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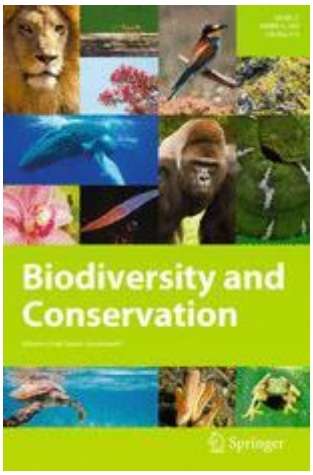

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Smallholder perceptions and communication gaps shape East African riparian ecosystems

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Abstract

Human livelihood needs and nature conservation often contradict. Yet, healthy ecosystems are crucial for human livelihood quality. The semi-arid regions of East Africa suffer under demographic pressure and soil depletion. Ecosystem degradation becomes particularly visible along rivers in semiarid regions of south-east Kenya, where former pristine riparian forests have been transformed into agricultural fields and settlements with negative effects on ecosystem services. In this study, we aim to understand how local smallholders perceive the challenges for the riparian ecosystems and what factors affect their engagement in environmental conservation. We surveyed about 200 farmers and performed expert interviews with representatives from governmental institutions from the field of land- and resource management along Nzeeu River in south-east Kenya. We assessed the level of education, land use practices, environmental knowledge, attitudes and the willingness to contribute to nature conservation. We tested for spatial bias to understand smallholders' perceptions on environmental challenges. Our data show that land division due to inheritance is not perceived as a problem by the farmers. However, owners holding <1 ha of land property are less willing to spare some of their land for conservation, as opposed to those holding land plots above this size. Despite a high level of general willingness to conserve ecosystems, our data underline that local people hardly actively engage in conservation action. Furthermore, our data indicate a communication gap between local smallholders and regional governmental officers as well as overconfidence in mass media through the radio which can contradict successful adoption of pro-environment behavior. Sustainable land management in our study area is not a matter of education, but depends from the size of land property. There is an urgent need to bridge this communication gap, as a prerequisite to improve sustainable land management.

Keywords: Smallholders; Spatial bias; Environmental communication; Ecosystem services; Habitat degradation; Human needs; Conservation; Riparian forest; Kenya

Introduction

Since the release of the Millennium Ecosystem Assessment Report (2005), there exists a strong agreement that intact ecosystems provide various ecosystem services which are crucial for the human wellbeing (Ferraro and Simpson 2002). Ecosystem services are particularly of relevance for smallholder farmers and the local agricultural markets; they are the prerequisite to safeguard food security. However, human demographic pressure and increasing life standards have accelerated the demand on natural resources (Vitousek et al. 1997; Geist and Lambin 2002; Wackernagel et al. 2002). In consequence, ecosystems are negatively affected by habitat destruction and the deterioration of ecosystem quality (Laurance and Bierregaard 1997; Habel et al. 2016). This trend diminishes ecosystem services and thus negatively impact human livelihood quality (Vitousek et al. 1997; Foley 2005). Negative effects from ecosystem degradation become particularly visible in the semi-arid regions of the tropics (Osborne 2012), characterized by a high level of poverty, high human demographic pressure (Geist and Lambin 2002), weak governance structures (Barrett et al. 2001), and complex land tenure systems (Rocheleau et al. 1995; Cotula 2007). All these factors interact with diverse present-day realities, historical legacies (reminisce of colonial land alienation) and international and national policies (Rocheleau et al. 1995; Alessa et al. 2008). These factors strongly impact smallholders´ decisions on land management.

Studying the perceptions of local people towards the environment is an important yet rarely considered component in ecosystem conservation (Fernández-Llamazares et al. 2016). Examining their perceptions is essential for understanding how local people utilize their natural resources, the legitimacy and acceptance of good environmental conservation practices as well as

92 ecological outcomes of conservation (Bennett et al. 2017). One way to evaluate perceptions
93 towards environmental problems is to analyze the spatial bias of local people. Spatial bias is the
94 tendency to incorrectly assess global environmental conditions as worse than local conditions
95 (Schultz et al. 2014). Previous studies have shown that spatial bias regarding environmental
96 problems may hinder pro-environmental behavior (Hatfield and Job 2001). Environmental
97 communication channels have been strongly attributed to contribute to spatial bias (Schultz et al.
98 2014).
99
100 In this study we analyze smallholder perceptions and which factors do influence their
101 engagement in environmental conservation, as well as the existence of communication gaps
102 between governmental institutions and smallholder farmers. For this study we selected a highly
103 degraded semi-arid landscape along Nzeeu River in south-east Kenya. The human population of
104 this region increased by almost 35% within 10 years (between 1999 and 2009) (KNBS 2009).
105 Local people are attracted by local rivers due to the access to (ground) water and fertile soils
106 (Kitui County Government 2014). Until the 1950s, Nzeeu River was framed by dense riparian
107 forests. In the meanwhile, riparian forests have been transformed into agricultural land and the
108 area became invaded by invasive and exotic species such as the West Indian lantana, *Lantana*
109 *camara*, which was formerly planted in gardens for ornamental purposes and to produce fodder
110 for life-stock (Habel et al. 2018).
111
112 The implementation and enforcement of environmental governance rules, such as the
113 conservation of riparian forest along rivers, remains difficult but its relevance is supported by the
114 existence of the law on riparian zone protection in Kenya (Matunda 2015). However, this

legislation is split into the Environment Management and Coordination Act (EMCA), the Water Quality Regulations, Water Resources Management Rules (WRMR), the Agricultural Act, the Forest Act, the Land Act, the Water Act, and the Wildlife (Conservation and Management) Act, all with overlapping mandates. This often leads to poor coordination, application and realisation of the riparian zone protection law (Matunda 2015). While some of the aforementioned acts attempt to define a riparian area and its ownership to different degrees, the reality of land tenure systems in Kenya remains highly complex as it is determined by a mix of customary and formal rules (Ministry of Environment, Water and Natural Resources 2013). For instance, the Environmental Management and Co-ordination (Conservation and Management of Wetlands) Amendment Regulations (2017) states that a river shall have a protection zone of at least 30 meters measured from the highest water mark of the river. However, local smallholder farmers in our study area (and elsewhere in Kenya) do not consider this buffer zone rule and often it is considered land under private ownership. Good conservation management practices are therefore either individually driven or mostly lacking on riparian reserves.

Additionally, the practice of land inheritance through land division negatively impacts sustainable land management. For example, it is expected that land will be divided among children who will establish individual farms (Lindblom 1920; Kimanthi 2016). With increasing human population densities the land sizes per household have shrunk considerably over the past years (Rocheleau et al. 1995). Given that the local population is heavily reliant on natural resources as shown above, decreasing sizes of land plots per capita escalate ongoing land clearance for agriculture, agricultural intensification and natural resource depletion (Rocheleau et al. 1995).

These above discussed factors culminate into a multiplex facade that contradicts the conservation of pristine riparian forests with the resilience of landscapes and human livelihoods in south-east Kenya. We applied a structured questionnaire and conducted expert interviews to collect data on peoples´ perceptions, knowledge, attitudes, willingness and involvement in relation to ecosystem conservation. Based on the obtained data we will answer the following questions:

(1) What is the spatial bias on key environmental concerns?

(2) Which environmental communication channels are rated as most important by local smallholders?

(3) Which social economic factors significantly influence smallholder's willingness to adopt good environmental conservation practices?

Material and methods

Study region

Our study region is located close to Kitui town, south-eastern Kenya (1.42°S, 38.02°E). The region is characterized by semi-arid climatic conditions and two discrete annual rainfall seasons (short rainy season from November till December, with 250–300mm precipitation, long rainy season from March till May with 400–450mm of precipitation); Monthly mean temperature ranges from 15.7°C to 27.2°C. The dominating soils are acrisols, luvisols and ferralsols, all characterized by low soil fertility and thus provide limited agricultural productivity (Jaetzold et al. 2006). Main food crops cultivated in our study region are maize, pigeon peas, beans and cowpeas. This region is characterized by strong demographic pressure. For instance, in 2009, the population density of the larger Kitui county was 44 persons/ km² while Kitui Central, the sub-county that encapsulates our study area recorded 197 persons/ km² (KNBS 2009). The local people belong to the Kamba ethnicity and first settled in this area during 1715 (Lindblom 1920). An estimated 63.5% of the human population lives in poverty (KNBS 2009) and more than 90% rely on smallholder farming and small livestock keeping as the main income (FAO 2014; Teucher et al. 2016). The livelihoods of these smallholders rely on intact ecosystems with various ecosystem services, such as groundwater, trees for charcoal production, burning of bricks, timber as well as sand harvesting. Today, the landscape is strongly degraded and consists of a mosaic of agricultural fields, riparian thickets dominated by invasive exotic species such as *L. camara*, and human settlements (Habel et al. 2018).

Survey of local smallholders and expert interviews

A structured questionnaire was administered to the local smallholders. It covered four thematic sections: (1) basic social and demographic data of smallholders (age, gender, education, number

of children, level of income, land ownership); (2) land-use (production of goods, reasons for production, size of land); (3) environmental awareness (reasons for living and cultivating along the river, perceptions towards protection of species, environmental attitudes, knowledge of existing environmental rules and sources of environmental information and news); (4) willingness (personal efforts in ecosystem conservation and willingness to adapt good environmental conservation practices). The questionnaire was designed in English and translated into Swahili language. The survey was conducted in April 2016. The complete questionnaire is provided in Appendix 1. Details on socioeconomic characteristics of the responding smallholder farmers and their activities are given in Appendix 2 and 3.

A guide for semi-structured, open-ended expert interviews was developed, focusing on: (1) experts' knowledge and understanding of the state of local ecosystems and human-ecosystem interactions; (2) existing riparian protection laws, regulations and policy and their implementation and barriers; (3) personal experiences from shortcomings of local ecosystems management. Expert interviews were conducted in May and June 2017. Questions for these semi-structured interviews are given in Appendix 4.

Sample selection

Survey participants were selected through convenience sampling. Convenience sampling is a non-probability sampling technique where participants are determined on certain practical criteria, such as geographical proximity, availability at a given time, or the willingness to participate (Dörnyei 2007). This sampling technique was mainly chosen because the target group of this study is smallholders living within a 3 km radius along the river and due to the fact that

there is a lack of socio-economic knowledge of this target group. Many people below the age of 18 visited boarding schools, and the majority of young adults (mostly those with at least high school education) moved into neighboring cities to look for employment. Thus, in most households the following groups were overrepresented: (1) Pre-school children; (2) elderly who never attended formal education or those who had retired; (3) married women and the youth who did not attained higher levels of education (beyond primary school). For these reasons, it was difficult to pre-determine the composition of a typical household.

By restricting the study radius to 3 km along the river, our target group was finite. Therefore, we included every household in the survey where people were present within this geographical area (Dörnyei 2007). Only one individual, nominated by the rest of the household members, represented a household. In households that were headed by a man and he was available at the time of the interview, he was preferred to participate by the other members otherwise the senior most females available were also mostly chosen. In total, 191 smallholder farmers completed the questionnaire on either side of the river.

We performed expert interviews with eight officials representing organizations that had direct mandate in decision making processes as well as implementation of policy and solutions to the local environmental problems. The following organizations were considered: Kenyan Forest Service (KFS), Kenya Forestry Research Institution (KEFRI), National Museums of Kenya (NMK), Ministry of Environment Kitui County, National Environment Management Authority (NEMA), and Water Resource Management Authority (WRMA). With the permission of the experts, interviews were recorded and notes simultaneously taken.

221

222 Data analysis

223 Data collected from local smallholders were analyzed using the software SPSS v. 24.0. First,
224 descriptive statistical data such as frequency distribution of question responses as well as the
225 thematic codes of open-ended questions were generated. Here we considered percentage and
226 dispersions (standard deviation) of gender, age, level of education, occupation, level of income,
227 size of land and number of children. This descriptive data analysis formed the basis to further
228 explore the data (Russell and Booth 2005). For instance, to test smallholders´ perceptions on
229 chosen aspects of ecosystem degradation, we used Likert scales. The four dependent variables
230 tested were soil erosion, soil fertility, land division due to inheritance and invasive species.
231 Participants were asked to rate on a scale of 1 (strongly agree) to a scale of 5 (strongly disagree)
232 how problematic these dependent variables were to them on an individual scale (i.e. on their own
233 farm) vis-à-vis on a national scale (i.e. Kenya). The aim of this comparison between responses
234 for the local and national scale was to analyze for optimism bias. To test for optimism bias, we
235 performed paired-Samples T Test on four dependent variables (soil erosion, soil fertility, land
236 division, and invasive species such as *L. camara*). We also tested for the relationship of these
237 perception variables on four independent variables (level of income, level of education, farm
238 sizes, and number of children) using logistic regression.

239

240 Participants' willingness to adapt practices that enhance the ecosystem was tested using logistic
241 regression. Four dependent variables were tested (land sparing to plant indigenous trees,
242 observing the buffer zone rule, changing farming techniques, and adapting drought resistant
243 crops). These dependent variables were tested on four social–economic independent variables

(level of income, level of education, farm sizes, and number of children). The relationship between land size and willingness was tested using independent-Samples T-test.

Expert interviews were transcribed, and thematic analysis was used to explore the data. Thematic analysis is a method used to identify, analyze, and report themes within data (Braun and Clarke 2006). The themes developed were data-lead, meaning that the process of coding did not try to fit into a pre-existing coding framework. This analysis followed the six thematic data analyses as described by Braun and Clarke (2006): (1) Familiarization with the data and marking potential patterns; (2) generation of possible codes; (3) sorting the different codes into broader themes; (4) reviewing if the themes are representative of the actual data; (5) defining the generated themes with accompanying narratives from the data; and (6) producing the report (this article).

Results

Survey of smallholder farmers

Our results indicate very small difference margins between how the problem of soil erosion is perceived for the national scale (mean ± SD, 4.47±1.27) and the farm level (mean ± SD, 4.31±1.43). This is also replicated for soil fertility challenges (mean ± SD, 4.55±1.1 and mean ± SD, 4.34±1.3, respectively). However, smallholders perceived land division as a more serious problem nationwide (mean ± SD, 4.47±1.23) than on individual farms (2.92±1.91). A similar perception was identified for invasive species (nationwide: 3.00±1.93; local farm level: 2.25±1.80) (Table 1). Using logistic regression, we found no statistically significant relationship between these four dependent variables (perceptions on soil erosion, soil fertility, land division and invasive species at farm and national level) and the four social-economic independent variables (level of income, level of education, land sizes, and number of children).

We used descriptive statistics to study participants' knowledge on environmental laws and regulations. The results showed that 59% (n = 110) of the respondents were not aware of any conservation law or regulation that focus on the protection of riparian ecosystems. Of the 41% (n= 77) who were aware of conservation laws and regulations, 60 participants knew the existence of a buffer zone for rivers, 58 were aware that sand harvesting is prohibited, and 17 were aware of other environmental laws and regulations, such as tree planting, the creation of terraces for agricultural fields, and waste management. Using logistic regression, we tested whether the level of income, level of education, land size and number of children had statistical significance on participants' knowledge on existing environmental laws and regulations. Among the tested

278 independent variables, only the level of education ($F=3.2$, $p<0.001$) significantly influenced
279 knowledge on these laws and regulations.
280
281 Participants were further asked to name the sources from which they had learnt about
282 conservation regulations and laws. Only 25% of these smallholders indicated government
283 environmental officers as their sources of information. The most common sources of information
284 were chief's meetings (65%) and radio (63%). Radio was evaluated as the most useful
285 information source (4.76±0.7), followed by chief's meetings (4.5±1.1). Information from
286 government officials was rated as the second least useful (2.60±1.62) after the internet
287 (2.23±1.50) (Table 2).
288
289 We tested for potential effects from social demographic variables (level of income, level of
290 education, land size, number of children) on the willingness of the smallholders to adapt good
291 environmental conservation practices (adapting drought resistant crops, keeping a buffer zone,
292 changing farming techniques and land sparing to plant indigenous trees) using logistic
293 regression. Among the independent variables tested, only the size of land significantly influences
294 smallholders´ willingness to change behavior. For instance, the size of the land significantly
295 impacts on willingness to adopt drought resistance crops ($F=14.3$, $p<0.001$), willingness to keep
296 a buffer zone ($F=91.2$, $p<0.001$) and willingness to change farming technique ($F=28.3$, $p<0.008$).
297 The number of children, the level of income, and the level of education showed no significant
298 effect on farmers´ behavior.
299

Descriptive statistics showed that 90% of the participants (n=171) derive resources from the river every day. For instance, through water collection, harvesting firewood from riparian forests for brick burning and charcoal production, sand harvesting, grazing animals along river banks and planting vegetables inside the river bed in the dry season to maximize on the availability of moisture. Furthermore, all interviewed smallholders (n=191) produce food crops on land plots along the river either through irrigation or rain-fed agriculture (Table 1). More than 80% (n=156) of the participants produce goods for private consumption. These finding correlates with the socio-economic structure, showing that 75% (n=144) of the respondents are smallholder farmers and half of the interviewed smallholders earn less than 50$ per month (Table 1). To analyze potential reasons of settle and farm along the river we compared means of responses given by participants we used One-Sample T-test. The most occurring reasons were; (1) family tradition (4.8±0.8), (2) high soil quality for agriculture (4.40±1.1), (3) good infrastructure as road system (4.40±1.2), (4) access to ground water (4.4±1.2) and (v) soil for brick production (4.12±1.5).

The four variables for willingness (willingness to spare land for conservation, keep a buffer zone, change farming technique and use drought resistant crops) were computed into one variable used as an indicator of general willingness. The general willingness to conserve the ecosystem was high (4.14±1.0). At the same time, only 13% (n=24) of all respondents affirmed that they were involved in conservation practices along the river (for example tree planting), while 38% (n=72) professed to not being involved. A common reason given for not engaging in good environmental conservation practices along the river was that the responsibility lied with smallholders whose farms were directly adjacent to the river.

Expert interviews

We derived five main cross cutting themes in all the expert interviews that were attributed to ecosystem conservation challenges along the Nzeeu River: (1) Lack of financial and personnel resources; for instance, the National Environmental Management Authority (NEMA) office in Kitui is mandated with enforcing riparian environmental laws and regulations but it was reported to have only two officers and relied heavily on unpaid interns to fill in the gap arising from understaffing. The experts also claimed that they lack facilitation funds, such as for vehicles and fuel to conduct field visits. (2) Conflicting interpretations of traditional and modern government laws; Experts argued that smallholders often do not understand why they should follow the 30-meter buffer zone on either side of the river bank while traditionally that land is considered to be under private ownership and management. (3) Overlap and confusion of responsibilities among organizations especially under the newly devolved government system in Kenya. For instance, one officer reported that "the newly created County government has not yet invested in conservation and has no capacity presently to do so. Investing in conservation is a long-term benefit. The County government is under pressure to show economic results and is therefore concentrating on short-term goals which may have negative effects for the environment". (4) Ignorance and lack of knowledge among local smallholders; the experts alleged that the many smallholders are illiterate and possess limited knowledge and skills to implement the good environmental conservation practices that they are taught. (5) Inherent biophysical challenges such as semi-arid conditions, erratic rainfalls and climate change.

Discussion

Our data indicate that people rate environmental problems to be more severe at the national scale than at the individual farm scale. This trend goes congruent with previous studies (Gifford et al. 2009; Schultz et al. 2014). The spatial bias is consistent throughout different social economic characteristics such as the level of education and income as well as size of family and land. Elsewhere, studies have shown that spatial bias is a cognitive egocentric process that assumes the immediate and local is better than elsewhere (Weinstein 1980; Gifford et al. 2009). Consequently, if smallholders optimistically perceive the magnitude of environmental problems for themselves, they are less likely to take up good environmental conservation practices. It is therefore important for conservationists and other environmental practitioners to take into account spatial bias because the arising perceptions are closely connected to the legitimacy and acceptance of conservation as well as the reception of environmental communication and awareness (Bennett et al. 2017). Kitui, compared with many other counties in Kenya, has a long history of good soil conservation practices (Zaal and Oostendorp 2002). For example, smallholders have invested in terracing as a measure of controlling soil erosion and increasing agricultural yields for decades (Tiffen et al. 1994). Land division is viewed positively for individual farms perhaps because the practice has a long-standing tradition (Lindblom 1920) and only in recent years has land per capita decreased significantly (Tiffen et al. 1994; Government of Kenya 2014). Furthermore, smallholders displayed very limited knowledge of invasive species which points to abstractness of the problem at the farm-level.

Our results indicate that over half of the participants are not aware of environmental rules and regulations on rivers and riparian zones. Agricultural intensification along the riparian buffer

zone has significantly contributed to the deterioration of riparian forest along Nzeeu River, as well as along other rivers. Different environmental government agencies in Kenya, under the umbrella of National Environment Authority Management (NEMA), are tasked with the mandate of disseminating environmental information and knowledge to smallholder farmers. However, our data points to a big communication gap between environmental officials and local smallholders. This officials-smallholder communication gap was identified by expert interviews. Here we identified a lack of financial and personal resources to act in the field, a confusion of roles and responsibilities among different governmental organizations, and we identified an ignorance of local smallholders towards government officials. We assessed the different communication channels of environmental communication available to smallholders and their rated usefulness, as one way of understanding this disparity. The most common source of environmental communication in our study area is the local chief followed by the radio. However, the radio is classified as the most useful channel of environmental communication, followed by the local area chief. Word of mouth is rated third in terms of usage and usefulness. Government environmental officials are the least rated both in usage and usefulness. These ratings on the usefulness of information through different channels offer insights into their perceived credibility (Aerts and Cormier 2009). Information from government environmental officials who have the official mandate on educating the public on good environmental conservation practices are often negatively perceived by locals.

Previous studies acknowledged a close link between environmental communication channels and spatial bias (Hatfield and Job 2001; Schultz et al. 2014). Mass media has been shown to emphasize environmental sensitization more on global environmental topics in comparison to the

local environmental challenges. Our data show that one of the most common and trusted source of information for this locality is the mass media through radios. While we did not ascertain the specific environmental reports published by local radio stations, previous scientific literature offers the possibility that by giving global environmental concerns more coverage, mass media misguides people not to accept personal vulnerability, and in consequence impedes pro-environmental behavior (Schultz et al. 2014). We argue that it would be beneficial for local conservationists to target radio, radio presenters and chiefs with local-based environmental information and knowledge as they may be more effective in influencing the legitimacy and acceptance of good environmental conservation practices as opposed to government officials directly communicating with smallholders. The findings on communication channels also indicate that smallholder farmers are constantly and actively interacting with different sources of information. Therefore, further research would be beneficial to ascertain how the complex dynamics of the different communication channels affect the credibility and uptake of information (for example type of radio station, likeability, expertise, age, language and backgrounds of communicator) and recipients' factors (for example personality traits, literacy and skills). These factors might strongly influence the uptake of information, awareness, willingness and behavior as well as the dynamics as to why government channels are rated lowly.

Besides the link between spatial bias and communication channels, we also find that the land size disposable to smallholders significantly influences their willingness to conduct sustainable agriculture and to adopt good environmental practices as compared to other social economic indicators such as level of income and education. Our data show that all smallholders are highly

413 reliant on different provisioning ecosystem services from the river's riparian zone such as fuel
414 wood and regulating ecosystem services that are important for clean water and fertile soils. The
415 most common reasons for settling along the river include family tradition, fertile soils, ground
416 water availability and good soils for brick production, which is a common income generation
417 activity in this region. Consistent with other findings, immediate livelihood needs often take
418 precedence over good intentions (Kollmuss and Agyeman 2002). Our study area is located in a
419 semi-arid region, characterized by erratic rainfall patterns (Jaetzold et al. 2006). The majority of
420 the human population depends on low income (53% <50$/month). This situation aggravates high
421 food insecurity and necessitates locally tailored sustainable agriculture.
422
423 Despite our significant trends and interesting coherences found here, we would like to stress the
424 following limitations of this study: First, the use of convenience sampling techniques may inhibit
425 the generalization of our findings. And second, some of the respondents may have overstated or
426 understated their willingness and involved in good environmental conservation practices. Thus,
427 further research is needed to establish the relationship between spatial bias, willingness to adopt
428 good practices and actual pro-environmental behavior.
429
430 Conclusions
431 Despite a high level of general willingness to conserve the ecosystem, our data underline that
432 local smallholders hardly actively engage in conservation action. We found that while
433 smallholders often express the good-will to take up pro-environmental action, there are important
434 often overlooked challenges that inhibit the implementations of these good intentions. We have
435 elaborated three potential factors driving this discrepancy. First, we have positively affirmed the

436 tendency to overestimate the severity of environmental concerns at country (Kenya) level if
437 compared to the farm level. This is a psychological phenomenon popularly known as spatial bias.
438 We argue that radio, rated as the most credible channel of environmental information could
439 influence spatial bias because of tendencies to overwhelmingly cover environmental problems
440 that are not local (Hatfield and Job 2001; Milford et al. 2011; Schultz et al. 2014). Secondly,
441 sustainable land management in our study area is not primarily a matter of education but depends
442 on the size of the land property. Smallholder farmers holding <1 ha of land property have less
443 fallow land stages and are less willing to spare some of their land for nature conservation, as
444 opposed to those holding land plots above this size. Third, there is an urgent need to close the
445 communication gap between environmental officers and the local smallholders. One way to do
446 this would be the preparation of practical advices and its local-based dissemination by local
447 chiefs and the radio. However, closing this communication gap should take place not only as a
448 one-way dissemination (from environmental officers to the local people); the communication
449 should be more reciprocal and the management processes more participatory, with opportunities
450 and settings for presenting and considering local people's perceptions and realities.
451

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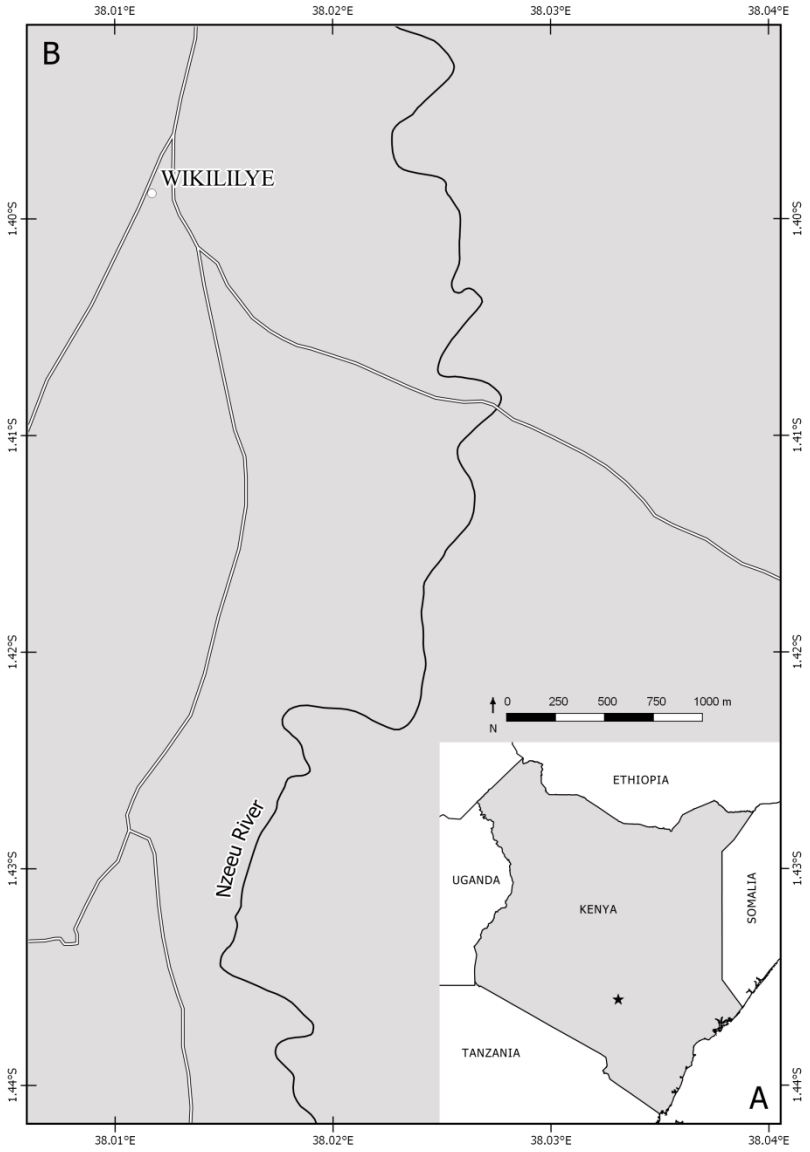
549

550 Figure 1: Location of the study region in Kenya (indicated by a star in map A), and the study

551 area covering a section of Nzeeu River close to Wikililye, south of Kitui city (map B).



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553

554 Table 1: Spatial optimism bias in perceptions on four factors that contribute to ecosystem
555 degradation; Given are variables, mean values with standard deviations (in parenthesis), and
556 respective P-values.

	Variable	**Mean (Standard deviation)**	P-Value
Pair 1	Soil erosion is a serious problem in Kenya;	4.49 (±1.27)	P<0.01
	Soil erosion is a serious problem on my farm	4.31 (±1.43)	
Pair 2	Soil fertility/productivity is a serious problem in Kenya;	4.55 (±1.1)	P<0.01
	Soil fertility/productivity is a serious problem on my farm	4.34 (±1.3)	
Pair 3	Too small fields due to land division is a serious problem in Kenya;	4.47 (±1.23)	P<0.001
	Too small fields due to land division is a serious problem for me	2.29 (±1.91)	
Pair 4	Invasive plant and tree species are a serious problem in Kenya;	3.00 (±1.93)	P<0.001
	Invasive plant and tree species are a serious problem on my farm	2.25 (±1.79)	

557

558 Table 2: Sources of environmental communication and their rated usefulness based on the
559 opinions of participants.

Information source	Usage (%)	Usefulness (%)	Mean usefulness (Standard deviation)
Chief's meetings	65%	89%	4.5 (±1.1)
Radio	63%	96%	4.76 (±0.7)
Word of mouth	42%	82%	4.2 (±1.3)
Government officials	25%	37%	2.6 (±1.6)
Internet and social media	5%	25%	2.23 (±1.5)

560

561 Appendix 2: Socio-economic characteristics of participants, including the parameters gender,

562 age, level of education, occupation, number of children, and land size owned.

Variable	Classifications	N	%
Gender	Male	67	35
	Female	124	65
Age	<18	1	0.5
	18-50	116	61.1
	>50	73	38.4
Education	None	9	4.7
	Primary School	118	62.2
	Secondary School	57	30
	Higher education	6	3.2
Occupation	Fulltime farmer	117	61.3
	Farmer and other job	27	14.1
	Fulltime other job	47	24.6
Income	<5000 (50 $)	101	53.4
	<1000 (100$)	55	29.1
	<20000 (200$)	19	10
	>20000 (200$)	14	7.4
Number of children	0-2	63	33.0
	3-4	78	40.8
	>5	50	26.2
Land size	<1 acre	40	21.2
	>1 acre	149	78.8

563

564 Appendix 3: Activities of smallholder farmers along Nzeeu River, grouped into four thematic
565 fields: (i) Involvement in conservation activities, (ii) Working days per week; (iii) Land use
566 along the river, and (iv) reasons for production. Given are total values and respective
567 percentages.

Variable	Classification	N	%
Involvement in conservation activities	Always	24	13
	Sometimes	94	49
	Not at all	72	38
Working days per week	Everyday	171	89.5
	<6 days	20	10.5
Land use along the river	Crop production	191	100
	Brick production	105	55
	Animal grazing	91	47.9
	Sand harvesting	78	40.8
	Charcoal production	25	13.2
Reasons for production	Private use	156	81.7
	Private use and selling	32	16.8
	Selling	3	1.6

568