvesting honey and hunting of game meat was the second major activity mentioned by 15.9 percent of the respondents, of whom 64.7 percent had not implemented the strategy and 6.3 percent who had. Other activities and their percentages are presented in Table 5. The results show that there was a significant association of the main drivers degrading the wetlands between those who implemented the strategy and those which did not ($\chi 2 = 82.789$, df = 5, $p < .05$).

Generally, the results showed that providing incentives through the WFI strategy to farmers did not generate

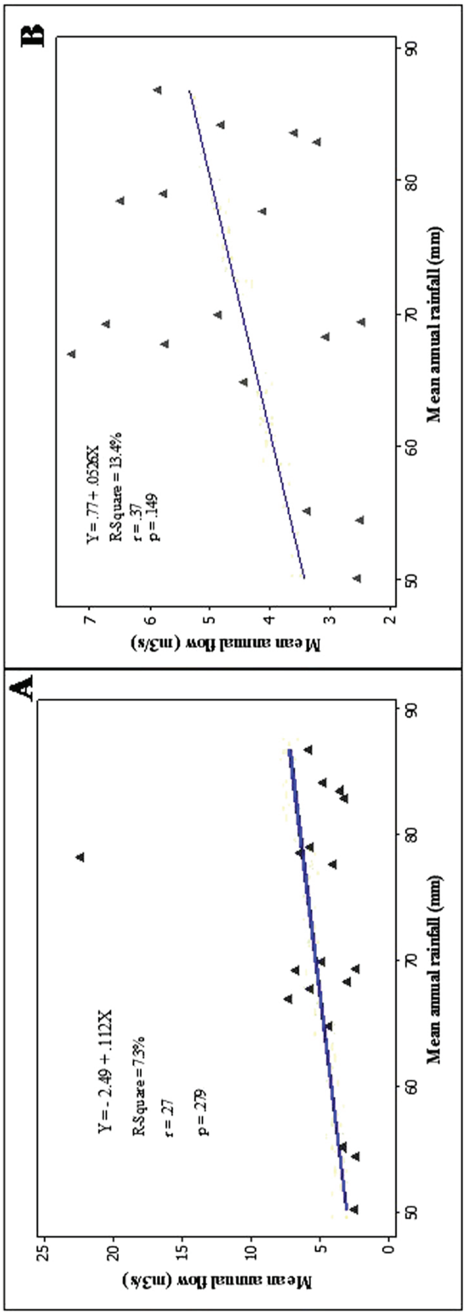


**Figure 2** Correlation of water flow and rainfall; (A) with and without outliers (B)

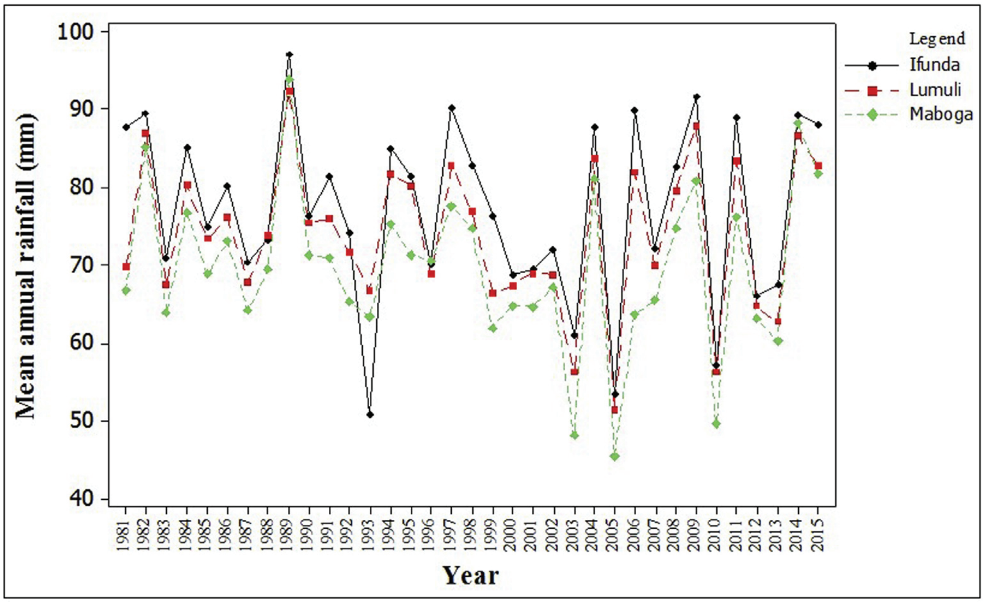


**Figure 3** Long-term rainfall distributions in the study area between 1981 and 2015

positive outcomes that affected the area cover in all the major wetland types and the water flow as argued in the null hypothesis. Instead the outcomes of providing incentives through the WFI strategy were determined by additional factors including land conversion from grassland and bushland to cultivated land, settlements, drivers for land use change, and other national policies. Therefore, the study accepted the null hypothesis that *the implementation of the wetland friendly investment strategy had no effect on wetland cover and water flow.*

## Conclusion and Recommendations

This paper investigated the implementation effects of incentive policies on Tanzanian wetland ecosystems. The results showed that the area cover for all the major wetland types (swamp, floodplain, and open waters) and the water flow continued to decline despite the introduction of the WFI strategy in the study area. Greater amounts of decline in cover were caused by land conversion from grassland and bushland to cultivated land than in the declined cover

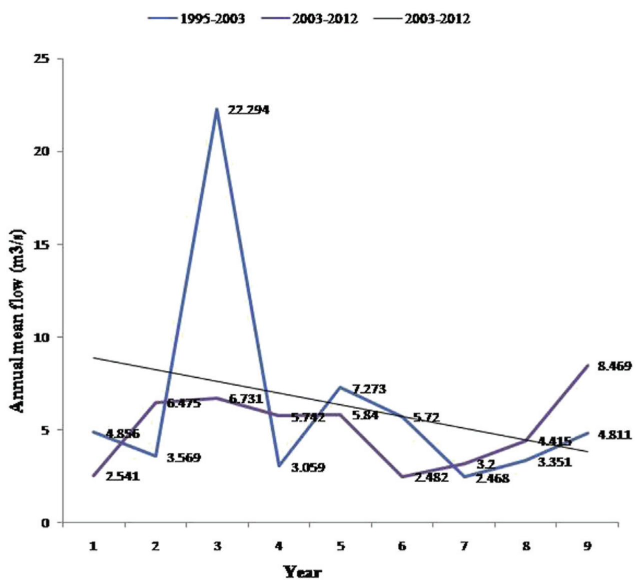


**Figure 4** A trend line of water flow post - strategy period

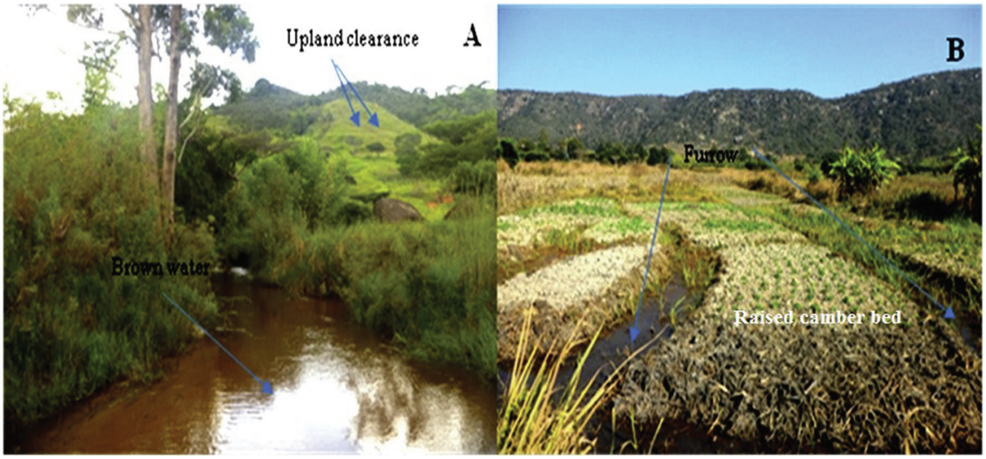


**Figure 5** Factors limiting water flow; (A) upland clearance; (B) raised camber beds

**Table 5**
Main activities affecting wetlands area cover in the study area

| Variables | Household category | | Total | Chi–Square test |
|---|---|---|---|---|
| | WFI households | Non WFI households | | |
| Wildfires | 11 (6.3) | 22 (64.7) | 33 (15.9) | |
| Brick making | 9 (5.2) | 5 (14.7) | 14 (6.7) | $\chi2 = 82.789$, |
| Grazing | 25 (14.4) | 0 (0.0) | 25 (12.0) | df = 5, |
| Farming | 108 (62.1) | 7 (20.6) | 115 (55.3) | $p = .001^{**}$ |
| Hunting of game meat | 9 (5.2) | 0 (0.0) | 9 (4.3) | |
| Collection of clay soil | 12 (6.9) | 0 (0.0) | 12 (5.8) | |
| Total | 174 (83.7) | 34 (16.3) | 208 (100) | |

Key: Figures in bracket = percentage; outside = count; $\chi2$ = Chi-square; df = degree of freedom; ** Significant at $p = .05$
**Source**: Field survey

for swamp and floodplains. These findings represent one failure of the WFI incentives to address the ecological effects of wetland use/cover and water flow in the wetlands of local importance. These results are important because they showed that the use of the WFI strategy alone was not enough for the complete promotion and improvement of wetland conservation at least in the short-term. Integrating livelihood and land use issues into incentive policies can increase WFI incentive implementation practices for sustainable land conservation in the study area. The multimethod approach used minimized human behavior-response limitations and therefore can be replicated elsewhere. This paper suggests that the short period over which the study was conducted after termination of the strategy in 2013 could be one of the limitations for not revealing any short-term effect of the strategy on the ecological variables of land use land cover change and water flow. A better understanding of the human behavior response to changes in incentive policies can improve decision making for an effective WFI strategy.

## Conflict of Interest

There is no conflict of interest.

## Acknowledgments

The Flemish Interuniversity Council for Development Cooperation (VLIR-UOS) and Mzumbe University are acknowledged for financial support.

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