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IMPACT OF IMPROVED COOKING TECHNOLOGIES DISTRIBUTION PROJECT IN REDUCING ATMOSPHERE POLLUTION CASE OF GICUMBI, NORTHERN PROVINCE, RWANDA

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Abstract: ***The work entitled "improved cooking technologies distribution project in reduction of atmosphere pollution. Case of green Gicumbi project (component of improved cooking stoves distribution)" was conducted for assessing the validity of four specific objectives such as: to assess the significance of new cooking energy saving technologies on reduction of atmosphere pollution, to evaluate the significance of use of alternative energy fuels for cooking on reduction of atmosphere pollution, to examine the significance of acceptance of innovated technology on reduction of atmosphere pollution and to assess the significance of capacity building on reduction of atmosphere pollution. The study is developed with reference to 3 theories such as community participation and sustainability theory, driving factor to innovation and management theory and climate change as barriers theory. This study is census, descriptive, qualitative, and quantitative design. The study was used both primary data and secondary data. 99 respondents as entire population was assessed; the study has adopted census technique. Study results obtained were presented in form of descriptive statistics and inferential statistics. The results were presented as follows: The model has resulted R Square equal to 0.790 implies that using improved cooking technologies (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)), indicate that the model is perfectly fit at 79% or contribute 79% toward atmospheric pollution reduction. Due to that, use of improved cooking technologies is a tool to reduce atmospheric pollution. Atmospheric pollution reduction the main target of the world in today's development. Due to that atmospheric pollutant are being prevented in all projects where, no project financed by international organizations without climate mitigation certificate. It is in that context green Gicumbi project was developed and implemented and its impact is significant to atmospheric pollution, however there are still CO2 emissions from the firewood meaning that, both project management and beneficiaries should look on other less emitting fuels like gas, electricity and improved biomass.***

Keywords: Impact; Improved Cooking Technologies; Distribution; Project; Reducing Atmosphere Pollution, Green Gicumbi Project.

0. Introduction

In Rwanda, 80.37% of Rwandan Households use firewood for cooking, however there is significant increase in use of alternative cooking technologies manifest in the increase in use of LPG now at 5.65% of households on average compared to under 1.15% reported in EICV5 (NISR, 2018). LPG consumption is concentrated in urban areas, used by 25.6% of urban households, but only 0.4% of rural households. At Households levels Rwanda faces several challenges in improving access to modern energy cooking Solutions:

As cooking fuels are concerned, we observed an extremely low percentage of households that use clean fuels. Households using biogas are estimated at 0.21% LPG at 5.65% and electricity at only 0.21%. Dependence to biomass fuel remains high with firewood being used by 80.37%; charcoal at 18.03% and crop residues at 9.54% of households. Regarding cooking technologies, traditional three stones stoves keep the lead at 69.4% for firewood and 78,8% for crop residues burning while for charcoal and wood Medium efficient stoves, Metal clay stove and Rondereza plus stove respectively contribute to 30.2%, 25.6% and 21.2% of all stoves used for burning wood fuels, all with a thermal efficiency below 30% (NISR, 2018).

Stove stacking (using multiple cook stoves) reflects households' aspiration to use higher performing solutions or the need for backup solutions, which are often used in addition to (rather than instead of) existing cooking solutions. Standardization of improved cooking stoves is paramount to guide households in their choice of a more efficient stove to improve their economies and safeguard the environment (NISR, 2018).

1. Statement of the problem

Continued reductions in air pollution and greenhouse gas (GHG) emissions are essential, as they pose serious threats to both people's health and the environment across the world. Air quality and climate policies can provide mutual benefits: climate change mitigation actions can help reduce air pollution, and clean air measures can help reduce GHG emissions leading to reductions in global warming. There can also be trade-offs, if reducing a particular pollutant emission led to additional atmospheric warming rather than cooling (Baharane, 2020).

Furthermore, air pollution and climate change influence each other through complex interactions in the atmosphere. Increasing levels of GHGs alter the energy balance between the atmosphere and the Earth's surface which, in turn, can lead to temperature changes that change the chemical composition of the atmosphere. Direct emissions of air pollutants (eg black carbon, Particulate Matter and Carbon Monoxide...) (Huaping, 2020), or those formed from emissions such as sulphate and ozone, can also influence this energy balance. Thus, climate change and air pollution management have consequences for each other. It is very essential to highlight on the behavior, resistance, and adaptability of the community when it comes to switch to new culture and livelihood habits. Therefore, this study aims at investigating the improved cooking technologies distribution project in reduction of atmosphere pollution (Gicumbi District) even though there was continuous restructuring in the project that has led to low satisfaction in performance of the reduction atmosphere pollution (Eryigit, 2020).

Green Gicumbi project (component of improved cooking stoves distribution) is mainly focusing on vulnerable population, meaning people in 1st Ubutaha category, people with disability and poor families which struggling for access on cooking fuels. Beneficiaries are these mainly collecting firewood for cooking due to the lack of means to buy charcoal, gas and other fuels for cooking. The issue which is not considered by the project is the quantity of fuel used by the targeted beneficiaries as mostly they cooking once in a day due to the insufficient capacity of access on food. While the non-supported households using non improved cooking stoves use more fuels as they cooking twice or more than twice per day. Thus, the project could take under consideration, for more contribution in atmosphere pollution reduction, these using more fuels should be supported to reduce the daily emissions. Thus, the project can consider both all household's category in balanced way or more for these consuming more cooking energies. Thus this study intends to evaluate the significance of improved cooking technologies distribution project in reduction of atmosphere pollution case of green Gicumbi project (component of improved cooking stoves distribution).

2. Objectives of the study

The main purpose of this study is to assess the influence of improved cooking technologies distribution project in reduction of atmosphere pollution in Gicumbi District: Green Gicumbi Project. And specifically this study intends:

1. To assess the significance of new cooking energy saving technologies on reduction of atmosphere pollution.
2. To evaluate the significance of use of alternative energy fuels for cooking on reduction of atmosphere pollution.
3. To examine the significance of acceptance of innovated technology on reduction of atmosphere pollution.
4. To assess the significance of capacity building on reduction of atmosphere pollution.

3. Literature review

Reference is made to the assessment made by OECD (2019) on the Innovation and Business/Market Opportunities associated with Energy Transitions and a Cleaner Global Environment. The green transition depends on the development and diffusion of new technological, economic, social, behavioral and business model cooking technologies. These include electricity production, distribution and storage; agriculture and forestry; natural resource exploitation; buildings; transportation; water supply and treatment; waste management; and environmental remediation. Many of the necessary cooking technologies in each of these sectors already exist and now need to be diffused and scaled up. This process can be eased thanks to the development of enabling cooking technologies such as artificial intelligence, the internet of things and block chain technologies. At least in the technological domain, the pace of innovation for the green transition has accelerated markedly since the mid-2000s (OECD, 2019).

However, it is still insufficient to address the environmental challenges facing the planet today, and there is evidence to suggest that the pace of green innovation has slowed again in recent years. This suggests that major barriers remain and need to be lifted in order to accelerate the transition. The green transition spans multiple sectors of the economy. It is therefore difficult to quantify the size of the business opportunity associated with the transition. However, recent estimates indicate that the green economy is growing fast, and could represent 10% of global market capitalization by 2030, approximately the same size as the health or the banking sectors. Transitioning to a green economy has also been shown to deliver additional benefits, from high knowledge spillovers from green innovation to enhanced health and workers' productivity from lower air and water pollution (OECD, 2019).

Another reference is taken to the study made by Eryigit (2020), Eco-Innovation as Modern Era Strategy of Companies in Developing Countries: Comparison Between Turkey and European Union. Eco-innovation is developing new ideas, promoting new operations, products and processes to protect the environment, so obtaining environmental sustainability. Eco-innovation supports the survival of the companies as proposing an acceptable image for these companies to stakeholders. The innovation which decreases the environmental damages and hereby develops the sustainability of the firms, including eco-products, eco-processes and eco-organizational factors is called eco-innovation. Eco innovation is one of the aims of European Union (EU), and establishes a part of the development and economic policies. Technological progress makes the companies benefit from eco-innovation. Besides the environmental benefits; there are also cost related gains for the companies which apply eco-innovation. Organizations take eco-innovative actions because of the governmental pressures, consumers' pleasures and the great risk of changing climate in all over the world.

Climate change, ozone layer depletion, acidification, eutrophication, decreasing biodiversity and land degradation are some of the environmental threats that face the humanity and also the companies' survival. Hence multiple stakeholders of the societies expect the

companies to be sensitive about eco-innovation to protect the environment in order to save the nature and human lives. Eco-innovation is one of the leading strategies to promote resource and energy efficiency and create a low a carbon society in EU; because this strategy has other advantages like decreasing the costs of material purchasing. So it leads EU to be more competitive in global world. Eco-innovation is simply contributing to the sustainable company survival by challenging the environmental issues in the eyes of multiple stakeholders in the society. In this study we have comparisons between Turkey and EU in the framework of eco-innovative behaviors of the firms (Eryigit, 2020).

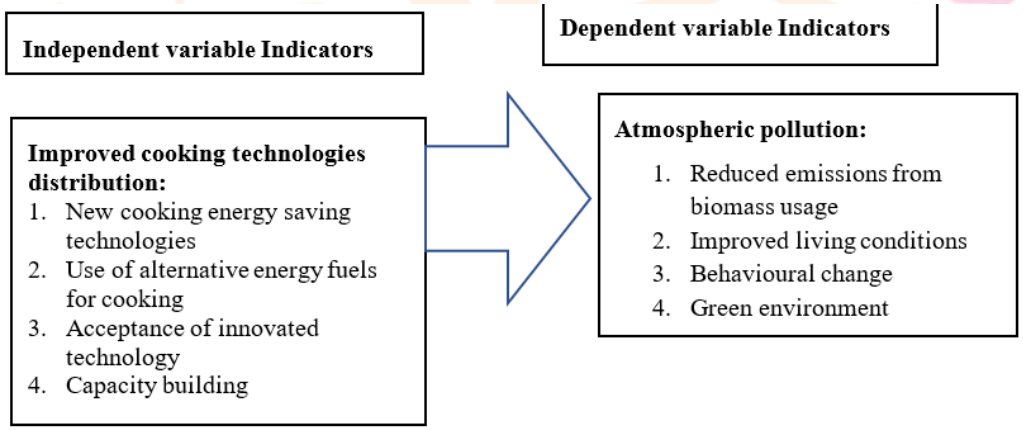
The assessment as presented in the empirical review, show that, all the studies Baharane (2020), Eryigit (2020), Jaques (2023), and OECD (2019) all studies, focuses on different contents rather than looking improved cooking technologies distribution project in reducing atmospheric pollution. In other case this study is more specific as it intends to focus on the Green Gicumbi project only more specific on the component of Distribution of improved cooking stoves. The studies also did not recommend which step could be taken once a project achieved the targets. While the current study looks the importance and gap of the entire improved cooking technologies distribution project and how it can maximize the scope in Rwanda starting from Gicumbi district and which insight will create and to be followed after the project covered the whole scope.

4. Conceptual framework of the study

The conceptual framework is a clear illustration of key relationships among independent and dependent variables. It has considered three critical issues for organizational change that is; organizational culture, employee empowerment and organizational citizenship behavior as illustrated below: Conceptual framework for effective improved cooking technologies distribution project in reduction of Atmosphere pollution.

The assessment of variables was made using specific indicators, where on the side of independent variable (improved cooking technologies distribution toward energies), 4 indicators were taken such as: New cooking energy saving technologies, Use of alternative energy fuels for cooking, Acceptance of innovated technology and Capacity building. On the side of dependent variable (Atmospheric pollution) also 4 indicators were considered such as: Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment. Both independent and dependent variables are not independent phenomena but are the results of international, regional and national strategy and policies which defined in National Strategy for Transformation and Sustainable Development Goals.

Figure 1: Conceptual Framework of the Study



Source: Eryigit (2020)

5. Methodology of the study

Methodology shows techniques and methods that will be used during the study. It gives the background against which data is to be collected, assessed, and analyzed. It will present the research design, study population, sample size, sampling methods, data collection methods and instruments, procedure for data collection validity and reliability, data management and analysis and measurement of variables.:

5.1 Reserch design

This study is descriptive, correlative, quantitative, and qualitative design. It intends to describe the usefulness of improved cooking stoves among sampled households. It intends to assess the correlation between independent variable and dependent variable. And the study intends to use both qualitative and quantitative data. This research proposes a research design using a case study approach. Therefore, the research design to be used is exploratory, that is, largely making use of qualitative and quantitative research methods. The aim of using such a design is to capture the overall scenario of issues pertaining to organizational change and organizational performance in government parastatals.

5.2 Study population

The population on which the researcher ultimately wants to generalize the results is the target population (Jinghua, 2020). For purposes of this study the target population will be 99 respondents. The population will be divided in several categories of different stakeholders of the project (See table 3.1 for the category of the population). As populations seems to be small (less than 100) better the study adopt to conduct a census and assess all target population.

Table 3.1: Sample size and samples selection

Category of respondents	Population	Sample size	Sampling technique	Data collection method
Management	10	10	Census	Questionnaire and Interview.
Project Team	25	25		
Contractors	6	6		
Local government staff	58	58		
Total	**99**	**99**		

Source: Gicumbi District, July 2023

The target population all people who have information on the progress implementation and outputs of green Gicumbi project on the components of distribution of improved cooking stoves. Here include 10 district management staff of the green Gicumbi Project, 25 project team members, 6 contractors of improved cooking stoves, 9 staff at sector office in addition to 49 cells social economic development officers from all 9 sectors of the project (Bwisige, Byumba, Cyumba, Kaniga, Manyagiro, Mukarange, Rubaya, Rushaki, and Shangasha). The total population is 99 respondents.

5.3 Instrument of data collection

Questionnaires with both open and closed questions will be used, with detailed guiding instructions regarding the way respondents will fill questionnaires independently with minimal supervision. Kobo toolbox questionnaire is to be used to seek response from the respondents for appropriate collection. Documentation includes related literature in reports, journals, textbooks, magazines, newspapers, internet, circulars; annual reports and unpublished thesis and any relevant material pertaining to organizational change.

5.4 Data Analysis

The statistical package to be used for analysis and presentation of data in this study is the statistical package for social scientists (SPSS) version 20. Different statistical techniques will be used namely: Bivariate correlation and Linear regression model analysis. The upper level of statistical significance for hypothesis testing will be at 5%. All statistical significance test results will be computed at 2-tailed level of significance and judged at 5% or 0.05.

This study will use bivariate correlation:

And the researcher also will use Linear regression model for testing the validity of research hypotheses:

$$Y_{1;2;3\&4} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4$$

“y” from 1 to 4 represents 4 indicators listed in the framework on the side of the dependent variable and β_0 is the coefficient, 1 to 4, and “x” values from 1 to 4 represent 4 indicators listed in the conceptual framework representing the variable that is not dependent.

Y= Reducing atmospheric pollution

X= Improved cooking technologies distribution

X1: New cooking energy saving technologies

X2: Use of alternative energy fuels for cooking

X3: Acceptance of innovated technology

X4: Capacity building

Y1: Reduced emissions from biomass usage

Y2: Improved living conditions

Y3: Behavioural change

Y4: Green environment

6. Findings

Findings presentation in form of descriptive statistics was made using parameters like total sample, frequency, percentage, mean, standard deviation, comment, test, significance and decision on the hypothesis. They are important to analyze or assess the perception of respondents on each item assessed either from independent and dependent variables. The mean was analyzed and classified with reference to the codes assumed to the perception level (see chapter three and questionnaire).

This means that reading mean gives an insight on how respondents considered same statement or the meaning under the statement. Standard deviation explains the spread of respondent’s perception from the general perception or mean. A higher standard deviation (greater than 0.5) means that some respondents chose perception far from the general mean. For example, if the mean is between 4 to 5 (agree to strongly agree) and standard deviation is greater than 0.5 means that not all agreed some disagreed or strongly disagreed on a specific statement or item assessed. The test of hypotheses refers to the acceptance of the statement as it is (reject the null hypothesis)

or failure to accept the statement as it is (accept the null hypothesis) and the alternative hypothesis is the statement itself and null hypothesis is the opposite of the statement assessed.

6.1 Perception of respondents on improved cooking technologies distribution in Gicumbi District

The study has evaluated a total 12 items categorized under 4 indicators (New cooking energy saving technologies, Use of alternative energy fuels for cooking, Acceptance of innovated technology and Capacity building) under independent variable (Improved cooking technologies distribution). Per each indicator three items were assessed and for each item, perception of respondents was captured using scaling measurement (strongly agree, agree, not sure, disagree and strongly disagree coded 5 to 1 respectively). The analysis was focused on the mean, standard deviation, significance, comment, test, significance and decision. Comment is combining the category of the mean and the standard deviation. The test represents the decision whether the hypothesis on the item assessed is valid or rejected. Note that, the null hypothesis is against the original assessed item (opposite). Here below are details:

Table 2: Perception of respondents on the Improved cooking technologies distribution best functions within Green Gicumbi project

Items assessed	N	Mean	Stdv.	Comment	Test	Sig.	Decision
New cooking energy saving technologies							
Green Gicumbi project has distributed improved cooking stoves which using less firewood for cooking.	99	4.26	.442	Strong Homogeneity	One-Sample Binomial Test	.000	Reject the null hypothesis
Green Gicumbi project has distributed improved cooking stoves which using less charcoal and other modern biomass fuels for cooking.	99	4.33	.979	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has promoted domestic companies to develop solutions on expensive cooking fuels by providing improved cooking and saving technologies.	99	5	.000	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Use of alternative energy fuels for cooking							
Green Gicumbi project has promoted use of alternative energy fuels for cooking and people move from firewood to gas and charcoal.	99	4.2	.915	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has made people to reduce quantity of energy being used with adoption of modern biomass energy fuels for cooking.	99	4.11	.426	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has facilitated households in some other categories to adopt new cooking technologies via awareness.	99	4.43	.702	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Acceptance of innovated technology							
Green Gicumbi project has introduced new innovated technology of improved cooking stoves.	99	4.45	.576	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has made people in rural areas to be aware on the importance on use of improved innovated cooking technology “Cana Rumwe”.	99	4.23	.424	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has made people to understand and accept technological change via awareness and activities outcomes, mainly learning from the pioneers of the project.	99	4.45	.704	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Capacity building							
Green Gicumbi project has trained people or beneficiaries and managers on the need of improved cooking technologies as well as the expected outcomes.	99	5	.000	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green Gicumbi project has promoted youth to innovate more technologies in cooking facilitations and this was mainly sensitized in technical schools like polytechnic universities and Technical Vocational Colleges.	99	4.29	1.090	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis

Items assessed	N	Mean	Stdv.	Comment	Test	Sig.	Decision
Green Gicumbi project has created regular field visit and awareness on the role of using less cooking fuels for environmental sustainability purposes.	99	4.12	.500	Strong Homogeneity	One-Sample Chi-Square Test	.044	Reject the null hypothesis

Source: Primary data, August 2023

Keys: *Strongly agree (SA) was coded 5, Agree (A) coded 4, Not Sure (NS) coded 3, Disagree (D) coded 2, and Strongly Disagree (SD) coded 1. The mean classification was into 3 categories such as weak (1.00-2.49), moderate (2.50-3.49) and strong (3.50-5.00) and standard deviation was into two categories such as homogeneity (Stdv. <0.5) and heterogeneity (Stdv. >0.5). N: Total population (respondents), mean: Average of perception from all 99 perceptions as coded in numbers and Stdv: Standard deviation which signify gap between individual perception from the general perception or mean. The null hypothesis was rejected for sig. or p-value less or equal 0.05 or 5% level of significance, once p-value is greater 0.05 or 5% lead to the acceptance of null hypothesis.*

The project has conducted a capacity building on both sides: how to sue improved cooking technologies and alterative cooking fuels and also the extent to which the adoption of these cooking technologies make change in living conditions and facilitate for time and cash savings. The study findings confirm that Green Gicumbi project has trained people or beneficiaries and managers on the need of improved cooking technologies as well as the expected outcomes (mean 5.00; standard deviation 0.000, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis), Green Gicumbi project has promoted youth to innovate more technologies in cooking facilitations and this was mainly sensitized in technical schools like polytechnic universities and Technical Vocational Colleges (mean 4.29; standard deviation 1.090, strong heterogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis) and Green Gicumbi project has created regular field visit and awareness on the role of using less cooking fuels for environmental sustainability purposes (mean 4.12; standard deviation 0.500, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis).

6.2 Perception of respondents on the performance of Gicumbi district in reducing pollution of atmosphere as outcome of improved cooking technologies distribution project case of Gicumbi district, Northern Province, Rwanda

In this section, the researcher has assessed the perception of Green Gicumbi project staff and stakeholders on the extent to which, the implementation of the project has contribution in atmospheric pollution reduction. A total 12 items were assessed under 4 indicators (Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment) and all were developed under the dependent variable (atmospheric pollution). Here below are detailed findings on each item assessed (12 items in total):

Table 3: Perception of respondents on the Performance of atmospheric pollution reduction

Items assessed	N	Mean	Stdv.	Comment	Test	Sig.	Decision
Reduced emissions from biomass usage							
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves CO2 and other gas emissions were reduced in Gicumbi atmosphere.	99	4.41	.756	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves pollutant gas to human respiratory system were reduced mainly in cooking period.	99	4.61	.491	Strong Homogeneity	One-Sample Binomial Test	.044	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves, the quantity of emissions per capita in Gicumbi district was reduced.	99	4.23	.424	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Improved living conditions							
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves people use less energy and this lead to increased savings.	99	4.36	.952	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves people cook less time and their respiratory system were secured from emissions.	99	5	.000	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves, people get more interests and spend less time in collecting fuels and this save lives of children and women who mostly collect firewood from the environment.	99	4.31	1.066	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Behavioral change							

Items assessed	N	Mean	Stdv.	Comment	Test	Sig.	Decision
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves beneficiaries or people in Gicumbi district has fully accepted the new cooking technology.	99	4.09	.476	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves local authorities has adopted and sensitized the new cooking system and technology.	99	4.09	.858	Strong Heterogeneity	One-Sample Binomial Test	.027	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves, people work hard to change cooking fuels and even to adopt more clean cooking stoves like LPG stove and electric cooking stove where possible. And even once the stove is damaged, the household replace itself without waiting free distributed stove.	99	4.62	.489	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Green environment							
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves forest catting for firewood search has reduced.	99	4	.474	Strong Homogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves people plant trees and use less energy while cooking needs are satisfied.	99	4.01	.920	Strong Heterogeneity	One-Sample Chi-Square Test	.000	Reject the null hypothesis
Due to the performance of Green Gicumbi project in distribution of improved cooking stoves plants or environment become free and grow in the nature without disturbances of people looking for firewood for cooking.	99	4.69	.466	Strong Homogeneity	One-Sample Binomial Test	.025	Reject the null hypothesis

Source: Primary data, August 2023

The assessment on the extent to which green Gicumbi project (improved cooking stoves distribution component) has contributed in performance of green environment, findings confirm that due to the performance of Green Gicumbi project in distribution of improved cooking stoves forest catting for firewood search has reduced (mean 4.00; standard deviation 0.474, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis), due to the performance of Green Gicumbi project in distribution of improved cooking stoves people plant trees and use less energy while cooking needs are satisfied (mean 4.01; standard deviation 0.920, strong heterogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis), and due to the performance of Green Gicumbi project in distribution of improved cooking stoves plants or environment become free and grow in the nature without disturbances of people looking for firewood for cooking (mean 4.69; standard deviation 0.466, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis).

6.3 Inferential statistics

As explained in methodology the inferential statistics was made via both bivariate correlation analysis and linear regression model. Both models were made using codes attributed to respondents' perceptions and these codes were used to calculate mean which represent the indicator assessed and the mean of the mean to present the variable assessed (both dependent and independent variable).

Table 4: Independent Bivariate correlation analysis for the study indicators under variables

Correlations						
Tested Variable and Indicator		**Atmospheric pollution**	**Reduced emissions from biomass usage**	**Improved living conditions**	**Behavioral change**	**Green environment**
New cooking energy saving technologies	Pearson Correlation	**.547****	.528	.461	.529*	.351
	Sig. (2-tailed)	**.000**	.005	.046	.022	.036
	N	**99**	**99**	**99**	**99**	**99**
	Pearson Correlation	**.380****	.216*	.632	.579	.572

Correlations						
Tested Variable and Indicator		**Atmospheric pollution**	**Reduced emissions from biomass usage**	**Improved living conditions**	**Behavioral change**	**Green environment**
Use of alternative energy fuels for cooking	Sig. (2-tailed)	**.000**	.032	.004	.006	.009
	N	**99**	**99**	**99**	**99**	**99**
Acceptance of innovated technology	Pearson Correlation	**.382****	.503	.206*	.432	.291**
	Sig. (2-tailed)	**.000**	.010	.041	.007	.001
	N	**99**	99	99	99	99
Capacity building	Pearson Correlation	**.738****	.610	.595**	.352**	.457
	Sig. (2-tailed)	**.000**	.004	.000	.000	.006
	N	**99**	**99**	**99**	**99**	**99**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Primary data, August 2023

Table 4 show that, new cooking energy saving technologies is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment. In other words, new cooking energy saving technologies contribute 54.7% to atmospheric pollution reduction, 52.8% on Reduced emissions from biomass usage, 46.1% Improved living conditions, 52.9% Behavioral change and 35.1% Green environment.

Use of alternative energy fuels for cooking is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment. In other words, Use of alternative energy fuels for cooking contribute 38% to atmospheric pollution reduction, 21.6% on Reduced emissions from biomass usage, 63.2% Improved living conditions, 57.9% Behavioral change and 57.2% Green environment.

Acceptance of innovated technology is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment. In other words, Acceptance of innovated technology contribute 38.2% to atmospheric pollution reduction, 50.3% on Reduced emissions from biomass usage, 20.6% Improved living conditions, 43.2% Behavioral change and 29.1% Green environment.

Capacity building is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment. In other words, Capacity building contribute 73.8% to atmospheric pollution reduction, 61% on Reduced emissions from biomass usage, 59.5% Improved living conditions, 35.2% Behavioral change and 45.7% Green environment.

Table 5: Model Summary

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.889[a]	.790	.781	.0584790

a. Predictors: (Constant), Capacity building, Use of alternative energy fuels for cooking, Acceptance of innovated technology, New cooking energy saving technologies

Source: Primary data, August 2023

As seen from table 5, the model had Adjusted R2 of 0.790, implies that ensuring Improved cooking technologies distribution (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)), indicate that the model is perfectly fit at 79%. R-squared is a measure of how closely the data in a regression line fit the data in the sample. The closer the r-squared value is to 100%, the better the fit. An r-squared value of 0 indicates that the regression line does not fit the data at all, while an r-squared value of 1 indicates a perfect fit.

Table 6: Analysis of Variance (ANOVA)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.210	4	.302	88.455	.000[b]
	Residual	.321	94	.003		

Total	1.531	98

a. Dependent Variable: Atmospheric pollution

b. Predictors: (Constant), Capacity building, Use of alternative energy fuels for cooking, Acceptance of innovated technology, New cooking energy saving technologies

Source: Primary data, August 2023

As seen from table 6, the results show that the model had an F ratio of 88.455 and the P value was 0.000<0.05, signifying that the F ratio was statistically significant, therefore the overall regression model for all the variables tested were statistically significant and can be used for prediction at 1% significant level. This further indicate that the predictors variables (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)) used in this study are statistically significant to performance of Atmospheric pollution reduction (Y). Therefore, it is confirmed that there is a significant and positive influence of Improved cooking technologies distribution (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)) on performance of Atmospheric pollution reduction (Reduced emissions from biomass usage (Y1), Improved living conditions (Y2), Behavioral change (Y3) and Green environment (Y4).

As explained in open discussion for each respondent (Green Gicumbi project on its component of improved cooking stoves distribution stakeholders), Improved cooking technologies distribution was adopted as an outcome of energy efficiency and renewable energies policies, environmental sustainability policies and other national strategies and policies as defined in Sustainable Development Goals (SDGs), Vision 2050 and National Strategy for Transformation 1 (NST1) (WHO, 2020). These improved cooking technologies distribution are linked to the use of non-pollutant cooking technologies and fuels. This targeting for reducing the firewood used in Gicumbi district.

Pollutants of Gicumbi atmosphere are not different from other pollutant of the other areas, these are linked to use of firewood for cooking (around 80% of the households in Gicumbi district use firewood as main cooking fuel). However, there are also more other pollutants but not concerned for this study once they are far from the energies cooking technologies.

Table 7: Summary of coefficients

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	.393	.292		1.345	.002
	New cooking energy saving technologies	.024	.042	.031	.575	.007
	Use of alternative energy fuels for cooking	.312	.029	.521	10.813	.000
	Acceptance of innovated technology	.214	.040	.273	5.353	.000
	Capacity building	.362	.028	.710	12.933	.000

a. Dependent Variable: Atmospheric pollution

Source: Primary data, August 2023

As seen from table 7, the beta (β) sign shows the positive correlation of the independent variable's coefficients over the dependent variable. Table above shows that, beta values for all independent variable indicators are positive meaning positive correlations on the predicted dependent variable. β1=0.024, t=0.575, p=0.007<0.05; β2=0.312, t=10.813, p=0.000<0.05; β31=0.214, t=5.353, p=0.000<0.05 and β4=0.362, t=12.933, p=0.000<0.05. That means, any increase in the independent variables lead to increase in the dependent variable and vice versa. The regression model become as follows:

Y or Performance of Atmospheric pollution reduction = 0.393 + 0.024X1 + 0.312X2 + 0.214X3 + 0.362X4. Thus, the study concluded that ensuring best practices in New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4) have positive correlation on Performance of Atmospheric pollution reduction. In other words, if these determinants are not available, Performance of Atmospheric pollution reduction will be equivalent to 0.393 units.

As explained by the respondents green Gicumbi project on its component of distributing improved cooking stoves among households or population has made positive impact in reducing Gicumbi atmospheric pollution, mainly starting from the users. As explained beneficiaries of distributed improved cooking stoves are safey with reduced CO2 emissions from firewood as by this stove, they use like 1/3 of the quantity were using before. Women and children were spending long time collecting firewood and now this time spend before also was reduced three times, people also are enjoying quick cooking stove and some others also were educated on other alternative cooking stoves and fuels.

6.4 Views of respondents and discussion of findings

In this section the study presents findings on the open questions assessed from 99 respondents. It presents also a comparative of study findings vis a vis the empirical review and study theories.

Types of improved cooking stoves distributed by green Gicumbi project: the stove distributed under Green Gicumbi project is the stove using wood called "Canarumwe". This used less stove and it is movable and it has high efficiency to use less wood and generate

sufficiency energy for make food cooked. This was distributed to lower income people who struggle or don't have forests or income for buying wood for cooking. This good and similar to the assessment of (Sulkowski, 2022) where defined that, if people are increasing and relay on natural resources for surviving, will make stress to the environment and if not managed will create impacts which are harmful to the same population. The current study is weak as it cannot be sufficient to satisfy all the population using wood for cooking in Rwanda (this is the gap of the current study).

Most pollutants of Gicumbi atmosphere: The pollutants of Gicumbi district are not different to the pollutant of the entire Rwanda atmosphere. These include from domestic or household emissions, emissions from infrastructures, emissions from industries, vehicles, etc. Here the main focus under the study are the pollutant of emissions from wood burned while cooking (Jinghua, 2020). The entire study show that the use of improved cooking stoves has reduced the quantity of wood fuels burned for food cooking and now the quantity required was reduced which is also proportional to the emissions saved and this is good for atmospheric pollution reduction. This imply that, distribution of more wood improved stoves increase the number of emissions saved and increase the performance of atmospheric pollution reduction.

Link of the activities or outputs of Green Gicumbi Project on its component of distributing improved cooking stoves among population toward reducing Gicumbi district atmosphere pollution: As defined in the community participation and sustainability theory (Sulkowski, 2022), driving factor to innovation and management theory (Mousa, 2020) and climate change as barriers theory (Jacques, 2023) any person in the world was mobilized to contribute in climate change mitigation process and improvement of quality environment. This why the green Gicumbi project is making distribution of improved cooking stoves, and community accept this change. The study findings has shown that people in Gicumbi district have fully adopted the new cooking technology and it is being utilized in all days for cooking which save the required wood fuels required for cooking and save their money and times as well as their lives where saves their respiratory system from carbon emitted in cooking.

7. Summary of major findings, conclusion and recommendations

This section starts with this introduction, summary of major findings in line with study objectives, conclusion, and recommendations. All are about the effect of internal control components on financial performance of financial institutions in Rwanda. Specifically, in Bank of Kigali Plc.

7.1 Summary of major findings

The work entitled "improved cooking technologies distribution project in reduction of atmosphere pollution. case of green Gicumbi project (component of improved cooking stoves distribution)" was conducted for assessing the validity of four specific objectives such as: to assess the significance of new cooking energy saving technologies on reduction of atmosphere pollution, to evaluate the significance of use of alternative energy fuels for cooking on reduction of atmosphere pollution, to examine the significance of acceptance of innovated technology on reduction of atmosphere pollution and to assess the significance of capacity building on reduction of atmosphere pollution.

This study is census, descriptive, qualitative, and quantitative design. The study was used both primary data and secondary data. 99 respondents as entire population was assessed; the study has adopted census technique. Data was collected using questionnaire and documentation. Analysis of data was performed using SPSS (Statistical Package for Social Scientists) version 20 and results obtained were presented in form of descriptive statistics and inferential statistics. The results were presented as follows:

Reference to the 1st study objective, the findings confirm that Green Gicumbi project has distributed improved cooking stoves which using less firewood for cooking (mean 4.26, standard deviation 0.442, strong homogeneity, p-value = 0.000 using One-Sample Binomial Test and decision Reject the null hypothesis). New cooking energy saving technologies is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment.

Reference to the 2nd study objective, Green Gicumbi project has promoted use of alternative energy fuels for cooking and people move from firewood to gas and charcoal (mean 4.20; standard deviation 0.915, strong heterogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis). Use of alternative energy fuels for cooking is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment.

Reference to the 3rd study objective the findings confirm that, Green Gicumbi project has introduced new innovated technology of improved cooking stoves (mean 4.45; standard deviation 0.576, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis). Acceptance of innovated technology is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment.

Reference to the 4th study objective, the findings confirm that, Green Gicumbi project has created regular field visit and awareness on the role of using less cooking fuels for environmental sustainability purposes (mean 4.12; standard deviation 0.500, strong homogeneity, p-value = 0.000 using One-Sample Chi-Square Test and decision Reject the null hypothesis). Capacity building is statistically significant (all p-values remain less than 0.05 or 5%) to atmospheric pollution reduction, Reduced emissions from biomass usage, Improved living conditions, Behavioral change and Green environment.

7.2 Conclusion

The study was conducted to assess whether there is significant correlation of improved cooking technologies distribution project in reduction of atmosphere pollution reduction in Gicumbi District: Green Gicumbi Project. Indicators tested has shown that the model had an F ratio of 88.455 and the P value was 0.000<0.05, signifying that the F ratio was statistically significant, therefore the overall regression model for all the variables tested were statistically significant and can be used for prediction at 1% significant level. This further indicate that the predictors variables (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)) used in this study are statistically significant to

performance of Atmospheric pollution reduction (Y). Therefore, it is confirmed that there is a significant and positive influence of Improved cooking technologies distribution (New cooking energy saving technologies (X1), Use of alternative energy fuels for cooking (X2), Acceptance of innovated technology (X3) and Capacity building (X4)) on performance of Atmospheric pollution reduction (Reduced emissions from biomass usage (Y1), Improved living conditions (Y2), Behavioral change (Y3) and Green environment (Y4).

7.3 Recommendations

Atmospheric pollution reduction the main target of the world in today's development. Due to that atmospheric pollutant are being prevented in all projects where, no project financed by international organizations without climate mitigation certificate. It is in that context green Gicumbi project was developed and implemented and its impact is significant to atmospheric pollution, however there are still CO2 emissions from the firewood meaning that, both project management and beneficiaries should look on other less emitting fuels like gas, electricity and improved biomass.

The study has seen that; improved cooking technologies are being distributed to some population while 76.1% of households in Rwanda were counted using firewood as main cooking fuel. Due to that project managers and government authorities could develop project covering the whole households, here also there is a need to plan future perspectives for improved technology which is greater than improved wood cooking technologies. Here there is a need of planning for adopting electric cooking technologies and liquefied petroleum gas (LPG).

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