Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

Global Journal of Science Frontier Research: H

Environment & Earth Science

Highlights

- Surface Optimization Analysis
- Kenyan Coastal Riparian Ecosystem
- Carbon Dioxide CO2 Emissions
- Green Spaces in Sana'a Old City

Discovering Thoughts, Inventing Future

VOLUME 22 ISSUE 7 VERSION 1.0

Global Journal of Science Frontier Research: H
Enviornment & Earth Science

Global Journal of Science Frontier Research: H
Enviornment & Earth Science

Volume 22 Issue 7 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*
Sponsors: *Open Association of Research Society*
Open Scientific Standards

Publisher's Headquarters office

Global Journals® Headquarters
945th Concord Streets,
Framingham Massachusetts Pin: 01701,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals Pvt Ltd
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Excluding Air Parcel Charges):

Yearly Subscription (Personal & Institutional)
250 USD (B/W) & 350 USD (Color)

Contents of the Issue

Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 22 Issue 7 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Desirability Function Approach to Response Surface Optimization Analysis of Atmospheric Carbon Dioxide CO_2 Emissions in Africa

By Mohamed Ali Abu Sheha, Christ P. Tsokos & Lohuwa Mamudu

University of South Florida

Abstract- The continuous growing worlds' impact of climate change (global warming), including frequent natural disasters such as earthquakes, wildfires, etc.; rising food insecurity, infectious diseases, etc.; among others, causing economic, political, and civil unrest cannot be downplayed. Carbon dioxide (CO_2) is the most significant contributor to climate change, mainly generate through human-induced industrial and techno logical advancement activities. Africa is most vulnerable to the impact of climate change in the world. Hence, any effort to combat climate change in Africa will be an outstanding achievement towards mitigating the excessive effect of climate change globally. We proposed a surface response optimization method to optimize (mini mize) the CO_2 emissions in Africa. We utilized the desirability function approach to obtain the optimum value of the risk factors that minimize Africa's CO_2 emissions. The minimum value of the CO_2 was obtained along with a 95% confidence region.

GJSFR-H Classification: *DDC Code: 363.73874 LCC Code: QC879.8*

DESIRABILITYFUNCTIONAPPROACHTORESPONSESURFACEOPTIMIZATIONANALYSISOFATMOSPHERICCARBONDIOXIDECOEMISSIONSINAFRICA

Strictly as per the compliance and regulations of:

Desirability Function Approach to Response Surface Optimization Analysis of Atmospheric Carbon Dioxide CO_2 Emissions in Africa

Mohamed Ali Abu Sheha [α], Christ P. Tsokos [σ] & Lohuwa Mamudu [ρ]

Abstract- The continuous growing worlds' impact of climate change (global warming), including frequent natural disasters such as earthquakes, wildfires, etc.; rising food insecurity, infectious diseases, etc.; among others, causing economic, political, and civil unrest cannot be downplayed. Carbon dioxide (CO_2) is the most significant contributor to climate change, mainly generate through human-induced industrial and techno logical advancement activities. Africa is most vulnerable to the impact of climate change in the world. Hence, any effort to combat climate change in Africa will be an outstanding achievement towards mitigating the excessive effect of climate change globally. We proposed a surface response optimization method to optimize (mini mize) the CO_2 emissions in Africa. We utilized the desirability function approach to obtain the optimum value of the risk factors that minimize Africa's CO_2 emissions. The minimum value of the CO_2 was obtained along with a 95% confidence region.

Also, the bivariate interaction effect of the risk factors on the CO_2 was obtained. The optimization process is well-validated to satisfies the necessary conditions, achieving a desirability function of 0.99. The proposed method provides a robust mitigating approach towards combating CO_2 emission, limiting the impact of climate change in Africa and its impact on the world. The subject of essential findings is based on the very high quality of a predictive real data-driven statistical model developed by the authors that identify the significant risk factors and interactions that produce CO_2 emissions in the atmosphere.

I. Introduction

Global warming, also called climate change, is mainly a human-caused rise of the Earth's climate system's average temperature. It is a long-growing global concern politically and economically. It is driven by the greenhouse effect caused by human emissions of harmful gases and wild weather patterns. The physical and natural occurrences causing global warming are inevitable and unequivocal. However, when these occurrences or activities become excessive, our planet earth and the ecosystem's inhabitants pose a danger. Carbon dioxide CO_2 has been identified as the greatest contributor to global climate change, contributing 76% greenhouse gas emissions (GHG) through human activities. Other gases include methane (CH4), contributing 16%, nitrous oxide (N2O) contributing 7%, and fluorinated gases (F-gases) 2%, which include hydrofluorocarbons (HFCs), per-fluorocarbons (PFCs), and sulfur hex afluoride (SF6) [1]. In 2010, the economic activities resulting in global GHG emissions includes electricity and heat production (25%); industry (21%); agriculture, forest, and other land use (24%); transportation (14%); building (6%); and other energy (10%) [20, 21].

Noticeably, the use of fossil fuel is the primary source of CO_2. Other activities resulting in the emission of CO_2 are direct human-induced impacts on the use of land and forest, such as land degradation and deforestation for agricultural purposes [1]. Moreover, the swift increase in climate change is due to the rapidly growing civilization, industrialization, and technological advancement in which Africa is not exempted. In 2014, China, the United States, the European Union, India, the Russian Federation, and Japan were the world's top CO_2 emitters. The primary sources of CO_2 emissions were fossil fuel combustion and cement manufacturing, and gas flaring, representing a large proportion of total global CO_2 emissions [20]. The Inter governmental Panel on Climate Change (IPCC) has notified Africa to be among the most vulnerable continents to climate change [7], mainly due to weak adaptive ca pacity, over-reliance on the ecosystem for livelihood, and less developed agricultural production systems [8], prompting the risk or threat on lives and the sustainable development prospects in Africa [9].

The consequences of climate change can be tremendously dreadful and unprecedented. Most parts of the world are already experiencing and suffering from the impact of climate change, including growing natural disasters such as earthquakes and tsunamis like the 2004 Indian ocean earthquake and tsunami that swept an entire city of Indonesia, killing hundreds of thousands of people and destroying several infrastructures [5]; floodings; hurricanes; volcanic eruptions; a sharp rise in oceans, seas, and earth temperature; wildfires like the Amazon rainforest wildfire in 2019 [3] and 2020 California wildfire [4]; heatwaves; increasing deserts; and many others [6].

Author α σ: Department of Mathematics and Statistics, University of South Florida, Tampa, FL. e-mails: mabusheha@usf.edu, ctsokos@usf.edu
Author ρ: Department of Mathematics and Statistics, University of South Florida, Tampa, FL, Department of Public Health, California State University, Fullerton, CA.

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022 1

Many abrupt effects of climate change have been seen in the past and now with the rising current warming level around 1.1˚C (2.0 °F) [10]. Climate change impacts have been projected to increase significantly according to a series of reports by the IPCC as warming continues to 1.5˚C (2.7 °F) and beyond [11]. A report by NASA shows 2016 was the warmest year since 1880. Figure 1 was published by NASA, which shows a continued rising global temperature trajectory [12].

Although there is a continuous global fight against global warming, the causes and the impact vary from country to country, and so should the mitigation process. For instance, the United Nations fact sheet on climate change reported in 2006 that Africa is the most vulnerable to climate change, and its impact has a direct effect on the lives of the people in Africa. They further reported that Africa has warmed by 0.7˚C during the 20th century and project that average surface temperatures in Africa could increase from 2 – 6˚C by 2100 [13]. The statistics are alarming and endangering millions of lives if nothing is done. Hence, the need for strong mitigating efforts to fight climate change in Africa. The most vulnerable African countries are the Seychelles Islands, Cape Verde, and Mauritius and large African deltas such as the Niger Delta, Nile Delta in Egypt, the Kalahari, and Okavango Deltas in Botswana. This means that climate change must be taken more seriously and tackled within the African Continent setting rather than the global setting. The bottom-top mitigating strategy will be a more effective and efficient policy in combating global warming. Thus, the fight against climate change should start from country to continent to global and not otherwise, because the cause, effect, and impact varies from country to country and continent to continent.

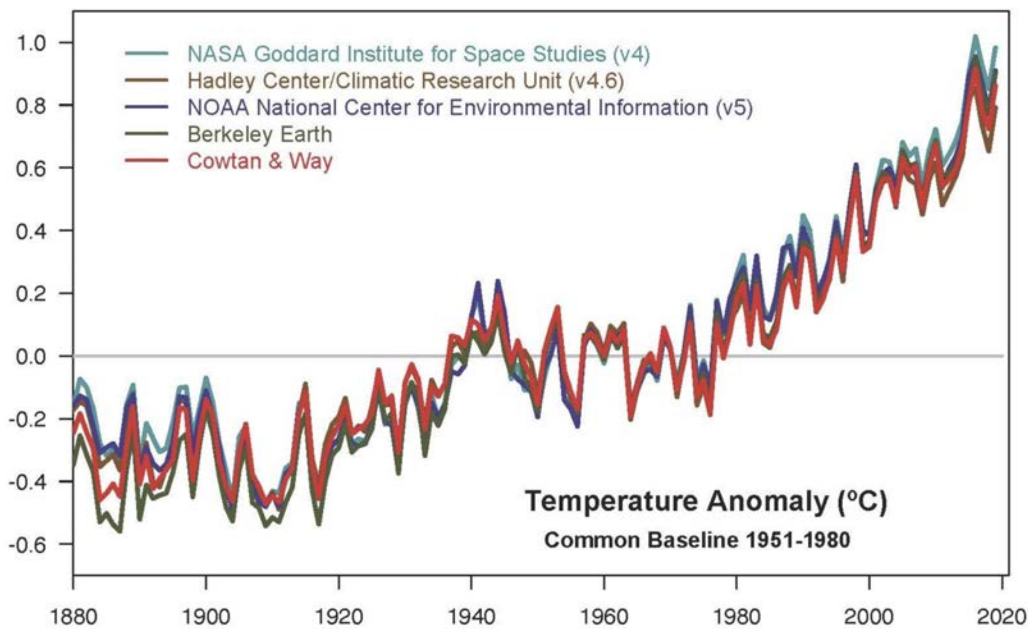


Figure 1: Temperature Data Showing Rapid Warming in the Past Few Decades, the Latest Data Going up to 2019

Admittedly, the mitigation against climate change is a global fight. However, it is only feasible if individual continents and countries play a major independent role in the mitigation process from within. The mitigation course requires great efforts, including research, policies to reduce fossil fuel emissions, developing and adopting low-carbon energy technologies, enhancing reforestation, forest preservation, and energy efficiency. Given that CO_2 is the most significant driver of climate change contributing to 76% of the world's global warming [1], most research to curb global warming has focused on CO2 and remedies to minimize its excessive emission [14] [17]. The increasing use of fossil fuels is the major contributor to CO_2 emissions in the atmosphere.

The current study is about CO_2 minimization in Africa. As mentioned earlier, Africa turns out to be the most at risk in the event of excessive climate change. Most African countries are third-world countries lacking the advanced technologies to combat the impact of climate change. The IPCC predicts a persistent increase in water stress among millions of people in Africa due to climate variability and change [7]. Surface runoff and water availability are directly affected by changes in precipitation patterns [25]. The public health systems are least efficient in African countries globally, the World Health Organization [19]. African countries are highly susceptible to infectious diseases such as malaria, dengue fever, meningitis, schistosomiasis, etc., especially in the Sub-Saharan African region. These diseases continue to exacerbate and are very sensitive to climate variability [25]. Many African countries are already suffering from the impact of climate change, including the rising food insecurity and inadequate or lack of water (especially hygiene water), the increasing mortality rate (especially infant mortality), malnutrition, among others. The combat against climate change in Africa must be taken highly seriously and should not be underestimated. Therefore, it is imperative to research CO_2 emissions in Africa to combat climate change, Africa. As a contribution to mitigating the excessive emissions of CO_2 in Africa, the world at large, Abu Sheha, M. and Tsokos, C. (2019) developed a statistical model of fos sil fuel emission factors contributing to atmospheric carbon dioxide in Africa. They found Liquid fuels (Li), Solid fuels (So), Gas fuels (Ga), Gas flares (Gf), and Cement production (Ce), and seven interaction factors among them to be significant contributions to fossil fuel emissions. Also, they showed the rank of the risk factors' contribution to CO_2 emissions on the Africa map [16]. The present study focused on building upon the model they developed. Thus, in the present study, we employed the desirability function approach to surface response optimization anal ysis of the CO_2 emissions based on the identified risk factors. Our objective is to obtain the optimal or minimum value of the CO_2 by identifying the individual risk factors' optimum value and interactions along with their weights. Lohuwa Mamudu and Chris P Tsokos [23] applied the desirability function approach to optimize corn production returns in the United States (US). However, this study's methods use the *single response surface optimization (SRSO)* and *desirability function approach (DFA)* to optimize Africa's atmospheric carbon dioxide emissions. We also obtained the 95% confidence region of CO_2 for which the hypothesis of the amount of carbon dioxide emissions in Africa can be accessed. The optimization method used has been well-validated and satisfies all necessary conditions utilizing the desirability function, R^2, R^2_{adj} , and R^2_{pred} statistic, and the 95% confidence interval (CI) and prediction interval (PI) of the optimal values.

The data used in this study was obtained from Oak Ridge National Lab (Division of US Department of Energy), consisting of the amount of atmospheric CO_2 emissions in metric tons (MT) along with five risk factors from 1964 to 2014. Figure 2 shows the time series trend of CO_2 emissions in Africa's atmosphere from 1964 to 2014, which is generally increasing.

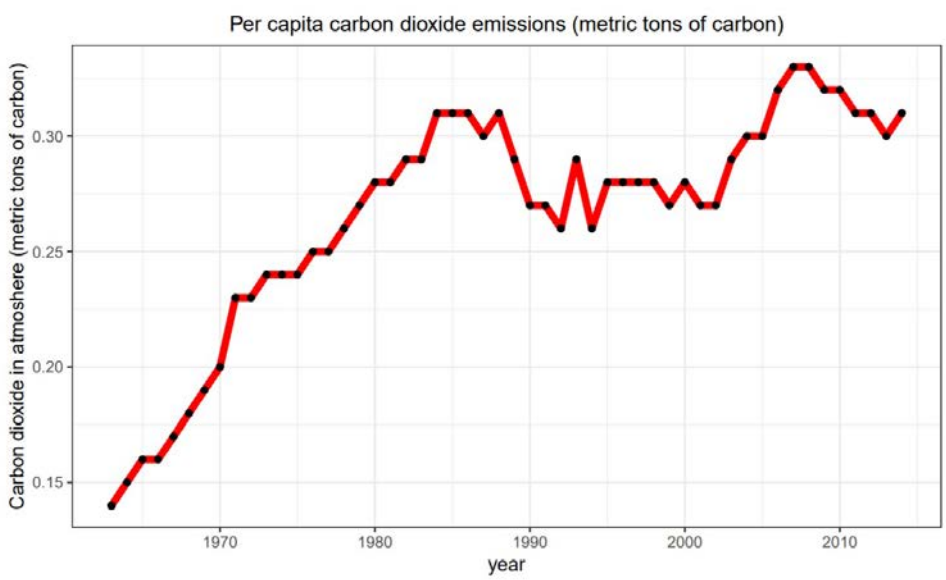


Figure 2: Annual CO_2 Emission in Africa in Metric Tons from 1964 to 2014

II. Method and Results

a) Overview of Desirability Function Approach

In the present study, we utilized the desirability function approach to optimize atmospheric carbon dioxide emissions in Africa. The desirability function approach is a commonly used optimization method that assigns values to a set of responses and chooses the factors that optimize the response's values. [24] proposed the different desirability function classes to optimize the response by obtaining the minimum, max imum, or target values. The method uses the constraints of the factors or predictors, x, and obtain optimum values of x that provide the best-desired value of the response, y. The objective of the optimization process is to maximize, minimize, or obtain a target value of the response, y_i with desirability function $d_i(y_i)$. $d_i(y_i)$ assigns a score between 0 and 1 for each value of y_i, where $d_i(y_i) = 0$ is the most undesired values of y_i and $d_i(y_i) = 1$ is the most desired value of y_i. Thus, as $d_i(y_i)$ approaches 1, the more y_i approaches the optimal point. For example, $d_1(y_1) = 0.75$ gives a more desire optimal value of y_1 than $d_1(y_1) = 0.60$. The following are the three-desirability function we can obtain based on the objective of our optimization process.

If the optimization process is to obtain the target value of the response, y_i for a set of values of predictor variables x_i, then the desirability function approach (DFA) $d_i(y_i)$ is given by

$$d_i(\hat{y}_i) = \begin{cases} 0, & \hat{y}_i(x) < l_i \\ \left(\frac{\hat{y}_i(x)-l_i}{t_i-l_i}\right)^{\tau_1}, & l_i \leq \hat{y}_i(x) \leq t_i \\ \left(\frac{u_i-\hat{y}_i(x)}{u_i-t_i}\right)^{\tau_2}, & t_i \leq \hat{y}_i(x) \leq u_i \\ 0, & \hat{y}_i(x) > u_i. \end{cases} \quad (1)$$

Thus; if the optimization process is to maximize the value of the response, y_i for a set of values of predictor variables x_i, then the estimated desirability function $d_i(y_i)$ is given by

$$d_i(\hat{y}_i) = \begin{cases} 0, & \hat{y}_i(x) < l_i \\ \left(\frac{\hat{y}_i(x)-l_i}{t_i-l_i}\right)^{\tau}, & l_i \leq \hat{y}_i(x) \leq t_i \\ 1, & \hat{y}_i(x) > t_i. \end{cases} \quad (2)$$

If the optimization process is to minimize the value of the response, y_i for a set of values of predictor variables x_i, then the estimated desirability function $d_i(y_i)$ is given by

$$d_i(\hat{y}_i) = \begin{cases} 1, & \hat{y}_i(x) < t_i \\ \left(\frac{u_i-\hat{y}_i(x)}{u_i-t_i}\right)^{\tau}, & t_j \leq \hat{y}_i(x) \leq u_i \\ 0, & \hat{y}_i(x) > u_i. \end{cases} \quad (3)$$

where τ_1, τ_2, and τ are the weights that define the shape of the desirability function $d_i(\hat{}y_i)$. In equation (1), if $\tau_1 = \tau_2 = 1$. It means that the shape of $d_i(\hat{}y_i)$ is positively linear; for a concave shape, $\tau_1 > 1$ and $\tau_2 > 1$; and for convex shape, $\tau_1 < 1$ and $\tau_2 < 1$. In equation (2), t_i denotes the large enough value of the response variable and $t_i$in equation (3), represents the small enough value of the response. Furthermore, t_i, l_i, and u_i are the desired target values, lower values, and upper values for the response variable y_i, respectively. To obtain the overall desirability function D, we utilize the geometric mean of a combined function of individual desirability's $d_i(\hat{}y_i)$, given by

$$D = \left[\prod_{i=1}^{c} d_i(\hat{y}_i)\right]^{1/c} = [d_1(\hat{y}_1)d_2(\hat{y}_2)...d_c(\hat{y}_c)]^{1/c}. \quad (4)$$

where c represents the estimated number of responses, $\hat{}y$. Note that the optimization of a single response variable for a set of controllable factors or risk factors is known as a single response optimization. Whereas the optimization of two or more responses is known as multiple response optimization.

b) *Statistical Analysis for Optimization of Atmospheric Carbon Dioxide CO_2 Emissions in Africa*

We adopt the following algorithmic procedure to optimize a given phenomenon's response based on the desirability function approach.

1. Develop the model that accurately predicts the response y for a set of control lable risk factors or predictors x_i.
2. Obtain the constraints of the response and input factors, for $a < y_i < b$ and $c < x_i < d$.
3. Define the desirability function(s) $d_i(y_i)$ for the response(s) based on the opti mization objective.
4. Obtain the optimal value of the response by maximizing the desirability function concerning the controllable input factors.
5. Validate the optimization process based on the coefficient of variation R^2 and the prediction accuracy R^2_{pred}.

The following are the results obtained in the optimization process of the atmospheric carbon dioxide emission in Africa using the desirability function approach based on the stated algorithm. The objective is to minimize or obtain the minimum CO_2 emissions with respect to the controllable input variable or risk factors Li, So, Ce, Ga, and Gf. In equation 5 below, we obtained a statistical model that predicts CO_2 missions in Africa with R^2 of 97%. We then obtained the constraints of the response and the input factors, as shown in Table 1. Using the defined desirability function as given by in equation 3, we optimize the CO_2 by obtaining the minimum CO_2 with a maximum desirability function, $d(CO\hat{}2) = 0.99$, R^2 along with R^2_{adj} of 98.97% and 98.42%, respectively, and R^2_{pred} of 97.71%, as shown in Table 3. In Table 2, we display the attained minimum values of the CO_2 along with the corresponding optimum values of the input factors. We further obtained a 95% confidence region and predictive interval for the attained minimum value of CO_2 emissions in Africa, as shown in Table 3, below.

$$\begin{aligned}\hat{CO_2} = &-0.0656 + 0.18 \times 10^{-3} So + 0.115 \times 10^{-3} Li - 0.882 \times 10^{-5} Ga \\ &-0.195 \times 10^{-3} Ce + 0.126 \times 10^{-3} Gf - 0.13 \times 10^{-8} So.Li \\ &-0.468 \times 10^{-8} So.Ga + 0.184 \times 10^{-7} So.Ce \\ &-0.615 \times 10^{-8} So.Gf + 0.561 \times 10^{-8} Li.Ga \\ &-0.114 \times 10^{-7} Li.Ce + 0.572 \times 10^{-8} Ce.Gf. \end{aligned} \tag{5}$$

See [16] for the development of this statistical model.

Table 1: The Constraints of the Response and Risk Factors.

Response (CO_2) in metric tons per capita	**Input Risk Factors**
$0.14 \le CO_2 \le 0.33$	$16537 \le Li \le 125427$
	$29800 \le So \le 124526$
	$1320 \le Ce \le 23631$
	$196 \le Ga \le 67972$
	$313 \le Gf \le 23942$

Table 2: The Minimum Value of the Response and Optimum Value of the Risk Factors

$\hat{CO_2}$	Li	So	Ce	Ga	Gf
-1.13973	16537	29800	23631	67972	313

Also in the Appendix, we display in Figures 3 and 4 a contour plots and their corresponding 3D plots of the combination of two risk factors in maximizing the response holding other risk factors constant.

Table 3: Validation of the Optimization Process and Confidence Regions of the Optimal CO2 Emissions

R-sq	R-sq(adj)	R-sq(pred)	$d(\hat{CO_2})$	95% CI	95% PI
98.79%	98.42%	97.71%	0.99	((-1.386, -0.893)	(-1.387, -0.893)

The validation results attest to the excellent results of obtaining the optimum values of the risk factors that will minimize the output of CO_2 emissions.

III. Discussion

Climate change (global warming) has become the world's greatest problem in recent years. On top of this, no sufficient human or national action has been taken to address climate changes. The United Nations Environment (UN Environment) IPCC outlined climate changes as the defining issue of our time, causing a change in the weather patterns that threatens food production, causing widespread food insecurity, and rising sea level that increases the risk of catastrophic flooding [25], among others. The IPCC further reported that carbon dioxide CO_2, mainly from burning fossil fuel, contributes to two-thirds of greenhouse gas (GHG) emissions. Similarly, the European Environment Agency pointed out climate change as one of the biggest challenges of our time, stating that climate change is already happening with evidence of rising temperatures, drought and wildfires, a shift in rainfall patterns, melting of glacier and snow, and drastic increases in the mean sea level [26]. They further postulated that we could mitigate or reduce climate change by decreasing or preventing the emission of human-linked activities. In 2019, MIT Sloan School Management reported the five biggest challenges of fighting climate change [27]. They mentioned that climate change is a global threat and requires superhuman sacrifice and awareness to address it. They further pointed out that CO_2 is globally polluted and cannot be locally contained.

Given that CO_2 is the biggest threat or risk factor of climate change, most mit igation factors and efforts must reduce CO_2 emissions. The interesting question is, what minimum value of CO_2 emission can be considered less or no threat to climate change or global warming? In the present study, we utilized the desirability function approach of response surface optimization to optimize the atmospheric CO_2 emission in Africa, achieving the minimum value of CO_2 needed as a mitigating factor for climate change -1.13973. The optimal value for CO_2 was attaining after develop ing a high-quality predictive model of CO_2 with an R2 of 97.28%, identifying five individual risk factors and seven interaction terms [16]. We proceeded with the op timization process by obtaining the five individual risk factors' constraints and the response CO_2, as given in Table 1. We then utilized the desirability function method to obtain the minimal value of CO_2, maximizing the value of the desirability func tion. The optimization algorithm resulted in the minimum value of CO_2 emission in Africa of -1.13973 and a maximum desirability value of 0.99. Thus, implying that the controllable risk factors are 99% effective in explaining the attained minimum value of CO_2. The CO_2 of -1.13973 is the minimum value Africa needs to achieve to reduce or control climate change. Our results are consistent with reports by [28], [29], who reported that negative emissions are needed to stabilize global warming to 1.5 degrees Celsius. Almost all studies on pathways to achieving the global warming of 1.5°C in the special report by the Intergovernmental Panel on Climate Change (IPCC) reveal carbon removal to achieve net negative emission is the best approach. Therefore, the minimum negative value of CO_2 emission is ideal for Africa to curb climate change, contributing to stable global warming.

The probability of obtaining the minimum value of CO_2 of exactly -1.13973 seems not feasible. Therefore, we obtained a confidence region of (-1.386, -0.893) along with a predictive interval of (-1.387, -0.893), which gives us 95% confidence in capturing the minimum value of CO_2 emissions. The resulting R^2 at the end of the optimization process was 0.9879, approximately equal to the R^2 of the original model, attesting to the robustness and high quality of the optimization process we performed. Also, the optimization process resulted in a predictive accuracy of 97.71%, as given in Table 3. From Table 2, to attain the minimum value of CO_2 of -1.13973 required the combination of the optimal value of Liquid fuels of 16537, Solid fuels of 16537, Gas fuels (Ga) of 67972, Gas flares (Gf) of 313, and Cement production (Ce) of 23631. Combining the controllable factor needed to attain the optimal value of CO_2 may vary from data to data. However, the Optimal value of CO_2 should be within the limit of the confidence region. The individual risk factors Ga and Ce, including the interactions, $So \cap Li$, $So \cap Ga$, $So \cap Gf$, and $Li \cap Ce$ are negatively associated with the atmospheric CO_2 emissions. Whereas the individual significant risk factor So, Li, and Gf with interactions $So \cap Ce$, $Li \cap Ga$, and $Ce \cap Gf$ are positively related to CO_2. The finding of So and Li as positively associated with CO_2 emissions in Africa is consistent with South Korea's result by D. Kim and C. P. Tsokos [30].

Similarly, Ga's finding as negatively associated with CO_2 emission in Africa is consistent with the results in South Korea and the USA by Yong Xu, Chris P. Tsokos (2013) [17]. In contrast with the USA's findings [17], Ce was found to influence Africa's CO_2 emission negatively. Also, we displayed contour and 3D plots showing the combination of the controllable or attributable factor impact on CO_2 emissions in Africa. The blue-colored region of the contour plots is a region of minimization of CO_2 emission. Thus, the deeper the blue color, the closer the approach to the optimal or minimum region of CO_2 emissions. For example, by reducing Li and So in the first contour plot, we minimize CO_2 emission.

Although mitigation against climate change is a global responsibility, we believe that every country/continent has an independent role to perform if we are to achieve the optimal level of CO_2, which is harmless to our globe. The rate of atmospheric CO_2 emissions and contributing risk factors vary from country to country or continent to continent, with some experiencing higher emissions than others. Therefore, different mitigation policies and efforts will be required. Although a global push for accelerated climate change mitigation is needed, enacting, and implementing policy relevant should be left in the hands of individual countries or continents. Thus, given that an optimal (minimum) CO_2 emissions of -1.13973 within a confidence region of (-1.386, -0.893) needs to be attained to stabilize the impact on global warming in Africa, this may differ from the required minimum emission of CO_2 in other conti nents. As a result, this study is only applicable to global warming policy intervention in Africa. However, the methodology or approach can be applied to find the minimum CO_2 emissions for other countries or continents. The optimization algorithm allows to set the CO_2 to a specific target value and obtain the values of each attributable variable needed to achieve the target value. The present study provides a strategy for controlling CO_2 emissions in Africa, hence a mitigating strategy for controlling climate change or global warming.

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022

IV. Conclusion

In the present study, we achieved five important major uses of the response surface optimization method to minimize the atmospheric CO_2 emissions in Africa. First, the desirability function approach was utilized to determine the attributable variables' values that minimize Africa's CO_2 emissions. Second, we identified the minimum value of -1.13973 CO_2 emission in Africa's atmosphere using a data-driven statistical model with an R2 of 97.28% obtained using real data from 1964 to 2014. Third, we also identified a 95% confidence region for the attained minimum value of CO_2 of (-1.386, -0.893), which can be used to assess the statistical significance of the optimal/minimum value of CO_2 emissions. Fourth, the bivariate interaction effect on atmospheric CO_2 emissions was obtained, including 3D and contour plots to assess the combination of individual risk factors' impact on atmospheric CO_2 emissions in Africa. Lastly, the optimization process is well-validated to satisfy the necessary conditions, achieving an excellent desirability function of 0.99.

Given the IPCC goal of meeting 1.5°C of global warming, our finding of the minimum value of -1.13973 provides Africa with a real direction, a set goal, and a policy intervention strategy to mitigate climate changes, a contribution effort to fighting global warming. The results obtained from this study are only applicable to the Africa continent and cannot be generalized. However, the optimization approach or algorithm can be applied to CO_2 data from other continents that have been statically modeled to identify the risk factors and interactions to assess the needed minimum value of CO_2 emission.

References Références Referencias

1. United States Environmental Protection Agency (2020). Overview of Greenhouse Gases, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data
2. Climate Change: Vital Signs of the Planet (28 March 2020). Scientific Consensus: Earth's Climate is Warming, https://climate.nasa.gov/scientific-consensus/
3. BBC News (August 21, 2019). Record number of fires' in Brazilian rainforest, https://www.bbc.com/news/world-latin-america-49415973
4. Center for Disaster Philanthropy (23 September 2020). 2020 North American Wildfire Season, https://disasterphilanthropy.org/disaster/2020-california-wildfires/
5. Lay, Thorne and Kanamori, Hiroo and Ammon, Charles J. and Nettles, Meredith and Ward, Steven N. and Aster, Richard C. and Beck, Susan L. and Bilek, Susan L. and Brudzinski, Michael R. and Butler, Rhett and DeShon, Heather R. and Ekström, Göran and Satake, Kenji and Sipkin, Stuart (2005) The Great Sumatra-Andaman Earthquake of 26 December 2004, American Association for the Advancement of Science, Science, Vol. 308, No. 5725, 1127–1133. https: //doi.org/10.1126/science.1112250
6. Paolo D'Odorico and Abinash Bhattachan and Kyle F. Davis and Sujith Ravi and Christiane W. Runyan (2013) Global desertification: Drivers and feedbacks, Advances in Water Resources, Vol. 51, 326-344. https://doi.org/10.1016/j.advwatres.2012.01.013
7. Schneider, SH and Semenov, S and Patwardhan, A and Burton, I and Maga dza, CHD and Oppenheimer, M and Pittock, AB and Rahman, A and Smith, JB and Suarez, A and others (2007) Assessing key vulnerabilities and the risk from climate change. Climate Change 2007: Impacts, Adaptation and Vulner ability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. ML Parry, OF Canziani, JP Palutikof, PJ van der Linden, and CE Hanson, Eds,Cambridge University Press, Cambridge, UK, 779–810.
8. Ofoegbu, Chidiebere and Chirwa, Paxie W (2019) Analysis of rural people's attitude towards the management of tribal forests in South Africa, Taylor & Francis, Journal of Sustainable Forestry, Vol. 38, No. 4, 396–411. https://doi.org/10.1080/10549811.2018.1554495
9. Intergovernmental Panel on Climate Change (2014) Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part B: Regional Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report, Cambridge University Press, Vol. 2, 1199–1266. https://doi.org/10.1017/CBO9781107415386.002
10. Rebecca Lindsey and LuAnn Dahlman (August 14, 2020) Climate Change: Global Temperature, https://www.climate.gov/news-features/understand-ding-climate/climate-change-global-temperature
11. Masson-Delmotte, Valérie and Zhai, Panmao and Pörtner, Hans-Otto and Roberts, Debra and Skea, Jim and Shukla, Priyadarshi R and Pirani, Anna and Moufouma-Okia, W and P´ean, C and Pidcock, R and oth ers (2018). Global warming of 1.5°C, An IPCC special report on the impacts. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_HR.pdf
12. Climate Change: Vital Signs of the Planet (28 March 2020), Scientific Consensus: Earth's Climate is Warming,https://climate.nasa.gov/scientific-consensus/
13. United Nations (2006), United Nations Fact Sheet on Climate Change.
14. Worrell, Ernst and Price, Lynn and Martin, Nathan and Hendriks, Chris and Meida, Leticia Ozawa (2001) Carbon dioxide emissions from the global

cement industry, Annual Reviews 4139 El Camino Way, PO Box 10139, Palo Alto, CA 94303-0139, USA, Annual review of energy and the environment, Vol. 26, No. 1, 303–329.
15. Raich, James W and Potter, Christopher S (1995) Global patterns of carbon dioxide emissions from soils, Wiley Online Library, Global biogeochemical cycles, Vol. 9, No. 1, 23–36. https://doi.org/10.1029/94GB02723
16. Sheha, Mohamed Ali Abu and Tsokos, Christ P (2019) Statistical Modeling of Emission Factors of Fossil Fuels Contributing to Atmospheric Carbon Dioxide in Africa, Scientific Research Publishing, Atmospheric and Climate Sciences, Vol. 9, No. 3, 438–455. https://doi.org/10.4236/acs.2019.93030
17. Xu, Yong and Tsokos, C P. (2013) Attributable variables with interactions that contribute to carbon dioxide in the atmosphere, Frontiers in Science, Vol. 3, No. 1, 6–13. https://doi.org/10.5923/j.fs.20130301.02
18. Fowler, Hayley J and Blenkinsop, Stephen and Tebaldi, Claudia (2007) Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling, Wiley Online Library, International Jour nal of Climatology: A Journal of the Royal Meteorological Society, Vol. 27, No. 12, 1547–1578. https://doi.org/10.1002/joc.1556
19. Sambo, Luis Gomes and World Health Organization and others (2014) The health of the people: what works: the African Regional Health Report 2014, World Health Organization.
20. Change, IPCC Climate and others (2014) Mitigation of climate change, Contribution of Working Group III to the Fifth Assessment Report of the Intergovern mental Panel on Climate Change, Vol. 1454.
21. Tubiello, FN and Salvatore, M and Cóndor Golec, RD and Ferrara, A and Rossi, S and Biancalani, R and Federici, S and Jacobs, H and Flammini, A (2014) Agriculture, forestry and other land use emissions by sources and removals by sinks, Rome, Italy.
22. Pachauri, Rajendra K and Allen, Myles R and Barros, Vicente R and Broome, John and Cramer, Wolfgang and Christ, Renate and Church, John A and Clarke, Leon and Dahe, Qin and Dasgupta, Purnamita and others (2014) Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland, 151 pp.hdl:10013/epic.45156
23. Mamudu Lohuwa, Tsokos Chris P (2020) Response Surface Optimization of the Returns from Corn Production in the US Using the Desirability Function Approach,Under US Pattern Review.
24. Derringer, George and Suich, Ronald (1980) Simultaneous optimization of several response variables, Taylor & Francis, Journal of quality technology, Vol. 12, No. 4, 214–219. https://doi.org/10.1080/00224065.1980.11980968
25. Fowler, Hayley J and Blenkinsop, Stephen and Tebaldi, Claudia (2007) Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling, Wiley Online Library, International Journal of Climatology: A Journal of the Royal Meteorological Society, Vol. 27, No. 12, 1547–1578. https://doi.org/10.1002/joc.1556
26. Fanelli, Carlo (2014) Climate Change: 'The Greatest Challenge of Our Time, Alternate Routes: A Journal of Critical Social Research, Vol. 25. http://www.alternateroutes.ca/index.php/ar/article/view/20592
27. Kara Baskin (Dec 27, 2019). The 5 greatest challenges to fighting climate changes, https://mitsloan.mit.edu/ideas-made-to-matter/5-greatest-challenges-to-fighting-climate-change
28. de Coninck, Heleen and Revi, Aromar and Babiker, Mustafa and Bertoldi, Paolo and Buckeridge, Marcos and Cartwright, Anton and Dong, Wenjie and Ford, James and Fuss, Sabine and Hourcade, J-C and others (2018) Strengthening and implementing the global response, Inter-governmental Panel on Climate Change. http://pure.iiasa.ac.at/15516
29. Energy and Climate Intelligence Unit, London (17 Sep 2018). Negative emissions: why, what, how?, https://ca1-eci.edcdn.com/briefings-documents/Negative-emissions-PDF-compressed.pdf?mtime=20190529123951&focal= none
30. Kim, D and Tsokos, C P. (2013) Statistical Significance of Fossil Fuels Contributing to Atmospheric Carbon Dioxide in South Korea and Comparisons with USA and EU, Journal of Applied Statistical Science, Vol. 21, No. 4, 337-347.

Appendix A

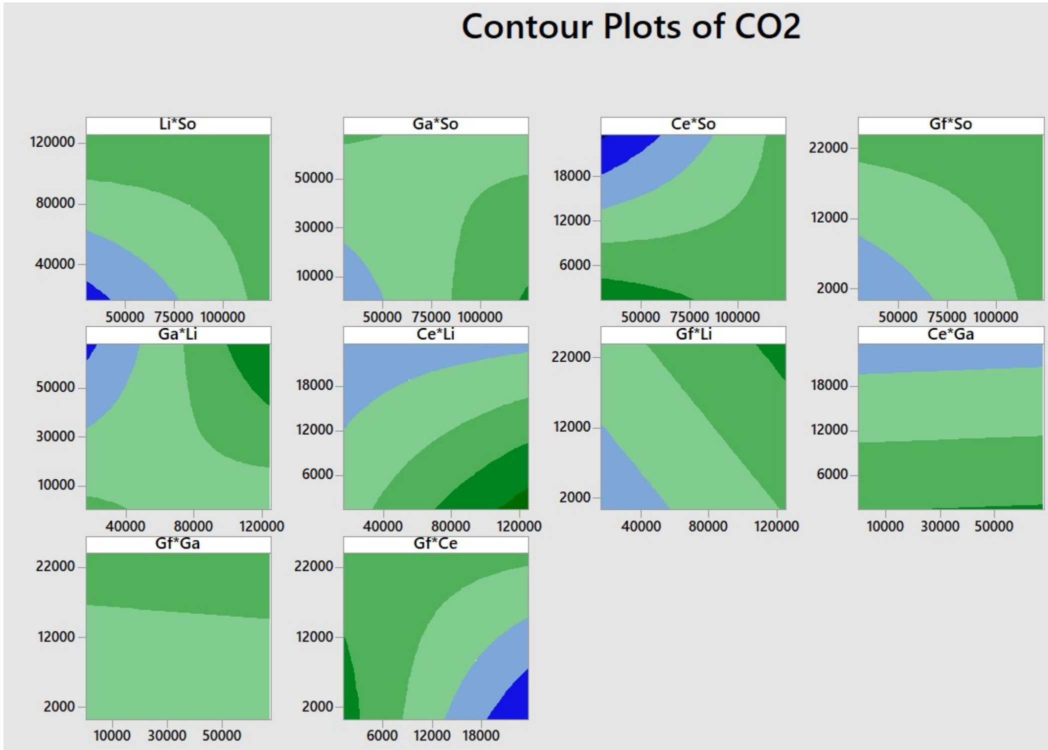


Figure 3: Contour Plots of CO_2 Emission in Africa in Metric Tons

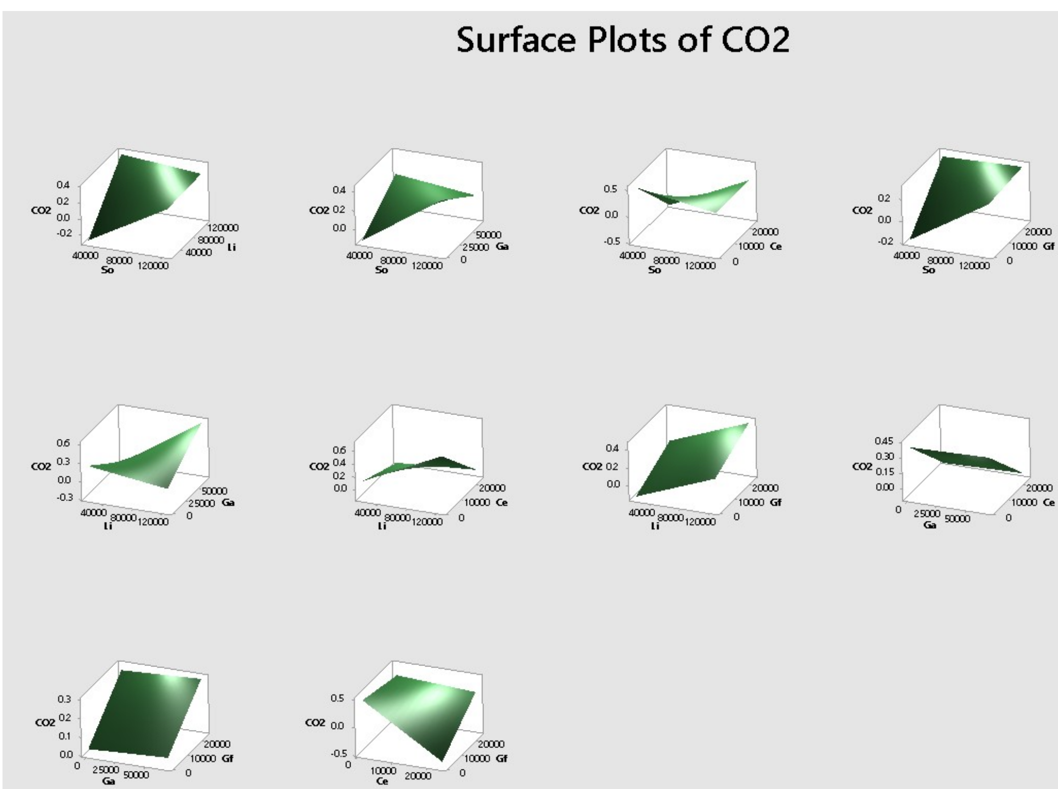


Figure 4: Surface Plots of CO_2 Emission in Africa in Metric Tons

This page is intentionally left blank

Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 22 Issue 7 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Green Spaces in Sana'a Old City – Yemen between Past to Present

By Samira Saleh Hussein AlShawesh & Nada Ibraheem Al-Abyad
Sana'a University

Abstract- The presence of nature was evident in the cities and villages of Yemen - a country located on the southern tip of the Arabian Peninsula - with a varied topography between mountains, plains, deserts, and islands. Formerly Yemen was given many names. For example, the Greeks and Romans called it "Arabia Felix", while Arab historians called it "green Yemen" due to its fertility, greenness, and picturesque nature. Ancient Yemeni settled in good geographical areas with suitable natural conditions and practised agriculture. Despite the rugged terrain of the mountainous heights, he built agricultural terraces on the mountains and found irrigation systems, so he dug wells and built dams such as the Ma'arib dam.

Keywords: *green spaces, old city, sana'a, yemen, urban garden, miqshamah, bustan.*

GJSFR-H Classification: *DDC Code: 358.4009533 LCC Code: UG635.Y46*

GREENSPACESINSANAAOLDCITYYEMENBETWEENPASTTOPRESENT

Strictly as per the compliance and regulations of:

Green Spaces in Sana'a Old City – Yemen between Past to Present

Samira Saleh Hussein AlShawesh [α] & Nada Ibraheem Al-Abyad [σ]

Abstract- The presence of nature was evident in the cities and villages of Yemen - a country located on the southern tip of the Arabian Peninsula - with a varied topography between mountains, plains, deserts, and islands. Formerly Yemen was given many names. For example, the Greeks and Romans called it "Arabia Felix", while Arab historians called it "green Yemen" due to its fertility, greenness, and picturesque nature. Ancient Yemeni settled in good geographical areas with suitable natural conditions and practised agriculture. Despite the rugged terrain of the mountainous heights, he built agricultural terraces on the mountains and found irrigation systems, so he dug wells and built dams such as the Ma'arib dam.

As a result, settlements appeared that were not separated from nature but united or merged with it. The local architecture appeared integrated with the land, harmonious with the green spaces that permeate and surround it, which form a distinctive image in all its cities and towns, described by its visitors as a "total garden".

Sana'a old city is a vivid and extraordinary example of a traditional human settlement. A city at the foot of Nuqum mountain, founded by Shem, son of Noah, and inhabited for more than 2500 years.

This paper deals with the state of the green spaces in Sana'a old city from past to present. The importance of these spaces in the city's fabric, its types, characteristics, roles, and sustainability concepts that can be deduced. Sana'a old city is a model of ancient cities which contained urban green spaces, surrounded by a group of towers that constitute a basic urban unit to form the city. Thus, green spaces spread in most parts, surrounded by the dwellings' walls, creating a distinctive urban fabric. The study aims to identify the current condition and determine the changes that have taken place to the green spaces in Sana'a old city. On-site spatial observation and interviews were conducted in addition to the available information on green spaces during the past decades.

The study revealed the extent of the deterioration of green spaces and the loss of many essential roles. Results presented in this paper are necessary to consider these spaces' dire state and give decision-makers recommendations to improve them and benefit from sustainable agricultural thought.

Keywords: green spaces, old city, sana'a, yemen, urban garden, miqshamah, bustan.

Author α: Associate Professor in Architectural Design & Environmental Control, Department of Architecture, Faculty of Engineering, Sana`a University, Sanaa, Yemen. e-mail: s.alshawesh@gmail.com

Author σ: Department of Architecture, Faculty of Engineering, Sana'a University, Sana`a, Yemen.

I. Introduction

The presence of nature was evident in the cities and villages of Yemen - a country located on the southern tip of the Arabian Peninsula - with a varied topography between mountains, plains, deserts, and islands. Formerly Yemen was given many names. For example, the Greeks and Romans called it "Arabia Felix", while Arab historians called it "green Yemen" due to its fertility, greenness, and picturesque nature (Lehner, 1996). Ancient Yemeni settled in good geographical areas with suitable natural conditions and practiced agriculture. Despite the rugged terrain of the mountainous heights, he built agricultural terraces on the mountains and found irrigation systems, so he dug wells and built dams such as the Ma'arib dam (CSO et. al., 1994). As a result, settlements appeared that were not separated from nature but united or merged with it. The local architecture appeared integrated with the land, harmonious with the green spaces that permeate and surround it, which form a distinctive image in all its cities and towns, described by its visitors as a "total garden" (Ceccherini et. al., 1986)

Sana'a old city is a vivid and extraordinary example of a traditional human settlement. A city at the foot of Nuqum mountain, founded by Shem, son of Noah, and inhabited for more than 2500 years. It played an essential role in many civilizations, including the Sabaean and Islamic ones. It was included in the World Heritage List in 1986 as a world cultural heritage and has gained wide attention (UNESCO, 2011). The city's urban fabric is one of its exceptional features, as it has preserved its components from the Middle Ages until now as a unique and authentic urban extension (Naeem, 2015). A masterpiece of a walled city with ornate, mud brick tower buildings interspersed with courtyards and green spaces. Together, they form an integration between urban fabric and nature. Green spaces exist in most of the city's neighborhoods. However, there are different types, this paper concentrate on two types that represent urban gardens, known as Miqshamah and Bustan due to their importance.

II. A Brief History of Sana'a Old City

Sana'a city represented an essential political and economic center in the Arabian Peninsula. A city that has endured through the centuries with its decorated tower buildings rendered in gypsum, narrow and winding streets, and open and green spaces (Serageldin, 1995). Sana'a is located in the center of the Republic of Yemen, in the Central Region of the western mountains. Yemen's historian Al-Hamdani described it as the mother and pole of Yemen. Lies on the bottom of a plain surrounded from the east by Mount Nuqum and Mount Aiban from the west, from the south by Niqil Yasleh, and from the north by Shibam al-Firas (Al-Hadad, 1999).

The city has gone through different historical phases, divided into:

- Pre-Islamic era.
- Islamic era.
- Modern Era (Ottoman Rule and Beyond).

The first phase of Sana'a's history was characterized by mystery and legends. Because Sana'a was a populated city, it was not easy to study the archaeological record for this phase and relied only on written records (R B Serjeant and Ronald lewcock, 1983). However, it was found in the wall inscriptions that the southern Arabian region was inhabited from the eighth millennium BC (Lehner, 1996). The earliest mention of Sana'a in Yemeni inscriptions was around 70 CE (Baydani, 2001). The founder of Sanaa was Shem, son of Noah; he built the Ghumdan Palace and dug its well. Also, Sana'a was called Azal by its builder, Azal bin Yaqtn, who lived during the Sabaean era. Sana'a had a significant role during the period of the Sabaeans because it was a strong and impregnable city, so they called it Sana'a, which means the fortified town. Sana'a was subjected to the Abyssinian invasion and the Persian occupation in 575. Persian control of Yemen ended with the entry of Yemenis to Islam (Al-Taher, 2005).

The second phase began with the entry of Yemenis to Islam. Sana'a flourished, and its architecture developed and became a model for an Islamic city. The Great Mosque (Al-Jami Al-Kabir) was built by order of the Prophet Muhammad (R B Serjeant and Ronald lewcock, 1983). However, the city was affected by Islamic controversies, and this involved the city's expansion or decline. The buildings of Sana'a were counted in different periods, sometimes one hundred and twenty thousand houses and sometimes eighty thousand (Al-Hubaishi, 1980). In the third phase, Sana'a witnessed a rotation between Ottoman rule and the Imams. As a result, the city expanded toward the west (Bir Al-Azab and Qaa Al-Olufi), thus forming Sana'a historical city.

The urban fabric was affected by the historical and cultural phases that the city went through, so many architectural and urban elements interacted until they were adequately and acceptable integrated into all phases (Al-Shawesh, 2011). Residential and commercial areas were the city's main components. The market (Souk) represented the city's pole, extended from the main city gate (Bab al-Yamen) in the south to another Gate (Bab Shu'ub) in the north, and contained specialized markets and shops on the sides of the road (Laila Ahmed Haidara, Anuar Talib, 2013). The residential part consists of several areas, including the Al-Qate area, east of the market and near the palace. Al-Sarr Al-Sharqi area, which lies west of the market, is separated by Al-Sayilah from the third Al-Sarr Al-Gharbi area—followed by the fourth region represented by Bir Al-Azab and Al-Qaa.

Sana'a old city has a compact and dense urban fabric containing 6,500 buildings and 48 historical mosques (masajid) and is surrounded by a wall that contains 9 gates. At its center is a commercial market that includes 2,000 shops, 48 specialized markets, 26 hotels (samaser), and 12 steam baths (Al-Shawesh, 2011). These elements formed building blocks punctuated by narrow meandering corridors that connect to open urban spaces. The forms of open spaces varied between squares (Sarha), areas of multiple sizes, and green spaces. The city contains 43 green spaces distributed in the city center and boundaries (Al-Taher, 2005).

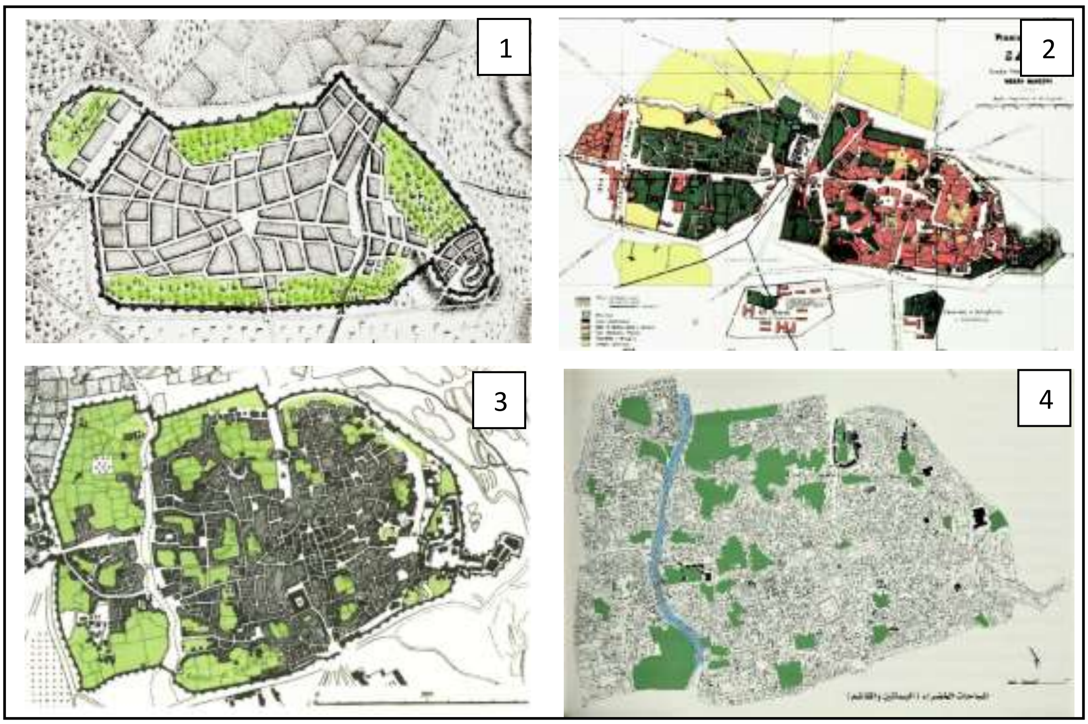
III. Green Spaces in Sana'a Old City

Green spaces are an essential and valuable part of the urban fabric of Sana'a old city, representing nature's easily regulated presence. It expressed nature's alliance with urban communities and the human need to communicate and interact with nature (Ceccherini et. al., 1986). The green spaces are linked with the mosque (Masjid) and the group of residential buildings in an integrative relationship, constituting the basic unit in forming the city's fabric. Also, they play an important environmental, economic, social, and aesthetic role in the city.

No information and documents are available about green spaces in Sana'a old city during the first historical period (Pre-Islamic era). However, in the second period (Islamic era), many historians described Sana'a city with its components, including its green spaces. For example, in the fourth century AH, Al-Razi described Sana'a and its mosques (masajid). Describing the Great Mosque, he mentioned that the area located on the masjid's left is better than its right and that when anyone comes out of the door on the left side of the masjid, they will find on the right "a garden from the gardens of Paradise" (Baydani, 2001).

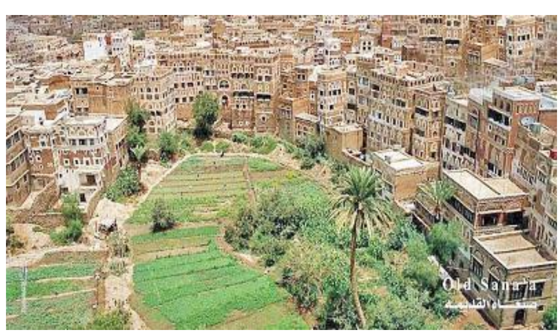
This description matches the existing Miqshamah, located next to the Great Mosque (G30). Another description of Sana'a city during the rains, the torrents are directed toward green spaces to benefit from the rainwater (Al-Hubaishi, 1993). The buildings of Sana'a and other components were counted in different periods, mentioning that the houses were forty-five thousand and fifty-five green spaces in the days of al-Mansur Billah Ali ibn Salih (Al-Hubaishi, 1980).

In the third period (Modern Era), many city maps were drawn during different periods. The first map was drawn in 1763 by Christine Niebuhr. Although the components of the city are not precise, green spaces separate the building block from the city wall in the north, east, and south. In 1879, Renzo Manzoni drew a map of the city, showing that green areas were defined as about 25% of the area of the old city, while in the Ottoman Quarter (Bir Al-Azab and Al-Qaa), the green spaces were defined as about 75%. Finally, in 1929, Rathiens and Von Wissman drew the historical city. When comparing this map with the previous one, there are no differences in the percentage of green spaces in the two periods. The significant change that affected green spaces over nearly a hundred years appears by comparing the modern maps and aerial photographs with the Rathiens and Von Wissman map. Construction spread unfairly at the expense of the green areas in the Ottoman Quarter, so these areas were reduced or almost non-existent. As for the old city, the green spaces changed significantly in the western part of sayilah (Torrent path). In the Rathiens and Von Wissman map, the percentage of green spaces in this part was about 75%, while now only 25% remain (Lehner, 1996). Green spaces currently occupy about 16.9 hectares, constituting 12.2% of the city's total (Al-Taher, 2005). Figure 1.



3.1 *Types of Green Spaces*

Green spaces in Sana'a old city - figure 2- are named under different terms due to their differences in the area, the feature of use, and the land ownership. Can be classified as follow (Al-Shawesh, 2017):



3.1.1 Miqshamah.

3.1.2 Bustan.

3.1.3 Residential building garden.

3.1.4 Roof Garden or Roof plants.

Defined as follows:

3.1.1 Miqshamah

A small urban farm, an area for agricultural production within the walls of Sana'a old city. A functional element is considered a major income source for those in charge. And its ownership is a waqf. It specializes in cultivating vegetables consumed daily, such as radishes, leeks, onions, and aromatic plants (Barceló, 2004).

It is mentioned in the Yemeni Dictionary of Language and Heritage that "Qoshm is a plural name originally given to vegetables and fruits." Although it is common to associate the word Qoshmi with radish, its basis and meaning indicate the comprehensiveness of the types of vegetables and fruits. The name Maqshom was given to the small baskets that contained fruits. For example, when someone buys a small bowl or basket containing fruit, they call it maqshom figs. Based on Qoshm, the area in which it is grown is called Miqshamah. Moreover, its plurality is Maqashim, and the farmer is called Qasham (Al-Eryani, 1996).

3.1.2 Bustan

A garden is larger than the area of Miqshamah and more diverse in its planting and trees. It is not the primary goal of productivity as a source of income because there are other sources, and their ownership is private. Vegetables with an undesirable smell, such as radishes and leeks, are not grown there. However, various vegetables and fruits, such as figs, pomegranates, grapes, and others, are grown in addition to roses and basil trees (Al-Taher, 2005). Bustan is an Arabic word that means "a garden with scattered trees and palms that can be planted between them," Its plural is Basateen (Dictionary, 2022).

3.1.3 Residential Garden

The outer courtyard of residential buildings represents a miniature presence of nature in the yard of a single dwelling or residential group. It is limited in size, with little vegetation and space for daily activities (Al-Shawesh, 2017; Al-Taher, 2005).

3.1.4 Roof plants

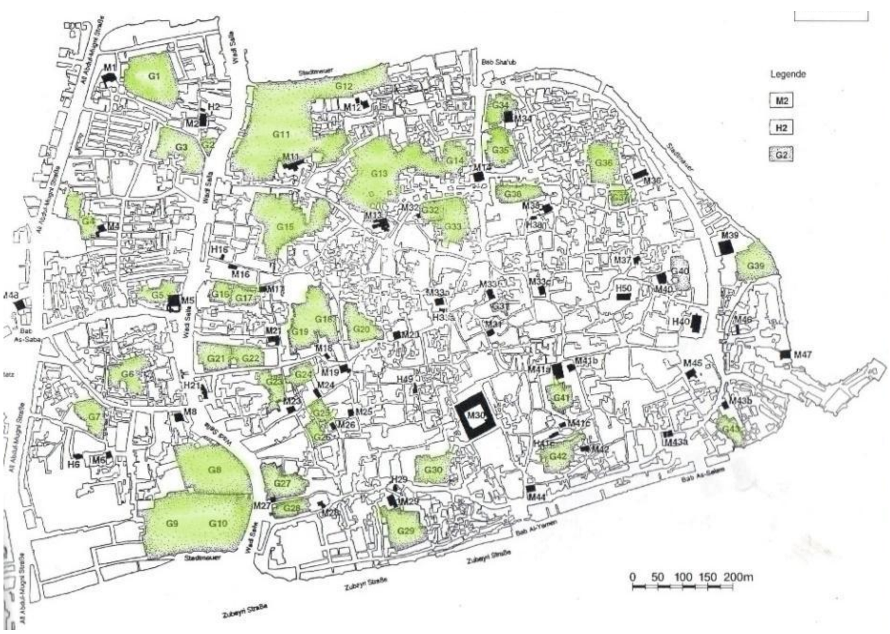
A group of shrubs, especially aromatic ones, are planted in pots and distributed on the roof of the residential building (Al-Shawesh, 2017).

Due to its practical and essential role, this study focuses on the first and second types of green spaces mentioned in the previous classification (Miqshamah and Bustan). Forty-three green spaces are distributed in the city center and edges, serving as the city's lungs and a source of connection to nature (Al-Afari, 2020). Urban gardens that produce vegetables and fruits, practical and aesthetic spaces that smell nature and tranquillity, are stable in the city's heart and isolated from the daily hustle (Barceló, 2004). Each green space has a name. For example, Maqashim were named after the associated mosque (masjid), while Basateen were named after the owner's family name. A list of green spaces is shown in table 1.

Table 1: Green Spaces (Lehner, 1996)

No.	Name	No.	Name
G1	Miqshamat Al-Hurqan	G23	Miqshamat Al-Washali
G2	Miqshamat Samrah	G24	Miqshamat Gamal Al-Din
G3	Miqshamat Samrah	G25	Miqshamat Maad
G4	Miqshamat Al-Tabari	G26	Miqshamat Al-Jadid
G5	Miqshamat Al-Nahryn	G27	Miqshamat Barrum
G6	Bustan Nahshal	G28	Miqshamat Al-Qasimi
G7	Bustan Al-Sultan	G29	Miqshamat Al-Abhar
G8	Bustan Al-Amri	G30	Miqshamat Aljami Al-Kabir
G9	Bustan Ingad	G31	Miqshamat Al-Shahidayn
G10	Bustan Al-Habal	G32	Miqshamat Ghozl Al-Basha
G11	Bustan Al-Habal/ Miqshamat Al-Alami	G33	Miqshamat Al-Zumor
G12	Miqshamat Mua'mar	G34	Miqshamat Al-Khudhir
G13	Miqshamat Al-Fulayhi	G35	Miqshamat Al-Khudhir
G14	Bustan Al-Na'man	G36	Miqshamat Al-Madrasah
G15	Bustan Al-Gauza	G37	Miqshamat Al-Madrasah
G16	Miqshamat Al-Jala'a	G38	Miqshamat Al-Tawashi
G17	Miqshamat Ibn Al-Hussein	G39	Miqshamat Al-Bakiryah
G18	Miqshamat Talha	G40	Miqshamat Salah Al-Din
G19	Miqshamat Tawuse	G41	Miqshamat Al-Humydi
G20	Miqshamat Dawud	G42	Miqshamat Musa
G21	Miqshamat Al-kharraz	G43	Miqshamat Al-Basha
G22	Bustan Dalal		

[3] The term refers to property permanently donated for a religious purpose or as a charity. It cannot be sold or used for purposes other than for which it was intended.

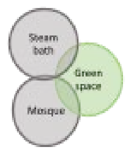
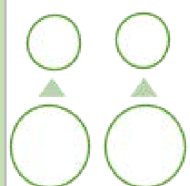
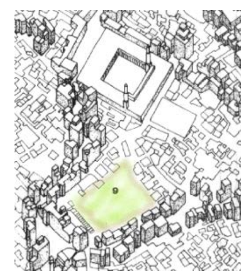


Examples of some Maqashim and Basateen (Top to bottom G6, G17, G20, G24, G28, G32) (Author)

3.2 *Characteristics of Green Spaces*

Green spaces in Sana'a old city have many characteristics, the most important of which are in the following table 2:

Table 2: Characteristics of Green Spaces (Authors)

No	Characteristic	Description	No	Characteristic	Description
1	**Basic Urban Component** 	1. Considered an urban component in an essential trilogy due to the water circulation system (Mosque, Steam bath, green space). 2. Linked spatially to the mosques (masajid), and if the steam bath (Hamam) is found, it will be near them (Lehner, 1996). 3. There is a well at every mosque, and water is collected in basins called Matahir, where the worshipers perform ablution and wash their feet before entering. Then, the purified water is drained into a pond to irrigation green space through canals. (Al-Hubaishi, 1993).	4	**Depth**  *Fi Section showing green spaces level and street level CITATION AIT05 \l 2057 (Al-Taher, 2005)(Edited by Author)*	1. Its level is lower than the level of the city's streets. 2. Differences in the depth may reach 4 m from the street level. 3. The first possibility is that clay was taken from these areas as a building material. House was built around where the necessary building material was taken (Lehner, 1996). 4. The second possibility, the level was deliberately reduced so that the torrents are drained to take advantage of it to irrigate the green spaces (Al-Taher, 2005).
2	**Land Ownership** 	1. Waqf means that the property belongs to the state and cannot be sold or built in[4]. 2. Preserved the existence of green spaces because Maqashim are waqf. 3. Basateen are the private property of some of the old families in the city. (Naeem, 2015)	5	**Privacy**  *G30 CITATION Rit86 \l 2057 (Cecchenini et. al., 1986)(Edited by Author)*	1. A visitor to Sana'a old city is unaware of the presence of green spaces in their actual proportion. 2. usually walled or surrounded by towers and its low level increases its privacy. 3. Invisible to passers-by but are seen from the surrounding tower houses. 4. The entrance is not straightforward. It cannot be reached quickly to preserve the privacy of the residents of the area, the farmers, and their families. 5. Doubly hidden, a walled city contains walled gardens (Mackintosh-Smith, 2006).
3	**Space and Shape** 	1. Linked to the water system, which requires building a slope called marna', starts with the well and descends in the opposite direction; the depth of the well limits its length. 2. The animal moves in this path (marna'), pull the rope attached to the bucket to raise the water, and empties it into a pool. This made the path specify one of the minimum possible dimensions of one of the green space sides (Barceló, 2004). 3. Basateen had no limitation for the area, as it is more extensive than Maqashim. 4. The shape is determined by wrapping the residential buildings around them, forming polygons like a rectangle in some cases.	6	**Agricultural Production** 	1 Has a triple for its continuity: water, soil, and human. 2. Water is available from mosques (masajid), the soil is permanently fertilized with natural fertilizers, and the farmers take care of the land. 3. Miqshamah contains annual plants consumed daily, such as radishes, onions, leeks, salads, and aromatic plants, such as mint and basil. 4. Palm trees were planted, and farmers benefited from their leaves as raw materials for making baskets and binding sold vegetables (Al-Shawesh, 2017). 5. Basateen contains intense fruit trees, and space between the fruit trees may be planted with aromatic plants such as roses and basil. These trees bear fruit from once to twice a year and are for personal consumption. (Barceló, 2004)

[4] It is mentioned that when the great plague broke out in Sana'a in 933 AD, many families died, leaving money and wealth for which there was no heir. Therefore, Imam Sharaf al-Din ordered the creation of large green spaces for many mosques, wells were dug, and purifiers and ponds were built, and he allocated this abandoned money to spend on green spaces and their maintenance (Naeem, 2015).

3.3 *Role of Green Spaces*

Green Spaces are functional elements in the city's fabric that play many roles, as follows:

i. *Environmental role*

A city with a high density, tall, towering buildings, and narrow streets like Sana'a is in dire need of ventilation. Openings were opened in the direction of these spaces not only to get a view but to allow air movement (Lehner, 1996). The vegetation cover also purifies the air, raising the humidity and reducing the temperature and noise. Green spaces have an essential role in the disposal of waste figure 8. First, by using the waste ablution water from the mosque (masjid), the result of the presence of water is to benefit from it by growing vegetables and fruits. Second, by using solid human waste, this is done in a system as an integration that starts from a waste collection in a collection room located below the toilets in residential buildings. It is mixed with ashes, and after it dries, it is packed in fabric bags and transferred to steam baths, where the waste is used to heat the water by burning it, and all germs are eliminated through burning. Ashes are produced from this process and used as a natural fertilizer for the land (R B Serjeant and Ronald lewcock, 1983).

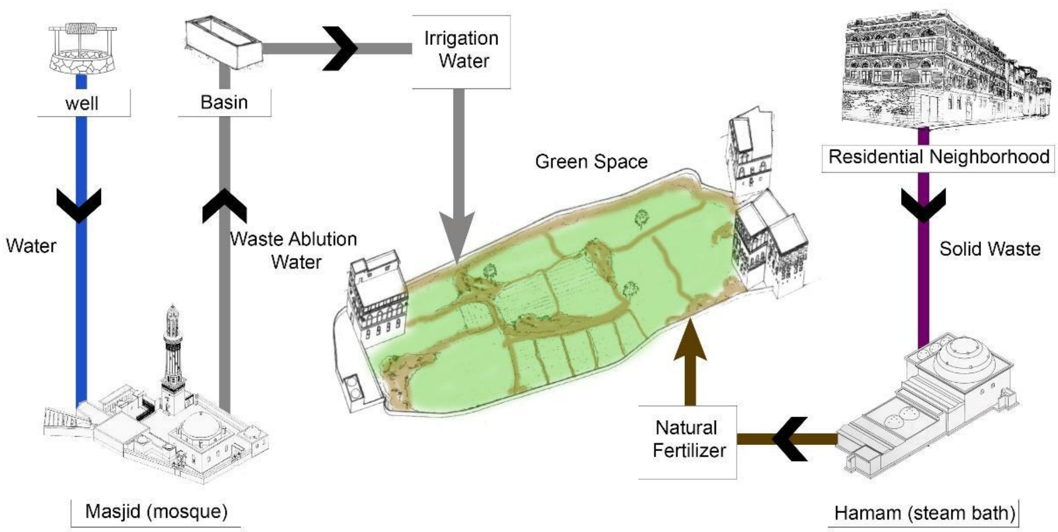


Figure 8: Waste Disposal System (Authors)

ii. *Economic role*

The economic role was represented by being a productive element on which the farmers depended to provide their daily food base and to sell the surplus from the harvest. These spaces constituted a source of income for impoverished families and gave them the right to take care of the land and use it to provide services to the mosque (masjid), such as cleaning ponds and drawing water from wells. The financial condition of these families improved, and job opportunities were provided (Barceló, 2004). On the other hand, agricultural products played a significant role in making the city self-sufficient. Various vegetables are grown in Maqashim, seasonal fruits are grown in Basateen, and animal products for the animals found in, such as chickens, rabbits, goats, and camels. It is mentioned that Sana'a old city was self-sufficient by its green spaces when it was besieged for a whole year, and it was exposed to wars different time periods (Lehner, 1996).

iii. *Social role*

The social role of Maqashim and Basateen lies in raising the level of a vulnerable social group (the farmers) and integrating them with society. Gatherings in these spaces while purchasing products and exchanging conversations between the residents and farmers strengthen social cohesion. Farmers' free distribution of basil after Friday's pray adds friendliness and intimacy to society. These spaces represent places for women to meet in the open air, as the privacy of green spaces enabled women to feel safe and gather there during the morning periods to exchange conversations.

iv. *Aesthetic role*

Green spaces are the colour that brings vitality to a city with natural, earthy colours. They formed an inward-looking character for the dwellings as an inner courtyard, thus becoming an aesthetic element and a breather for the city (Al-Ghazali, 2005). A diverse view varies according to the level of vision, as the best way to enjoy the view of the green spaces is by overlooking them. Each floor of the tower buildings surrounding the green space has a distinct perspective, and higher floors have a more comprehensive view. As a result, more gardens reveal themselves, and the tops of trees mark the edges of other green spaces (Mackintosh-Smith, 2006).

IV. Existing Condition

Green spaces constitute an essential and valuable part of the constituent elements of the city and express an indispensable free area in the urban fabric. However, the attention given to preserving the city's buildings and streets, green spaces have not been given the same attention as other components of the world's cultural heritage (Lehner, 1996). That caused a lack of information about green spaces in the city. Therefore, studying existing conditions relied on On-site spatial observation, interviews, aerial photos, and two studies prepared on green spaces in Sana'a old city were used as a reference to compare the past with the present. Brigitte Lehner prepared the first study in 1996, and a team directed by Miquel Barceló prepared the second study from 2000 to 2001.

Green spaces face many variables that deteriorate their conditions. Various factors caused a drastic change from what it was before. The existing condition was assessed by the following:

4.1 *Space Decreasing*

Green spaces represent a fragile agricultural area distributed throughout the city, facing rapid urbanization and urban sprawl. Until the middle of the twentieth century, it constituted more than 33% of the city's total area (Al-Taher, 2005). However, that percentage has diminished because of the political changes in Yemen, the growth spurt that hit the city of Sana'a, and the construction spread of several green spaces.

Previous studies showed that green spaces decreased from 1962 until the study. Many changes have occurred in the green areas, especially Basateen, due to changes in owners' needs. Modern residential buildings were built on the edges of some green spaces, or spaces were invested for other uses. For example, Bustan Ingad and Al-Habal (G9-G10) became a market and an area for building stones. As a result, the number of Green spaces are decreased from 43 to 41 (Barceló, 2004).

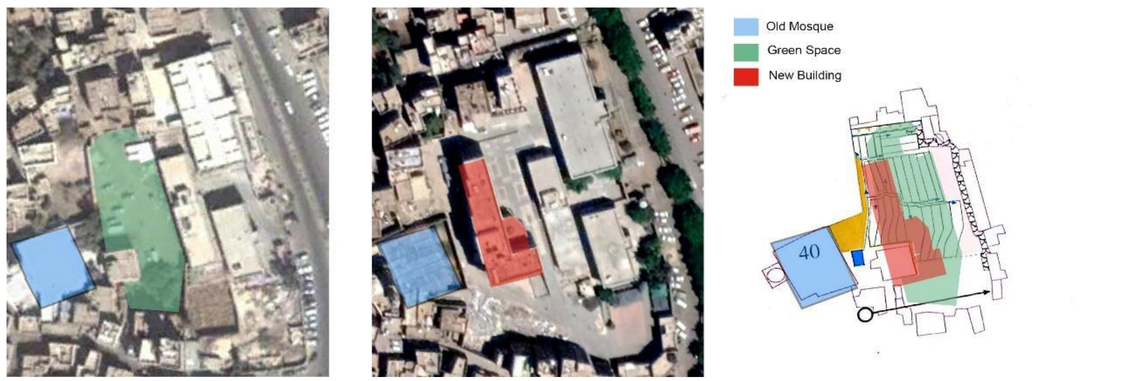
Twenty years have passed since the last study for green spaces, bringing about many changes. Changes have appeared by comparing available maps, aerial photos, and site visits. A change in the area occurred in three cases, namely, Miqshamat Al-Nahryn (G5), Miqshamat Salah al-Din (G40), and Bustan Al-Habal/ Miqshamat Al-Alami (G11).

In the case of Miqshamat al-Nahryn (G5), following the demolition of the historic mosque by a decision by the Local authorities nearly two years ago, a new mosque is built (with modern design, construction methods, and materials) that extends over part of the Miqshamat as shown in Figure 9.

Aerial photo- Feb.2020 (Google Earth) | Aerial photo- Aug.2022 (Google Earth) | G5 Map (Barceló, 2004) edited by Authors

Figure 9: G5 Changes

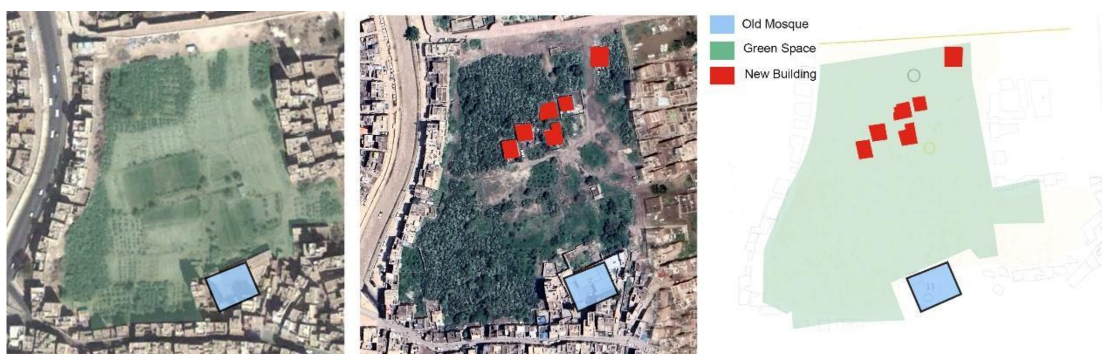
As for Miqshamat Salah al-Din, a military facility (with modern materials and methods) was built on its site several years ago, although the two studies in 1996 and 2001 mentioned its excellent condition and that it was fully planted. The result was noted through aerial photos and maps (no site visit due to the privacy of the military facility). Figure 10. Although the ownership of Maqashim returns to the Local authorities as a waqf and must protect it. Still, in the previous two cases, the Local authorities was the aggressor in these areas.



Aerial photo-Dec.2004 (Google Earth Aerial photo- Aug.2022 (Google Earth) G40 Map (Barceló, 2004) edited by Authors

Figure 10: G40 Changes

In the case of Bustan Al-Habal/Miqshamat Al-Alami (G11), more than six apartment buildings were built. These buildings were located in the middle of the site, as shown in the figure 11.



Aerial photo-Dec.2004 (Google Earth) Aerial photo- Aug.2022 (Google Earth) G40 Map (Barceló, 2004) edited by Authors

Figure 11: G11 Changes

As a result, the area of green spaces in the city decreased (regardless of its agricultural condition). These abuses constitute a danger that may affect more green spaces if these spaces are not protected. In conclusion, there are 41 green spaces in Sana'a old city, Bustan Ingad (G9) was excluded because it was transformed into a market, and Miqshamat Salah al-Din (G40) a military facility on it. Bustan Al-Habal (G10) has not been excluded as it was in part of a previous study because it can be revived. The rest of the cases presented were not excluded because they still have an area and may be planted in the future.

4.2 *Condition and use*

At first glance, it is clear that the planted area does not match the total area of Green spaces. The depletion of wells and the scarcity of water supplied to green spaces are among the most critical factors that have caused a significant change in the existing condition. Also, paving the city's streets and Sayilah (flood path) without finding alternative systems to increase the groundwater level caused a severe problem. All of the above led to the drought of green spaces, and thus the city lost one of its most important wealth.

The conditions of several green spaces have changed, while others have become dumping grounds for waste or remnants of building materials. In addition, the use of some Basateen changed to suit the owners' desires.

Lately, a type of green space (parks) appeared that was not present in the old city of Sana'a. Al-Na'man Park and Al-Tabari Park are located west of Al-Sayila and were established by the Municipality of the Capital. Al-Na'man Park was built on vacant land, while Al-Tabari Park was built on a wood market land both parks contain space for children, seating areas, and rose trees as shown in Figures 12, 13.

Eventually, due to the change in agricultural products, green spaces lost their connection to their names, such as Miqshamah and Bustan. Maqashim generally specialized in vegetable cultivation, and Basateen specialized in fruit cultivation. However, most Maqashim planted fruit trees in the current situation, and the cultivation of vegetables has declined to types and a limited area due to the lack of water. Vegetables need much water, unlike fruit trees that depend on seasonal rains. As for Basateen, the fruit trees have receded to a few types, including pomegranate, berries, and prickly pears.

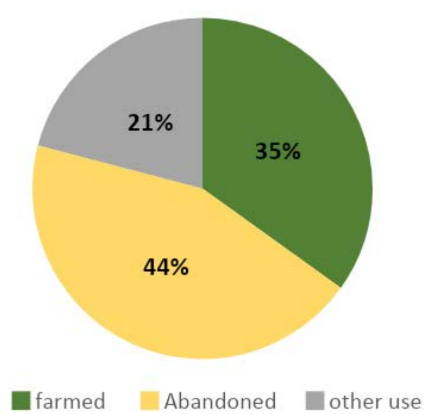
V. Results

The green spaces gradually deteriorated due to the imbalance in agricultural production. As mentioned, water, soil, and human are the basis for the sustainability of these areas, so any change that happens to one of these components will affect the rest. The lack of water led to the drying up of green spaces, and the farmers stopped paying attention to the land, plowing and cultivating it. Due to the connection between the quality of green spaces with the farmers providing the necessary care, green spaces were classified into three categories:

- Farmed (receive care).
- Abandoned (no care).
- Change the use (other use).

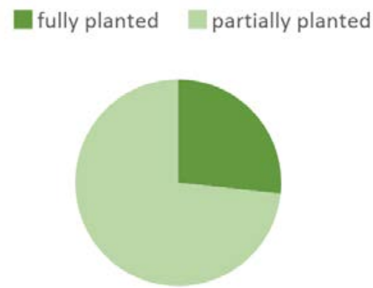
The first category contains all the green spaces planted in whole or part, receive permanent care, and are irrigated periodically. The second category includes green spaces that do not receive the necessary care and are not irrigated but depend on seasonal rains. Usually, these green spaces contain mulberry, pomegranate, and prickly pear trees. Finally, the third category includes abandoned green spaces for other utilitarian purposes, such as parking lots or other activities shows in table 3.

Table 3: Classification and Percentage of Green Spaces (Author)

Classification	Percentage
Farmed (15)	
G2- G3- G20- G21- G23- G24- G25- G26- G28- G30- G32- G34- G36- G37- G41	
Abandoned (19)	
G1- G6- G7- G8- G13- G14- G16- G17- G18- G19- G22- G27- G29- G31- G33- G35- G38- G42- G43	
Change the use (9)	
G4- G5- G9- G10- G11- G12- G15- G39- G40	

As a result, 15 out of 42 Green spaces are planted (about 35%). They show the extent of the deterioration that affected the green spaces in the city. The farmers abandoned 19 green spaces due to a lack of water (about 44%). The old wells dried up, and deeper wells were dug during the past decades, reaching a depth of about 200 m. However, the groundwater level declined until the wells' depth reached 500 m (G23). Although some artesian wells are inside some green spaces, the water is used for other purposes (G8). Formerly, Maqashim was watered from the pools of ablution water from the mosques (masajid), and although the basin still exists, the water that collects in is not enough. Some mosques (masajid) are no longer fed from wells; water is transported to them by trucks. This alarming deterioration poses a threat to the city's green space system. For many years, the dryness of green spaces made the community use these spaces differently (G9). 9 Dried green spaces are used for different functions as parking lots (G4, G11, G12, G15) or commercial markets (G9) (about 21%). Furthermore, if quick solutions are not found to tackle the deterioration, then in the coming years, the condition will deteriorate until the green spaces disappear from the city.

Table 4: Farmed Green Spaces Classification and Percentage



Fully Planted
G25- G26 G28- G30
Partially Planted
G2- G3- G20- G21- G23- G24- G32- G34- G36- G37- G41

In farmed areas that still receive care (15 Green spaces). Only four are fully planted and receive good care periodically. The remaining eleven are partially planted, and the area which is planted in them varies from one to the other.

It is noticeable that the cultivated green spaces have two irrigation water sources. For example, Miqshamaht Al-Washali (G23) contains an artesian well that feeds the neighboring mosques (masajid) and Al-Maqshim (G26, 28). In addition to ablution water is collected in basins. As for Miqshamat Aljami Al-Kabir (G30), the water coming from the mosque is abundant due to the large number of worshipers in the mosque because it is the oldest mosque (masjid) in Sana'a old city.

The partially planted areas may range from 50% of their total area or less. The reason is the lack of water and the multiplicity of farmers who care about it. Some green spaces contain several families (some have a kinship relationship, and some are not), as some are interested in cultivating their area, while others do not plant and leave it dry (G21, 36). Accordingly, the percentage of the cultivated areas that are fully developed is 27%, and the partially cultivated is 73% of the total area that receives care, figure 4.

Twenty-six years have passed since the study that Brigitte Lehner prepared for green spaces in Sana'a old city, and nearly 20 years have passed since the report of Miquel Barceló and his team. These years' political, economic, and social changes impacted the city's green spaces. A comparison between the past (represented by the two mentioned studies) and the existing condition is shown in the following, table 5:

Table 5: A comparison between the past and the present (Authors)

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G1		100% planted	Farmed and in good condition	Abandoned
G2		0 -10% planted	Farmed and in good condition	Partially planted

[5] Due to the monsoon rains, thorns and weeds grew, and some spaces appear green but were not planted.

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G3		30 – 40% planted	Abandoned and had another use	Partially planted
G4	Could not take a picture	60 – 75% planted	Farmed but in bad condition	Abandoned and had another use
G5		100% planted	Farmed and in good condition	Abandoned and had another use
G6		0 -10% planted	-	Abandoned
G7		100% planted	Farmed and in good condition	Abandoned
G8		100% planted	Farmed and in good condition	Abandoned
G9		0 -10% planted	Another use (market)	Another use (market)
G10		0 -10% planted	Abandoned	Another use

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G11		50% planted	Under restoration	Abandoned and had another use
G12		50% planted	Farmed and in good condition	Abandoned and had another use
G13		60 – 75% planted	Farmed and in good condition	Abandoned
G14		100% planted	Farmed and in good condition	Abandoned
G15		30 – 40% planted	Abandoned	Abandoned and had another use
G16		60 – 75% planted	Under restoration	Abandoned

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G17		30 – 40% planted	Under restoration	Abandoned
G18		0 -10% planted	Farmed seasonally (only in summer)	Abandoned
G19		0 -10% planted	Farmed seasonally (only in summer)	Abandoned
G20		50% planted	Under restoration	Partially planted
G21		60 – 75% planted	Farmed but in bad condition	Partially planted
G22		0 -10% planted	Abandoned	Abandoned
G23		80 – 90% planted	Farmed and in good condition	Partially planted

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G24		80 – 90% planted	Under restoration	Partially planted
G25		100% planted	Farmed and in good condition	Fully planted
G26		100% planted	Farmed and in good condition	Fully planted but in a bad condition
G27		50% planted	Abandoned	Abandoned
G28		100% planted	Farmed and in good condition	Fully planted
G29		0 – 10% planted	Farmed but in bad condition	Abandoned

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G30		100% planted	Farmed and in good condition	Fully planted
G31	Could not take a picture	30 – 40% planted	Farmed and in good condition	Abandoned
G32		80 – 90% planted	Partially farmed and in bad condition	Partially planted
G33		0 – 10% planted	Abandoned	Abandoned
G34		100% planted	Farmed and in good condition	Partially planted
G35	Could not take a picture	0 – 10% planted	Abandoned (except for a small farmed part)	Abandoned
G36		100% planted	Farmed and in good condition	Partially planted
G37		100% planted	Farmed and in good condition	Partially planted

No.	Picture[5]	Lehner, 1996	Barceló, 2000-2001	Existing condition Sep.2022
G38		100% planted	Farmed and in good condition	Abandoned
G39	Could not take a picture	100% planted	Farmed and in good condition	Another use
G40	Could not take a picture	100% planted	Farmed and in good condition	Another use
G41		100% planted	Farmed and in good condition	Partially planted
G42		0 – 10% planted	Under restoration	Abandoned
G43	Could not take a picture	0 – 10% planted	Abandoned	Abandoned

Changes in the state of green spaces happened during the periods specified in the above table. The situation worsened in 17 green spaces (G1, G4, G5, G7, G8, G11, G12, G13, G14, G15, G16, G17, G27, G31, G38, G39, G40). These spaces were planted, some of which were in excellent condition, but now they are abandoned. On the other hand, 23 green spaces remained in their original state (G3, G6, G9, G10, G18, G19, G22, G23, G24, G25, G26, G28, G29, G30, G32, G33, G34, G35, G36, G37, G41, G42, G43) whether it was planted or abandoned, with some differences as to whether it was wholly or partially planted. The situation of 3 green spaces has improved (G2, G20, G21), and they have been revived and planted again. This indicates the possibility of reviving the abandoned spaces in the future despite their poor condition in the current condition.

The green spaces operated in an environmentally, economically, and socially integrated system. This integration has been disrupted, and green spaces have lost many roles over the past centuries. The environmental, economic, social, and aesthetic status has changed, as shown in the table 6.

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022

Table 6: Current Status of Green Spaces Roles

NO.	Current Status
Environmental Role	1. Water shortage, dry wells, and low groundwater level. 2. The change of the traditional irrigation system and the disappearance of its elements (well, marnaa, basin). 3. The change in the liquid and solid waste disposal, replacing it with a sewage system. 4. The change in traditional agriculture and its components (animals and natural fertilizers) and replacing them with industrial equipment and materials. The farmer Ahmed Zaid expressed his concern about the groundwater level, as the depth of the artesian well has reached more than 500 m, and it is the only resource for mosques and nearby green spaces. He also no longer uses natural manure because it is unavailable, and he cannot afford the cost of industrial fertilizer. (G23)
Economic Role	1. Water shortage and the deterioration of agricultural production led to a deterioration in the standard of living of farmers and their families. 2. Competitive and alternative markets and agricultural products that provided products instead of what green spaces provided. 3. -Job opportunities changed, so some farmers left their profession and searched for governmental jobs, while the uneducated farmers took up simple daily jobs. 4. Search for alternative land outside the city to provide water as an alternative to the spaces inside the city. The farmer Hussein Asabh takes good care of his Miqshamah (G25), yet he rented land outside the city in Bani Al-Harith area to cultivate it. The new land represents a source of income for him, as Miqshamah is no longer economically feasible and cannot be considered a good source of income.
Social Role	1. The social fabric has changed due to the political and economic changes that the city has undergone. 2. The increase in the number of family members of farmers (the heirs) led to the division of the green space into smaller plots for each family. The small area of agricultural lands belonging to each farmer of the same family reduced their production and financial returns, which caused their abandonment. 3. Throwing waste resulting from surrounding houses and the lack of awareness of the residents of the area about the importance of green space. 4. The encroachment and intrusion of children on green spaces and agricultural products. 5. Some farmers adhere to the profession of their ancestors and consider it a significant inheritance. Cousins Muhammad and Yahya Al-Ma'ali, complain about the lack of water to cultivate their land (G38), despite their urgent desire to practice agriculture because it is a profession inherited from their ancestors.
Aesthetic Role	1. Several barren lands have lost their attractive landscape. 2. The presence of piles of remnants of building materials and waste causes visual pollution. 3. The decreased trees and agricultural plots make the space lose its aesthetic appearance. Citizen Muhammad al-Ghail described his memories of Bustan Nahshel (G6) when his grandfather used to buy him the best types of nuts. He also mentioned that he used to live in one of the houses overlooking the green space and spend the afternoon in his house enjoying the view. Finally, he expressed his regret at what happened to green spaces in Sana'a Old City.

Green spaces are an essential component of the city's fabric. However, it has lost its importance and role in the city. This situation may pose a threat to the sustainability of these spaces.

Recommendations

This study concluded with the following recommendations:

- Stop the deterioration of green spaces urgently and thoughtfully, find urgent solutions to revitalize them, and return them to their ecological system through the following:
  - Provide water sources and use rainwater by harvesting it and collecting it in ground basins distributed near green spaces.
  - Renew old irrigation systems in Mosques
  - Remove waste from green spaces and raising awareness about maintaining the cleanliness of green spaces and imposing penalties for those who throw waste in them.
  - Re-divide agricultural plots among family members (the heirs), redistribute the plots to the most interested farmers and obligate them to plant them.
- Economically revitalizing green spaces through:
  - Rent green spaces (Maqashim) to farmers wishing to plant them from outside the inheriting families and oblige them to take care of these spaces and not harm them.
  - Fertilize all agricultural areas at the expense of the competent authorities to obtain year-round revenue.

- Rehabilitate farmers and their families and empower the role of women in agriculture.
- Establish weekly markets for agricultural products and market the products by organizing agricultural events and festivals.

o Activate the social role of green spaces through:

- Educate the community about the importance and role of green spaces in the old city of Sana'a in particular and in the modern city of Sana'a in general, and present the dangers that threaten its existence.
- Allocate some green spaces to be community gardens where community members can participate in the planting.
- Encouraging farmers and providing them with the necessary care, such as health care, free of charge, at the expense of the local authorities, to support them in the continuity of the practice of agriculture.
- Establish public parks in abandoned orchards and allocate places for the activities of children and adults.

o Enact laws and activate strict penalties for anyone who causes damage to green spaces, whether community members or local authorities.

o Establish agricultural research unit concerned with green spaces within the General Organization for Preservation of Historic Cities in Yemen (GOPHCY) and provide research on the cultivation of new varieties and the revival of old ones.

o Involve the tourism sector in making internal trips for citizens and students of schools and universities to the green spaces in the Sana'a old city to inform them of their importance.

o Benefit from the sustainable agricultural thought, reactivate it in the old city and apply it in the modern parts of the city's extensions.

References Références Referencias

1. Al-Afari, A. S., 2020. *Exaggeration and alienation in the form and content of Yemeni architecture and mechanisms of communication with heritage - Sanaa City- Case Study, Master Thesis.* Sana'a, Yemen: University of Science and Technology Yemen.
2. Al-Eryani, M. A., 1996. *The Yemeni dictionary A in language and heritage - about special vocabulary from Yemeni dialects.* Damascus, Syria: Dar Al-Fikr.
3. Al-Ghazali, A. S. A. H., 2005. "*The impact of new building technologies and materials on the local architecture in Sana'a - Yemen*" *Master Thesis.* Egypt: Faculty of Engineering, Al-Azhar University.
4. Al-Hadad, A. A. S., 1999. *Sana'a History and Ancient Homes.* Cairo: Dar al-Afaq al-Arabiya.
5. Al-Hubaishi, A. M., 1980. *History of Sana'a by Ishaq bin Yahya bin Jarir Al-Tabari Al-San'ani (450 AH).* Sana'a, yemen: Al-Sanhani Library.
6. Al-Hubaishi, A. M., 1993. *Sana'a description "Set from the Book of Character Publications".* Sana'a, Yemen: French Center for Yemeni Studies.
7. Al-Shawesh, S. S. H., 2011. *Enhancing the Climatic Performance of Urban Residential Spaces in Sana'a City – Yemen PhD Thesis.* Egypt: Department of Architecture, Faculty of Engineering, Assiut University.
8. Al-Shawesh, S. S. H., 2017. The Elements of Sustainability in Residential Communities and Buildings in The Architecture of The Old City of Sana'a and Their Use in Modern Architecture. *Science and Technology Journal,* Volume 22 (1), pp. 1-30.
9. Al-Taher, C. E. C., 2005. *The Principles of Architectural Design and Urban Planning in The Various Islamic Eras - An Analytical study on The Capital, Sana'a, the Republic of Yemen.* Sana'a, Yemen: Organization of Islamic Capitals and Cities.
10. Althawrah, 2017. *Old Sana'a's Muqashem, when will it return to its former glory as beautiful gardens?.* [Online] Available at: https://althawrah.ye/archives/488067 [Accessed 2 October 2022].
11. Barceló, M., 2004. *Basateen and Magashim of old city of Sana'a (Yemen),* Barcelona, Spain: French Institute of Archeology and Social Sciences Sana'a, Social Fund for Development - Sana'a and University of Atonuma - Barcelona.
12. Baydani, E. M. A., 2001. *Sana'a in The Writings of Muslim Geographers in The Fourth Century AH from 300-400 AH.* Aden, yemen: The House of Arab Culture for Publishing, Translation and Distribution, and Aden University.
13. Ceccherini et. al., 1986. The Town As A Garden: The Case of Yemen. *Journal of Islamic Environmental Design Research Center 2,* Issue Environmental Design, pp. 48-55.
14. CSO et. al., 1994. *Yeman Demographic and Maternal and Child Health Survey,* Calverton, Maryland: SCO and MI.
15. Dictionary, 2022. *Translation and Meaning in Almaany English Arabic Dictionary.* [Online] Available at: https://www.almaany.com/ar/dict/ar-ar/%D8%A8%D8%B3%D8%AA%D8%A7%D9%86/ [Accessed 16 september 2022].
16. Laila Ahmed Haidara, Anuar Talib, 2013. Adaptive Reuse in the Traditional Neighbourhood of the Old City Sana'a -Yemen. *Procedia - Social and Behavioral Sciences,* pp. 811-822.
17. Lehner, B., 1996. *Gardens of Sana'a (Maqashim and Basateen) - as a model of an ancient Islamic cultural heritage.* Munich: Technical University of Munich-weihenstephan.

18. Mackintosh-Smith, T., 2006. *The Secret Gardens of Sana'a.* [Online]
Available at: https://archive.aramcoworld.com/issue/200601/the.secret.gardens.of.sana.a.htm
[Accessed 9 September 2022].
19. Naeem, M. A. A. M., 2015. An objective reading of the urban transformation of street use in the old city of Sana'a. *Journal of Engineering Sciences,* june, Volume 4 (1), pp. 23-40.
20. R B Serjeant and Ronald lewcock, 1983. *Sana'a an Arabian Islamic City.* London: The World of Islam Festival Trust, London.
21. Serageldin, I., 1995. Conservation of Old Sana'a Yemen. In: C. C. D. a. I. Serageldin, ed. *Architecture Beyond Architecture: Creativity And Social Transformations In Islamic Cultures The 1995 Aga Khan Award For Architecture.* s.l.: The Aga Khan Award For Architecture, pp. 41-47.
22. UNESCO, 2011. *UNESCO World Heritage Convention.* [Online]
Available at: https://whc.unesco.org/en/list/385/
[Accessed 15 September 2022].

Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 22 Issue 7 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Ecosystems in a State of Flux: Evidence from a Kenyan Coastal Riparian Ecosystem

By Elias K. Maranga & Leila A. Ndalilo
Egerton University

Abstract- Riparian ecosystems are considered hotspots of carbon and nitrogen transformations. These biochemical transformations are driven by anthropogenic activities in the immediate riverine water catchments. The anthropogenic activities may include and not limited to extraction of goods such as agricultural products, wood products, honey, plant based pharmaceutical products, livestock products, firewood, water and grass for thatching homesteads. Riparian ecosystems also provide important tangible and intangible ecosystem services comprising spiritual and aesthetic functions, pollination, ecosystem detoxification functions, carbon and nitrogen sequestration and CO2 sinks for amelioration of climate change impacts among others. These ecosystems are increasingly threatened by degradation attributed to land use changes. Human perturbations such as crop farming on riparian land, overgrazing and population pressure on land resources influence degradation of riparian ecosystems, with profound effects on biodiversity conservation and local livelihoods. Evidence from the literature indicates that although there is a general understanding regarding the response of terrestrial and wetland ecosystems to human perturbations, there is a dearth of information on the response of African riparian ecosystems to ecologic and socio-economic impacts.

Keywords: *riparian ecosystem; biodiversity loss; ecosystem goods and services; land use and land cover changes; anthropogenic disturbance.*

GJSFR-H Classification: *DDC Code: 543.66 LCC Code: QD96.N8*

ECOSYSTEMSINASTATEOFFLUXEVIDENCEFROMAKENYANCOASTALRIPARIANECOSYSTEM

Strictly as per the compliance and regulations of:

Ecosystems in a State of Flux: Evidence from a Kenyan Coastal Riparian Ecosystem

Elias K. Maranga [α] & Leila A. Ndalilo [σ]

Abstract- Riparian ecosystems are considered hotspots of carbon and nitrogen transformations. These biochemical transformations are driven by anthropogenic activities in the immediate riverine water catchments. The anthropogenic activities may include and not limited to extraction of goods such as agricultural products, wood products, honey, plant based pharmaceutical products, livestock products, firewood, water and grass for thatching homesteads. Riparian ecosystems also provide important tangible and intangible ecosystem services comprising spiritual and aesthetic functions, pollination, ecosystem detoxification functions, carbon and nitrogen sequestration and CO2 sinks for amelioration of climate change impacts among others. These ecosystems are increasingly threatened by degradation attributed to land use changes. Human perturbations such as crop farming on riparian land, overgrazing and population pressure on land resources influence degradation of riparian ecosystems, with profound effects on biodiversity conservation and local livelihoods. Evidence from the literature indicates that although there is a general understanding regarding the response of terrestrial and wetland ecosystems to human perturbations, there is a dearth of information on the response of African riparian ecosystems to ecologic and socio-economic impacts. The purpose of this paper is to present research evidence on the response of River Lumi riparian ecosystem to ecologic and socio-economic impacts and contextualize management implications for arresting biodiversity loss.

River Lumi riparian ecosystem in Taita Taveta County was stratified into three land use systems comprising livestock production, mixed crop-livestock system and pure crop production system in the upper, middle and lower reaches of the river respectively. The objective of the study was to examine the role of anthropogenic influence on riverine vegetation structure, tree species diversity soil characteristics and household livelihoods. Thirty-six belt transects were established perpendicular to the river and plots measuring 30.0m by 15.0m were designated to assess forest structure and tree species diversity. On the basis of semi-structured questionnaires, 353 households living adjacent to the riparian ecosystem were interviewed to determine the interaction between socio-economic factors and household response to degradation. Statistical testing for significance was performed at 95% confidence interval. Tree species diversity ($F(1, 2) = 0.94$; $p=0.401$)), seedling density ($F(1, 2) = 0.07$; $p=0.937$), sapling density ($F(1, 2) = 0.44$; $p=0.647$) and tree stand density ($F(1, 2) = 2.23$; $p=0.110$) were not significantly different in the three-land use production systems. However, diameter at breast height (DBH) values in the livestock production system were significantly different from those in the mixed and crop farming systems ($F(1, 2) = 2.98$; $p=0.052$). Livestock production system favoured larger tree sizes compared to the crop farming system. Soil characteristics influenced the occurrence and distribution of dominant tree species ($F(1000) = 7.1$; $p=0.001$), and less dominant tree species ($F(1000) = 2.4$; $p=0.01$). Household response to degradation was influenced by gender of household head ($r = 0.025$; $p=0.661$) and household income ($r = 0.016$; $p=0.762$). Evidence from this study shows that agricultural expansion, overgrazing and human population growth have contributed to accelerated human induced transformation of riparian forest structure, biodiversity erosion and loss of critical CO2 climate change sinks associated with River Lumi riparian ecosystem. Evidence is adduced here for the need for development of a land use plan and auxiliary effective legal, policy and institutional infrastructure for effective management of riparian ecosystems.

Keywords: riparian ecosystem; biodiversity loss; ecosystem goods and services; land use and land cover changes; anthropogenic disturbance.

I. Introduction

Riparian ecosystem fluxes are a function of the pulsations of the water cycle mainly controlled by climate and anthropogenic perturbations. The increasing pressure on these ecosystems for provision of goods and services in the 21st century and beyond coupled with increasing sensitivity to climate change poses a threat to their sustainability (Capon et al., 2013, Maxwell et al., 2016). Isolated evidence in the literature is suggestive of a likelihood of acquired resilience of these systems to climate change due to exposure to extreme conditions of environmental variability (Capon et al., 2013). There is consensus among scholars that management adaptation and mitigation strategies are critical in the quest to reduce vulnerability and enhance capacity for adaptation to changing environmental and extreme hydrological conditions (Hulme, 2005, Palmer et al., 2007 and Steffen et al., 2009).

There is no doubt that riparian ecosystems at various spatial and temporal scales influence flow of energy and material cycling between and within connected terrestrial and aquatic ecosystems. The ecological significance of energy transfer and material cycling in the performance of trophic systems associated with trophic level interactions, food webs and

Author α: Associate professor of systems ecology and microclimatology/ Consultant in Natural Resources Ecology and Management, Department of Natural Resources, Faculty of Environment and Resources Development, Egerton University, Kenya.
Author σ: Research scientist, Kenya Forestry Research Institute, Coast Eco-Region Research Programme, Malindi, Kenya.
e-mails: emaranga@egerton.ac.ke, ekmaranga@yahoo.com

food chains as well as provisional services for supporting human livelihoods cannot be overemphasized. At the abiotic level, riparian functions have considerable influence on the carbon and nitrogen sequestration, hydrologic and geomorphological processes, sulphur and phosphorous cycles as well as biogeochemical cycles and other processes in landscapes. Integrated biotic and abiotic interactions at larger scales of riparian ecosystem functions regulate climate, biodiversity, hydrologic processes, nutrients, soils, and autotrophic and heterotrophic level performance (Sala et al.,2000, Habel and Ulrich, 2021). Non-disturbed ecosystems with rich biodiversity have been demonstrated to effectively and efficiently offer ecosystem functions compared to degraded and homogenous ecosystems (Winqvist et al., 2011). Anthropogenic activities erode ecosystem functions. Overgrazing, deforestation as well as selective extraction of plant materials from riparian ecosystems influence hydrologic processes that cause microclimatic modification with significant consequences on water and energy budgets (Lawrence and Vandecar, 2015, Felipe-Lucia et al., 2020). Introduction of invasive exotic species with the potential of hybridization and adulteration of indigenous plant material genetic pools reduce the diversity of ecosystem functions on offer (Linderset al., 2019, Baude et al., 2019).

The diversity of riparian ecosystem functions provides a super structural base for human development through extraction of primary resources in the form of goods and benefit from services as well as a support system for other abiotic- biotic interactions that provide synergies for physiological and ecological processes (Millennium Ecosystem Assessment, 2005, Klein et al., 2007, Power, 2010 and Tschumi et al., 2018).

Subsistence farmers dependent on livestock products and limited non-rainfed horticultural production serviced by coastal riparian ecosystem functions for their livelihood must continue to contend with a high food security risk in the absence of successful adaptation and mitigation efforts to reduce vulnerability to environmental variability and climate change (Hulme, 2005). This scenario is predicated by inappropriate land use systems, increasing demographic pressure as well as weak infrastructural frameworks for the management and governance of riparian ecosystems.

The need for adaptation options and mitigation efforts anchored on baseline ecological and socioeconomic profiles for conservation of dynamic and rapidly degenerating riparian ecosystems provided the motivation for the current study.

Previous research work on riparian ecosystems affirms the fact that there is a general understanding regarding the response of terrestrial and wetland ecosystems to human perturbations, however, there is a dearth of information on the response of riparian ecosystems to ecologic and socio-economic impacts(Sala et al, 2000, Hooper et al., 2005,Power, 2010,Habel et al., 2015, Habel et al., 2018).The primary objective of this paper is to present research evidence on the response of River Lumi riparian ecosystem to ecologic and socio-economic impacts and contextualize management implications for arresting biodiversity loss.

II. Materials and Methods

a) Description of Study Area

The source of River Lumi is Mt. Kilimanjaro. The river flows north eastwards traversing a water catchment rich in riparian vegetation, closed and open wood vegetation and open shrubs before crossing the border from Tanzania to Kenya and draining into Lake Jipe in Taita Taveta County (Figure 1). River Lumi riparian ecosystem with an area of 590km^2 provides goods and services for the communities that have settled along the river(Ngugi et al., 2015). These include irrigation water, timber and grass for house construction as well as firewood for supply of energy for cooking and other purposes. The river ecosystem provides a life support system for wildlife in the adjacent Tsavo East and West National Parks.

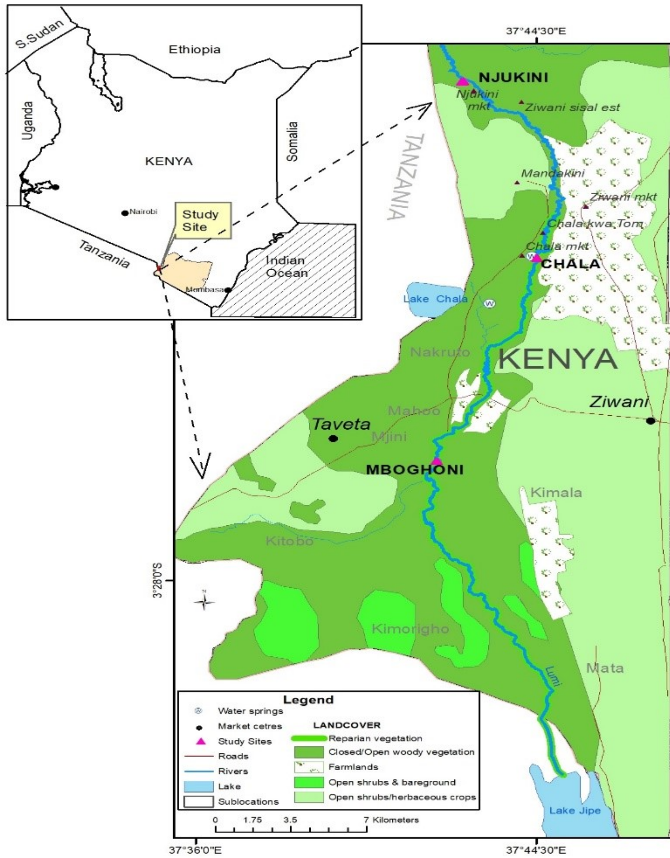


Figure 1: Location of study sites

b) Topography and Climate

The study area is a dissected lava plateau with half dozen isolated hills south of Taveta and Mt. Kilimanjaro volcanic pile. The tertiary lavas of Mt. Kilimanjaro volcanic pile consist of Rombo series with manifestations of Kijabe type basalts, olivine basalts and olivine soda trachytes. River Lumi watershed area exhibits topographical variations ranging between 1200 meters above sea level (m.a.s.l) and 1800m.a.s.l. There are innumerable small volcanic cones represented by Kijabe basalt. Projecting above the landscape, between Lake Chala and Lake Jipe are pyroclastic cones contaminated with olivine basalts.

The climate of River Lumi riparian ecosystem is characterized as semi- arid area receiving a mean annual rainfall of 616mm.Mean monthly maximum temperature is of the order of 32 ^{0}C and a mean monthly minimum of 17 ^{0}C (Republic of Kenya, 2014).

c) Geology and Drainage

The geology of the River Lumi water catchment consists of parent metamorphic rocks that have disintegrated by weathering and geomorphological processes into sedimentary alluvium and deposited by several streams that feed into River Lumi before it drains into Lake Jipe. Substantial superficial deposits on the flood plain include calcareous and ferruginous clays and white gritty and greyish limestone with carbonaceous material of fluvio-lacustrine origin(Bear, 1955, Horkel, et al., 1979: Geology of Taita Hills Quadrangle; with a geological map 1:50.000, Kenya).

River Lumi cuts deeply across the grain of the basement rocks and is fed by several springs at the junction of Njoro Kubwa before it empties into Lake Jipe. The ruggedly eroded channel is approximately 4metres deep and is characterized by heavy deposition of alluvium and sedentary soils of metamorphic origin in the lower reaches of the river. The bed of the channel is mainly basalt. The river is prone to considerable flooding and materially destructive to road and railway infrastructure as well as irrigation projects in its flood plain. There are traces of effects of tertiary volcanity that may have deflected Lumi streams that flowed into the Tsavo to the east of Sambera where the watershed between Lumi and Njoro is less than 100 metres (Horkel et al., 1979).

d) Biodiversity

River Lumi ecosystem has diverse flora and fauna. The natural vegetation type is savannah grassland with scattered Acacia trees, bushes and semi-arid scrubs. Belts of evergreen riverine vegetation occur particularly in the fringes of the flood plain. Dominant tree species include *Tabernaemontana*

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022

stapfiana, Pauridiantha clauracea and Acacia nubica (Wekesa et al., 2018). The riparian ecosystem provides a life-support system for the rich fauna including a variety of water birds, zebras, elephants, impalas and gazelles in the Tsavo West National Park. River Lumi flood plain is an extensive area supporting irrigation agriculture. The dry savannah is an important grazing area for livestock.

e) Settlement and Land Uses

The communities that have settled along River Lumi watershed carry out subsistence crop and livestock farming with limited commercial irrigated farming (Muli, 2014). According to KNBS, 2019, a population of 9122 are dependent on small business enterprises in the major trading centres in the riparian ecosystem. These enterprises revolve around livestock and crop products and mainly horticultural products, timber craft wares, as well as fishing within Lake Jipe. River Lumi riparian ecosystem and its proximal areas have a large proportion of squatters whose livelihood activities have contributed significantly to degradation of the ecosystem (Ngugi et al., 2015).

f) Socio-economic Profiles

Economic production systems based on land uses were identified and categorized into three socioeconomic profiles. The upper reaches of River Lumi ecosystem represented by Njukini location is a livestock grazing area mainly used by the Maasai community. A large number of livestock are kept on private ranches on the river Lumi water catchment. There is also a considerable density of medium scale livestock subsistence farming to cater for the livelihood requirements of the communities in the water shed area. The middle zone represented by Chala location is a mixed crop-livestock area mainly used by the Kamba community. The lower reaches of River Lumi represented by Mboghoni is a predominantly crop farming area utilized by the Taita Taveta community. Commercial horticultural crops based on irrigation systems such as tomatoes, cabbages, kales, capsicum are grown. Other crops include bananas and maize (Muli, 2014, Ngugi et al., 2015 and Njiriri, 2016). There are scattered small business enterprises as well as fishing mainly in Lake Jipe to complement the income sources of the community settled in the riparian ecosystem (Njiriri, 2016).

III. Environmental and Socioeconomic Data

Exploratory socio-economic surveys as well as vegetation measurements were carried out. Semi-structured household questionnaires and Focus Group Discussions (FGD) were designed to obtain data on the interaction between socio-economic factors comprising demographic change, gender, income and education levels, land size relegated to crops and livestock, commodity prices and household response to the degradation of River Lumi ecosystem. Field assessments of forest structure, tree species diversity and soil characteristics that influence tree species type and distribution in Njukini, Chala and Mboghoni locations yielded the data requirements of this study.

a) Vegetation Data

Tree height and diameter at breast height (DBH), species richness, species diversity and regeneration were determined in plots and sub-plots along 36 belt transects. The plots measured 30.0m by 15.0 whereas the sub-plots were 15.0m by 7.5m. The plots were established with the long side perpendicular to the river bank.

A diameter tape was used to measure DBH of trees greater than 2.5m. Nested sub-plots within main plots measuring 15.0m by 7.5m and 10.0m by 5.0m were used for measurements of saplings and seedlings. Saplings were designated as trees with DBH $\geq$1.0cm $\leq$ 2.5 cm whereas seedlings were defined as trees with DBH $\leq$ 1.0cm.

Tree species diversity was estimated using Shannon-Weiner diversity index(Shannon and Weaver, 1963; Krebs, 1999), whereas species richness was determined by counting different tree species found in the plots. Shannon-Weiner index is a measure of species diversity in a community and accounts for species abundance and evenness. Typically, Shannon diversity index values range between 1.5 and 3.5 and rarely exceed 4.0 in most ecological studies. Usually, values less than 1.5 signify low diversity, values between 1.5 and 2.5 indicate medium diversity and values greater than 2.5 represent high diversity.
Shannon-Weiner index is defined as:

$$H = -\sum_{i=1}^{s} (Pi \ln Pi)$$

Where,

H =Species diversity index

Pi = Proportion of individuals of each species belonging to the ith species of the total number of individuals

S= Number of species in the community

Species richness and diversity was compared in the three land use systems (livestock production, mixed farming and crop farming) along River Lumi riparian ecosystem.

b) Soil-vegetation Interaction Data

Soil samples were collected from Njukini, Chala and Mboghoni locations in July 2019 and 2020 for determinations of soil pH, organic carbon, nitrogen, phosphorous, potassium and soil moisture content. Soil augers were used to collect three replicates of soil samples from 0-15cm and 15-30cm soil depths within the sub-plots in the 36 belt transects where vegetation measurements were carried out. A total of 300 composited soil samples were analyzed at the Kenya Forestry Research Soil Science Laboratory in Muguga, Kenya.

Samples were air dried and sieved using 2.0mm sieve prior to analysis. Soil moisture content was gravimetrically determined using Okalebo et al., 2002 procedure. Olsen and Kjeldahl methods were used in the determination of nitrogen and phosphorous (Okalebo et al., 2002). The Walkley-Black method was used in the determination of organic carbon through complete oxidation (Walkley and Black, 1934). Potassium was determined using Kjeldahl procedures and photometric analysis using a photoelectric flame photometer(Okalebo et al., 2002). Soil pH was measured using a pH meter as described by Anderson and Ingram 1993. Soil pH, soil moisture content and soil chemical composition were used in providing plausible explanations for the variation and distribution of tree species along River Lumi riparian ecosystem.

The measure of association between the distribution of tree species and soil chemical characteristics in the upper, middle and lower reaches of River Lumi was determined by Canonical Correspondence Analysis (Wekesa, 2018). Tree species were classified into dominant, less dominant and rare categories where the proportion of occurrence in the sampled plots was at least 10%, less than 10% and 5% respectively.

An estimate of species heterogeneity was obtained through detrended corresponding analysis (DCA) prior to Canonical Correspondence analysis (CCA).Preliminary DCA test revealed that the tree species interactions exhibited unimodal responses of six standard deviations (SD), making CCA the most appropriate method for analysis (Leps and Smilauer, 2003). The association between soil characteristics and tree species distribution as well as the relationship between dominant tree species, less dominant and rare species along River Lumi riparian ecosystem was determined by the application of CCA with automatic forward selection using 1000 permutations at 95% probability level and verified by Monte-Carlo Permutation Test (MCPT).

c) Socio-economic Data

Socioeconomic data was obtained from three stratified administrative units within Njukini, Chala and Mboghoni locations using systematic sampling procedures. These administrative units comprised Njukini springs-Chala Kwa Tom in the upper reaches of River Lumire presenting the livestock production system, Madulu springs-Darajaniin the middle zone was representative of the mixed farming system whereas Njoroya Katembo-Mboghoni in the lower reaches of River Lumire presented the crop production system. The households with settlements approximately five kilometers from River Lumi were systematically sampled in proportion to the total number of households in each location. The estimated number of households in Njukini, Chala and Mboghoni was 2,295, 1,325, and 790 respectively (KNBS, 2010). Thus 184, 105 and 64 households representing at least 10% (Mugenda and Mugenda, 1999) of the households living in Njukini, Chala and Mboghoni locations were selected and interviewed using semi-structured questionnaires. A total of 353 respondents were interviewed.

The 2009 Kenya National Bureau of Statistics Household Census data for the selected locations (Njukini, Chala and Mboghoni) was used in determining the sample size. The three study locations have 4,410 households (KNBS, 2010). The sample size for the households was calculated using the following formulae recommended for population size of less than 10,000 (Cochran, 1963).

$$nf \quad = n/1 + n/N$$

N

where nf is desired sample size when population is less than 10,000

n is the desired sample size

N is the estimated population of the three locations

Therefore, the total sample size for the 3 locations was,

$$nf = 384 = 353$$

$$1 + (384\text{-}1)$$

$$4{,}410$$

This figure (353) was distributed in the three locations proportionately based on total number of households as shown in Table 1.

Table 1: Sample size of households by location

Location	Total number of households	Sample size (nf)
Njukini	2,295	184
Chala	1,325	105
Mboghoni	790	64
Total	4,410	353

Focus Group Discussions (FGDs) and semi-structured questionnaires were used in the collection of primary household data. Secondary data regarding population profiles, levels of education, land sizes relegated to different land use systems, income level, gender, household size and market dynamics was obtained from Kenya Government Departments as well as Kenya National Bureau of Statistics. A total of 35 questionnaires comprising 10% of the sample projected for the larger parent study (Connelly, 2008) was used in the pilot survey. Pilot surveys for pretesting the research instrument for validity and reliability were conducted in Nakuruto village adjacent to Chala location in the middle zone of the riparian ecosystem. The focus of sample survey revolved around the land resource ownership, livelihood activities and their consequences on the dynamics of the integrated resources of the watershed, water resources governance and community participation in the conservation of riparian resources. Current and historical drivers of riparian degradation were constructed through discussion discourses (FGDs) involving mixed-crop production systems, crop production and livestock production systems in the three study locations. Government and non-Governmental key informants as well as community-based organizations (CBOs) were involved in interactive discourses to provide and verify information on the significance of socio-economic factors on the dynamics of the riparian ecosystem.

d) Data Analysis

Prior to data analysis, normality and reliability attributes were tested using Cronbach alpha reliability function for socioeconomic data and Levene's test for ecological data respectively. Square root transformation of count data on the number of tree species per plot for each observation was performed to correct non-normality before parametric analysis. Parametric statistics were used to analyze tree species diversity, stand density, species richness, diameter of trees at breast height and height as well as household income.

Tukey's post hoc test with a 5% probability significance threshold was used to separate least significance difference in means. The F-test isolated significant effects associated with the independent variables at 95% confidence interval. The association between land tenure, education level, income level, gender, household size and house hold response to degradation through participation in conservation activities was evaluated by means of Spearman's rank correlation analysis.

IV. Results and Discussion

a) Vegetation dynamics in the contrasting livestock, mixed farming and crop production systems

Natural regeneration plays an important role in forest succession and enhances tree species diversity. Tree species regeneration along the riverine ecosystem was studied in the context of varying land production systems. The seedling density was higher inthe crop production system (461.77±255.16 stems/ha), as compared to livestock production system (400.20±169.57 stems/ha), and mixed farming system (387.62±64.44 stems/ha) (Figure 2). The seedlings density in the three land use systems was, however, not significantly different (F (1, 2) = 0.07; p=0.937). Similarly, the sapling density in the three land use systems was not significantly different (F (1, 2) = 0.44; p=0.647), although the saplings density was higher in crop farming system (385.23±74.49 stems/ha) than mixed farming system (302.58±37.76 stems/ha) and livestock production system (293.64±59.75 stems/ha). A similar trend was observed in shrubs density (stems/ha).The shrubs stand density in the three land use systems was not significantly different (F (1, 2) = 0.77; p=0.471), although higher shrub density was recorded in mixed farming system (1037.56±255.01) than in livestock production system (799.20±274.78) and crop farming system (448.44±153.87).

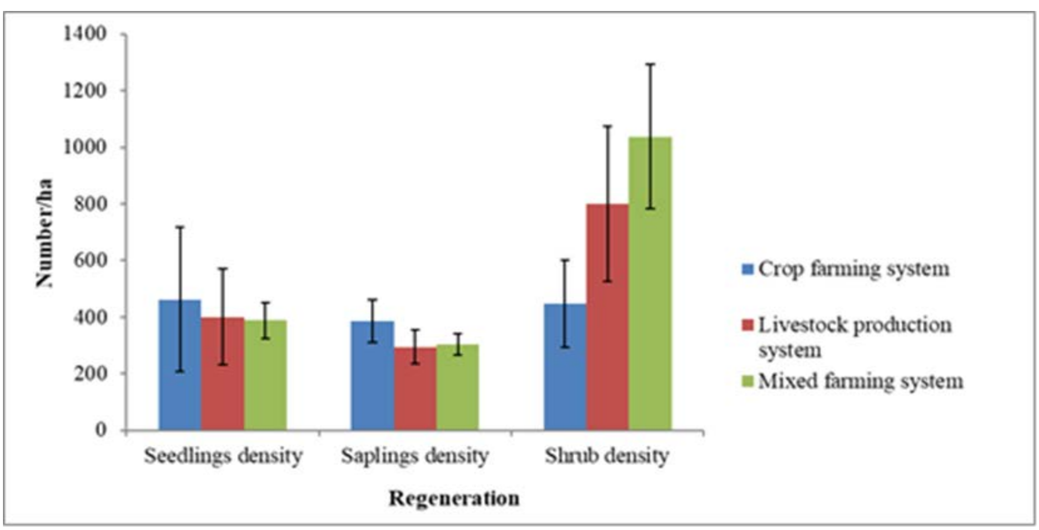


Figure 2: Comparison of seedling density, sapling density and shrub density in the three land use systems along River Lumi riparian ecosystem. Error bars represent SEM)

The effect of land production system on natural regeneration was evident in the three land use systems. Both seedling and sapling densities were higher in crop farming system than in mixed farming system and

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022

livestock production system. Mixed farming and livestock production systems had negative impacts on natural regeneration. The low seedlings and saplings density in the livestock production system was attributed to browsing and trampling by animals as well as soil compaction which inhibits seedlings and saplings growth. These results are in conformity with the intermediate disturbance hypothesis (IDH) which predicts the behaviour of species diversity under different disturbance levels in stream ecosystems (Connell, 1978). According to IDH, moderately disturbed areas record high species diversity due to the low magnitude and frequency of disturbances which have a minimal effect on plant communities. On the contrary, areas with more frequent and intense disturbance often have low species diversity since species that regenerate quickly between disturbance events will prevail. In this study, the crop farming system was characterized by moderate disturbance while the livestock production and mixed farming system were characterized with heavy disturbance. The heavy disturbance due to overgrazing in the livestock production system as well as the multiple land uses (crop farming and livestock production) in the mixed farming system could explain the low natural regeneration in the two land use systems. Evidence from previous studies shows that intense land use such as overgrazing impedes forest recovery. This is mainly due to high prevalence of grasses and other herbaceous species which inhibit the establishment of woody vegetation (Zahawi and Augspurger, 1999; Kennard, 2002; and Makana and Thomas, 2006).

The crop farming system had adequate light in the understory, and had higher species diversity which provided a seed source to facilitate tree seedling growth (Nostrand et al., 2003). In Mboghoni location, the crop farming zone experienced wet environmental conditions facilitating seed germination and seedling growth as compared to Chala (the mixed farming zone) and Njukini (livestock production zones) which are situated in arid and semi-arid lands (ASALS) (Republic of Kenya, 2018).Dry conditions slow litter decomposition (Didham, 1998) and accumulating litter may affect seed germination and seedling survival negatively (Bruna, 1999; Wekesa, 2018).River Lumi flood plain where the crop farming system is practiced receives deposits ofalluvial soils along the river bank enhancing the nutrient levels which facilitate growth of seedlings and saplings. High soil moisture content resulting from irrigated farming and alluvial soil deposits in the crop farming system also provided favourable environmental conditions for seedling growth. These findings are in agreement with previous studies that have corroborated evidence that site-specific factors such as soil type and nutrient availability, soil pH, moisture, sunlight, micro-topography and competition have an effect on species regeneration and growth (Nostrand et al., 2003; Wekesa et al., 2018). As expected, shrub density was marginally higher in mixed farming system and livestock production system than in crop farming system. The low seedling and sapling densities in mixed farming and livestock production systems were attributed to high shrub density. Dwire et al., (2018) who assessed the effects of climate change on riparian areas in the Blue Mountains in Oregon, USA established that reduced soil moisture resulting from drought and dry weather conditions often leads to increase in non-native species and transition from riparian woody plants to drought tolerant conifers and shrubs. The results of this study imply that climate change may have influenced the low seedling and sapling densities in the mixed farming and livestock production systems which are vulnerable to extreme climatic conditions due to their location in semi-arid areas. According to Adel et al., (2018), an increase in shrub density in riparian areas intensifies competition for light and nutrients between tree seedlings and shrubs leading to reduction in seedling density. Additionally, shading from shrubs reduces tree seedling density. Hudson et al., (2014) observed that the shading effect of shrubs along riverbanks reduced seedling density and tree regeneration, while Sarr et al., (2011) noted that high shrub densities in riparian forests caused out-competition of seedlings leading to low seedlings densities and regeneration.

There were higher densities of shrubs in both crop-livestock system and livestock production system. The shifts in botanical composition arising from differential livestock utilization has been demonstrated by Ratovonamana et al., (2013). In their study, they found that changes in the structure of woody plant species resulting from browsing favours the growth of herbaceous and unpalatable species. On the basis of this evidence, it can be surmised that the higher densities of shrubs in both mixed farming system and livestock production system may be attributed to differential utilization by livestock. Ratovonamana et al., (2013) also found evidence that regeneration potential in livestock production zones depends on the browsing intensity and grazing pressure (Reed and Clokie, 2001; Sassenand Sheil, 2013) indicating that intensive grazing hampers forest regeneration. Thus, there is need to ensure appropriate stocking levels that will reduce the grazing pressure particularly in the livestock production system. The complex interactions between land use and land cover in human-dominated landscapes interfere with biotic and abiotic factors and processes, with negative impacts on wildlife habitats, species diversity and abundance, as well as distributional ranges of species (Sala et al., 2000). For instance, forest regeneration in tropical landscapes is often hindered by disturbance in most agricultural landscapes resulting from soil compaction, nutrient loss, and low seedling availability (Ferraz et al., 2005; De Paula, 2018). According to Malik and Bhatt (2016) and Maua et al., (2020), the population dynamics of seedlings, saplings and adults tree species can determine the regeneration status of a forest, and effective management of natural forest ecosystems require an understanding of the natural regeneration processes and dynamics.

b) Effect of land production system on forest structure

Stand density and tree sizes are attributes of forest structure that influences the ability of the forest to provide ecosystems goods and services. The mean DBH of trees in the three land use systems was significantly different (F (1, 2) = 2.98; p=0.052).The livestock production system had trees with larger diameters (41.50±5.818) than mixed farming system (32.48±2.527) and crop farming system (27.61±2.50). On the contrary, the mean height of trees was not significantly different in the three land use systems (F (1, 2) = 1.35; p=0.259) although the mean height of trees was higher in crop farming system (12.31±1.01) than livestock production system (11.20±1.004) and mixed farming system (10.38±0.628). Similarly, tree stand density in livestock production system, mixed farming system and crop farming system was not significantly different (F (1, 2) = 2.23; p=0.110). The tree stand density was, however, higher in crop farming system (54.95±11.82) than livestock production system (52.60±6.77) and mixed farming system (39.55±3.21), Figure 3.

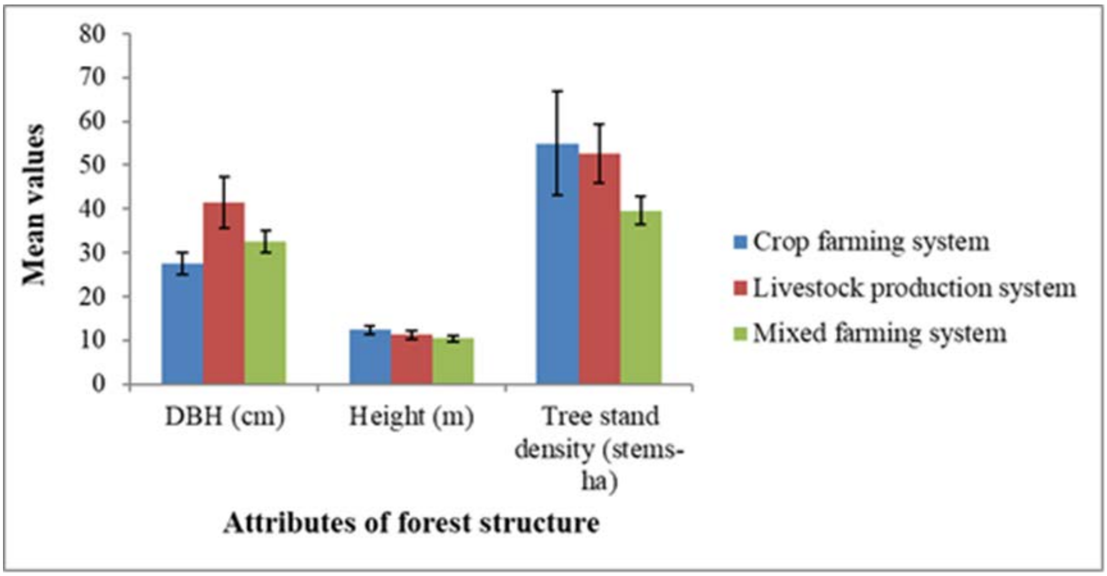


Figure 3: Comparison of tree stand density, diameter at breast height and height in the three land use systems along River Lumi riparian ecosystem. Error bars represent standard error of the mean

The higher tree stand density in the crop farming system than in livestock production system and mixed farming system may be attributed to high fertility of the soils in the irrigated flood plain frequently enriched by alluvial soil deposits. The fertile riparian flood plain coupled by favourable soil moisture supplies provided a favourable environment for seedling growth leading to higher tree stand density. De Paula (2018) argued that high soil moisture is a precursor to favourable conditions for microbial activity, enhancing decomposition and mobilization of critical mineral nutrients that promote tree growth. Illegal logging and charcoal burning were prevalent in the mixed and livestock production systems. These anthropogenic activities opened up riparian forest areas in Njukini and Chala. Evidence from previous studies also suggests that the low density of trees in Njukini and Chalais due to over-exploitation of such trees through illegal logging and charcoal production among other anthropogenic disturbances (Girma et al., 2014; Maua et al., 2020).

The low tree heights in the mixed farming system were attributed to high demand for crop stakes which are used for supporting tomato crop, a major crop grown in the area. The low mean tree height in mixed farming systems and livestock production systems were further attributed to browsing, trampling and breakages resulting from grazing pressure (Ratovonamana et al., 2013). The livestock production system is dominated with herbaceous vegetation and shrubs which are generally short. Ramirez et al. (2018) has contended that the density and browsing intensity of animals determine the net effect of defoliation on the ecosystem.

Big trees in the crop farming system were cut to attenuate their shade effect on crops. Livestock production in both crop-livestock and livestock production systems had an effect on seedling and sapling density through browsing and trampling hence affecting regeneration, but had no observed effect on mature trees. This explains the higher DBH in the two land use systems.

Previous studies indicate that habitat modification alters ecosystem composition, species distribution and numbers (Stomsand Estes, 1993; Guariguata and Ostertag, 2001), leading to change in ecosystem composition, structure, and functioning (Budowski, 1965; Franklin et al., 2002; Chazdon, 2014). For instance, a study conducted to assess the effect of land use on the structure and diversity of riparian vegetation in the Duero River watershed in Mexico revealed that the land uses adjacent to the riparian area modified attributes of riparian vegetation, particularly species richness and density of stems and individuals (Mendez-Toribio et al., 2014). It was further established that there was a drastic loss of species diversity related to the disturbance generated by the anthropogenic activities ongoing in the vicinity of the river bank.

Evidence from other studies shows that the ecosystem trajectory after a disturbance will depend on the intensity, duration, and frequency of the disturbance, as well as the resilience and stability of the ecosystem (Holling, 1973; Chapin et al., 2011; Clewelland Aronson, 2013). Ecosystems are more likely to bounce back to their pre-disturbance conditions if the disturbance is less severe (Chapin et al., 2011; Hodgson et al., 2015), while in cases of severe disturbance, the ecosystem may shift to an alternative stable state that can persist beyond the disturbance (Holling, 1973; Chapin et al., 2011). The alternative stable state often experiences reduced ecological processes than the previous ecosystem thus sustaining less biodiversity (Clewelland Aronson, 2013). In this study, livestock production system experienced the highest form of disturbance as indicated by the observed land degradation attributed to over-grazing and soil erosion. There is evidence that species composition and vegetation structure significantly changed with increasing grazing pressure. From previous results, it has been established that grazing leads to desertification and soil erosion, resulting to loss of essential nutrients and soil organic matter which support vegetation growth (Guggenberger et al., 1994; Foley et al., 2005).

c) Interaction between soil characteristics and dominant tree species

There was a significant interactive effect between soil physical and chemical characteristics and distribution of five dominant tree species (*Vachellia (Acacia) nubica, Ekerbergia capensis, Grewia bicolor, Tabernaemontana stapfiana* and *Trichilia emetica*), and soil physical and chemical characteristics (soil moisture, organic carbon, phosphorous, nitrogen, potassium and pH)along River Lumi riparian ecosystem (F (1000) =7.1; p=0.001). The occurrence of dominant tree species was mainly influenced by soil moisture, organic carbon and pH. The occurrence of *Ekerbergia capensis* was strongly influenced by moisture level in the soil while the occurrence of *Grewia bicolor* was significantly determined by pH and organic carbon (Figure 4). Occurrence of *Tabernaemontana stapfiana* and *Trichilia emetica* was slightly influenced by pH and organic carbon while the occurence of *Vachellia (Acacia) nubica*, had no correlation with the soil variables. Nitrogen, phosphorous and potassium did not affect the distribution and abundance of dominant tree species along the riparian forests of River Lumi.

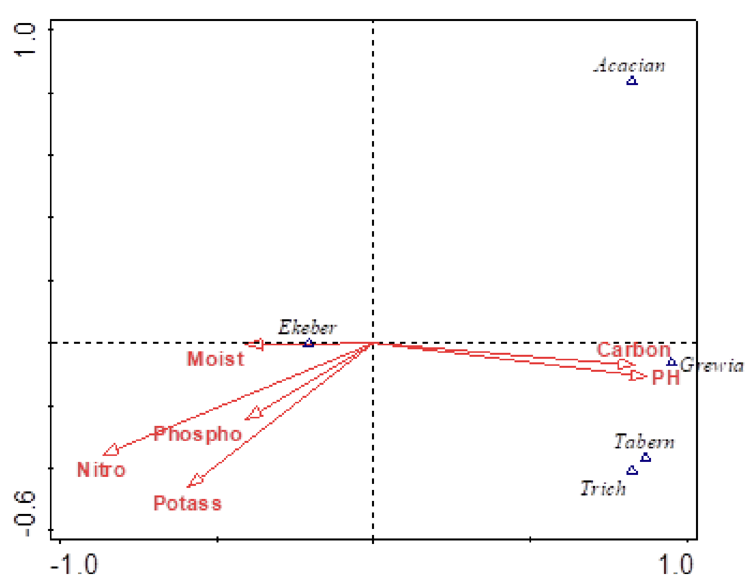


Figure 4: Canonical Correspondence Analysis (CCA) of five key dominant tree species and soil variables along River Lumi riparian ecosystem. Acacian=*Vachellia (Acacia) nubica*, Ekeber=*Ekerbergia capensis*, Grewia=*Grewia bicolor*, Tabern=*Tabernaemontana stapfiana*, Trich=*Trichiliaemetica*, Carbon=Organic carbon, Nitro=Nitrogen, Potass=Potassium, Phospho=Phosphorus, Moist=Soil moisture.

Soil pH, organic carbon, nitrogen and potassium were not significantly different in livestock and mixed production systems. However, phosphorous and soil moisture were significantly different. Soil pH was higher in the livestock production system than in mixed and crop farming systems. Evidence from previous results indicates that irrigated areas in crop and mixed farming systems had higher pH levels than non-irrigated areas where livestock grazing is mainly undertaken(Muli 2014). According to Muli (2014), crop irrigation leads to salinization and affects availability of soil nutrients such as nitrogen, phosphorous and potassium which are easily lost through leaching. High pH recorded in the livestock production system in this study was attributed to the dry conditions in the area while the high acidity found in the crop and mixed farming systems was attributed to the effect of acidifying synthetic fertilizers which were heavily used in the two land use systems. There is evidence that, nitrogen inputs from synthetic fertilizer increases soil acidity in the absence of lime addition (Tarkalson et al., 2006; Liebig et al., 2017). Soil pH has a major influence on the availability of potassium, phosphorus and other nutrients which affect plant growth, hence affecting tree species occurrence and distribution in riparian forests (John et al., 2007).

Phosphorous is frequently excreted via livestock excreta (Wang, 2016) and is thus concentrated in the livestock production system, while continuous harvesting of crops which is mainly practiced in irrigated areas, often depletes phosphorous at a faster rate than natural regeneration (NyanjomandK'Onyango, 2008; Muli, 2014). This is a plausible explanation for lower levels of phosphorous in continuous irrigated crop farming systems. The higher soil moisture content in the crop farming system was attributed to higher rainfall experienced in the crop farming land use system coupled with irrigated farming (Ngugi et al., 2015).

d) Interaction between soil characteristics and less dominant tree species

Soil characteristics were found to influence the distribution of less dominant tree species (F (1000) =2.4; p=0. 01). Occurrence of *C. africana, M. excelsa* and *A. xanthophloea* was strongly influenced by nitrogen content, available phosphorous and soil moisture content.*A. abyssinicus* had a positive correlation with phosphorous and potassium while *A. drepanolobium* had a weak positive correlation with potassium (Figure 5). The abundance of *F. sur* and *F. thonningii* was slightly influenced by organic carbon, while *F. sur, A. melifera, A. abyssinicus* and *A. drepanolobium* had negative relationship with pH.

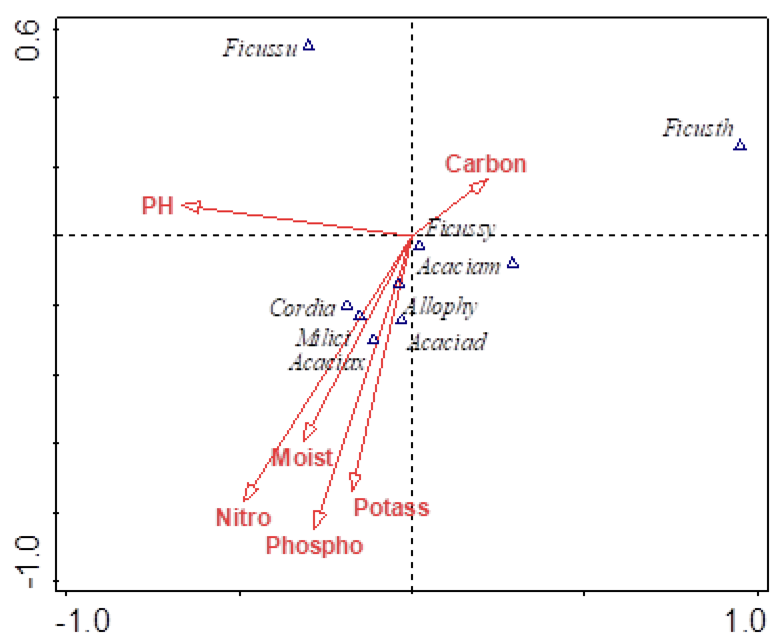


Figure 5: Canonical Correspondence Analysis (CCA) of less dominant tree species and soil variables along River Lumi riparian ecosystem. Acaciad= *Vachellia (Acacia) drepanolobium, Acaciam= Vachellia (Acacia) melifera, Acaciax= Vachellia (Acacia) xanthophloea, Allophy= Allophyllusabyssinicus, Cordia=Cordia Africana, Ficusth=Ficusthonningii, Ficussu= Ficussur* and*Ficussy=Ficus sycomorus,* Carbon=Organic carbon, Nitro=Nitrogen, Potass=Potassium, Phospho=Phosphorus, Moist=Soil moisture

The occurrence of less dominant tree species was mainly influenced by nitrogen, phosphorous and potassium which play a critical role in plant growth (Omoro et al., 2011), as well as soil pH which affects availability of plant nutrients (John et al., 2007).

Global Journal of Science Frontier Research (H) Volume XXII Issue VII Version I Year 2022

e) *Interaction between soil characteristics and rare tree species*

Environmental variables did not have a major influence on the occurrence and distribution of rare tree species which included *(Albizia glaberrima, Albizia gummifera, Bridelia micrantha, Xymalos monospora, Senna denimetria, Senna spectabilis, Croton macrostachyus, Rauvolfia caffra, Ehretia petiolaries, Tapra fisc, and Sorindeia madagascariensis)* (F (1000) =2.3; p=0.002). Accordingly, there was no relationship between *Albizia glaberrima, Bridelia micrantha, Xymalos monospora, Senna denimetria, Senna spectabilis, Croton macrostachyus, Rauvolfia caffra, Taprafisc,* and *Sorindeia madagascariensis* with any of the soil characteristics studied. *Ehretia petiolaries* and *Albizia gummifera*, however, exhibited a strong positive relationship with phosphorous, and a weak relationship with nitrogen and carbon (Figure 6).

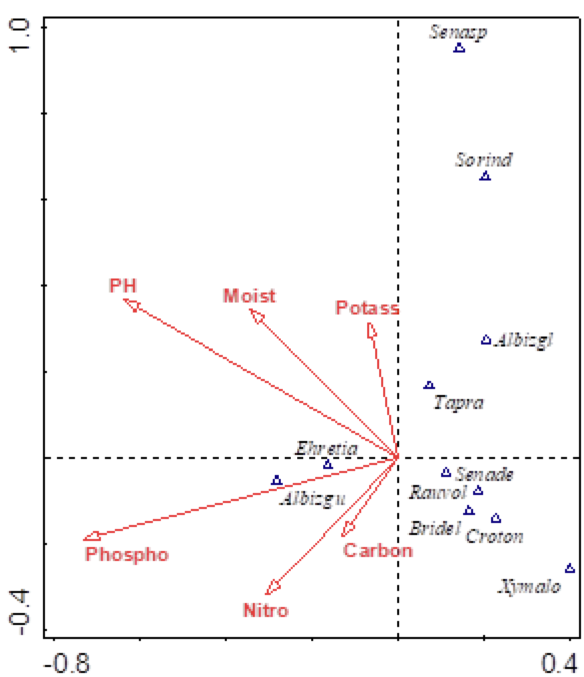


Figure 6: Canonical Correspondence Analysis (CCA) of rare tree species and soil variables along River Lumi riparian ecosystem. Albizgl=*Albizia glaberrima,* Albizgu=*Albizia gummifera,* Bridel=*Bridelia micrantha*, Xymalo =*Xymalos monospora*, Senade=*Senna denimetria,* Senasp=*Senna spectabilis,* Croton=*Croton macrostachyus,* Rauvol = *Rauvolfia caffra,* Ehretia=*Ehretia petiolaries,* Tapra =*Taprafisc,* and Sorind=*Sorindeia madagascariensis,* Carbon=Organic carbon, Nitro=Nitrogen, Potass=Potassium, Phospho=Phosphorus, Moist=Soil moisture

This would suggest that soil variables may not have been entirely responsible for the occurrence and distribution of the rare tree species. Chen et al., (2014), confirmed that external factors such as environmental and ecological conditions, prevalence of human activities and land use type affectedthe distribution patterns of rare plant species. Similarly, Thammanu et al., (2021) attributed species composition and distribution to a combination of topographic, edaphic, and anthropogenic factors.

f) *Interaction between dominant and less dominant tree species along River Lumi riparian ecosystem*

The occurrence of dominant (*Vachellia (Acacia) nubica, Ekerbergia capensis, Grewia bicolor, Tabernaemontana stapfiana* and *Trichilia emetica)*, with less dominant species *(Vachellia (Acacia) drepanolobium, Vachellia (Acacia) mellifera, Vachellia (Acacia) xanthophloea, Allophyllus abyssinicus, Cordia africana, Ficus thonningii, Ficus sur, Ficus sycomorus* and *Miliciaexcelsa)* was assessed to ascertain their interaction in the natural environment. Canonical Correspondence Analysis (CCA) model was significant for the interaction between dominant and less dominant tree species along River Lumi riparian ecosystem (F (1000) =2.5, p=0.005). *Vachellia (Acacia) nubica* and *Grewia bicolor* had a positive correlation with *Ficus thonningii.* Similarly, *Ekerbergia capensis* had a positive correlation with *Vachellia (Acacia) mellifera, Vachellia (Acacia) drepanolobium, Ficus sur* and *Ficus sycomorus. Trichiliaemetica* and *Tabernaemontana stapfiana* had a positive correlation with *Allophyllus abyssinicus, Milicia excelsa, Cordia africana* and *Vachellia (Acacia) xanthophloea* (Figure 7).

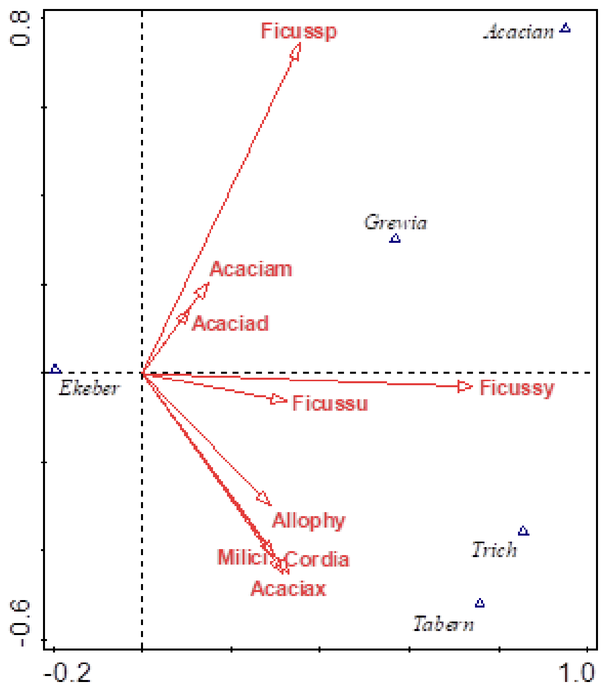


Figure 7: Canonical Correspondence Analysis of dominant and less dominant tree species along River Lumi riparian ecosystem. Acacian= *Vachellia (Acacia) nubica,* Ekeber=*Ekerbergia capensis,* Grewia=*Grewia bicolor,* Tabern=*Tabernaemontana stapfiana,* Trich=*Trichilia emetica,* Acaciad= *Vachellia (Acacia) drepanolobium,* Acaciam= *Vachellia (Acacia) melifera,* Acaciax= *Vachellia (Acacia) xanthophloea,* Allophy=*Allophyllus abyssinicus,* Cordia=*Cordia Africana,* Ficussp=*Ficus thonningii,* Ficussu=*Ficus sur,* Millici=*Milicia excelsa* and Ficussy=*Ficus sycomorus*

Vachellia (Acacia) nubica, Grewia*bicolor* and*Ficus thonningii*were dominant in the livestock production system. *Ekerbergia capensis* was a dominant species in themixed farming system and occurred together with *Vachellia (Acacia) mellifera, Vachellia (Acacia) drepanolobium, Ficus sur* and *Ficus sycomorus, while Trichiliaemetica* and *Tabernaemontana stapfiana* had a positive correlation with *Allophyllus abyssinicus, Miliciaexcelsa, Cordia africana* and *Vachellia (Acacia) xanthophloea.* The association between *Vachellia (Acacia) nubica, Grewia bicolor* and *Ficus thoningii* could be attributed to their tolerance to dry and saline conditions (Sanchez-Bayo and King, 1994)in the livestock production system. These species are also high value fodder trees in the livestock production system (Smith, 1992; Asmare and Mekuriaw, 2019). The association of *Ekerbergia capensis, Vachellia (Acacia) mellifera, Vachellia (Acacia) drepanolobium, Ficus sur* and*Ficus sycomoru* was attributed to their adaptation to a wide range of ecological conditions (Oginosako et al., 2005; Essien et al., 2012; Tilney et al., 2018). Moreover, these species enhance soil fertility through nitrogen fixation (Wekesa, 2018) hence their close association. *Tabernaemontana stapfiana, Allophyllus abyssinicus, Milicia excelsa, Cordia Africana* and *Vachellia (Acacia) xanthophloea* require moist and wet soil conditions (Omoro et al., 2010) which are commonly found in the crop farming system which is frequently flooded during the rainy season. These species also do well in adequately aerated soils typical of cultivated areas and enrich soil either through nitrogen fixation or organic matter addition through leaf litter fall. They are very valuable in improving soil fertility in crop farming areas (Wekesa, 2018).

Smit et al., 2006 and Mullah et al., 2013) found evidence showing that dominant tree species can either facilitate or inhibit recruitment of other forest species. Facilitation in which the presence of one plant species is beneficial to the growth and survival of another plant species in its proximity, often occur in stressful environments such as cold, saline and arid ecosystems. In the semi-arid livestock production zone, the dominant tree species which are stress-tolerant ameliorated adverse environmental conditions in their immediate environment through provision of shade and soil nutrients hence strongly influencing the occurrence of less dominant tree species. Dominant species such as *V. nubica, G. bicolor and E. capensis* which fix nitrogen, provided favourable conditions to facilitate growth of other species. Mullah et al., (2013) also found that nitrogen-fixing legumes like *A. gummifera* facilitate growth of other plants in naturally regenerating degraded abandoned fallows in the tropics. Restoration initiatives should therefore prioritize dominant tree species due to their critical role in facilitating the establishment of less dominant tree species.

g) Interaction between dominant and rare tree species along River Lumi riparian ecosystem

The CCA model was not significant for the interaction between dominant and rare tree species *(Albizia glaberrima, Albizia gummifera, Bridelia micrantha, Xymalos monospora, Senna denimetria, Senna spectabilis, Croton macrostachyus, Rauvolfia caffra, Ehretia petiolaries, Taprafisc,* and *Sorindeia madagascariensis)* along River Lumi riparian ecosystem (F (1000) = 1.3, p=0.119). *Vachellia (Acacia) nubica* was found to co-exist with *Xymalos monospora* while *Grewia bicolor* co-existed with *Albizia glaberrima, Senna denimetria* and *Croton macrostachyus. Ekerbergia capensis* occurred in association with *Rauvolfia Caffra* and *Albizia gummifera,* while *Trichiliaemetica* was found to co-exist with *Ehretiapetiolaries* and *Taprafisc. Tabernaemontana stapfiana* grew together with *Bridelia micrantha, Sorindeia madagascariensis* and *Senna spectabilis* (Figure 8).

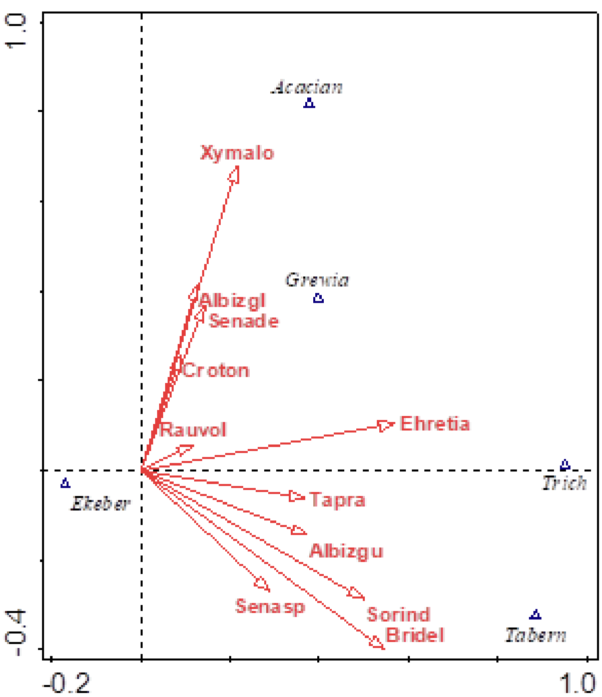


Figure 8: Canonical Correspondence Analysis of dominant and rare tree species along River Lumi riparian ecosystem. Acacian= *Vachellia (Acacia) nubica,* Ekeber=*Ekerbergia capensis,* Grewia=*Grewia bicolor,* Tabern= *Tabernaemontana stapfiana,* Trich=*Trichilia emetica,* Albizgl=*Albizia glaberrima,* Albizgu= *Albizia gummifera,* Bridel=*Bridelia micrantha,* Xymalo=*Xymalos monospora,* Senade=*Senna denimetria,* Senasp=*Senna spectabilis,* Croton=*Croton macrostachyus,* Rauvol=*Rauvolfia caffra,* Ehretia=*Ehretia petiolaries,* Tapra=*Taprafisc, and* Sorind=*Sorindeia madagascariensis*

Vachellia (Acacia) nubica was associated with *Xymalos monospora* whereas *Grewia bicolor* grew together with *Albizia glaberrima, Senna denimetria* and *Croton macrostachyus. Ekerbergia capensis* occurred with *Rauvolfia Caffra* and *Albizia gummifera,* while *Trichilia emetica* occurred with *Ehretia petiolaries* and *Tapra fisc. Tabernaemontana stapfiana* occurred with *Bridelia micrantha, Sorindeia madagascariensis* and *Senna spectabilis*. *A. nubica* and *X. monospora* compete aggressively to form thickets (Pratt and Gwynne, 1977; Oginosako et al., 2005), and are associated with high levels of disturbance hence their occurrence together mainly in disturbed areas along River Lumi riparian ecosystem. The close association between *Grewia bicolor, Albizia glaberrima, Senna denimetria* and *Croton macrostachyu* species is due to their drought tolerance and are commonly found in dry areas with limited moisture supplies as confirmed by Mullah et al., (2013). These species are also early colonizers in forest re-growth and are characteristic of secondary forests (Omoro et al., 2010). *Ekerbergia capensis, Rauvolfia Caffra* and *Albizia gummifera* are agro-forestry tree species hence their close association (Omoro et al., 2010). The roots of *A. gummifera* contain *Bradyrhizobium* bacteria that fix nitrogen in the soil (Wekesa, 2018), while *E. capensis* is a good soil stabilizer (Tilney et al., 2018). Both *E. capensis* and *R. caffra* experience heavy leaf fall which increases humus content of the soil especially during the dry season (Omoro et al., 2010; Mullah et al., 2013). Therefore, dominant and rare tree species with similar physiological characteristics occurred together. Similar to their effect on less dominant species, the dominant tree species ameliorated adverse environmental conditions thereby facilitating the growth of rare species which are often distributed in narrow areas with special microclimates (Chen et al., 2014). Rare tree species play an important role in biodiversity conservation (Mullah et al., 2013; Chen et al., 2014)), hence proper matching of dominant and rare tree species is critical for their growth and survival, and for successful restoration initiatives.

h) Livelihood sources and their contribution to household income

Mean household income (KES per annum) derived from mixed, crop and livestock production value chain along River Lumi riparian ecosystem was not significantly different (F (1, 2) = 1.30; p=0.275). However, the crop farming enterprise yielded the highest income (140,958±20,920). This was followed by the mixed farming system (131,427±14,669) and livestock production system (112,444±8,039). Similarly, the mean household income derived from business was not significantly different in the three land use systems (F (1, 2) = 0.47; p=0.626), although households in crop farming system derived more income (162,767±55901), than those in mixed farming system (133,512±35,492), and livestock production system (114,135±18,698). Mean household income derived from employment was also not significantly different in the three land use systems (F (1, 2) = 0.93; p=0.398. Income derived from employment in livestock production system was, however, higher (284,247±57,122) as compared to mixed farming system (249,271±36,943) and crop farming system (166,767±33,679). A similar trend was observed in the mean household income derived from remittance which was not significantly different in the three land use systems (F (1, 2) = 0.60; p=0.556) even though the income was higher in crop farming system (110,000±0) than in mixed farming system (76,588±10219) and livestock production system (60,083±19,468). Overall, the average household income was higher in the mixed farming system than in the crop farming and livestock production land use system (Figure 9).

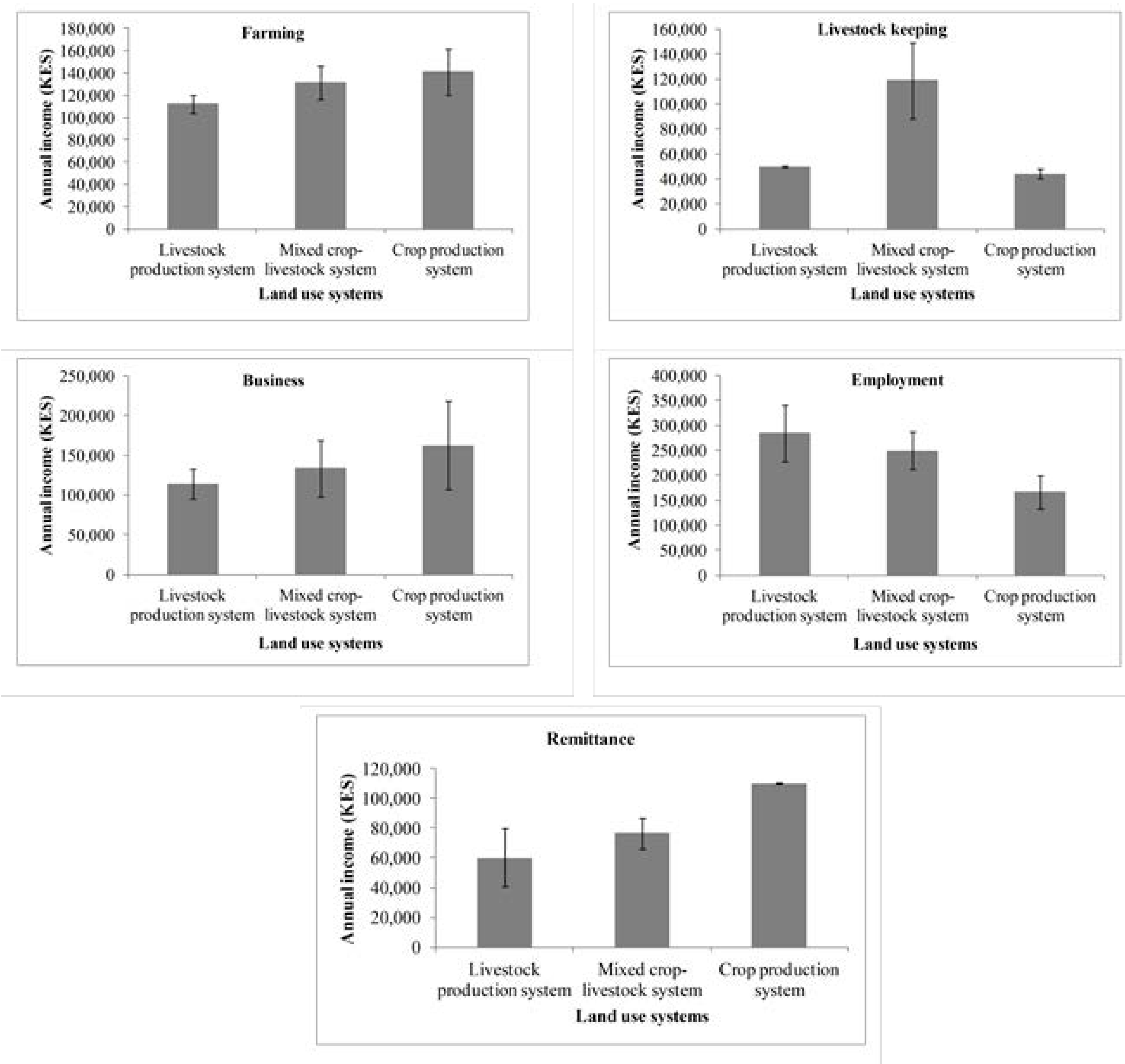


Figure 9: Comparison of mean income (KES) from livelihood sources in the three land use systems in River Lumi riparian ecosystem. Error bars represent SEM

Crop farming and livestock production were undertaken for commercial and subsistence purposes. The main crops grown were maize, bananas, tomatoes, onions, leafy vegetables, green grams and beans, while the main livestock kept were cattle, goats and sheep. The area under crop production increased considerably in the seven-year period between 2011 and 2018 in response to the need to diversify crop farming to ward off the negative impacts of climate change. Increased human population and concomitant expansion of the coastal towns of Voi, Mombasa and Malindi triggered increased demand of agricultural products. The pressure for increased crop yields and agricultural intensification is a significant driver for increased agricultural mechanization in crop irrigation farming and utilization of industrial fertilizers and pesticides (Foley et al., 2005, Muli, 2014). Although there was a decline in livestock numbers in River Lumiriparian ecosystem over the same period there was an influx of livestock from neighbouring pastoral communities and adjacent private ranches. Ecological degradation attributed to defoliation impacts from increased livestock densities was witnessed in the riparian ecosystem. Similar effects have been echoed in the studies of Lambin and Geist, 2006 who found that increased demand for food was associated with increased agricultural production leading to declines in natural vegetation and grasslands.

In the current study, there was evidence of human induced transformation of riparian forest structure as well as shifts in botanical composition of dominant, less dominant and rare species as reported elsewhere in this study. This is a clear testimony of the diminishing ecosystem integrity and resilience of River Lumi riparian ecosystem. Studies by Dibaba et al., 2020 revolving around the impacts of agriculture driven land use and land use land cover change in Finchaa Catchment in North- Western Ethiopia revealed that decrease in crop yields and reduced agricultural profitability, loss of biodiversity and concomitant loss of habitat and soil fertility were associated with weakened livelihood support systems.

Shackleton et al. (2007) and Kalaba et al. (2010) have adduced evidence indicating that poor communities are most affected by the negative impacts of environmental degradation in view of the direct dependence of their livelihood support system on land and natural resources.

i) Influence of socio-economic factors on production systems

Evaluations of interactions of factors of production embracing land income and land tenure, education levels as well as demographic attributes of gender, household size indicated negative Spearman rank correlation between household size and gender distribution (r= -0.209; p=0.000), household size and land tenure (r = - 0.072; p= 0.169), household size and household response to degradation (r=-0.050; p=0.355 and gender of household head and education level of household head (r=- 0.166; p= 0.003). However, there was a positive relationship between household size and education level (r=0.058; p=0.273), Table 2.

Table 2: Spearman rank correlation analysis of household size, gender of household head, education of household head, land tenure, household income and household response to degradation of River Lumi riparian ecosystem. HH size=Household size; Gender HH=Gender of household head; Education=Education of household head; Land tenure=Land tenure; HH Income=Household income; Resp=Household response to degradation

Variable	HH size	Gender HH	Education	Land tenure	HH Incom	Resp
HH size	1.000					
Gender HH	-0.209*	1.000				
Education	0.058	-0.166*	1.000			
Land tenure	-0.072	0.022	-0.004	1.000		
HH Income	0.019	-0.170*	-0.016	0.075	1.000	
Response	-0.050	0.025	-0.028	-0.022	0.016	1.000

**Correlation is significant at 0.05 level (2-tailed)*

Correlation is not significant for values without asterisks at 0.05 level (2-tailed)

Evidence has shown that community participation in conservation projects is important as it enhances local participation and flow of benefits to local communities, lessens potential resistance or conflict, helps to reduce implementation costs, and increases the likelihood of project success (Aganyira et al., 2020; Mogomotsi et al., 2020). However, despite its importance, community participation in conservation projects remains elusive for most rural communities in developing countries, and debates on the criteria for local participation remain critical (Aganyira et al., 2020).

There is evidence from the current study that household head did not influence household sizealbeit, house hold size had an influence on education and income levels. The likelihood of a greater number of educated people was associated with large households. There was also evidence that a high proportion of members from such households were engaged in several income generating activities contributing to household wealth. Gender of household head had an influence on land tenure and household response to degradation. As is the case for patriarchal rural African communities, land ownership is a preserve for male members of the household. Female members have delegated land use and land access rights. More male headed households responded to degradation of River Lumi riparian ecosystem through involvement in conservation initiatives than the female headed households. Decisions regarding the main land uses and livelihood activities such as commercial crop farming and livestock production were made by men who were also the greatest beneficiaries of economic returns from these activities. As such, men were more motivated to respond to degradation to prevent adverse effects on their livelihoods. Omollo et al., (2018) found that access to productive assets and other resources in the rural African context are strongly influenced by gender and female-headed households are constrained by limited access to natural resources. Male-headed households often have more access to productive resources such as livestock, land and finances compared to female-headed households, and are therefore more likely to adopt sustainable land management practices than their female counterparts (Wasonga, 2009).

Land ownership rights authenticated by the possession of title deeds facilitated accessibility to credit facilities for land development and other revenue generating activities. This explains the positive relationship between land tenure and household income. Previous studies have authenticated that lack of individual land tenure rights often led to absence of commitment and was responsible for poor choices of land management practices and land degradation (World Bank 2019).Other studies conducted in East Africa (Alden Wily, 2018; Muraoka et al., 2018; Schurmann et al., 2020) that examined the relationship between land rights and involvement in environmental conservation at household level confirmed that land rights influence the adoption of sustainable land use practices. According to Carter et al., (1994), community engagement in long-term resource conservation activities was positively correlated with the potential to derive benefits from related land uses during the term of the rights of use, with more long-term investments being frequently made in registered land.

There was a positive interaction between household income level and response to degradation. Household wealth was a function of response to land degradation mitigation initiatives. Households with higher income levels demonstrated greater commitment in the mitigation of adverse consequences of degradation such as charcoal production and illegal logging. Previous studies on the impacts of poverty on environmental degradation in Katonga Basin in Uganda (Niringiye et al., 2010) established that poverty was a major driver of deforestation. Additional evidence from the Bruntland Commission report authenticates that poverty is a major driver of environmental catastrophies (World Commission on Environment and Development, 1987). Schurmann et al. (2020) research work in Arabuko Sokoke forest established that household income had an effect on participation in conservation activities. High poverty levels amongst forest adjacent households in Arabuko Sokoke forest were responsible for over-extraction of fuelwood and building material leading to forest degradation. Mogomotsi et al., (2020) who evaluated the drivers of community involvement in wildlife conservation in Botswana adduced evidence that showed that household income and education levels had a positive correlation with community participation in conservation initiatives.

Evidence from the current study indicates that household size and education level had no influence on household response to degradation. Instead, household willingness, motivation and conservation awareness among members of the household were found to be major determinants of response to degradation. According to Htay (2020), conservation attitudes of local communities, level of conservation awareness and benefits accrued from the protected area influenced conservation support amongst local communities. Other studies (Infield and Namara, 2001; Tessema et al., 2010; Htun et al., 2012; Karanth and Nepal, 2012) have also indicated that people's willingness to participate in conservation programmes are strongly linked to their attitudes. People with positive attitudes are more likely to have conservation supportive inclinations whereas those with negative attitudes are likely to behave in less supportive manners (Ajzen, 1991; Nepal and Spiteri, 2011; Allendorf, 2022). The negative correlation between household education level and response to degradation observed in this study is also apparent in the research work of Kassie (2017), who established that households with lower levels of education generally had low willingness to engage in sustainable land management activities. Households with high levels of education are often engaged in activities with higher economic returns. In River Lumi riparian ecosystem, household members with high levels of education mostly migrated to urban areas in search for employment opportunities while agricultural production was mainly undertaken by unskilled workforce. This explains the negative correlation between household education levels and response to degradation.

Elucidated evidence from this study and that of other research workers lends credence to the premise that sustainability of conservation projects is dependent on the welfare of local communities, and must take into consideration community concerns and aspirations, as well as their specific needs in their design and implementation (Oldekop et al., 2016; Aganyira et al., 2020). Enhanced conservation awareness and community access to benefits are critical in ensuring conservation effectiveness.

V. Conclusions

Irrigated crop production system in River Lumi flood plain plays an important role in tree diversity conservation and has the potential for integration of other plant material restorative initiatives for enhanced livelihood and conservation gains.

Soil-plant species interactions along River Lumi riparian ecosystem could be used to guide the selection of suitable tree species genotypes for rehabilitation of areas of degraded riparian ecosystems and enhancement of livestock fodder production potential.

Crop -livestock production system is a major contributor to household wealth and a source of ecosystem goods and services with a latitude for sustainable development for improved livelihoods.

The key socio-economic determinants of household response to ecosystem degradation were gender and household income. Accordingly, biodiversity restoration initiatives require appropriate involvement of both gender as well as the provision of economic incentives to communities to mitigate the adverse impacts of poverty on riparian ecosystem degradation.

Research findings of the current study are pivotal in the development of interventions for appropriate restoration of ecological integrity of riparian biodiversity hotspots and realization of Sustainable development Goals (SDGs), 6 (ensuring availability and sustainable management of water and sanitation for all), SDG 13 (combating climate change and its impacts) and SDG 15, (promotion of sustainable use of land ecosystems including forests).

References Références Referencias

1. Adel, M.N., Pourbabaei, H., Salehi, A., Alavi, S.J., and Dey, C.D. (2018). Structure, composition and regeneration of riparian forest along an altitudinal gradient in northern Iran. *Folia Geobotanica, 53, 63-75.*
2. Aganyira, K., Kabumbuli, R., Muwanika, V.B., Tabutia, J.R.S., and Sheil, D. (2020). Determinants of participation in state and private PES projects in Uganda. *Scientific African, 8, e00370.*
3. Ajzen, I. (1991). The theory of planned behaviour: Organizational behaviour and human decision processes. *Volume 50, Issue 2 pp.179-211.* https://doi.org/10.1016/0749-5978(91)90020-T
4. Alden Wily, L. (2018). Risks to the sanctity of community lands in Kenya. A critical assessment of new legislation with reference to forestlands. *Land Use Policy, 75, pp. 661–672.*
5. Alexander, H., Gerhard, N., Okelo, R.E., Wachira, J.K., Nauta, W.J. and Pohl, W.L. (1979). Geology of the Taita Hills Quadrangle (with a geological map 1:50.000), Kenya. *Project: Metallogeny of Africa.*
6. Allendorf, T.D, (2022). A global summary of local residents' perceptions of benefits and problems of protected areas. *Biodiversity conservation, Issue 2, 2022.*
7. Asmare, B. andMekuriaw, Y. (2019). Assessment of *Ficus thonningii* tree production and utilization for livestock feed by smallholder farmers in North-western Ethiopia. *Agriculture and Food Security, 8(1).*
8. Baude, M., Meyer, B.C. and Schindewolf, M. (2019). Land use change in an agricultural landscape causing degradation of soil-based ecosystem services. *Science of the Total Environment, 659, pp. 1526-1536.* https://doi.org/10.1016/j.scitotenv.2018.12.455
9. Bear, L.M. (1955). The geology of the Taveta area: *Report 32 (1953), pp.48.* Geological Survey of Kenya, Nairobi.
10. Bruna, E.M. (1999). Seed germination in rainforest fragments. *Nature, 402, 139.*
11. Budowski, G. (1965). Distribution of tropical American forest species in a light of successional process. *Turrialba, 15, pp. 40-42.*
12. Capon, S.J., Chambers, L.E., Mac Nally, R., Naiman, R.J., Davies, P., Marshall, N., Pittock, J., Reid, M., Capon, T., Douglas, M., Catford, J., Baldwin, D.S., Stewardson, M., Roberts, J., Meg Parsons and Williams, S.E. (2013). Riparian ecosystems in the 21st. Century: Hotspots for climate change adaptation. *Ecosystems, 16: pp. 359-381.*
13. Carter, M.R., Wiebe, K.D., and Blare, B. (1994). Tenure security for whom? Differential effects of land policy in Kenya. *In J.W. Bruce, and S.E. Migot-Adholla (Eds.), Searching for Land Tenure Security in Africa. Kendall/Hunt.*
14. Chapin, F.S., Matson, P.A., and Vitousek, P.M. (2011). *Principles of Terrestrial Ecosystem Ecology (2nd ed.). Springer.*
15. Chazdon, R.L. (2014). *Second Growth: the promise of tropical forest regeneration in an age of deforestation.* The University of Chicago Press.
16. Chen, Y., Yang, X., Yang, Q., Li, D., Long, W., and Luo, W. (2014). Factors affecting the distribution pattern of wild plants with extremely small populations in HainanIsland, China. *PLOS ONE, 9(5), e97751.*
17. Clewell, A.F. and Aronson, J. (2013). *Ecological restoration: Principles, values, and structure of an emerging profession.* Island Press.
18. Cochran, W.G. (1963). *Sampling Techniques (2nd Ed.).* John Wiley and Sons.
19. Connell, J.H. (1978). Diversity in tropical rain forests and coral reefs. *Science 199; pp.1302-1310.*
20. Connelly, L.M. (2008). Pilot studies. *Medsurg Nursing, 17(6), pp. 411-422.*
21. De Paula, F.R. (2018). *Riparian forest management and regeneration: Effects on forest structure and stream ecological processes in streams of Eastern Amazon, Brazil.*PhD Thesis, University of British Columbia.
22. Dibaba, W.T., Demissie, T.A. andMiegel, K. (2020). Drivers and implications of land use/land cover dynamics in Finchaa Catchment, North-western Ethiopia. *Land, 9,113.*
23. Didham, R.K. (1998). Altered leaf-litter decomposition rates in tropical forest fragments. *Oecologia, 116, pp.397-406.*
24. Dwire, K. A., Mellmann-Brown, S., and Gurrieri, J.T. (2018). Potential effects of climate change on riparian areas, wetlands, and groundwater-dependent ecosystems in the Blue Mountains, Oregon, USA. *Climate services, 10, pp.44-52.*
25. Essien, C., Ofori, J., Sekyere, D. Owusu, F.W. and Tekpetey, S.L. (2012). Assessing the suitability of Ficus sur and Cola gigantea as raw material for pulp

and paper production in Ghana. *Annals of Biological Research, 3(10), pp. 4650-4656.*
26. Felipe-Lucia, M.R., Soliveres, S., Penone, C., Fischer, M., Ammer, C., Boch, S., Boeddinghaus, R.S., Bonkowski, M., Buscot, F., Fiore-Donno, A.M., Frank, K., Goldmann, K., Gossner, M.M., Holzel, N., Jochum, M., Kandeler, E., Klaus, V.H., Kleinbecker, T., Leimer, S., … Allan, E. (2020). Land use intensity alters networks between biodiversity, ecosystem function and services. *Proceedings of the National Academy of Sciences of the United States of America, 117(45), pp.28140-28149*. https://doi.org/10.1073/pnas.2016210117
27. Ferraz, S.F.B., Vettorazzi, C.A., Theobald, D.M., and Ballester, M.V.R. (2005). Landscape dynamics of Amazonian deforestation between 1984 and 2002 in central Rondônia, Brazil: assessment and future scenarios. *Forest Ecology and Management, 204, pp. 67-83.*
28. Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, S.F., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, C.I., Ramankutty, N., and Snyder, P.K. (2005). Global consequences of land use. *Science, 309, pp. 570-574.*
29. Franklin, J.F, Spies, T.A., Van Pelt, R., Carey, A.B., Thornburgh, D.A., Berg, D.R., Lindenmayer, D.B., Harmon, M.E., Keeton, W.S., Shaw, D.C., Bible, K. and Chen, J. (2002). Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. *Forest Ecology and Management, pp. 155, 399-423.*
30. Girma, A., Fischer, E. and Dumbo, B. (2014). Vascular plant diversity and community structure of Nandi forests, Western Kenya. *Journal of East African Natural History, 103(2), pp.125-152.*
31. Guariguata, M.R. and Ostertag, R. (2001). Neotropical secondary forest succession: Changes in structural and functional characteristics. *Forest Ecology and Management, 148, pp. 185-206.*
32. Guggenberger, G., Christensen, B.T. andZech, W. (1994). Landuse effects on the composition of organic matter in particlesize separates of soil: I. Lignin and carbohydrate signature. *European Journal of Soil Science, 45, pp. 449-458.*
33. Habel, J.C. and Ulrich, W. (2021). Ecosystem functions in degraded riparian forests of southeastern Kenya. *Ecology and Evolution, 00, 1-11.*https://doi.org/10.1002/ece3.8011
34. Habel, J.C., Teucher, M., Ulrich, W. and Schmitt, T. (2018). Documenting the chronology of ecosystem health erosion, a long East African river. *Remote Sensing in Ecology and Conservation, 4(1), pp. 34-43.*https://doi.org/10.1002/rse2.55
35. Habel, J.C., Teucher, M., Hornetz, B., Jaetzold, R., Kimatu, J.N., Kasili, S., Mairura, Z., Mulwa, R.K., Eggermont, H., Weisser, W.W. and Lens, L. (2015). Real-world complexity of food security and biodiversity conservation. *Biodiversity and Conservation, 24(6), pp. 1531-1539.* https://doi.org/10.1007/s10531-015-0866-z
36. Hodgson, D., McDonald, J.L. and Hosken, D.J. (2015). What do you mean, 'resilient'? *Trends in Ecology and Evolution, 30, pp.503-506.*
37. Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics, 4, pp.1-23.*
38. Hudson, J.R., Hanula, J.L. and Horn, S. (2014). Impacts of removing Chinese privet fromriparian forests on plant communities and tree growth five years later. *Forest Ecology and Management, 324, pp.101–108.*
39. Hulme, P. E. (2005). Adapting to climate change: is there scope for ecological management in the face of a global threat? *Journal of Applied Ecology, 42, pp. 784-794.*
40. Htay, T. (2020). *Determinants of conservation support in local communities: A case study of Indawgyi wildlife sanctuary, Myanmar.* Master Thesis, Norwegian University of Science and Technology.
41. Htun, N.Z., Mizoue, N. and Yoshida S. (2012). Determinants of local people's perceptions and attitudes toward a protected area and its management: A case study from Popa Mountain Park, Central Myanmar. *Society and Natural Resources, 25, pp. 743–758.*
42. Infield, M. and Namara, A. (2001). Community attitudes, and behaviour towards conservation: An assessment of a community conservation programme around Lake Mburo, National Park, Uganda. *Oryx, 35, pp. 48–60.*
43. John, R., Dalling, J.W, Harms, K.E., Yavitt, J.B., Stallard, R.F., Mirabello, M., Hubbell, S.P., Valencia, R., Navarrete, H., Vallejo, M. and Foster, R.B. (2007). Soil nutrients influence spatial distributions of tropical tree species. *Proceedings of National Academy of Sciences, 104, pp. 864–869.*
44. Kalaba, F.K., Chirwa, P.W., Syampungani, S. and Ajayi, O.C. (2010). Contribution of agroforestry to biodiversity and livelihoods improvement in rural communities of Southern African regions: In T. Tscharntke, C. Leuschner, E. Veldkamp, H. Faust, E. Guhardja, and A. Bidin (Eds.), *Tropical rainforests and agroforests under global change pp. 461-476Springer.*
45. Karanth, K.K., and Nepal, S.K. (2012). Local residents' perception of benefits and losses from protected areas in India and Nepal. *Environmental Management, 49, pp. 372–386.*
46. Kassie, G.W. (2017). The Nexus between livelihood diversification and farmland management strategies

in rural Ethiopia. *Cogent Economics and Finance, 5(1), 1275087.*

47. Kennard, D.K. (2002). Secondary succession in tropical dry forest: patterns of development across a 50-year chrono sequence in lowland Bolivia. *Journal of Tropical Ecology, 18, pp.53-66.*
48. Klein A.-M., Vaissiere, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C. and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: *Biological Sciences, 274(1608), pp. 303-313.*
49. Kenya National Bureau of Statistics (KNBS). (2010). Kenya Population and Housing Census. Vol.1A. Ministry of Planning and National Development, Kenya. Krebs, C.J. (1999). *Ecological methodology* (2nd ed.). Wesley Longman. Lambin, E.F. and Geist, H.J. (2006). *Land use and cover changes, local processes and globalimpact. Springer.*
50. Krebs, C.J. (1999). *Ecological methodology.)*(2nd ed. Wesley Longman.
51. Lawrence, D. and Vandecar, K. (2015). Effects of tropical deforestation on climate and agriculture. *Nature Climate Change, 5(1), pp. 27-36.* https://doi.org/10.1038/nclimate2430
52. Liebig, M.A., Ryschawy, J., Kronberg, S.L., Archer, D.W., Scholl-jegerdes, E.J., Hendrickson, J.R. and Tanaka, D.L. (2017). Inte-grated crop-livestock system effects on soil N, P, and pH in a semi-arid region. *Geoderma, 289, 178-184.*
53. Makana, J.R. and Thomas, S.C. (2006). Impacts of selective logging and agricultural clearing on forest structure, floristic composition and diversity, and timber tree regeneration in the Ituri Forest, Democratic Republic of Congo. *Biodiversity and Conservation, 15, pp. 1375-1397.*
54. Malik, Z.A. and Bhatt, A.B. (2016). Regeneration status of tree species and 890 survivals of their seedlings in Kedarnath Wildlife Sanctuary and its adjoining areas in Western Himalaya, India. *Tropical Ecology, 57(4), pp. 677-690.*
55. Maua, J.O., Mugatsia Tsingalia, H., Cheboiwo, J., and Odee, D. (2020). Population structure and regeneration status of woody species in a remnant tropical forest: A case study of South Nandi Forest, Kenya. *Global Ecology and Conservation, 21, e00820.*
56. Maxwell, S.L., Fuller, R.A., Brooks, T.M. and Watson, J.E.M. (2016). Biodiversity: The ravages of guns, nets and bulldozers. *Nature, 536, pp. 143-145.* https://doi.org/10.1038/536143a
57. Mendez-Toribio, M., Zermeno-Hernandez, I. and Ibarra-Monriquez, G. (2014). Effect of land use on the structure and diversity of riparian vegetation in the Duero River watershed in Michoacan, Mexico. *Plant Ecology, 215(1), 1-12.*
58. Mogomotsi, G.E.J., Mogomotsi, P.K., Gondo, R. and Madigele, T.J. (2018). Community participation in cultural heritage and environmental policy formulation in Botswana. *Chinese Journal of Population Resources and Environment, 16(2), pp. 171–180.*
59. Millennium Ecosystem Assessment (2005). *Nature's Services: Societal Dependence onNatural Ecosystems.* Island Press.
60. Mugenda, O.M. and Mugenda, A.G. (1999). *Research methods quantitative and qualitative approaches.* African Center for Technology Studies Press.
61. Muli, J.M. (2014). *The Impact of Irrigated Agriculture in Dry Lands on the Natural Environment: A Case Study of Chala Ward in Taita Taveta County, Kenya.* Master Thesis, University of Nairobi.
62. Mullah, C.J.A., Klanderud, K., Totland, O. and Kigomo, B. (2013). Relationships between the density of two potential restoration tree species and plant species abundance and richness in a degraded Afromontane Forest of Kenya. *African Journal of Ecology, 52, pp. 77-87.*
63. Muraoka, R., Jin, S. and Jayne, T.S. (2018). Land access, land rental and food security: evidence from Kenya. *Land Use Policy, 70, pp. 611–622.*
64. Nepal. S. and Spiteri, A. (2011). Linking livelihoods and conservation: An examination of local residents' perceived linkages between conservation and livelihood benefits around Nepal's Chitwan National Park. *Environmental Management, 47, pp.727–738.*
65. Ngugi, K., Ogindo, H. and Ertsen, M. (2015). Impact of land use change on Hydrology of Mt. Kilimanjaro: The case of Lake Jipe catchment. *Geographical Research Abstracts, 17, pp.2015-4526.*
66. Niringiye, A., Wambugu, S., Karugia, J.E. and Wanga, E. (2010). An investigation of the poverty-environmental degradation nexus: A case study of Katonga Basin in Uganda. *Research Journal of Environmental and Earth Sciences, 2(2), pp.82-88.*
67. Njiriri, C. (2016). The challenges facing the implementation of IWRM in Lake Jipe Watershed, Kenya. *Community Action for Nature Conservation.*
68. Nostrand, D.V., Hatfield, C.A. and Bakacs, M. (2003). *Regeneration of woody plant species within riparian zones of headwater streams whose watersheds vary by dominant land cover. The Rutgers scholar.*
69. Nyanjom, A. and K'Onyango, J. (2008). *Peak Revision KCSE Agriculture.* East Africa Education Publishers Ltd.
70. Oginosako, Z., Kindt, R. and Mathenge, S.G. (2005). An ecological analysis and characterization of Acacia species in Kenya. *Tropics, 14(4).*
71. Oldekop, J.A., Holmes, G., Harris, W.E. and Evans K.L. (2016). A global assessment of the social and

conservation outcomes of protected areas. *Conservation Biology, 30, pp.133–141.*

72. Okalebo, J.R., Gathua, K.W. and Woomer, P.L. (2002). *Laboratory Methods of Soil and Plant Analysis: A Working Manual. TSBF, Nairobi.*
73. Omollo, E.O., Wasonga, V.O., Elhadi, M.Y. andMnene, W.N. (2018). Determinants of pastoral and agro-pastoral households' participation in fodder production in Makueni and Kajiado Counties, Kenya. *Pastoralism: Research, Policy and Practice, 8, 9.*
74. Palmer, M.A., Allan, J.D., Meyer, J., Bernhardt, E.S. (2007). River restoration in the twenty-first century: data and experimental knowledge to inform future efforts. *Restoration Ecology 15, pp. 472-481.*
75. Power, A.G. (2010). Ecosystem services and agriculture: Tradeoffs and synergies. Philosophical Transactions of the Royal Society B: *Biological Sciences, 365(1554), pp. 2959-2971.*
76. Pratt, D. J and Gwynne, M.D. (Eds.) (1977). *Rangeland Management and Ecology in East Africa.* Hodder and Stoughton.
77. Ramirez, J.I., Jansen, P.A. and Poortera, L. (2018). Effects of wild ungulates on the regeneration, structure and functioning of temperate forests: A semi-quantitative review. *Forest Ecology and Management, 424, pp. 406–419.*
78. Ratovonamana, R.Y., Rajeriarison, C., Roger, E., Kiefer, I. and Ganzhorn, J.U. (2013). Impact of livestock grazing on forest structure, plant species composition and biomass in southwestern Madagascar. *Scripta Botanica Belgica, 50, pp. 82–92.*
79. Republic of Kenya (2018). *Taita Taveta County Integrated Development Plan 2018-2022.* Government printers.
80. Reed, M.S. andClokie, M. (2001). Effects of grazing and cultivation on forest plant communities in Mount Elgon National Park, Uganda. *African Journal of Ecology, 38(2), pp. 154-162.*
81. Republic of Kenya. (2014). *Taita Taveta County Integrated Development Plan 2013-2017.* Government printers.
82. Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B. and Kinzig, A. (2000). Global biodiversity scenarios for the year 2100. *Science 287(5459), pp.1770-1774.*
83. Sanchez-Bayo, F. and King, G.W. (1994). Imbibition and germination of seeds of three Acacia species from Ethiopia. *S. Afr. J. Plant Soil, 11(1).*
84. Sarr, D.A., Hibbs, D.E, Shatford, J.P.A. and Momsen, R. (2011). Influences of life history, environmental gradients, and disturbance on riparian tree regeneration in western Oregon. *Forest Ecology and Management, 261, pp.1241–1253.*
85. Sassen, M. and Sheil, D. (2013). Human impacts on forest structure and species richness on the edges of a protected mountain forest in Uganda. *Forest Ecology and Management, 307, pp.206–218.*
86. Schurmann, A., Kleemanna, J., Furst, C. and Teucher, M. (2020). Assessing the relationship between land tenure issues and land cover changes around the Arabuko Sokoke Forest in Kenya. *Land Use Policy, 95, 104625.*
87. Shackleton, C., Shackleton, S., Buiten, E. and Bird, N. (2007). The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics, 9(5), pp. 558-577.*
88. Shannon, C.E. and Weaver, W.W. (1963). *The Mathematical theory of communication.* University of Juionis Press.
89. Smit, C., Gusberti, M. and Muller-Schaer, H. (2006). Safe for saplings, safe for seedlings. *Forest Ecology and Management, 237, pp. 411–477.*
90. Smith, J.P. (1992). Fodder trees and shrubs in range and farming systems in tropical humid Africa. In A. Speedy and P. Pugliese (Eds.): *Proceedings of the FAO Expert Consultation Held at the Malaysian Agricultural Research and Development Institute (AARDI) in Kuala Lumpur, Malaysia pp. 39-50), FAO.*
91. Steffen, W., Burbidge, A.A., Hughes, L., Kitchin, R., Lindenmayer, D., Musgrave, W., Stafford Smith, L., Werner, P.A. (2009). *Australia's biodiversity and climate change.* Collingwood: CSIRO Publishing.
92. Stoms, D.M. and Estes, J.E. (1993). A remote sensing agenda for mapping and monitoring biodiversity. *International Journal of Remote Sensing, 14, pp.1839-1860.*
93. Tarkalson, D.D., Hergert, G.W. and Cassman, K.G. (2006). Long-term effects of tillage on soil 7 chemical properties and grain yields of a dryland winter wheat-sorghum/corn-fallow rotation in the Great Plains. *Agronomy and Horticulture, 98, pp.26-33.*
94. Thammanu, S., Marod, D., Han, H., Bhusa, N., Asanok, L., Ketdee, P., Gaewsingh, N., Lee, S. and Chung, J. (2021). The influence of environmental factors on species composition and distribution in a community forest in Northern Thailand. *Journal of Forestry Research, 32, pp. 649–662.*
95. Tilney, P.M., Nel, M. and van Wyk, A. E. (2018). Foliar secretory structures in *Ekebergia capensis* (Meliaceae). *Heliyon, 4.*
96. Tessema, M.E., Lilieholm, R.J., Ashenafi, Z.T. and Leader-Williams, N. (2010). Community attitudes toward wildlife and protected areas in Ethiopia. *Society and Natural Resources, 23, pp.489–506.*
97. Tschumi, M., Ekroos, J., Hjort, C., Smith, H.G. and Birkhofer, K. (2018). Predation-mediated ecosystem services and disservices in agricultural landscapes.

Ecological Applications, 28(8) pp.2109-2118. https://doi.org/10.1002/eap.1799

98. Walkley, A. and Black, I.A. (1934). An examination of the Degtijareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science, 37, 29-38.*
99. Wang, Y. (2016). *The shaping of Tibetan grasslands: Combined effects of livestock-grazing and environment – a multi-site, interdisciplinary study*. PhD Thesis, Martin Luther University, Yunan, China.
100. Wasonga, V. O. (2009). *Linkages between land-use, land degradation and poverty in semi-arid rangelands of Kenya: The case of Baringo district.* PhD Thesis, University of Nairobi, Department of Land Resources Management and Agricultural Technology.
101. Wekesa, C. (2018). *Effects of forest fragmentation on forest cover change, tree species diversity and carbon stock in Taita hills, Kenya.* PhD Thesis, Egerton University, Kenya.
102. Winqvist, C., Benstsson, J., Aavik, T., Berendse, F., Clement, L.W., Eggers, S., Fischer, C., Flohre, A., Geiger, F., Liira, J., Part, T., Thies, C.T., Tschartke, T., Weisser, W.W, and Bommarco,R. (2011). Mixed effects of organic farming and landscape complexity on farmland biodiversity and biological control potential across Europe. *Journal of Applied Ecology, 48, pp. 570-579*. https://doi.org/10.1111/j.1365-2664.2010.01950.x
103. World Bank (2019). *Empowering women through equal land rights: Experimental evidence from rural Uganda.* World Bank.
104. World Commission on Environment and Development. (1987). *Our common future.* Oxford University Press.
105. Zahawi, R.A. and Augspurger, C.K. (1999). Early plant succession in abandoned pastures in Ecuador. *Biotropica, 31, 540-552.*

Global Journals Guidelines Handbook 2022

www.GlobalJournals.org

Memberships

Fellows/Associates of Science Frontier Research Council

FSFRC/ASFRC Memberships

Introduction

FSFRC/ASFRC is the most prestigious membership of Global Journals accredited by Open Association of Research Society, U.S.A (OARS). The credentials of Fellow and Associate designations signify that the researcher has gained the knowledge of the fundamental and high-level concepts, and is a subject matter expert, proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice. The credentials are designated only to the researchers, scientists, and professionals that have been selected by a rigorous process by our Editorial Board and Management Board.

Associates of FSFRC/ASFRC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FSFRC

Fellow of Science Frontier Research Council

FELLOW OF SCIENCE FRONTIER RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.

Benefit

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A FSFRC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Fellows can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Receive a print ed copy of a certificate

Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Fellows can use the honored title of membership. The “FSFRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FSFRC or William Walldroff, M.S., FSFRC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Fellow members of FSFRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All fellows get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Fellows receive discounts on future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Internal Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example, john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, fellows and associates receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Fellows are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

Fellows can publish articles (limited) without any fees. Also, they can earn up to 60% of sales proceeds from the sale of reference/review books/literature/ publishing of research paper. The FSFRC member can decide its price and we can help in making the right decision.

Exclusive Financial

Reviewers

Get a remuneration of 15% of author fees

Fellow members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

Access to Editorial Board

Become a member of the Editorial Board

Fellows may join as a member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. Additionally, Fellows get a chance to nominate other members for Editorial Board.

Career Credibility Exclusive Reputation

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 5 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 10 GB free secure cloud access for storing research files.

ASFRC

ASSOCIATE OF SCIENCE FRONTIER RESEARCH COUNCIL

ASSOCIATE OF SCIENCE FRONTIER RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

> The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

Benefit

To the Institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A ASFRC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Associates can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Receive a print ed copy of a certificate

Associates receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Associates can use the honored title of membership. The "ASFRC" is an honored title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., ASFRC or William Walldroff, M.S., ASFRC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Associate members of ASFRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All associates get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Associates receive discounts on the future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career Financial

GJ Internal Account

Unlimited forward of Emails

Associates get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example,
john [AT] globaljournals [DOT] org.

Career Credibility Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, fellows receive access to almost all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Associates are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career Credibility Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All associates receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 30-40% of sales proceeds

Associates can publish articles (limited) without any fees. Also, they can earn up to 30-40% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.

Exclusive Financial

Reviewers

Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

Associate	Fellow	Research Group	Basic
$4800 **lifetime designation**	$6800 **lifetime designation**	$12500.00 **organizational**	APC **per article**
Certificate, LoR and Momento 2 discounted publishing/year **Gradation** of Research 10 research contacts/day 1 **GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day 5 **GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word “Abstract” in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper’s subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION) BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

save our planet

Global Journal of Science Frontier Research

Visit us on the Web at www.GlobalJournals.org | www.JournalofScience.org
or email us at helpdesk@globaljournals.org

ISSN 9755896