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Analyzing Local People's Opinions on Incidences, Magnitude and Mitigation Measures of Human-Elephant Interactions Adjacent to the Serengeti National Park

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Abstract

We analysed local people's opinions to understand their knowledge on the magnitude, incidence, adverse impacts and techniques for minimizing the adverse impacts of human-interactions in the Bunda district. The survey involved 130 local people from 12 villages for survey and interviews. The survey used a purposive sampling technique to locate local people with relevant knowledge on human-elephant interactions occurrences. Researchers are grateful to incorporate local people's opinions into this study because their consolidated knowledge and skills, have for centuries, contributed to undisputed scientific knowledge in environmental conservation. In this study, researchers have learnt that crop damage was the main adverse impacts of human-elephant interactions while house damage was the least recorded incident. Despite crop damage being the most common impact of human-elephant interactions but hidden impacts are the largest adverse impacts. The majority of locals use traditional techniques to prevent and control problem elephants. However, the habituation of elephants to the techniques hinders their effectiveness. A minority of villagers use wounding traps, report to conservation agencies to reduce the damage from elephants. Local people claimed that elephants are docile as it was possible to approach them as close as 50 meters without any harm. Despite their docility, locals also claim that stopping elephants from crop damage may result into human deaths. Villagers acknowledge sighting more than 11 elephants every day in the farming areas. The study recommends the adoption and application of spatial and simulation technologies to identify where, why, how negative impacts of human-elephant interactions. This will suggest the appropriate size of landscape interface of human-elephant interactions in the district.

Keywords: Bunda District; Conservation corridor; Crop damage; Serengeti National Park; Grumeti Game Reserve; Hidden Impacts; Human death; Human-elephant Interactions; Local opinions; Serengeti National Park,

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1.0 Introduction

Human-elephant interaction (HEI) is a typology of human-wildlife interactions (HWI), which also include human-carnivore and human-omnivore interactions. The adverse impacts of HEI include human, wildlife and livestock deaths, crop damage and indirect impacts. Of all, people rate HEI as the worst case of HWI. Humans have been interacting with African elephants since the beginning of traditional agriculture (Osborn, 2004). Local people describe elephants as a major pest whose existence threatens not only their lives but also their properties. Inadequate government support and they usually intangible benefits people receive from elephants are part of what is intensifying their undesirable opinions against elephant conservation (Bandara & Tisdell, 2005; Barua et al., 2013). Added to this, is the lifestyle of an elephant that brings people into the conflict with human including the ability to forage on different types of plants, their requirement to drink about 300 liters of water in a day and their 18 hours per day of

activity adds to this negative perception (Advani, 2014). The ability of elephants to damage both field and stored crops make farmers feel insecure about their livelihoods (Lamarque et al., 2009). Humans and livestock fatalities, and competition for water, food, and space with livestock discourage local people from coexisting with elephants (Mduma et al., 2010; Nelson et al., 2003). The negative impacts of HEI usually occur in communities residing in proximity to elephant reserves (Leel et al., 2009; Muruthi, 2005). Crop damage is made more severe and localized because the majority of victims are subsistence farmers whose main socio-economic activity is agriculture (Lamarque et al., 2009).

Crop damage is the most frequently recorded impact of HEI (Desai & Riddle, 2015). The incidents are most severe on farms bordering unfenced protected areas, such as national parks and game reserves (Desai & Riddle, 2015; Lamarque et al., 2009). African elephants prefer crops because of their high nutrient value and low chemical and physical defense (Osborn, 2004). In some areas, male elephants are habitual crop raiders who take risks to obtain nutrients to maximise their reproductive success (Hoare, 1999). Elephants prefer plants that offer a high nutrient level and are easy to access (Osborn, 2004). Because the nutrition status of elephants determines birth rates and sex of their offspring, male offspring are more "expensive" than female offspring regarding nutrient investment (Hoare, 1999). Elephants choose grasses due to their high nutrient level, ease of harvest, low fibre content and low toxicity while avoiding bark and wood twigs because of lengthened handling time, lignification and thorns (Osborn, 2004). A prolonged exposure to adverse impacts makes people hostile towards elephants. In retaliation to these impacts, people respond by killing elephants, in turn becoming a threat to the size and structure of the elephant population in Africa (Graham et al., 2010). In the absence of timely support from conservation authorities, local people usually deploy cheap, traditional and farm-based mitigation measures (Sitati et al., 2005). People in Asia use crop guarding, noise, fire, alarms, repellents, fences, ditches, cactus fences and playback calls to repel problem Indian elephants (Fernando et al. 2008). Lamarque et al. (2009) described that in Africa, farmers use vigilance, fencing (including biological fences, such as cacti, Opuntia and euphorbia), trenches, chili and tobacco dust, and fire. If these methods fail, local people will use lethal methods to control elephants (Treves, 2007) (Hill, 2004).

Bunda District has a high incidence of HEI, with more than 500 events occurring every year (Mduma et al., 2010). Overall, HEI is poorly understood in the district but knowing the locations, frequencies, and magnitudes of impacts are critical for effective mitigation measures. To better understand the local people's perceptions and understandings of elephant movements and behaviours, a survey with interviews was carried out. The results from this survey informed elephant conservation stakeholders on the severity of the conflict in the district. The analysis aimed at gauging local people's knowledge and experience on the locations, magnitudes, incidences, adverse impacts, and techniques for minimizing the negative impacts of HEI in the Bunda District.

2.0 Material and methods

2.1 Study area

Bunda is the home of more than 25 ethnic groups. The most dominant and common tribes in the area are Kurya, Ikoma, Jita, Sukuma, Ikizu, Natta, Isenye, Zanaki, Zizaki, Ngoreme and Taturu. The main economic activity within the region is subsistence agriculture, which accounts for about 80% of the people's annual income (Kideghesho & Mtoni, 2008). Farmers normally grow maize, millet, cassava, and sorghum as food crops and cotton as cash crops. Furthermore, people keep sheep, goats, and cattle (Walpole et al., 2004). The majority of inhabitants are peasants, fisherman, livestock keepers, and small-scale traders. Bunda District had the highest human population density in Tanzania of about 200 people per km2, and annual population growth of about 3.0% (URT, 2013). The district is in the western part of the Serengeti ecosystem lying between latitude 1°30" and 2°45" S, and longitude 33°39" and 34°05" E. It is about 3,088 km2. The district has contributed a large part of its land surface to wildlife conservation. Lake Victoria occupies about 200 km2 of the area, and the Serengeti National Park occupies 480 km2. In that case, the Serengeti ecosystem makes up about 40% of the district's surface area (see figure 2.1.1).

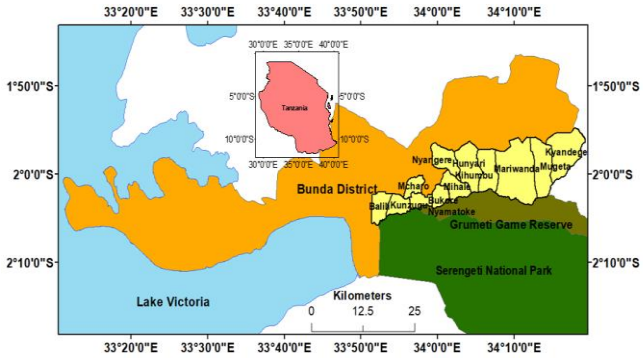

Figure 2.1.1: The study area villages bordering Lake Victoria, the Serengeti National Park and Grumeti Game Reserve.

There are wet and dry weather seasons in the area, with rainfall determining the type, length, and timing of the season. The wet season extends from November to May and the dry season from May to October. There is a rainfall gradient, which is relatively low in all areas closer to the boundary of Serengeti National Park and higher rainfall in areas closer to the shore of Lake Victoria. The average rainfall of western Serengeti ranges between 500 and 1200 mm (Kideghesho & Mtoni, 2008)

2.2 Data collection and analysis

The data was collected from 12 villages in the Bunda District, Tanzania (Fig 1). A survey deployed adaptive research techniques to cope with cultural diversity and the environment of the

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communities. Adaptive research techniques entailed the ability of a researcher to use different research techniques to match with respondents' culture, geographical location and willingness to participate in the study. Research methods included village meetings, interviews, and structured survey questionnaires. This incorporation of different research methods helped in establishing relationships with the communities based on trust, which facilitated a platform for interactive discussion and sharing of HEI experiences. Local research assistants with the ability to read, write, and speak Swahili fluently, as well as to speak more than one local language, and who were from the local communities, aided data collection. Research assistants were responsible for the translation of local languages, security and guiding in the area of study.

A non-probability or purposive (judgmental or expert sampling) sampling technique was used for the identification and selection of research participants (Singh, 2014). Application of purposive sampling occurred during village meetings, where adults with undisputed experience of HEI volunteered to participate in the study. In addition, researchers used door-to-door sampling techniques to identify the heads of households with adequate knowledge and expertise on HEI who did not attend the meetings. Household representatives from 12 villages bordering the Serengeti National Park (SENAPA) and Grumeti Game Reserve (GGR) were assessed for their adequacy of HEI knowledge and closeness of the household to SENAPA and GGR. Based on Yamane's formula for the number of participants needed, 130 people were selected for survey questionnaires and 60 participants for informal interviews (Singh, 2014).

The questionnaires included closed-ended and open-ended questions. The nature of the questions simplified data coding, analysis, and interpretations. Since it was a qualitative study, the open-ended questions provided an unlimited opportunity for participants to answer questions as with as much depth as they could. The research assistants helped in the dissemination of the structured questionnaires to 130 respondents. Before distributing the questionnaires, the researcher fully briefed participants about nature, aim and time required to respond to the survey during village meetings and when handing a questionnaire to the respondent. Furthermore, participants were asked to complete a consent form and assured that they could withdraw from the study at any time within a six-month period following the interview. The survey allocated 30 minutes for each participant to understand the questionnaire and 15 minutes to fill it with research assistants. In addition, the researcher allocated to respondents a maximum of seven days to respond to the survey at his/her convenient time. The survey sought the participation from both adult females and males with adequate experience. The collected data was analysed in IBM SPSS.

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3.0 Results

3.1 Demographic characteristics of the sample

A survey involved 130 questionnaires from twelve villages. Nyangere village produced the largest number of those surveyed while Nyamatoke, Mihale, Kyandege, and Bukore villages produced the lowest number of the respondents. The majority of responses were from married males who were farmers with only primary education.

3.2 Local peoples' opinions on HEI occurrences

The majority (70%) of respondents mentioned birth as the main reason for the increased human population in the district (see Table. According to their customary rights, respondents (96.2%) described their land as having a designated purposely for settlement or agriculture. The majority of respondents (46.9%) sighted elephants every day on village land. Likewise, (50%) of respondents sighted elephants in both dry and rainy seasons. In village areas, respondents (78.5%) sighted elephants mostly in the farming areas. Moreover, respondents (64.6%) anticipated sighting more elephants near households in the future. In many circumstances, the majority of respondents (83.4%) sighted a group or family of elephants with more than 11 individuals. According to the respondents (54.6%), the minimum distance that the elephant can detect and attack humans was 50 meters (see Table 3.2.1).

In addition, a large group (42.3%) stated that when an elephant finds a farmer guarding crops, that the elephant could kill the human. When a farmer finds an elephant damaging crops, the majority (64.6%) stated that the farmer would run away from elephants. According to respondents (82%), human death occurs when people attempt to scare problem elephants away from farms. Most (33.8%) of respondents had never seen people killing elephants, or were unwilling to report so due to fear of government prosecution. The respondents (87.7%) stated that HEI occurrences are increasing. Crop damage was the most common adverse impact of HEI. The largest group of respondents (40%) said that elephants do not damage their houses. Of all respondents (74.6%) agreed on the presence of hidden impacts in the district. The majority (69.2%) mentioned traditional methods, such as farm guarding, are the frequently used mitigation measure for HEI. However, the respondents failed to provide annual statistical data on elephant death, crop damage, human death and hidden impacts. In that situation, this study used secondary data, as outlined below.

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Table 3.2.1: Responses to HEI variables in the percentage.

Variable	Responses (%)				
How often are elephants sighted in the village	**Everyday**	**once a week**	**Once a month**	**once in six months**	**No elephant**
	46.9	9.2	13.8	22.3	2.3
The number of elephants per incident	**One elephant**	**2-4 elephants**	**5-10 elephants**	**More than 11 elephants**	**Other**
	2.3	3.1	4.6	83.8	6.2
The area where elephants are frequently sighted in the village	**Farms**	**Settlements**	**Water tap**	**Rivers**	**Other**
	78.5	16.2	0.0	3.1	2.3
A possible area that an elephant may be sighted in the future	**Farms**	**Settlements**	**Water tap**	**Rivers**	**Other**
	26.9	64.6	2.3	2.3	0
A time of the year people sight elephants in the village	**Rain**	**Dry**	**Rain and Dry**	**Other**	-
	31.5	14.6	50.0	3.8	-
The minimum distance elephant can sense and attack human	**50 meters**	**51 to 100 meters**	**151 to 200 meters**	**Other**	-
	54.6	20.8	3.1	7.7	-
The way elephants react after seeing a human guarding a farm	**Run away**	**Cause injury**	**Kill human**	**Keep eating crops**	**Other**
	14.6	8.5	32.3	42.3	2.3
Reaction of local people after sighting elephants raiding crops	**Run away**	**Cause injury**	**Kill elephant**	**Scare it away**	**Faint**
	64.6	12.3	7.7	14.6	0.8
Impacts of elephants on houses	**Complete demolition**	**Slight demolition**	**Other**	-	-
	25.4	34.6	40.0	-	-
The main reason for an elephant to kill a human	**Guarding crops**	**Water taps**	**Injuring elephants**	**Killing elephants**	**Other**
	81.5	0.8	4.6	3.1	9.2
The main reason for a human to kill an elephant	**Crop damage**	**Human death**	**Infrastructure damage**	**Others**	**-**
	28.5	30.8	6.9	33.8	-
The trend of HEI occurrences in the district	**Increase**	**Decrease**	**Neither**	**Other**	**Increase**
	87.7	3.8	1.5	4.6	87.7
Are there hidden impacts in the district	**No**	**Yes**	-	-	-
	24.6	74.6	-	-	-

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4.0 Discussion

Local people suggest that birth rate is the leading cause of rapid human population growth in the Bunda District. This rapid human population growth intensifies the magnitude of HEI because of constant and ongoing competition for necessary resources between humans and elephants in the district. Population growth stimulates a higher demand for food and human settlements. As a way of meeting the increased resource demand, humans encroach into natural elephant ranges for settlement, food, industrial raw materials and construction of areas for the development infrastructure. The human occupation of unprotected elephant habitats usually interferes with foraging behaviours and movement patterns of the animals. The human population density in the district amounts to 200 people per square kilometre (URT, 2013a). Such a high density triggers the demand for basic resources to satisfy the growing human population.

While residents had mixed views about the designation of their areas, the majority of locals viewed their land as being agricultural and settlement land inherited from their ancestors. A small number of locals identified their areas as wildlife corridors. From a legal perspective, URT (1999) recognises conservation corridors as village land. The URT (2009) recognises conservation corridors as an undeclared buffer zone for Serengeti National Park and Grumeti Game Reserve. The presence of wildlife migratory routes and dispersal areas, the proximity of the villages to protected areas and the continuous HEI occurrences may lead to the transfer of villages to other areas

Residents asserted that incidents of elephant damage are increasing every year.
The severity of elephant damage is high as most elephant events involve more than 11 individual animals at a particular time and place. In the case of a group size of elephants, local statements correspond to the most recent elephant estimates in the ecosystem, with groups of elephants having between 2 to 26 individuals in the district (TAWIRI & KWS, 2014). Some respondents mentioned having seen 200 to 2000 elephants at a time though it is difficult for anyone to count 2000 (or even 200) elephants from one point at ground level, and this must be viewed with some skepticism. Residents do have an incentive to exaggerate the group size of elephants as it allows the locals to gain the attention of the government and other stakeholders.

The majority of local people claimed to see elephants every day, in both dry and rainy seasons, especially around crop farms. The visitations on the farms coincided with crop damage. A small number of respondents encountered elephants near houses and rivers. A stable elephant population in the Serengeti ecosystem and active migratory corridors in the district may have influenced the daily sightings of elephant activities in the communities. It is important to acknowledge that residents sometimes tend to overstate the extent of HEI incidents when appealing for compensation (Bandara & Tisdell, 2002). In the case of seasonality, elephant activities coincide with local agricultural calendars and climates, causing the pachyderms to be active in both dry and rainy seasons. While many residents claimed to see elephants throughout a particular crop calendar, a minority claimed that elephant activity is only observed when crops are ready to harvest. A few respondents were not sure as they asserted that elephants are unpredictable animals. Resource scarcity due to unpredictable weather makes elephants highly mobile. In the buffer zones, where humans and elephants share undifferentiated landscapes, elephant damage may occur throughout the year (Lenin & Sukumar, 2011).

Local people experienced direct and indirect impacts of elephants. As elsewhere in the world, residents mentioned crop damage as the most noticeable adverse effect of HEI in the district. Other adverse effects included hidden impacts, infrastructural damage, and livestock and elephant deaths. In the case of crop damage, most of the agricultural farms are near conservation areas, which are unguarded and unfenced. Therefore, elephants damage farms quickly and frequently. The pachyderms unselectively damage different types of food and cash crops, fields and stored crops. As generalist feeders, elephants consume different types of crops and various parts of the plants, which makes them highly destructive and unfavourable to local people. In the Bunda District, local people stated that they saw elephants frequently eating several food crops, sorghum, rice, maize, watermelons and pumpkins, and cash crops, sisal, and cotton. In the matter of house damage, local people asserted that elephants do not perpetrate any adverse impacts on houses except when animals occasionally break into the isolated grain stores when foraging seeds in dry seasons.

Residents asserted that human and elephant deaths are rare in the district. Local people had never killed problem elephants, but elephants have killed four people in Kunzugu, Mcharo, Balili and Kyandege villages since 2006. Local people admitted to lacking the motivation for killing problem elephants as the species is highly protected, hard to kill and is the symbol of the ecotourism industry in the country. However, some residents suggested retaliation killing of elephants after human deaths and crop raiding. This suggests that the majority of residents are cognizant of the socio-economic contribution of elephants. Because of the legal prohibition of elephant killing in Tanzania, elephant deaths may go unnoticed because of fear of prosecution.

Locals reported adverse impacts from HEI. For instance, residents claimed that elephants sometimes restricted their movements to certain areas and certain times. Consequently, hidden impacts severely affected their participation in socio-economic and social activities. Routine guarding of crops threatened the marriages of some local people in Bukore village. One respondent claimed that a wife cheated on her husband while he was guarding crops against elephants. Hidden impacts are the second-largest adverse effects after crop damage, and these are technically difficult to describe and quantify. In a similar manner, locals perpetuate hidden impacts on elephants through the conversion of elephant habitat into agricultural farms,

development of infrastructure that affect the habitual movements, feeding patterns and mating behaviours of elephants (Advani, 2014; Ladan, 2014; Lamarque et al., 2009; UNDP, 2014).

Locals deploy traditional methods to control problem elephants. Despite the risk, the techniques are convenient and affordable. Lenin and Sukumar (2011) assert that traditional methods are short-term tactical solutions that usually provide limited success. In the case of effectiveness, local people stated that, in many events, when elephants find residents guarding crops, they often damage crops in their presence without either hurting or killing a villager. A few locals stressed that after making noises and blowing whistles, elephants might move from the crop farm. Ineffectiveness of traditional control techniques does not prevent elephants from becoming habitual crop raiders because they get used to the techniques with time (Desai & Riddle, 2015; Nelson et al., 2003). A few locals used snares to control pest elephants before they approached their farms. The snares injure but seldom kill, and keep the elephants off crop fields. However, the effectiveness of the wire traps remains uncertain, as many residents were hesitant to provide detailed information fearing prosecution. Local people sometimes report HEI to Serengeti National Park, Grumeti Game Reserve and District Game Office for immediate response. Timely response from the conservation agencies becomes relatively difficult due to geographical challenges and logistical problems. However, the Ministry of Natural Resources and Tourism of Tanzania has already completed the construction of the base camp for problem animal control in the Hunyari village.

Local people have innovated and used local knowledge and skills for centuries to address living with elephants. Therefore, for proper prescription of specific mitigation measures to environmental problems, it is important to adopt, learn and if possible, improve the existing local knowledge and skills. Locals acquired knowledge and expertise about their environment in the absence of formal education institutions and they understand and conserve natural resources in an informal way. Part of their consolidated knowledge and skills have led to undisputed scientific innovations in the discipline of conservation such as using stinging bees to control problem elephants (Ndlovu et al., 2015). In this study, locals may approach elephants as close as 50 meters without any harm to humans. From a management perspective, local people have demonstrated that neither elephant killing nor traditional techniques can significantly reduce elephant damage. However, science-based methods should replace conventional methods to halt elephant damage in the district.

Responses from the survey and the unstructured interview remain the most valuable and the cornerstone of addressing the mitigation measures for human-elephant interactions. The responses provide a grass-root information for stakeholders to use in decision-making as well as for developing appropriate measures. They are essential for comparative studies, as geography, climate and the culture of people tend to influence the magnitude and frequency of HEI. Finally, yet importantly, it is essential to acknowledge that the quality of survey data is representative, as most of the responses provided similar information with what is already known about HEI. In addition, the researchers conducted a survey and informal interview in the language best understood by the respondents. The respondents were well informed on the aim and objective of the study before participating in the survey. This avoided exaggerations of the responses as they were also informed that the study was not for compensation of property and life loss resulted from HEI. Moreover, the survey was confidential and voluntary, which provided them with an opportunity for free expression. Furthermore, the researcher also participated in the dissemination and collection of the survey. This made it possible to relate what is in the survey and the reality of the study area.

Getting information directly from villagers is useful to get a balanced understanding of the HEI occurrences in the district. Local people who directly interact with elephants have a broader outlook on HEI occurrences than researchers who mostly read about it from literature. Local people's opinions provide technical and scientific knowledge about HEI. In addition, villagers provide contextual knowledge about the whereabouts and history of HEI. However, low levels of participation, perception and attitudes, communication barriers and resistant leaders are some of the obstacles that may hinder local people participated in the research. Local people may offer inadequate participation if they were involved in a similar project in the past, which was unsuccessful. It is hard to for local people to involve in the project with unclear objectives. The political and ethnic ideologies may influence the leaders to discourage villagers to participate in the research.

5.0 Conclusion

Embracing local knowledge for developing effective mitigation measures of human-elephant interactions (HEI) is essential. Local people, as the main interacting party, may provide essential facts for a clear understanding of HEI occurrences. In the Bunda District, crop damage is the most common impact of HEI, but hidden impacts may also play a large role. The frequency and magnitude of the HEI occurrences are increasing alongside the increasing human population. Traditional mitigation measures become ineffective and result in elephants becoming habitual crop raiders. Such methods are not only dangerous to humans and elephants but also lack scientific testing. Introduction of effective mitigation measures is important for saving lives and property. However, scientific tests of the methodologies are required to design, test and recommend the best mitigation measures of HEI.

In that case, application of spatial and simulation technologies can provide clear answers about where, why, how and when negative impacts occur is equally important. The answers will provide the framework for decision-making. The study recommends an adoption of simulation techniques for studying the HEI to understand its dynamics. HEI is the complex problem that requires conceptual

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reasoning; it is dynamic in both time and space. In that case, it hard to predict about what, where, how and when the HEI patterns may occur. A computation modelling and simulation technique may use people opinions from the survey as interactions rules to model and simulate the interactions between human and elephants. The computational model reflects the mechanism behind human-elephant interactions, and more importantly, provides a flexible environmental to design and test different modelling scenarios of HEI.

There are studies that surveyed different types of human-wildlife interactions. The modelers may use such surveys to understand not only the adverse impacts from such interactions but also habitat utilization of problem animals in human landscape, impacts of anthropogenic activities on endangered species, impacts of human population on the wildlife habitats and the status of the conservation corridors in the human landscape. However, it is safe to mention that computational modelling and simulation requires some computer programming skills, which can be very demanding to some wildlife researchers. In addition, to make the simulation more realistic, it requires the proper knowledge and skills on geographic information systems and remote sensing. However, it is possible to learn the easiest integrated development environment (IDE) such as Netlogo in a short time.

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Statement of competing interests

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Authors' contribution

We solemnly declare that this research has neither been submitted for consideration nor published elsewhere. We confirm that all authors have contributed substantially to this work, and all responsible organizations which technically and logistically contributed to this study have authorized its publication.

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