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POPULATION DYNAMICS AND LAND-USE CHANGES AROUND PROTECTED AREAS. A CASE OF BWINDI IMPENETRABLE NATIONAL PARK.

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ABSTRACT: Increasing rates of human population growth and anthropogenic impacts on a global scale have left few populations of plants and animals undisturbed. Land-use activities impact heavily on the ecosystem goods and services, ecosystems health as well as their structures around protected areas. Land-use change and related habitat loss and fragmentation have long been recognized as important drivers of past and present ecosystem change. Most protected areas in developing countries are surrounded by high population densities high poverty and dependence on natural resources which is a major threat for the conservation of the protected areas. It is not clear whether land-use leads to perturbations of ecosystems around Bwindi Impenetrable National Park. The problem seems to be attributed and compounded by intensive agriculture, deforestation, forest fires, soil erosion and degradation of the ecosystems. The area of study was Bwindi Impenetrable National Park in south western part of Uganda. The research design was descriptive and included both qualitative which majorly explained the phenomena and quantitative data that comprised of statistical or measurable aspects like land area, land use activities, carbon stock quantities and population. These were obtained by use of primary and secondary data sources and purposive random sampling was applied. The data collection tools included questionnaires, interview guides and oral interviews. Analysis of data was done by use of regression and correlation coefficients, frequencies, percentages and by help of SPSS. The results indicated that high population densities coupled with illiteracy, intensive agriculture, and poverty have a significant impact on land use practices around the protected area. Deforestation and settlements were also found to play a crucial role in influencing land-use activities. It was therefore recommended that the local community should be empowered, sensitized and encouraged to get involved in conservation.

Key words*:* Ecosystem services, ecosystems, eco-tourism, anthropogenic impacts, protected areas, land-use and sustainability.

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INTRODUCTION

On the global scale, as humans tries to meet their daily needs, they subject forests, woodlands and grasslands to the highest rates of change (Pomeroy & Tushabe, 2004; MEA, 2005) resulting in land use/cover changes (Mwavu and Witkowski, 2008; Egeru and Majaliwa, 2009). These studies point out the human activities on ecosystems but do not reveal the link between population dynamics on ecosystem services.

According to Millennium Ecosystem Assessment (2005) human beings are wholly dependent on nature; healthy ecosystems provide vital services such as food, fresh water, clean air and protection from disease and disaster. The earth's ecosystems are under great stress. In the last five decades, ecosystems have been more rapidly and extensively modified by man than in any comparable period of human history. In the tropics however, deforestation is estimated to account for forested area decline of 13 million hectares per year as a result of conversion to agricultural land (FAO, 2005; MEA, 2005).

The conversions have not spared the forests in and around Bwindi Impenetrable National Park in Southern western Uganda. The protected forest has a unique eco-system with diverse gene reserves with worldwide interest. It is most popular for gorilla tourism attraction (Nkurunungi *et al*., 2004). The area is of particular concern due to the rapid land conversion practices and sensitivity to human impact. The growing population cultivates the land immediately surrounding the Park where no forest now remains (UNEP-WCMC, 2007).

Prior to BINP attaining national park status in 1991, there was widespread timber harvesting and other forms of resource exploitation, including hunting and gold mining, and gathering of firewood, poles and stakes (T. Butynski, unpublished report 1984; Howard 1991). These activities were widespread, but were most intensive within 1 km of the Park edge (T. Butynski, unpublished report 1984), while the outer 61% of the Park was heavily logged (Howard 1991). Changes in habitat extent through time have been recorded (Westman *et al.* 1989; Ite and Adams 1998; Hudak & Wessman 2000; Mayaux *et al.* 2000; Vascouscelos *et al.* 2002; Ambrose & Bratton 2005; Sivrikaya *et al.* 2007; Forrest *et al.* 2008). Cascading effects of edge creation have been reported, for example, high fire frequency can trap woodlands in a regeneration phase and persistent burning can slowly regress the woodlands to fire climax grassland (Croze 1974; Norton-Griffiths 1979).

Similarly, Namara, *et al,* (2001) argue that recent research reveals that the area's status has changed frequently with an increase in protection status and spatial extent (from 207 km2 in 1932 to 321 km2 in 1991). Butynski (1984) estimated that between 512 and 1049 people entered the forest daily to illegally remove wood, bamboo, livestock forage, minerals, honey, and meat. Until 1991, timber extraction, gold mining, and hunting were the gravest threats, leading to one of the highest anthropogenically related gap sizes and frequencies known for tropical forests (Babaasa *et al.* 2001) and the extinction of at least two mammal species from the area: buffalo *(Synerus caffer)* and leopard *(Panthera pardus;* Butynski 1984). Timber extraction, greater than 80% of which was illegal, was widespread throughout the reserve (Butynski 1984), although it was probably more intense along the edge than in the interior (Howard 1991). These findings and study are general in that they emphasize anthropogenic factors but not particularly drivers of land cover changes such as population density which degrades ecosystems around the protected area.

The Problem is that adjacent areas around Bwindi Impenetrable National Park are densely populated, with an estimated population of 800,000, or 400-600 persons per km2. The majority of population in this area depends on agriculture for livelihood. Today, virtually no forest remains outside of the park, and most of the papyrus swamps to the south have been cleared for fuel wood and drained for agriculture by the landless. The extremely high human population density around the forest coupled with a history of forest degradation through logging and other forms of human disturbance, has resulted in significant challenges to BINP conservation (Kasangaki *et al*. 2006). The growing population cultivates the land immediately surrounding the Park where no forest now remains (UNEP-WCMC, 2007). Land degradation around BINP is rampant and has been attributed majorly to factors such as deforestation, agriculture, grazing and settlements (Pomeroy & Tushabe, 2004; MEA, 2005). Therefore understanding the influence and the link between anthropogenic perturbations on ecosystems could serve as a basis for development of mitigation strategies for the areas in and around the protected forest and contribute to improvement of the environment quality. It is against that background that prompted the study to be carried out. The main aim of the study was to ascertain the population dynamics and land-use changes around Bwindi Impenetrable National Park. While specific objectives were: To identify the different factors that cause ecosystem degradation around BINP; To determine the negative effects of ecosystem degradation by the local community around BINP; To find out the strategies that can be applied to mitigate the negative effects of ecosystem degradation around BINP

MATERIALS AND METHODS

Description of study area

Bwindi Impenetrable National Park covers 321 km2 and is located in southwestern part of Uganda at 0◦ 53’–1◦ 08’S, 29◦ 35’–29◦ 50’E. It is one of a series of protected areas in the Albertine Rift, a region globally famous for its biodiversity thought to result from proximity to a Pleistocene refugium for many species of flora and fauna now endemic to the Rift (Hamilton 1976). The park is characterized by steep hills and narrow valleys with continuous forest vegetation throughout. The Park also comprises of steep-sided hills and extends in an altitude that ranges to 1400 m on average, tilting from the highest point of 2607m in the south-east to the lowest 1190m in the north-west (T. Butynski, unpublished report 1984). Further, the soils in the area are characterized by well differentiated humic ferralsols which have a well developed and moderately to strong sub-angular structure, with moderate to high acidity, and deficient in bases (Twongyirwe *et al*., *unpubl.*).

The park receives annual rainfall ranging from 1400 to1900 mm and the wettest periods are March to April and September to November. In addition the annual mean minimum and maximum temperature ranges are 7–15oC and 20–27oC respectively (Howard, 1991). In the protected area, the vegetation is classified as medium altitude moist evergreen forest and high altitude submontane forest (Langdale- Brown *et al*., 1964). More than 61% of the forest was heavily exploited by pitsawyers (between 1932 and 1991), while 29% was selectively pitsawed and only about 10% remained relatively intact (Howard 1991). However, following the change of status to national park, more effort was made to stop excessive exploitation and degradation, although limited extraction of plants for medicinal and weaving purposes was subsequently permitted in some parts of the park.

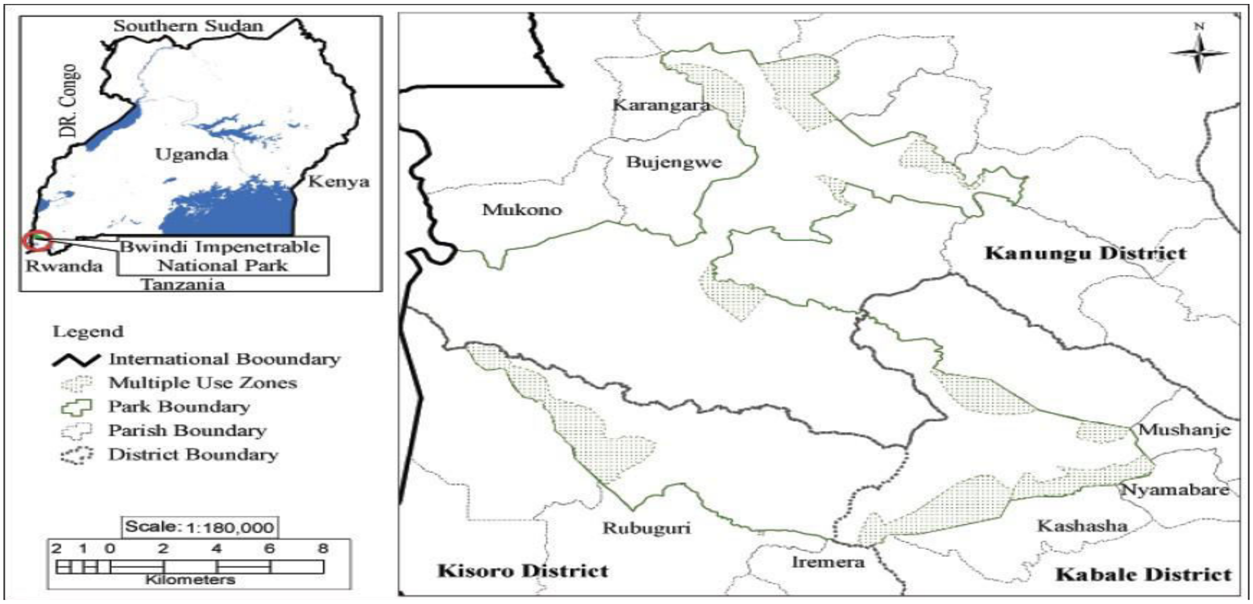

Figure-1: Map of Bwindi National Park and its surroundings

Research Methodology

The study was carried out in and around Bwindi Impenetrable National Park which is surrounded by a high density population. Population was from parishes which were formed due to decentralization adopted in 1991, which constitutes the main governance framework, The Local Governments Act 1998. The study utilized the sample that was obtained from the parishes (smallest administration unit of government) in which the households were considered. The procedure in the collection of data was done by first consulting the local leaders in the areas of interest who introduced me to the local community. The study to obtain the required parishes, used the 2012 population census list. The park is surrounded by 22 parishes and for this study systematic sampling was done. This was carried out by listing all the 22 parishes on the paper and systematically picking all the parishes. The study selected in each parish two (2) households and every one leader of the homestead was identified for interviewing. The sample was 44 households that were selected considering that each parish registered 2 household representatives. The interview guide was the collection tool that used to obtain data from the sample. In this case there was 100% response rate because all the 44 participants accepted to be interviewed and gave the required data. The source of data included both primary and secondary data. In this study primary data was obtained from the participants directly and secondary data was obtained from reports and documents in the park. The presentation of data was done by use of figures, tables and text format. The analysis was carried out by the regression analysis to establish the deviations from the mean of the parameters, correlation coefficients to understand the relationship of parameters and standard deviations.

RESULTS AND DISCUSSION

The results revealed a trend that as population increased, agricultural land area also increased while the forest cover area of Bwindi reduced. Taking 1973 as a base year, results indicated that the un-protected woodland forest area declined at 1.9% on average each year between 1973 and 2010. In contrary the forest protect area reduced at a rate of -0.2%. The results further revealed that between 1973 and 2010 the cultivated area of small scale farming increased by 0.4% and tea plantations increased by 2.1%.

The trends in results indicated that the agricultural land increased by 29.4% in 1973 which resulted in the reduction of the protected forest area by 56.23%. Meanwhile in 1987 the agricultural area increased further by 30.3% and the forest area also decreased by 54.88%. Not only that, but also in 2010 agricultural land increased by 33.6% whereas the forest area reduced by 51.91%. The trend in results suggested that there was increase in cultivated tea area by 6.4% and grazing land by 2.2% in 1973. Apart from that in 1987 tea area increased by 5.5% while the grazing land also increased by a small rate of 0.5%. More to that in 2010 the cultivated tea area increased by 11.5% and grazing land increased by 1.5% as compared to 2015 where the small scale farming increased by 55.3%. The trend also indicated that the unprotected woodland area increased from 5.8% to 9% between 1973 and 1987 but reduced to -24% in 2015 which indicated that human activities destroyed forests and even reduced the forest cover areas (Table 1).

Table 1: Land use change in and around Bwindi National Park 1973-2015

Land use	1973 area (ha x100)	Percentage cover 1973	1987 area (ha x100)	Percentage cover 1987	2010 area (ha x100)	Percentage cover 2010	2015 area (ha x100)	Percentage Cover 2015
Protected area	359.1	56.2	350.1	54.8	331.2	51.9	331.0	-0.91
Grazing lands	14.4	2.2	3.6	05	9	1.5	7.8	-13.3
Unprotected Woodland	36.9	5.8	57.6	9.0	10.8	1.7	8.2	-24
Small scale farming	188.1	29.4	193.5	30.2	214.2	33.5	332.7	55.3
Tea plantations	41.4	6.4	35.1	5.5	73.8	11.5	75.3	2.0

Source: Uganda Wildlife Authority (UWA, 2015)

The model summary table shows the R square values as $R^2 = 0.432$, 43. 2%, $p < .001$ of the observed variability in the effects of the anthropogenic activities on the ecosystem characteristics in and around the national Parks explained by the three independent variables that is; plant harvesting, Pole-wood cutting and Firewood collection. This indicated a significant influence of human activities on ecosystems. $R^2 = 0.312$, $p < .001$ is the correlation coefficient between the observed value of the dependent variable and the predicted value based on the regression model. The result shows a weak relationship between anthropogenic activities and ecosystem characteristics in and around the park. This means that the increase in the anthropogenic activities does not strongly affect the ecosystem characteristics. The Adj., $R^2 = 0.431$, $p < .001$ is the proportion of the variability in the dependent variable explained by the linear regression (Table 2).

Table 2: Model Summary of predictors that affect ecosystem characteristics

Model	R	R Square	Adjusted R Square	Std. Error of the estimate
1	.312[a]	.432	.431	5.165

[a]Predictors: (Constant), plant harvesting, Pole-wood cutting, Firewood collection

Using Linkert's 5 scale (1,2,3,4,5), respondents were asked to rank what they believed were the core causes of land cover changes around Bwindi with 5 the highest and 1 the lowest. The results revealed that the majority 79.5% ranked agriculture 5, as compared to 20.5% who did not rank it. The results also revealed that the second highest was under the ranking of 4, where settlements recorded 72.7% as compared to timber harvesting which recorded 47.7% (Table3) below;

Table 3: Respondents' rankings of the causes core land cover changes

Rankings of core causes	5(very strong)	4 (strong)	3(fair)	2(weak)	1(Very weak)	Total
Settlements	2	32	4	6	0	44
Agriculture	35	4	1	3	1	44
Grazing	8	10	24	1	1	44
Timber	10	6	21	3	4	44

The results revealed that the forests and woodlots around the park were degraded and continue to be degraded by human activities. This are in line with earlier studies done by Olupot *et al.* (2006) and Kasangaki *et al*. (2006) who argued that in forest reserves especially those that are surrounded by dense human populations and do not have effective procedures to protect and limit forest exploitation, it is likely that all categories of trees will decline in density particularly near the edges. They further argued that it is unclear whether saplings and poles will be reduced to the point where they cannot replace old trees that are usually harvested by local people or that succumb to edge effects. However, around Bwindi Impenetrable National Park such studies were not fully carried out apart from those that emphasized the decline in park size.

The results indicated that as the population increases, the forest cover reduces as a result of deforestation for agricultural purposes, settlements and demand for timber products. Also results suggested that small scale farming around the park increased as the forest cover area declined over the years. These results are similar to the studies by Majaliwa *et al.*, (2010) who discovered that woodland and grasslands were declining as small scale farming and built up areas were increasing around Kibale national park in South-western Uganda over the period of 1973 to 2009. Mwavu and Witkowski, (2008) also found that Budongo forest cover in Northern Uganda had decreased significantly as sugarcane plantations had increased between 1988 to 2002. They attributed these changes to agricultural expansion, increasing human population exacerbated by large influxes of refugees, conflicts of interest and political interference in the management of Budongo Forest and the unclear land tenure.

The results of this study suggested that the local communities identified the key factors that lead to deforestation around the protected areas. These factors included agriculture, grazing, timber and settlements. These findings are similar to Mwavu and Witkowski, (2008), Namara *et al* (2006) and Olupot *et al* (2006) who argued that in the extensive area that adjoins Bwindi Impenetrable National Park, the presence of multiple-use programs in local parishes had a strong negative impact on tree and pole density and firewood extraction; these effects were especially strong in areas designated for beekeeping. In contrast, human population density accounted for a small proportion of the variance in intensity of local resource extraction, although the presence of nearby settlements was significant

Another driver of land use/cover change around Bwindi impenetrable National Park is the weak environmental laws and policies. This is comparable to the findings made by Olson *et al.,* (2004) and Kasangaki *et al*. (2006) in their studies about local communities surrounding tropical high forests in Uganda. The weak land use/cover conservation laws around the park have been exploited by the local communities especially the on-going small scale illegal pit sawing and timber harvesting activities in tropical high forest, unprotected forests and wetlands. Mwavu (2008) also noted that the weak laws are responsible for the clearances of land cover because they are highly violated and usually have lighter penalties.

Carbon stock trend in and around BINP between 1990- 2015

Deforestation and degradation of ecosystems impacted on the amount of carbon stock in the forests in Uganda. Results suggested that 109 million metric tons of carbon were stored in the forests but the amount had declined over years. Considering 1990 as a base year, the results indicated that carbon stock in living forest reduced from 171 million metric tons to 140 million metric tons in 2000 (18%) decline as compared to the period between 2000 and 2005, when carbon stock decreased from 140 million metric tons to 124million metric tons (11.4%). However, the results suggested that from 2005 to 2010, the carbon stock decreased again from 124 million metric tons to109 million metric tons (12%).

Similarly, the total forest cover had reduced by thousands of hectares. Therefore taking 1990 as base year, 4751,000 hectares of forest reduced to 3869000 hectares (18.56%) as compared to the period from 2000 to 2005, during which the forest area decreased fom 3,869,000 to 3,429,000 hectares (11.37%). The results further indicated that the annual forest area change rate from 1990 to 2000 was -2.03%, as compared to the period from 2005- 2010 that had the change rate of -2.72%, a negative which indicated deforestation. The trend revealed that as forest area decreased, the amount of carbon stock also reduced at almost the same rates between 1990 and 2010. However from 2012 to 2015 a small percentage change in forest cover led to abigger change in carbon stock decline (Table 4) below.

Table 4: Trends in forest cover and carbon stock between 1990-2015

year	Forest cover (1000ha)	Percentage change	Carbon stock (million tons	Pecentage change
1990	4751	0	174	0
2000	3869	-18.56%	140	-18%
2005	3429	-11.37%	124	-11.4%
2010	2988	-12.86%	109	-12%
2011	3158	5.7%	102	-6.4%
2012	3136	-0.6%	98	-3.8%
2013	3132	-0.13%	86.10	-12.1%
2014	3098	-1.1%	78.41	-8.9%
2015	2924	-5.6%	60.20	-23.2%

Source: National Forest Authority (NFA), 2015 Negative indicates reduction in forest area

Results through analysis of the data by (ANOVA) revealed that all the parameters significantly impacted on the forest ecosystems as indicated by the 1-tailed outcomes. Results suggested that deforestation impacted more significantly on the forest ecosystems services because a large percentage of forest area was cleared which resulted into big loss of carbon stock and analysis equated to magnitude of $F = 0.735$, $P < 0.001$ (73.5%). This indicated a significantly relationship between reduction in forest area cover and decline in carbon stock in the forest.
The results indicated that 11(25%) strongly agreed as compared to 4 (9.1%) strongly disagreed about ecosystem services/benefits derived from the forests/ study area. Results also revealed that 9 (20.5%) disagreed about ecosystem services as compared to the majority 13 (29.5%) who agreed that local community derive services from the ecosystems. These, results indicated that majority agreed benefits/ecosystem services were derived from the forest whereas some few respondents were not sure if such benefits existed (Table 5) below.

Table 5: Respondents' views on ecosystem services derived from the forests/ study area

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Strongly agree	11	25	25	25
	Agreed	13	29.5	29.5	54.5
	Not sure	7	15.9	15.9	70.4
	Disagreed	9	20.5	20.5	90.9
	Strongly disagreed	4	9.1	9.1	100.0
	Total	44	100.0	100.0	

Results revealed that the forests decline had direct effect on the carbon stock stored in the forests as one of the services performed by the forests. These results are in agreement with UNEP (2002) who suggested that forest cover helps to maintain a thermal balance in the atmosphere through evapotranspiration. Again forests regulate hydrological cycles, soil and water quality, and support the highest biodiversity. Additionally in the same vein, forests also play a major role in carbon storage and exchange with the atmosphere and regulation of climate (FAO, 2001).

Mitigation measures

The results indicated that majority of respondents (50%) agreed that policies have to be implemented to minimize ecosystem degradation as compared to 4.5% who strongly disagreed. In the same line, results revealed sensitization of the local community was also agreed by 43% of the respondents as compared to 4.5% of respondents who ranked it was fair. The results indicated also that NGOs support was required and majority 34% participants ranked it fair as to compared to 6.8% who disagreed. Local community funding was strongly agreed upon as ranked by 34% of the participants as compared to 2.3% of respondents. Tree planting was strongly agreed upon by 31.8% of the respondents as compared to 6.8% respondents. Finally the majority of respondents 47.7% agreed that involving the community in park management was one of the mitigation measures as compared to 4.5% who strongly disagreed (Table 6) below.

Table 6. Mitigation measures suggested by participants

Mitigation measures ranked	5(strongly agree)	4 (Agree)	3(Fair)	2 (disagree)	1(strongly disagree)	Total
Policies	5	22	9	6	2	44
Sensitize the local community	16	19	2	4	3	44
Revenue sharing	8	10	21	3	2	44
NGOs support	10	12	15	3	4	44
Fund Local community associations	15	13	5	10	1	44
Tree farming projects	14	11	9	7	3	44
Involve the community in park management	9	21	7	5	2	44

CONCLUSION AND RECOMMENDATIONS

It can be concluded from the results and discussion that anthropogenic activities play an influential role in degrading ecosystems in and around the protected area. Also human activities such as deforestation, agriculture and timber harvesting affected the ecosystems health as well as the services and goods derived from them. Further it can be concluded that high population density and weak laws play an influential in ecosystem destruction. In addition from the results it is concluded that over harvesting of the forest resources by the local community impacts negatively on the ecosystems and ecosystem service quality. Conclusively mitigation measures such as involving the local community in park management activities and sensitizing the local communities about conserving the ecosystems and thus achieve ecosystem sustainability management. Following the conclusion and results above, it was recommended that the local communities around the park should be empowered economically so that they don’t look at the park as the only quick source of wellbeing. Finally it was recommended that the local communities should be given full mandate to participate in decision making process and resource allocation so that they don’t feel neglected.

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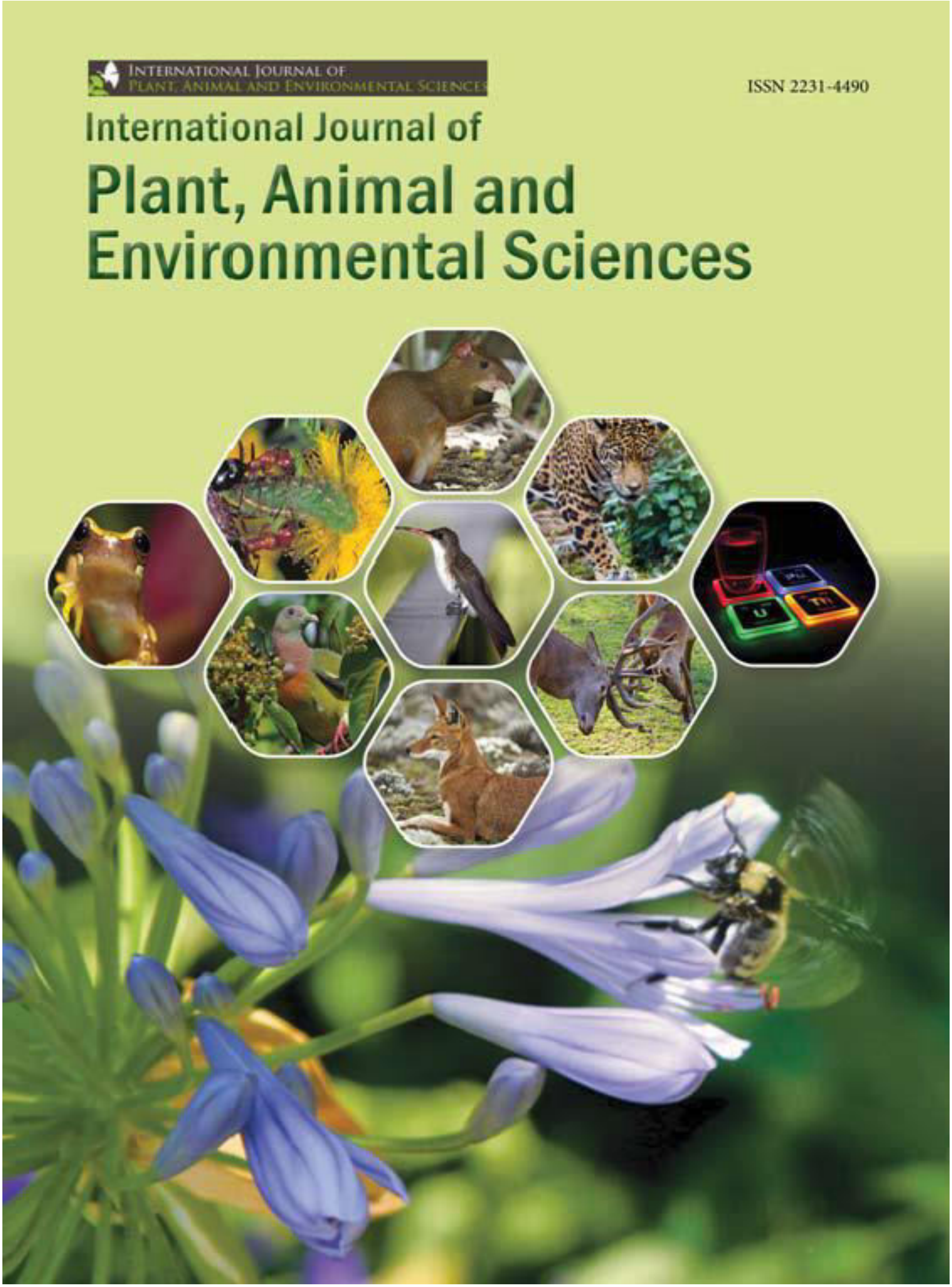
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