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The Impact of Informal Settlements on Forest Ecosystem Services Deterioration in Urban Area Case Study of Gasabo District

Onesphore Mutiganda[1, *], Abias Maniragaba[1], Evase Ntaganira[1], Zena Mbera[1], Marie Rose Mukarubayiza[2], Sing Pratap[3]

[1]Depertement of Environment, Economics and Natural Resources Management, University of Lay Adventists of Kigali, Kigali, Rwanda
[2]Department of Nursing and Midwifery, University of Rwanda, Kigali, Rwanda
[3]Departement of Irrigation and Drainage Engineering, University of Arba Minch, Arba Minch, Ethiopia

Abstract

This work is entitled "Impact of informal settlements on forest ecosystem services in Rwanda, case study Gatsata Sector in Gasabo District". The problem statement of forest ecosystem services deterioration through forest ecosystem provisioning services deterioration, forest ecosystem regulating services deterioration, ecosystem supporting services deterioration and ecosystem cultural services deterioration, all forest ecosystem services deterioration were indicated by increasing of greenhouse gases in the atmosphere, land degradation, increasing of floods and droughts, advancing deserts, underground water diminution and death of household for lack of forest ecosystem services sustainability of Gatsata Sector in Gasabo District. The purpose of this study was to analyse the level of informal settlement, to examine the existence of forest ecosystem services and to analyse the extent informal settlement reducing forest ecosystem services. The study population were comprised 181 local leaders within four years from 2016-2019 as sample size selected by using purposively sampling method and data collected by one questionnaire with 128 questions and Google Map which analysed by using methods of descriptive statistics and inferential statistics with SPSS, Excel and Arc GIS. The first specific objective findings average for correlation and regression between informal settlements indicators impact (deforestation, poor houses, population growth and unplanned infrastructure) and provisioning services, regulating services, supporting services and cultural services deterioration are r & R^2 = (76.4%, 58.4%) with (0.000), (80.5%, 64.7%) with (0.000), (78.6%, 64.5%) with (0.000) and (79.875%, 63.875%) with (0.000) respectively where findings of GIS to the area covered by informal settlements is 84.4% of total settlements. The second specific objective findings average for Non-correlation and Non-causality between existence forest ecosystem services (provisioning, regulating, supporting and cultural services) and informal settlement (deforestation, poor houses, population growth and unplanned infrastructure impact) are r& R^2 = (12.2%, 22.85%) with (0.000), (22.45%, 39.825%) with (0.000), (20.275%, 36.475%) with (0.000) and (16.575%, 30.325%) with (0.000) respectively where findings of GIS to the area covered by forest ecosystem is 32.2% of Gatsata sector. The correlation and regression results for third objective are r & R^2=99.7%, and 99.4%, (0.003). Conclusion and Recommendation were basing relocating households of informal settlements and reforestation to the forest ecosystem services sustainability due all hypotheses in this study were rejected due the significant level obtained are less than 0.05 significant level used.

Keywords

Informal Settlements, Forest Ecosystem, Provisioning Services, Regulating Services and Cultural Services

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* Corresponding author
Email address: omutiganda@yahoo.fr (O. Mutiganda), abiasrw@gmail.com (A. Maniragaba), ntevase@gmail.com (E. Ntaganira), rubayizarose@yahoo.com (M. R. Mukarubayiza), drpsingh49@gmail.com (S. Pratap), rutsiri@gmail.com (Z. Mbera)

1. Introduction of the Study

Globally, environmental management in informal settlements is affected by socioeconomic activities performed by people who are living in informal settlements which are associated with urban city and affect forest ecosystem services deterioration. These socioeconomic activities include unauthorized houses construction, deforestation, agriculture, population growth for industries works, unplanned infrastructure during constructing houses for rent, trade as well as income generating activities performed by majority of low income earners such as furniture manufacturing, food vending, car wash and garages [10]. The unsustainable development of these socio-economic activities in informal settlement contributing much to pollution and forest ecosystem services degradation such as lack of trees production, water reduction, air pollution, floods, soil erosion, loss of biodiversity and land resources to a great magnitude compared to the actions taken to improve forest ecosystem services sustainability in urban city [6].

The world is increasingly urbanizing, with approximately 54% of the world population living in cities. The United Nations World urbanization prospects expect this number to rise to 66% by 2050 [3]. If current trends continue, there will be twice the size of urbanized areas by 2030 and an additional 2.5 billion new urban inhabitants by 2050 [12]. Urbanization represents a great challenge to humanity but at the same time it provides an important opportunity to develop and implement policies to promote more forest ecosystem services sustainable and liable cities based on impact of informal settlement [8].

The forest ecosystem service provides a variety of services and also energy in the form of renewable bio-fuels and abiotic energy sources like charcoal. It helps in atmospheric regulation, water quality regulation, lifecycle maintenance & habitat protection, air flow regulation, dilution and sequestration. It also helps in religious and spiritual wellbeing; in recreation and community activities as well as in information & knowledge [1]. According to [7], Tanzania in Dar-es Salaam, informal settlements is the prime option for the land seekers where the public sector fails to manage urban growth according to its legal norms and the expectation of citizen which fuel the rapid growth of informal settlements. The city is found in the highly urbanizing region of East Africa with projected population of 5.7 million in 2010 and it is expected to double in 2025. This rapid urbanization has already started to generate ecosystem problems which need urgent response [6].

The first step to conservation and sustainable use of biodiversity and forest ecosystem services for food, wood, timber, erosion control, water quality and nutrition as well as maintaining the carbon stock is to return to local crops and traditional food systems [4]. In Rwanda, Forest ecosystem face different challenges related to the informal settlement as the way of gaining money for citizens and other domestic needs like wood for cooking energy and among others.

1.1. Problem Statement

The environment is not to be seen as a stand-alone concern. It cuts across all sectors of development as economic and social. The rapid increase in greenhouse gases in the atmosphere, land degradation, increasing floods and droughts, advancing deserts and deteriorating conditions of fragile ecosystems, death of household due to the erosion or flood, loss of biodiversity, loss of crops, loss of houses or other infrastructure like roads, pylons for electrical supply and environmental pollution have become subjects of serious global concern [9]. The overall impact of these phenomena is likely to result in increasing of informal settlements, depletion of ozone layer, change of climate, rise in sea-level, loss of natural resources, deforestation, population growth, poor houses, unplanned infrastructure and reduction in their productivity ultimately leading to an ecological crisis affecting livelihood options for development and overall deterioration in quality of agricultural technology [13].

The high rates of urbanization of Kigali city have resulted in uncoordinated urban expansion and significance increase of urban population. The uncoordinated urban development has resulted in informal settlement occupied mostly by low income earners on land that is considered hazardous and inappropriate for residential development. This is considered as greater challenges to the social economic development of city of Kigali because it does not only entail potential loss of live and property but also the human activities may contribute to environmental degradation [11]. In addition, insufficient and uneven distribution of basic infrastructures and social services has increased injustice or inequity in the society. Among other strategies to address the challenges and negatives consequences of informal settlements, it has recently been recommended by Rwanda Housing Authority report [14] that informal settlement in high risk areas such as those on steep slopes and wetlands, in three districts of Kigali city, should be giving first priority for relocation. In this regard, to date, Kigali city council has started implementing a resettlement policy with hope to improve the wellbeing of urban poor and forest ecosystem services sustainability through reducing informal settlements and improve ecosystem services with following objectives:

1.2. Specific Objectives

1. To analyze the level of informal settlement in Gatsata Sector,

2. To examine the existence of forest ecosystem services in Gatsata Sector,
3. To analyze the extent informal settlement in reducing forest ecosystem services in Gatsata

1.3. Research Hypothesis

H0: There is no relationship between informal settlement and forest ecosystem services deterioration in Gatsata Sector.

2. Method

2.1. Research Design

This study was non-experimental research study provides the procedural outline for conducting a study and it specifies procedures for collecting data, analysing data and reporting results in qualitative and quantitative research [2]. [5] State that an exploratory study is an important qualitative and quantitative research that enables the researcher to become familiar with basic facts, setting and concerns. In this case study the researcher used descriptive and inferential statistics.

2.2. Population of the Study

The study population was considered are local leaders worked in Gatsata sector with total numbers of 181 where in the total respondents each cell presented by cell leaders and land officer of Gatsata sector. The study research was focused on local leaders stay at Gatsata sector from periods of 2016 end 2019. The target population is composed by (181) Gastata sector with cells of Karuruma, Nyamugari and Nyamabuye.

2.3. Sample Techniques

Gasabo district in Gatsata sector was selected as an area of study because it currently has recorded the highest number of level informal settlements, and the most populated District in both Kigali city and Rwanda in general [11]. The purpose sampling was used as the respondent were homogeneous of local leaders. In this study, researchers used purposive sampling to select the local leaders of Gatsata sector who were expected to have relevant information than others. These populations are indicated in the table.

Table 1. Local leaders of sample size selected.

S/No	Rwanda village (umudugudu) committee members	number
1	village leader	1
2	village in charge security	1
3	village in charge development	1
4	village in charge social	1
5	village in charge information	1
	total members of village	5
	Gatsata cells and number villages	
1	Nyamugali cell	10
2	Nyamabuye cell	15
3	Karuruma cell	11
	total villages of Gatsata Sector	36
1	land officer of Gatsata sector	
	Sample Size	
	Total membes committee of Gatsata vallages	180
	land officer	1
	total sample size	181

Primary data, 2020

2.4. Research Instrument

Research instruments tools were used for 181 questionnaires with 128 questions for on questionnaire. The tool of Arc Map, Gatsata map, Gasabo map, Gasabo master plan update 2020 and categories settlements list of houses constructed, pen, notebook, computer for recoding and analysis data, and also a video camera was used. Questions included close-ended questions where the respondents allowed choosing from the owner answers by Likert scale methods with five compositions of strongly disagree, disagree, not sure, agree and strongly agree.

2.5. Data Analysis

Data collected from local leaders through questionnaires were analysed, summarized, and interpreted accordingly with the aid of descriptive and inferential statistics techniques such as min, correlation and coefficient of determination by using Statistical Package for Social Sciences 2020 (SPSS). For the second data collected from goggle map, area covered analysed by arc GIS.

2.6. Validity of the Instruments

The validity can be explained as the degree to which the research conclusions sound plausible to specific objectives and linked with the response to the questions asked by the researcher with come out problem statement as findings results interpreted from data collected in the population sampled in the field into primary and secondary data [15]. In addition, a pre-test was conducted in order test and improve on the validity of the questionnaire. In this research the pre-test of questionnaire instrument is shown below, the content validity index was calculated from the formula below:

$$CVI= n/N$$

Where:

CVI: Content Validity Index, n: Total number of items questions in one questionnaire.

N: Number of relevant items of the questionnaires for delivery to respondents, in this research the total number of items questions is (n) is equal to 128. The number of relevant sample size items as like total questionnaires (181) is equal to 181. Then the content validity index (CVI) is equal to 128/181= 0.71 or 71%. The validity index value above 0.7 is

good then the way of collecting answers and below 0.7 is not clear even it is not appreciated during data collection but in this study research the value of CVI is greater than 0.7 which means that the questionnaire tool is accuracy for data collection. The criterion-related validity of a test is measured by the validity coefficient. It is reported as a number between 0 and 1.00 that indicates the magnitude of the relationship, "r," between the test and a measure of job performance (criterion). The larger the validity coefficient, the more confidence you can have in predictions made from the test scores. However, a single test can never fully predict job performance because success on the job depends on so many varied factors. Therefore, validity coefficients, unlike reliability coefficients, rarely exceed r =.40.

Table 2. General Guidelines for Validity Coefficients.

Validity Coefficient Value	Interpretation
Above .35	Very beneficial
.21-.35	Likely to be useful
.11-.20	Depends on circumstances
Below 0.11	Unlikely be useful

Source: (William M., 2003)

As a general rule, the higher the validity coefficient the more beneficial it is to use the test. Validity coefficients of r =.21 to r =.35 are typical for a single test. Validities for selection systems that use multiple tests will probably be higher because you are using different tools to measure/predict

2.7. Reliability of the Instruments

According [8], explain reliability as the degree to which the results are repeatable and this repetition of results should be observed in both the measurement and outcomes, and in all occasions that these measurements are applied under similar conditions.

Test manuals and independent review of tests provide information on test reliability. The reliability of a test is indicated by the reliability coefficient. It is denoted by the letter "r," and is expressed as Cronbach's Alpha coefficient, a number ranging between 0 and 1.00, with r = 0 indicating no reliability, and r = 1.00 indicating perfect reliability but do not expect to find a test with perfect reliability as show in the table

Table 3. General Guidelines for Reliability Used.

Reliability	Interpretation
.90 and up	Excellent
.80-.89	Good
.70-.79	Adequate
Below .70	May have limited applicability

Source: (Hessen, et al, 2011)

Table 4. Reliability Statistics.

Cronbach's Alpha	N of Items
.94	181

Source: Primary data 2020

The results of table 4 shows the results .94 of test reliability as excellent as it was found to be greater than 0.9.

3. Results and Discussion

The objective of this chapter is to present, analyse and discuss about the findings on the impact of informal settlement on forest ecosystem services deterioration case study of Gatsata sector in Gasabo District. The number of questionnaires distributed were 181 and respondents targeted responded positively giving a response rate 100% and that all questionnaires were correctly answered. This conforms at some points that results are reliable.

Table 5. Relationship between informal settlements and forest ecosystem provision services deterioration.

Model	R	R Square	R Adjusted square	F	p-value or sig.
Values	0.744	0.553	0.550	221	0.0001
Percentage %	74.4	55.3	55		

Source: primary data 2020

The results founding in the table 5 indicate the correlation with R or r from square root of R^2 so is r=.744 or 74.4% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.553 or 55.3% of the variance in DV (provisioning services deterioration) is accounted for by IDVs scores (this is a strong effect) and adjusted square with $Radj^2$ 0.55 or 55%.

Table 6. Relationship between informal settlement and regulating services deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.761	0.578	0.576	246	0.0001
Percentage %	76.1	57.8	57.6		

Source: primary data 2020

The results founding in the table 6 indicate the correlation with R or r from square root of R^2 so is r=.761 as IDV or 76.1% with strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.578 or 57.8% of the variance in DV as regulating services deterioration is accounted for by IDVs scores (this is an effect) and adjusted square with R^2adj 0.576 or 57.6%.

Table 7. Relationship between informal settlements and supporting services deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.817	0.688	0.666	360	0.000
Percentage %	81.7	68.8	66.6		

Source: primary data 2020

The results founding in the table 7 indicate the correlation with R or r from square root of R^2 so is r=.817 as IDV informal settlement or 81.7% with strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.688 or 68.8% of the variance in DV as supporting services deterioration is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .666 or 66.6%.

Table 8. Relationship between informal settlements and cultural services deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.734	0.538	0.535	208	0.000
Percentage %	73.4	53.8	53.5		

Source: primary data 2020

The results founding in the table 8 indicate the correlation with R or r from square root of R^2 so is r=.734 as IDV informal settlement or 73.4% with strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.538 or 53.8% of the variance in DV as cultural services deterioration is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .535 or 53.5%.

Table 9. Relationship between informal settlement and provisioning, regulating, supporting and cultural services deterioration.

Regression model	R^2 coefficient of determination in %	correlation values r in %
Informal settlement and forest ecosystem provisioning	55.3	74.4
Informal settlement and forest ecosystem regulating services deterioration	57.8	76.1
Informal settlement and forest ecosystem supporting	66.8	81.7
Informal settlement and forest ecosystem cultural	53.8	73.4
Average of informal settlement impact on forest ecosystem services deterioration	58.4	76.4

Source: primary data 2020

The table 9 shows the variability of relationship and correction of informal settlement on forest ecosystem services deterioration with different values as follows informal settlements causality 55.3% with correlation of 74.4% to provisioning services deterioration, informal settlements causality 57.8% with correlation of 76.1% to the regulating services deterioration and informal settlement causality 66.8% with correlation of 81.7%, and informal settlement causality 53.8% with correlation 73.4% to the cultural services deterioration. Level of informal settlement when increased, becomes un-balanced in environmental management approach, there is a need to understand what specific type of skills is required by increment of informal settlements team at various urban areas.

Table 10. Relationship between Poor Houses and Provisioning services deterioration.

Model	R	R Square	R Adjusted square	F	p-value or sig.
Values	0.795	0.632	0.63	308	0.000
Percentage %	79.5	63.2	63		

Source: primary data 2020

The results founding in the table 10 indicate the correlation with R or r from square root of R^2 so is r=.795 or 79.5% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.632 or 63.2% of the variance in DV (provisioning) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj. 0.63 or 63%.

Table 11. Relationship between Poor Houses and Regulating Service Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.813	0.66	0.658	348	0.000
Percentage %	81.3	66	65.8		

Source: primary data 2020

The results founding in the table 11 indicate the correlation with R or r from square root of R^2 so is r=.813 as IDV or 81.3% with correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.66 or 66% of the variance in DV as regulating

services deterioration is accounted for by IDVs scores (this is an effect) and adjusted square with R^2adj .658 or 65.8%.

Table 12. Relationship between Poor Houses and Supporting Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.846	0.716	0.715	452	0.000
Percentage %	84.6	71.6	71.5		

Source: primary data 2020

The results founding in the table 12 indicate the correlation with R or r from square root of R^2 so is r=.846 as IDV or 84.6% with correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.716 or 71.6% of the variance in DV as supporting services deterioration is accounted for by IDVs scores (this is an effect) and adjusted square with R^2adj .715 or 71.5%.

Table 13. Relationship between Poor Houses and Cultural Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.756	0.571	0.569	238	0.000
Percentage %	75.6	57.1	56.9		

Source: primary data 2020

The results founding in the table 13 indicate the correlation with R or r from square root of R^2 so is r=.756 as IDV or 75.6% with correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.571 or 57.1% of the variance in DV as cultural services deterioration is accounted for by IDVs scores (this is an effect) and adjusted square with R^2adj .569 or 56.9%.

Table 14. Relationship Values between Poor Houses and Providing, Regulating, Supporting and Cultural services deterioration.

Regression model	R^2 coefficient of determination in %	correlation values r in %
Poor houses and forest ecosystem provisioning	63.2	79.5
Poor houses and forest ecosystem regulating	66	81.3
Poor houses and forest ecosystem supporting	71.6	84.6
Poor houses and forest ecosystem cultural	57.1	75.6
Average of poor houses/ unauthorized houses impact on forest ecosystem services deterioration	64.5	80

Source: primary data 2020

The table 14 shows the variability of relationship and correction of poor houses impact on forest ecosystem services deterioration with different values as follows poor houses causality 63.2% with correlation of 79.5% to provisioning services deterioration, poor houses causality 66% with correlation of 81.3% to the regulating services deterioration and poor houses causality 71.6% with correlation of 84.6%, and poor houses causality 57.1% with correlation 75.6% to the cultural services deterioration. Level of informal settlement when increased, becomes un-balanced in environmental management approach, there is a need to understand what specific type of skills is required by increment of informal settlements team at various urban areas.

Table 15. Relationship between population Growth and Provisioning Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.762	0.58	0.578	247	0.000
Percentage %	76.2	58	57.8		

Source: primary data 2020

The results founding in the table 15 indicate the correlation with R or r from square root of R^2 so is r=.762 or 76.2% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.58 or 58% of the variance in DV (provisioning services deterioration) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .578 or 57.8%.

Table 16. Relationship between Population Growth and Regulating Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.81	0.656	0.654	342	0.000
Percentage %	81	65.6	65.4		

Source: primary data 2020

The results founding in the table 16 indicate the correlation with R or r from square root of R^2 so is r=.81 or 81% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.656 or 65.6% of the variance in DV (regulating services deterioration) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .654 or 65.4%.

Table 17. Relationship between Population Growth and Supporting Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.836	0.698	0.696	414	0.000
Percentage %	83.6	69.8	69.6		

Source: primary data 2020

The results founding in the table 17 indicate the correlation with R or r from square root of R^2 so is r=.836 or 83.6% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.698 or 69.8% of the variance in DV (supporting services deterioration) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .696 or 69.6%.

Table 18. Relationship between Population Growth and Cultural Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.766	0.587	0.585	255	0.000
Percentage %	76.6	58.7	58.5		

Source: primary data 2020

The results founding in the table 18 indicate the correlation with R or r from square root of R^2 so is r=.766 or 76.6% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.587 or 58.7% of the variance in DV (cultural services deterioration) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .585 or 58.5%.

Table 19. Relationship values between Population Growth and Provisioning, Regulating, Supporting and Cultural Services Deterioration.

Regression model	R^2 coefficient of determination in %	correlation values r in %
population growth and forest ecosystem provisioning	58	76.2
population growth and forest ecosystem regulating	65.6	81
population growth and forest ecosystem supporting	69.8	83.6
population growth and forest ecosystem cultural	58.7	76.6
Average of population growth impact on forest ecosystem services deterioration	64.5	78.6

Source: primary data 2020

The table 19 shows the variability of relationship and correction of population growth on forest ecosystem services deterioration with different values from highest as follows to the ecosystem supporting services deterioration, causality 69.8% with correlation of 83.6% to the ecosystem supporting services deterioration, population growth causality 65.6% with correlation of 81% to the to the ecosystem regulating services deterioration, and to the ecosystem supporting services deterioration, causality 58.7% with correlation of 76.6% to the ecosystem cultural services deterioration.

Table 20. Relationship between Unplanned Infrastructure and Provisioning Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.801	0.642	0.64	321	0.000
Percentage %	80.1	64.2	64		

Source: Primary data 2020

The results founding in the table 20 indicate the correlation with R or r from square root of R^2 so is r=.801 or 80.1% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.642 or 64.2% of the variance in DV (Provisioning) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .64 or 64%.

Table 21. Relationship between unplanned Infrastructure and Regulating Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.805	0.647	0.645	329	0.000
Percentage %	80.5	64.7	64.5		

Source: Primary data 2020

The results founding in the table 21 indicate the correlation with R or r from square root of R^2 so is r=.805 or 80.5% strong

correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.647 or 64.7% of the variance in DV (regulating) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .645 or 64.5%.

Table 22. Relationship between unplanned Infrastructure and Supporting Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.84	0.705	0.704	428	0.000
Percentage %	84	70.5	70.4		

Source: Primary data 2020

The results founding in the table 22 indicate the correlation with R or r from square root of R^2 so is r=.84 or 84% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.705 or 70.5% of the variance in DV (supporting) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .704 or 70.4%.

Table 23. Relationship between unplanned Infrastructure and Cultural Services Deterioration.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.749	0.561	0.558	228	0.000
Percentage %	74.9	56.1	55.8		

Source: Primary data 2020

The results founding in the table 23 indicate the correlation with R or r from square root of R^2 so is r=.749 or 74.9% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.561 or 56.1% of the variance in DV (cultural) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .558 or 55.8%.

Table 24. Relationship Values between Unplanned Infrastructure and Provisioning, Regulating, Supporting and Cultural Services Deterioration.

Regression model	R^2 coefficient of determination in %	correlation values r in %
unplanned infrastructure and forest ecosystem provisioning	64.2	80.1
unplanned infrastructure and forest ecosystem regulating	64.7	80.5
unplanned infrastructure and forest ecosystem supporting	70.5	84
unplanned infrastructure and forest ecosystem cultural	56.1	74.9
Average of unplanned infrastructure on forest ecosystem services deterioration	63.875	79.875

Source: Primary data 2020

The table 24 shows the variability of relationship and correction of unplanned infrastructure on the forest ecosystem services deterioration with different values from highest as follows unplanned infrastructure causality 70.5% with correlation of 84% to the supporting, unplanned infrastructure causality 64.7% with correlation of 80.5% to the regulating and unplanned infrastructure causality 64.2% with correlation of 80.1% to provisioning. The average of unplanned infrastructure causality 63.875% and with correlation of 79.875% on Gatsata forest ecosystem services deterioration.

Table 25. Average of Relationship Values between informal Settlements, Poor Houses, Population Growth and Unplanned Infrastructure and Forest Ecosystem Provisioning, Regulating, Supporting and Cultural Services Deterioration.

Average of Regression model	R^2 coefficient of determination in %	correlation values r in %
Average of informal settlement impact on forest ecosystem services deterioration	58.4	76.4
Average of poor houses/ unauthorized houses impact on forest ecosystem services deterioration	64.7	80.5
Average of population growth impact on forest ecosystem services deterioration	64.5	78.6
Average of unplanned infrastructure on forest ecosystem services deterioration	63.875	79.875
General average of level informal settlements on Gatsata forest ecosystem services deterioration	62.87	78.84

Source: Primary data 2020

The table 25 shows the variability of average relationship and correction of informal settlements, poor houses, population growth and unplanned infrastructure impact on Gatsata forest ecosystem services deterioration with different values from highest as follows poor houses average causality 64.7% with correlation of 80.5% to the Gatsata forest ecosystem services deterioration, unplanned infrastructure causality 63.875% with correlation of 79.875% to the Gatsata forest ecosystem services deterioration and population growth causality 64.5% with correlation of 78.6% to the Gatsata forest ecosystem services deterioration. The general average of level of settlements causality 62.875% and with correlation of 78.84% on Gatsata forest ecosystem services deterioration.

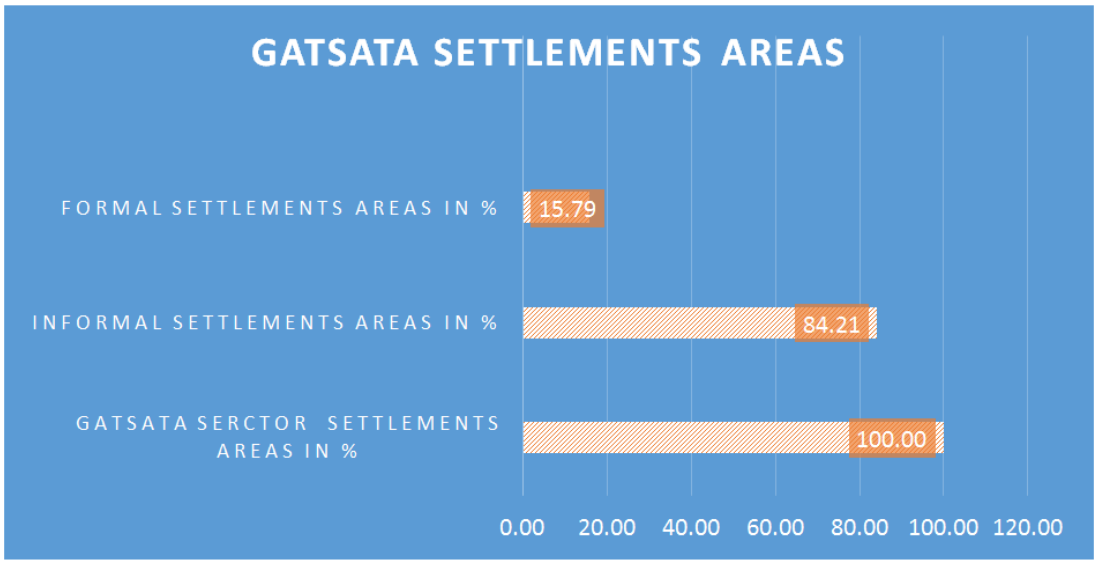

Figure 1. Gatsata Settlements Areas.

Source: Secondary data 2020 of Gatsata goggle map

Results of the secondary data collected from Gatsata sector area gives the total areas of each settlements and it means that in figure 1 the percentage of the level of informal settlement is 84.2% and it is highest percentage in urban area and means Gasabo District authorities and Kigali city authorities have not controlled urban master plan where 15.79% only is controlled and respect.

Table 26. Relationship between Informal Settlements and Existence Forest Ecosystem Services.

Model	R	R Square	R Adjusted square	F	p-value or Sig.
Values	0.997	0.994	0.991	316	0.003
Percentage %	99.7	99.4	99.1		

Source: Primary data 2020

The results founding in the table 26 indicate the correlation with R or r from square root of R^2 so is r=.997 or 99.7% strong correlation, positive, linear relationship. Then it gives a measure of effect R^2= 0.994 or 99.4% of the variance in DV (existence forest ecosystem services) is accounted for by IDVs scores (this is a strong effect) and adjusted square with R^2adj .991 or 99.1%. As indicated in table 26 again coefficient of determination above is R^2 where the results explain that: independent variable as informal settlements causality/ implies 99.4% to the dependent variable existence forest ecosystem services with p. value of 0.003 and F (316) test is strong where tell that at least two of the groups differ, but not which ones differ, the p-value is small than significant level of 0.01 so that, there is a significance relationship between informal settlements and existence forest ecosystem services. Therefore, the null hypothesis says that there is no relationship between informal settlements impact and existence forest ecosystem services is rejected.

4. Conclusion

The general findings of the study are illustrated from deforestation impact 58.4%, poor houses causality 64.7%, population growth causality 64.5%, unplanned infrastructure causality 63.875% to the Gatsata forest ecosystem services deterioration respectively.

Existence forest ecosystem provisioning service coefficient determination is 39.825%, existence forest ecosystem regulating service with coefficient determination is 36.475%, existence forest ecosystem supporting service non- coefficient determination is 30.325%, non- coefficient determination is 43.575%of ecosystem cultural services respectively. The findings of last objective are clarifying values of R square, R adjusted square, F test, and p- value between informal settlements impact and forest ecosystem services deterioration are 99.7%, 99.4%, 99.1%, 316, and 0.003 Respectively. The conclusion on the null hypothesis is said that there is no relationship between informal settlements impact and forest ecosystem services deterioration is rejected due significant level of 0.05 is greater than 0.003.

5. Recommendations

In this study the recommendation for environmental

managers especially who are responsible for urban master planners or land managers should focus on following parameters: involved in the construction authorization of the new building and construction houses location survey, environmental impact assessment documents and approved should be respected for avoid extension of deforestation, poor houses construction, population growth in the new unauthorized houses, and construction without respecting planned infrastructure area or the area which is unplanned infrastructure, emphasising on relocation of household and reforestation.

The study recommends local government about poor houses constructed for forest ecosystem services deterioration should be decided on the deconstruction of these illegal houses and substandard houses through site visit and houses survey on different informal settlements their materials used, appropriate location and urban master plan should be respected for avoiding deforestation, wood collection as reinforcing forest ecosystem provisioning services.

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