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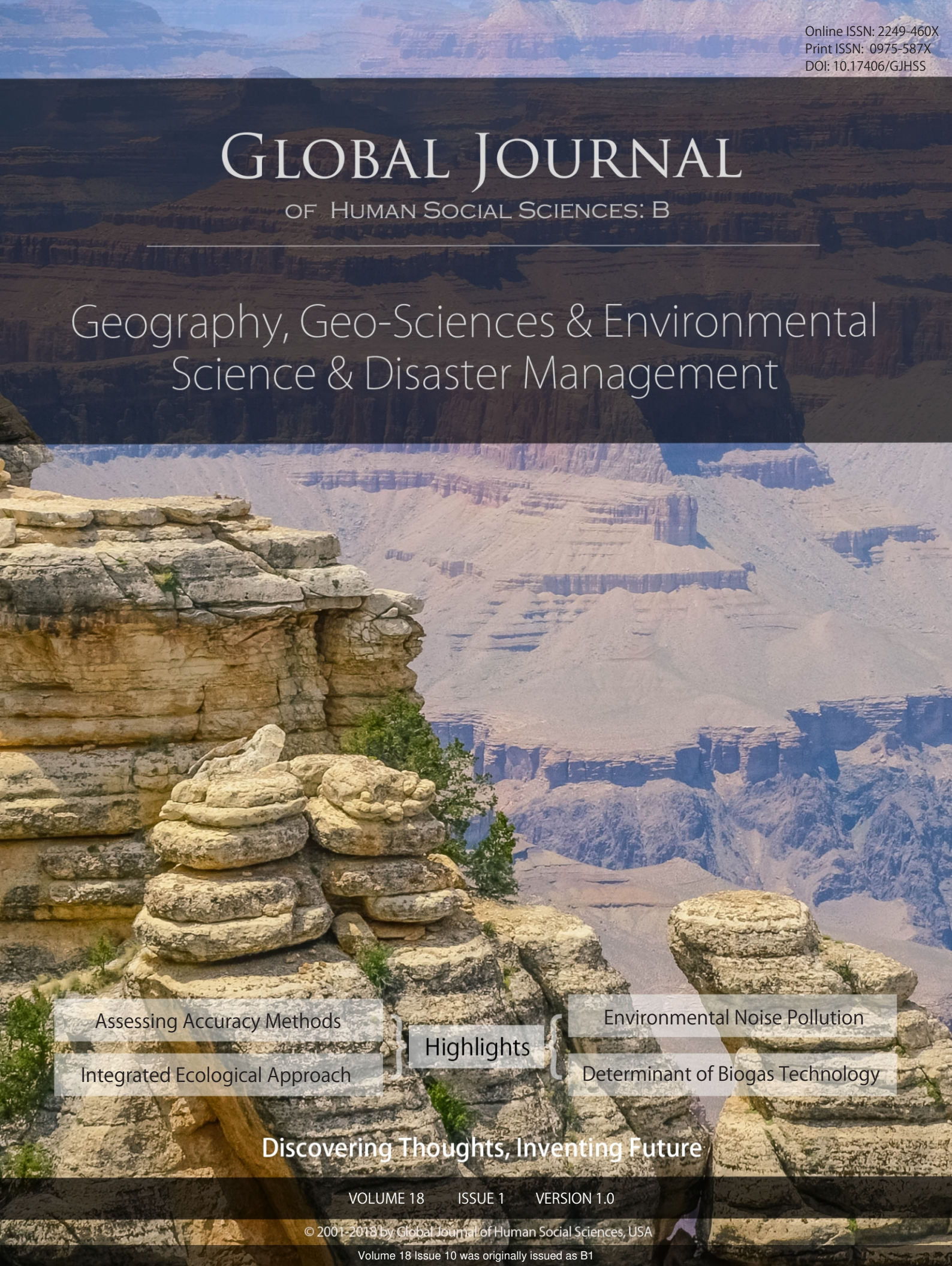

Assessing Accuracy Methods

Integrated Ecological Approach

Highlights

Environmental Noise Pollution

Determinant of Biogas Technology

Discovering Thoughts, Inventing Future

VOLUME 18 ISSUE 1 VERSION 1.0

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## Geography, Geo-Sciences, Environmental Science & Disaster Management

Volume 18 Issue 1 (Ver. 1.0)

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# Environmental Noise Pollution and Impact in Major Markets of Akwa Ibom State, Nigeria

By Aniefiok O. Akpan
*Akwa Ibom State University*

*Abstract-* Environmental noise pollution and impact in some markets of Akwa Ibom State, Nigeria have been carried out. The average maximum noise level of 90.4 dB(A), 85.2 dB(A) and 74.3dB(A), recorded in the mornings, afternoons and evenings constitute a health hazard for the vendors and buyers in these markets as they exceed the recommended standards. The average minimum values of 66.66, 63.7 and 60.0dB(A) were also recorded for mornings, afternoons and evenings. Reduced hearing acuity, speech intelligibility and clarity, communication disturbances and fatigue were some of the negative impacts on the market operators as acknowledged during the subjective assessment of the respondents. Lock-up shops which should serve as noise barriers should be provided in these market to replace the open market operations as this would reduce the emitted noise and the negative impacts.

*Keywords: environmental noise pollution, noise levels, hearing acuity, speech intelligibility and clarity, fatigue, communication.*

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# Environmental Noise Pollution and Impact in Major Markets of Akwa Ibom State, Nigeria

Aniefiok O. Akpan

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## I. Introduction

One of the environmental problems which have to be looked into is noise pollution in urban and rural communities in developing countries such as Nigeria when one considers the adverse effects on the citizenry.

Industrialization and urbanization have made people migrate to the developing areas of the communities thereby increasing human activities that have resulted in noise pollution. Periodic markets where buyers and vendors gather for their commercial, economic and social transactions are created in these communities and their activities as they gather result in noise pollution of the environment. Populations of vendors and buyers to the tune of 5000 to 10000 people as they gathered and coupled with the fact that these markets are operated in open spaces create a serious environmental problem as they transact their commercial businesses. Some of the vendors in an attempt to advertise their products thereby attracting customers shout and blare loudspeakers in full volume which result in unimaginable noise pollution. Herbal medicine vendors are not excluded from this act. Small power generating sets are used by some vendors to run their grinding machines, and these constitute serious noise hazard as the grinding machines themselves also produce noise.

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Tracks are created within the market space where trucks, lorries, cars, tricycles, and even motorcycles convey people, and goods into the market and these again are sources of noise. The whole market areas become so congested in market days such that human activities such as buying, and selling are being carried out on both sides of the road. In these days, everybody is so busy and this result in environmental noise pollution with impacts.

Exposure to noise for a long duration according to occupational safety and health act (Osha) may result to physical, physiological and even psychological roblems. These problems may include permanent or temporary hearing loss, interference with speech clarity and intelligibility, reduced productivity, increase blood pressure and even lack of concentration (Osha 2006).

## II. Literature Review

To address this issue of noise pollution, several studies have been conducted at different locations, occasions and cities in the entire globe. In the study of noise pollution during pre-carnival, carnival and post-carnival festivals in Calabar which is an occasion that people gather in numbers at a particular period of time and place just like the market, Akpan *et al*. (2013) concluded that the organisers of the festival should not only look at the merriment and income generating aspect of the festival. They should also consider the damaging effect of the noise on the well being of the people which includes temporary or permanent hearing loss. Mangalekar *et al*. (2012) in his study of noise pollution in Kolhapur city, India during Deepawali festival showed that there was an enhanced measure of noise at all sites due to increase in the number of vehicles and facilities of transportation. All the sites under study showed higher sound level than the prescribed limits by the Central Pollution Control Boards (CPCB).

Noise has been known to be a silent killer yet much has not been done to control it especially in developing countries like Nigeria. Even relatively low levels of noise have adverse effects on human health which may include hypertension, sleep disturbance or hinder cognitive development in children (Kiernan, 1997).

Esin *et al.* (2017) studied the spatial and temporal levels of noise pollution generated from urban traffic in Uyo metropolis, Nigeria and found that seven (7) out of eight (8) streets sampled for the study had



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noise levels exceeding the International Financial Agency and Environmental Protection Agency noise threshold of 55dB for residential and 70dB for industrial and commercial areas during weekdays and most weekends. They, therefore, recommended the promulgation and implementation of a noise bill and empowerment of regulatory agency as major ways of solving the menace of noise pollution from vehicular traffic.

All the twenty- seven (27) spots investigated during the study of the noise level in Nagaon District of Asam in India showed noise levels that were more than permissible standards (Debnath *et al*. 2013). The noise was as a result of uncontrolled movements of heavy vehicles like trucks and buses due to increasing rapid urbanization.

Pramendra *et al*. (2011) recommended an appropriate management strategy for limiting noise pollution on affected sites in Dehradun city, India due to vehicular transportation and frequent use of horn by vehicles. In this study, noise levels of 50.7 – 82.5 dB which were more than the recommended level of 30 – 75 dB were recorded in Server Shock, Prince Chock, Saharanpur Chock, Gandhi Park and Clock Tower.

Industrial noise pollution in 27 industries in South-eastern Nigeria showed a noise exposure rating greater than unity in over 20 of the investigated sites (Onuu and Akpan, 2006). Although almost all the workers contacted wanted the occupational noise pollution controlled because of its various effects, some of them liked it.

*a) About the study Area, Akwa Ibom State*

Akwa Ibom State is a state in Nigeria located in the coasted southern part of the Country and lying between latitude 4°32N and 5°33'N and longitude 7°25'E and 8°25'E. The state is located in the South-South geographical zone and is bordered by Cross River State on the East, Rivers State, and Abia State in the West and on the South by the Atlantic Ocean and the Southernmost top of Cross River State. The state is one of the thirty-six (36) states of Nigeria with people spread over three senatorial districts of Eket, Uyo, and Ikot Ekpene. In addition to English, the main spoken languages are Ibibio, Annang, Eket, and Oron (Wikipedia.org/wiki/Akwa Ibom State).

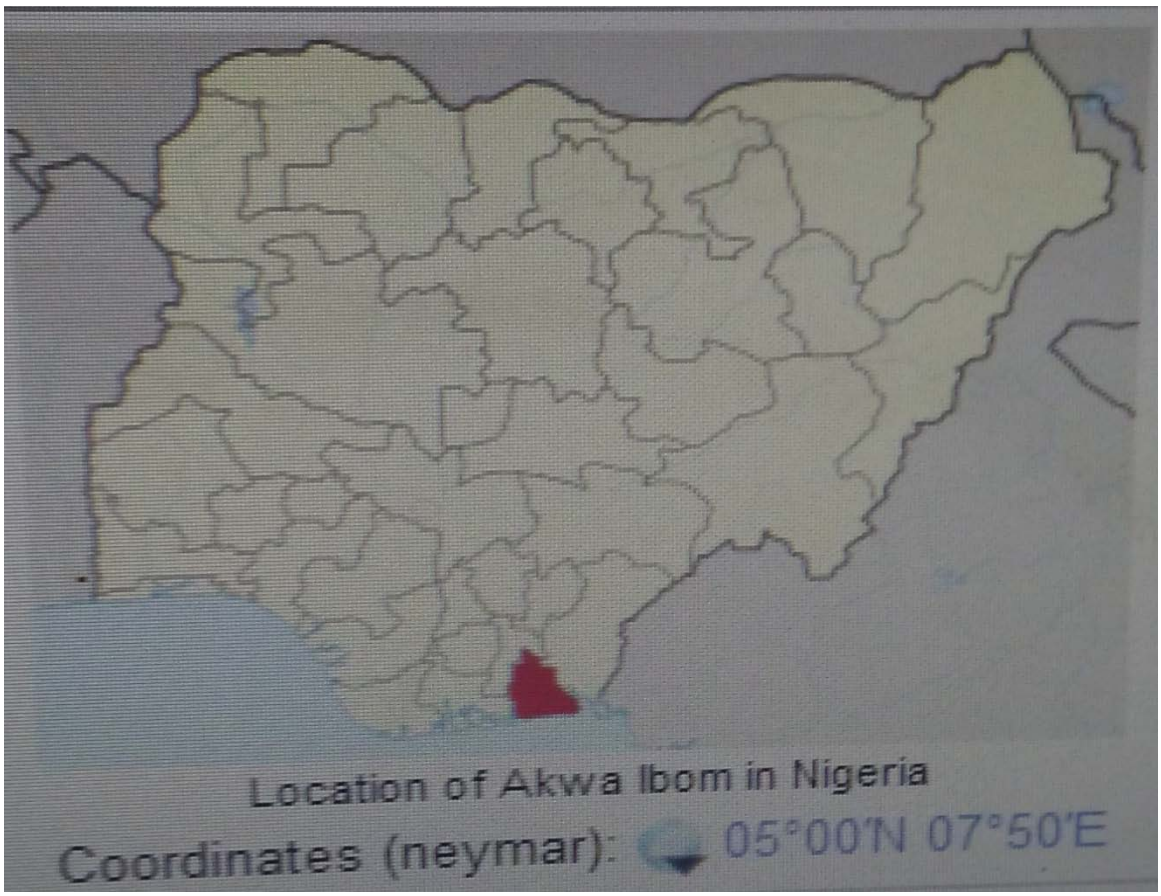


*Figure 1.0:* Map of Nigeria showing the Study Area



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## III. Materials and Methods

This investigation was carried out in some Markets in Akwa Ibom State, Nigeria that more than 8000 people, both young and old, male and female gather periodically for their commercial, economic, social and financial transactions as shown in label 1.0. The markets were carefully selected so as to cut across the three senatorial districts of the state namely Eket, Uyo, and Ikot Ekpene senatorial districts. These markets were given codes for analysis:

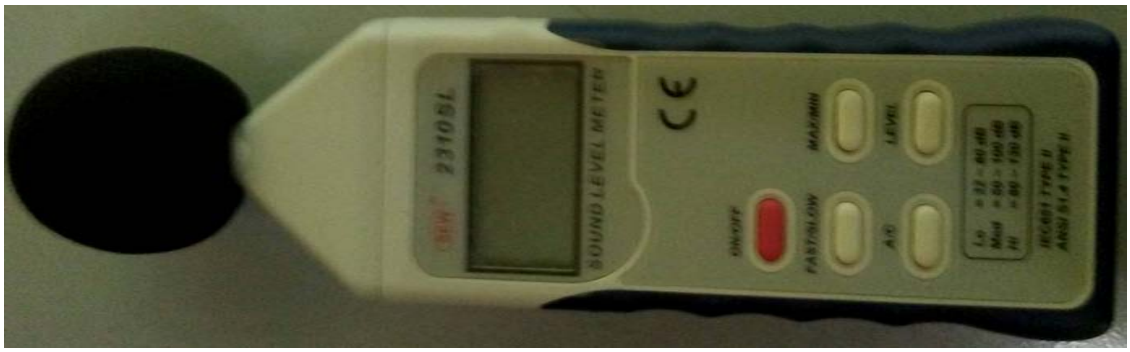


*Figure 2.0:* Sound level meter 2310SL

*Table 1.0:* Selected markets, locations, and codes

| Market names | Locations (Senatorial Districts) | Codes |
|---|---|---|
| Ukam | Eket | M1 |
| Ette | Eket | M2 |
| Nka | Eket | M3 |
| Akpan Andem | Uyo | M4 |
| Itam | Uyo | M5 |
| Kpokpo | Uyo | M6 |
| Awak | Ikot Ekpene | M7 |
| Tor | Ikot Ekpene | M8 |
| Obo | Ikot Ekpene | M9 |

The objective assessment of noise levels was carried out using 2310SL digital sound level tester with measuring range of 32 – 80 dB for low range, 50 – 100dB for medium range and 80 – 130dB for high range. This 4-digit LCD meter has a maximum and minimum function with A and C frequency weighting selection and has a 0.1dB resolution. Over and under range indicator, AC signal output and low battery detection are other features of this meter.

Sound level measurements were carried out at five (5) different locations in each of the markets with the sound level meter frequency evaluation filter (weighting|) set at A and at slow time evaluation because the noise generated was steady and had no sudden and rapid changes. The A filter was selected since it represents the characteristics curve of the human ear. At a distance of 1.3 to 1.5 m above the ground level and in middle locations in the market where activities were high, minimum and maximum level of noise generated were measured. Since the majority of the vendors in these markets have a low level of education, they were assessed subjectively by direct face-to-face interview to ascertain the impact of the noise on them; the buyers were also interviewed.

A preliminary survey was carried out which informed the setting of the level range of the meter at 50 – 100dB while carrying out the measurements. Measurements were carried out three times a day in a particular market i.e, during morning hours of 9 -11 am, afternoon hours of 12 – 2 pm and evening hours of 4 – 6 pm.

## IV. Results

*Table 2.0:* Measurement locations, period of measurements, and noise levels

| S/N | MARKET CODE | MEASUREMENT PERIODS AND NOISE LEVELS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Morning (9-11 am) | | Afternoon (12-1 pm) | | Evening (4 – 6 pm) | |
| | | Minimum dB(A) | Maximum dB(A) | Minimum dB(A) | Maximum dB(A) | Minimum dB(A) | Maximum dB(A) |
| 1 | M1 | 69.8 | 92.4 | 65.7 | 89.1 | 61.8 | 77.2 |
| 2 | M2 | 65.1 | 90.3 | 63.8 | 87.5 | 60.2 | 75.4 |
| 3 | M3 | 70.1 | 94.1 | 67.3 | 88.4 | 64.3 | 79.7 |
| 4 | M4 | 60.4 | 81.7 | 59.2 | 79.1 | 55.4 | 66.2 |
| 5 | M5 | 67.9 | 91.8 | 61.5 | 83.7 | 60.1 | 80.4 |
| 6 | M6 | 72.3 | 96.1 | 69.6 | 91.3 | 64.2 | 77.4 |
| 7 | M7 | 65.2 | 89.1 | 62.0 | 81.2 | 59.9 | 70.8 |
| 8 | M8 | 67.1 | 90.2 | 64.2 | 89.0 | 55.1 | 66.1 |
| 9 | M9 | 61.4 | 82.5 | 59.8 | 75.3 | 55.8 | 70.1 |

M = market



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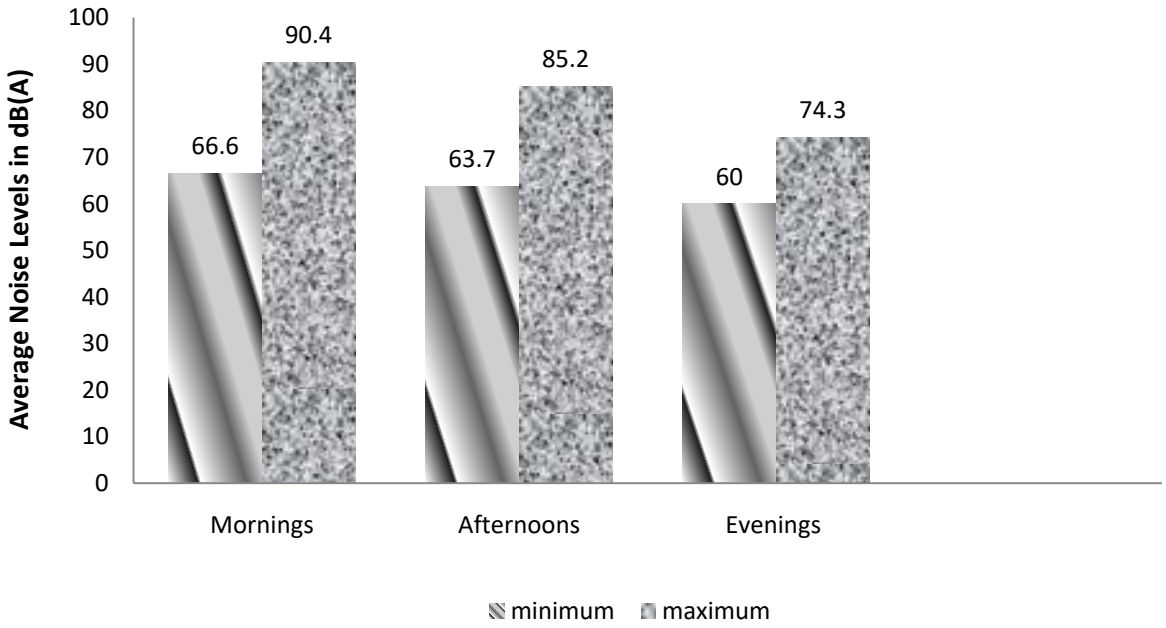


*Figure 3.0:* Comparing minimum and maximum average noise levels in the mornings, afternoons and evenings

## V. Discussion of Results

This study was aimed at knowing the average noise levels generated at selected periodic markets in Akwa Ibom State, Nigeria so as to know whether the noise levels are within the recommended standards and proffer advice if necessary. It was also aimed at looking into the impact of the noise on market vendors, and buyers as they converge for their commercial transactions periodically. From Figure 3.0 it is observed that noise levels were higher during morning periods as compared to the afternoon and evening periods. This is not unconnected to the fact that commercial activities are always at its peak in the mornings as the vendors and buyers come with full energy and would want to sell out or buy their good at these early hours. The increase in commercial activities at this early hour of the morning leads to high level of noise. Noise levels at the afternoon period were less as compared to the morning period as the vendors and buyers must have gone far with their commercial transactions and are somehow tired and satisfied. Noise in the evening period is further reduced as many of the vendors and buyers must have left the market and gone back home after the day transaction.

The average maximum noise levels of 90.4dB(A), 85.2 dB(A) and 74.3 d(B(A) recorded for the mornings, afternoons and evenings as shown in figure 3.0 are not too healthy for the vendors and buyer. The act of buying and selling have become a profession to the vendors and some of them have been in the business for a very long period which makes the prolonged exposure to such a high level of noise not healthy (Osha, 2006).

Noise levels at Akpan Andem market seem to be the least as compared to others. This is because most of the commercial activities are carried out inside lock-up shops between the vendors and buyers, the emitted sound is thereby confined and reduced.

The vendors admitted that their hearing acuity had been reduced as compared to when they started the business. Vendors in Akpan Andem, Nka and Tor markets which operate daily have ended up spending part of their life in the market absorbing these high - level noise dose. Many of them also admitted to the fact that their speech intelligibility and clarity have seriously been affected and they always have to shout on top of their voices as they communicate with their customers. Another effect of the polluted noise environment on the vendors is fatigue as acknowledged by the respondents during the interview.

Emotional, physical, mental, psychological and social well being which are the dimensional concept of quality of life as perceived by individuals gives reasons to look at health related outcome of noise (Akpan *et al*. 2012).

## VI. Conclusion

Noise levels emitted in some of the major markets in Akwa Ibom State, Nigeria and the impact on the vendors and buyers as they go about their commercial activities have been investigated. The noise levels were higher than its recommended standards and had been found to have unhealthy effect as acknowledged by the respondents during the interview. Though it is inevitable that these vendors and buyers converge in these markets for their commercial activities as a source of their livelihood, their health status should



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not be jeopardized. Health includes social, physical emotional and psychological well-being of the individual (WHO, 2011).

## VII. Recommendation

It is recommended that open market operations where communications are being masked by intruding noise resulting in the communicators shouting on top of their voices should be stopped. Lock-up shops which will otherwise serve as noise barriers should be provided in these markets and commercial activities should be carried out inside the shops, and not in the open.

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# Assessing Accuracy Methods of Species Distribution Models: AUC, Specificity, Sensitivity and the True Skill Statistic

By Farzin Shabani, Lalit Kumar & Mohsen Ahmadi
*University of New England*

*Abstract-* We aimed to assess different methods for evaluating performance accuracy in species distribution models based on the application of five types of bioclimatic models under three threshold selections to predict the distributions of eight different species in Australia, treated as an independent area. Five discriminatory correlative species distribution models (SDMs), were used to predict the species distributions of eight different plants. A global training data set, excluding the Australian locations, was used for model fitting. Four accuracy measurement methods were compared under three threshold selections of *i)* maximum sensitivity + specificity, *ii)* sensitivity = specificity and *iii)* predicted probability of 0.5 (default). Results showed that the choice of modeling methods had an impact on potential distribution predictions for an independent area. Examination of the four accuracy methods underexamined threshold selections demonstrated that TSS is a more realistic and practical method, in comparison with AUC, Sensitivity and Specificity. Accurate projection of the distribution of a species is extremely complex.

*Keywords:* *AUC, sensitivity, specificity, TSS, bioclimatic model, correlative model.*

*GJHSS-B Classification:* *FOR Code: 040699*




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# Assessing Accuracy Methods of Species Distribution Models: AUC, Specificity, Sensitivity and the True Skill Statistic

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*Abstract-* We aimed to assess different methods for evaluating performance accuracy in species distribution models based on the application of five types of bioclimatic models under three threshold selections to predict the distributions of eight different species in Australia, treated as an independent area. Five discriminatory correlative species distribution models (SDMs), were used to predict the species distributions of eight different plants. A global training data set, excluding the Australian locations, was used for model fitting. Four accuracy measurement methods were compared under three threshold selections of *i)* maximum sensitivity + specificity, *ii)* sensitivity = specificity and *iii)* predicted probability of 0.5 (default). Results showed that the choice of modeling methods had an impact on potential distribution predictions for an independent area. Examination of the four accuracy methods under-examined threshold selections demonstrated that TSS is a more realistic and practical method, in comparison with AUC, Sensitivity and Specificity. Accurate projection of the distribution of a species is extremely complex. As models provided slight variances in projections of the same group of species, it may be more expedient to use TSS as an intuitive method for measuring the performances of the SDMs, in comparison to AUC, Sensitivity, and Specificity.

*Keywords: AUC, sensitivity, specificity, TSS, bioclimatic model, correlative model.*

## I. Introduction

There is evidence of more widespread application of species distribution models (SDMs) to a broader range of practical and hypothetical questions (Guisan and Thuiller, 2005; Jeschke and Strayer, 2008). Also termed habitat or ecological niche models, bioclimatic envelopes and resource selection functions, these are examples of correlative models employing environmental and/or geographical data in order to describe the observed distribution patterns of particular species. This more widespread usage implies that such models are now being used to process alternative data forms, particularly recently having focused on occurrence records of museums and herbaria (Graham et al., 2004). In research into climate change and invasive species, predictions of SDMs may extend beyond the environmental or geographic areas in which the training samples originated (e.g. Araújo et al. (2005)). In the field of epidemiology, for example, SDMs are being used to predict the distributions and occurrences of diseases Peterson et al. (2002). Technological advancement of geographic information systems (Foody, 2008) and progress in data analysis (Breiman, 2001b), has supported the implementation of new modeling methods and applications, which have grown from simple environmental matching techniques, such as in Bioclim(Busby, 1991) and DOMAIN Carpenter et al. (1993), to non-linear relationships of greater complexity between the presence of a species and its environment (e.g., Generalised Additive Models (GAM))Hastie and Tibshirani (1990) and Maximum Entropy Modeling (MaxEnt) (Phillips et al., 2006)). The recent concentration on Bayesian methods and machine learning support the development of further new methods (Latimer et al., 2006; Prasad et al., 2006).

SDM uncertainty can generally be classified into two fundamental categories: model uncertainty and measurement uncertainty (Elith et al., 2002). The former arises from model simplifications, limitations or assumptions in describing processes of extreme complexity,such as future climate projections, or the algorithms of the relationships of species to environment. The latter arises from data imprecision and error, occurring through incorporation of incorrect geographic coordinates of species observations, or climatic datasets created inconsistently from a variety of weather stations, time periods, and interpolated into the mapping process. The origins of uncertainty in SDM predictions have been studied by comparison of the predictions of different types of modeling algorithms, based on a common species, or group thereof, or common environmental predictors (Anderson et al., 2006) or by maintaining a common set of species and algorithms and altering predictor variables (Watling et al., 2012). A few studies have made comparisons combining these multiple factors into a single structure(Buisson et al., 2010; Hanspach et al., 2011). One such example, using four sources of model and measurements of uncertainty regarding the modeling of a single species, ascertained that the algorithm was the main cause of uncertainty, and subsequently occurrence data and co linearity of predictor variables (Dormann et al., 2008).

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Assessing predictive accuracy is critical in the development process of distribution models (Barry and Elith, 2006; Guisan and Thuiller, 2005). Quantitative performance assessment for the determination of model suitability to application can be used to uncover aspects requiring improvement (Anderson et al., 2006; Barry and Elith, 2006; Vaughan and Ormerod, 2005), as well as providing the basis for selection of the most appropriate modeling technique for the specific application (Loiselle et al., 2003; Segurado and Araujo, 2004) in that it enables a researcher to investigate the impact of different data and species' properties on the degree of accuracy of the predictive maps generated (Kadmon et al., 2003). In practice, there are two facets in measuring SDM accuracy; discrimination capacity and reliability (i.e. classification accuracy)(Pearce and Ferrier, 2000), with the former generally considered more imposing on outcome than the latter (Ash and Shwartz, 1999). In modeling, discrimination capacity implies the ability to differentiate presence sites (those where the subject species is detected) and absence sites (i.e. pseudo-absence or background sites where it is known or supposed to be absent). Alternatively, reliability implies concord of the predicted occurrence probabilities and proportions of sites observed to be occupied by the species (Pearce and Ferrier, 2000). Reliability is a core facetof quality in probabilistic predictive modeling.

In modeling exercises, the selection of appropriate modeling techniques (e.g., DOMAIN, CLIMEX, MaxEnt, BRT, RF, Bioclim) and methods of measuring accuracy (e.g.,AUC, Sensitivity, Specificity, the True Skill Statistic) are crucial to the outcome. A variety of methods for accuracy measurers are available, each functioning in a slightly different manner. For the layman or novice, the basic decisions at the commencement of the process is which of these is most appropriate to the specific application. Thus, it is necessary to make a comparison of a variety of modeling techniques, associated accuracy measure methods and different species, since techniques perform differently with particular species and the distributions of each.

This study assessed four different methods of measures of accuracy (the area under the ROC curve (AUC), Specificity, Sensitivity and the True Skill Statistic (TSS)) on each of five types of correlative model (General Linear Model (GLM), Max Ent, Bioclim, Random Forest (RF), Boosted Regression Tree (BRT)) under three threshold selections of *i)*maximum sensitivity + specificity, *ii)*sensitivity =specificity and *iii)*probability value of 0.5 (hereafter default) on *Asparagus asparagoides*, *Triticumaestivum* L., *Lantana camara*L., *Opuntiarobusta*,*Triadicasebifera*, *Fusarium oxysporum*f. spp., *Phoenix dactylifera* L. and *Gossypium* (cotton) species distribution records for Australia and the remainder of the world. For this research, we purposefully selected different types of species covering cultivated, fungus, and invasive species and three different thresholds as these give a better basis for validation of the model and thresholds compared to selecting one type of species and threshold. In the primary stage five models were constructed, and thereafter compared using the four measures of accuracy and three different thresholds for each of the five modeling techniques based on projections of suitable climate, derived from observed distribution records of these eight species.

## II. Materials and Methods

### a) Distribution Records

Distribution data was collected from a variety of sources. Global distribution data was sourced from the Global Biodiversity Information Facility (2015), Atlas of Living Australia (2017), as well as published literature. ENM Tools (Warren et al., 2010) was used in the processing of each grid cell's georeferenced occurrence data to equal 1. Thus, the fact that a single grid cell may display multiple records is of no consequence to the projections or performance evaluation. Distribution records for each of the eight species at Global (GLS) and Australian (AUS) scale numbered as follows: i) *Asparagus asparagoides* GLS: 4924, AUS: 3836, ii) *Phoenix dactylifera* L. GLS: 529, AUS: 51, iii) *Fusarium oxysporum* f. spp GLS: 230, AUS: 30, iv) *Gossypium* GLS: 17322, AUS: 2656, v) *Lantana camara* L. GLS: 17856, AUS: 8324, vi) *Opuntiarobusta* GLS: 299, AUS: 57, vii) *Triadicasebifera* GLS: 1724, AUS: 53 and viii) *Triticumaestivum* L. GLS 50337, AUS: 142. Both native and exotic distribution records were included in the dataset, as it was beyond the parameters of the study scope to distinguish between the inclusion of only native, exotic, or both, in terms of the techniques to project climate suitability and the accuracy methods employed.

### b) Species distribution modeling

- Generalized Linear Model (GLM)

The technique of iterative weighted linear regression was employed in GLM to estimate maximum probability of parameters, with a linear expression of the distributions of observations by transformation of the exponential family and systematic effects. For GLM, parametric functions were employed to link the combined linear and quadratic explanatory variables. A standard polynomial approach in combination with an automatic stepwise model selection based on the Akaike Information Criterion (AIC) was used to fit the model. Modeling was done in R v. 3.3.2 (R Development Core Team, 2016).

- MaxEnt

MaxEnt desktop version 3.3.3k (Phillips et al., 2006) was used with modified parameters (Phillips and Dudík, 2008). MaxEnt is dependent on user coordinated

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geographical background data (Guillera-Arroita et al., 2014) in order to compare the climate factors of the sampled reference set of grid cells with those grid cells where the species is observed to be present. The definition of the background data set significantly affects output (Elith et al., 2011) and the complete range of the species across the searched areas should be included (Elith et al., 2010). Our MaxEnt algorithm compared presence locations and variable interactions to similar interactions of background locations, and established the maximum entropy probability distribution approximating uniformity, subject to the limitations imposed by observed spatial distributions and associated environmental factors. The minimizing of relative entropy between known locations and background point data in such a manner optimizes the maximum entropy probability distribution (Phillips et al., 2006).

- Bioclim

Bioclim (similar to GLM, MaxEnt, BRT and RF) employs the principle that current distribution is the fundamental indicator of the climatic needs of a species, in order to correlate these climate variables with the observed distributions of the species. The model uses the realized niche to describe bioclimatic envelopes, in that non-climatic factors, inclusive of biotic interactions, impose limitations on observed distributions. In contrast, a mechanistic relationship with a more physiological basis is established between the climatic parameters and species response in other types of bioclimatic models (Pearson and Dawson, 2003; Woodward, 1987). Thus, in these models, the fundamental niche is established by modeling the physiological limiting mechanisms in terms of climatic factors. An area of criticism of bioclimatic modeling has been that biotic interactions, species dispersal and evolutionary changes are excluded from the modeling process. These limiting factors and human impacts show that realized niches, as utilized in methodologies of correlative bioclimatic envelopes, are not necessarily the absolute limits of a range and that a future distribution may well be based on alternative factors comprising the realized niche (Pearson and Dawson, 2003). Thus, Bioclim, and its associated environmental envelope models, produce a 'climate profile' of a species, sometimes termed a 'boxcar' descriptor or 'parallelepiped classifier' (Busby, 1991). This basic hyper-box classificatory method thus describes the potential range of a species in terms of a multi-dimensional environmental space whose parameters are the minimum and maximum values for all presences (or 95% of these, or similar variations). In order to extrapolate the prediction within an independent area, we parameterized the model on the outlier-corrected (Skov and Svenning, 2004) observed minimum and maximum values of presence of the species for each variable climatic factor, to provide more conservative results. Bioclimmodel was implemented using the 'Dismo' package (Hijmans and Elith, 2015).

- Random Forest (RF)

The Random Forest is, in performance, one of the most accurate classificatory regression tree-based models. In RF, bootstrap aggregation is used to select many subsamples from the data, generated through a bagging algorithm, a large number of de-correlated regression trees (Breiman, 2001a). RF tree predictors are combined in a manner that each is dependent on the values of independently sampled random vectors, assuming similar distribution for each tree in the forest (Breiman, 2001a). An aggregating (averaging or majority vote) of the predictions of the ensemble forms the basis of the prediction (Svetnik et al., 2003). Out-of-bag observations from each tree are used in predicting model errors and the importance of variables. As in an ensemble approach, decision tree predictions are averaged. We used the 'RandomForest' package (Liaw and Wiener, 2002) to fit the RF models.

- Boosted Regression Tree (BRT)

In our BRT model we used a similar background area to the MaxEnt model, fitting sufficient combinations (decision trees) iteratively, and combining these to produce an optimal model with refined predictive performance. BRT incorporates two multiple regression tree algorithms. Using a binary division into rectangles of the predictor space, it relates the predictor responses to identify areas with the closest responses to predictors and incorporates boosting, an additional procedure, which merges the fitted trees for greater accuracy. For BRT model we employed the 'Dismo' package (Ridgeway, 2006)using an additional setting code recommended by Elith et al. (2008).

*c) Bioclim variables, Background data and the methods for providing weights for species records*

To remove models' complexity and screening explanatory variables we used the jack-knife analysis method and calculated pairwise Pearson correlation matrix of the variables to select the more important variables with low correlation ($R^2 < 0.5$). For example, the following variables; bio1 (Annual mean temperature (°C)), bio3 (Isothermality), bio8 (Mean temperature of wettest quarter (°C)), bio12 (Annual precipitation (mm)), bio15 (Precipitation seasonality (C of V)), bio17 (Precipitation of driest quarter (mm)), bio20 (Annual mean radiation (W $m^{-2}$)), bio21 (Highest weekly radiation (W $m^{-2}$), bio24 (Radiation of wettest quarter (W $m^{-2}$)), bio31 (Moisture index seasonality (C of V)), bio34 (Mean moisture index of warmest quarter) and bio35 (Mean moisture index of coldest quarter) were selected for the species *Asparagus asparagoides*. To broaden the background data in terms of the likelihood of fewer record returns from more recent locations of invasion



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and those poorly sampled, we gave greater importance to records with less geographic proximity. However, it was taken into account that without records on survey effort in terms of time, it is impossible to distinguish between unsuitable and under-sampled areas, and that the above-mentioned adjustments would unavoidably thus confuse these two categories of geographical area. For calculation of the weighting surface, we divided the number of weighted records (using Gaussian kernel method with standard deviations of default values in ArcGIS) in the selected geographical environment for each cell globally, but excluding Australia, by the weighted number of terrestrial cells of the specific area, to eliminate edge effects along coastal regions. Thereafter, the resulting grid was adjusted to maximum 20 and minimum 1, which excluded extreme values. This weighting method, as advocated by Elith et al. (2010), minimizes bias favouring records from densely sampled areas in relation to those from less sampled areas. The kernel density layer of each species and Hawths Tools extension (Beyer, 2004) were used to generate background points for the world, excluding Australia, for training purposes. The same method was used to generate background points for Australia, for comparing model performances. Thus, all SDM performances were evaluated against the same background data for every species.

*d) Accuracy Methods*

- The area under the ROC curve (AUC)

The receiver operating characteristic (ROC) curve provides an alternative technique for assessment of accuracy of ordinal score models (Fielding and Bell, 1997b). The construction of ROC curves uses all possible thresholds for classifying the scores into confusion matrices, obtaining each matrix' sensitivity and specificity; then comparing sensitivity against the corresponding proportion of false positives (equal to 1 − specificity). Using all thresholds avoids the arbitrary choice of a single threshold (Liu et al., 2005; Manel et al., 2001), and takes into account the trade-off of sensitivity and specificity (Pearce and Ferrier, 2000). The area below the ROC curve (AUC) is also valid as a single threshold-independent measurement of model performance (Brotons et al., 2004; Thuiller et al., 2005). AUC has been demonstrated to be independent of prevalence (McPherson et al., 2004; Somodi et al., 2017) and is seen to be an accurate measure of ordinal score model performance. However, in practice, SDMs used in conservation, such as for selection of representative sites and identification of biodiversity hotspots, frequently needs presence–absence maps of distributions of a species, and requires the selection of a threshold for the transformation of the ordinal scores into presence–absence predictions (Berg et al., 2004). In these circumstances, evaluation accuracy of prediction should be based on the specific threshold selected, as opposed to threshold-independent ROC curves. It is important to note that among the more frequently usedspecies distribution models (e.g. Bioclim, Nix (1986); GARP, Stockwell (1999)) dichotomous presence–absence distribution predictions are generated, to which it is not possible to apply ROC curves.

- Sensitivity and Specificity

Sensitivity represents the proportion of correctly predicted presence records and thus the quantification of omission errors. In calculation, Sensitivity equals $\frac{a}{a+c}$ where *a*denotes the number of correctly predicted presence cells and *c* the number of cells in which the species was found, but absence is predicted by the model. Specificity represents the proportion of correctly predicted absences and thus the quantification of commission errors. In calculation, Specificity equals $\frac{d}{b+d}$ where *b* denotes the number of cells in which the species was not found but presence is predicted by the model, and *d* is the number of cells correctly predicting absence. It is important to note that compared across models, sensitivity and specificity are independent of one another, as well as being independent of prevalence, which represents the proportion of sites where the species was recorded as present.

- True Skill Statistic (TSS)

The TSS is independent of prevalence and equals $\frac{ad-bc}{(a+c)(b+d)}$ . Allouche et al. (2006) have shown that TSS is an intuitive method of performance measurement of SDMs in which predictions are expressed as presence–absence maps. It was further shown that TSS gives results showing significant correlation with those of the threshold-independent AUC statistic (Allouche et al., 2006).

*e) Thresholds*

There are many methods of thresholds selections including taking 0.5 as the threshold (default), which is widely used in ecology (Pearson et al., 2002) or a specific level of sensitivity or specificity (e.g. 95%) is desired or deemed acceptable (Cantor et al., 1999) or thresholds are chosen to maximize the agreement between observed and predicted distributions. A third category of threshold selection identifies a threshold value that maximizes the percent of points correctly classified; maximizes sensitivity plus specificity; or maximizes Kappa, a measure that utilizes both sensitivity and specificity (Guisan et al., 1998). In this study the most commonly used thresholds of *i)*maximum sensitivity + specificity, *ii)*sensitivity = specificity and *iii)*default were examined to evaluate four accuracy methods of the species distribution models.

*f) Evaluating accuracy methods*

Presence points in this study were divided into two sample categories; training and test points per

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species. The training dataset comprised presence points of the complete global distribution of the species, excluding the Australian continent, while out-of-sample data (occurrences on the Australian continent) was used as a test of SDM performance. We concentrated on the area below the ROC curve (AUC), Sensitivity, Specificity and True Skill Statistic (TSS) of an independent area under three different thresholds, in order to evaluate accuracy for each species and model separately. Thus, eight species were evaluated using five correlative models. In that there was no data representing true absence of each species in Australia, the proportions of the extent of Australia identified as suitable were calculated, as an index of potential overestimations of the models.

## III. Results

Differences in the four methods of accuracy evaluation (AUC, Specificity, Sensitivity and TSS) of Bioclim, BRT, GLM, MaxEnt and RF in the projections of suitable climate under the three different thresholds, based on independent records of all eight species, are shown in Figure 1.

*a) AUC*

AUC produced similar results in all models. For example, AUC values for all models for *Asparagus asparagoides*, is around 0.94 (Fig 1) even though the output shows a clear difference. Similar comparative results occurred for *Fusarium oxysporum*f. spp.(≈ 0.63), *Gossypium* (≈ 0.70), *Lantana camara* L. ≠ 0.95), *Phoenix dactylifera* L. (≈ 0.55), *Triadicasebifera*(≈ 0.98) and *Triticumaestivum* L. (≈ 0.77) (Fig 1). However, in the case of *Opuntiarobusta*, AUC values of different models had some variation (inconsistency), giving AUC values from Bioclim, BRT, GLM, MaxEnt and RF as 0.51, 0.88, 0.85, 0.90 and 0.50 respectively. Results also show the mean AUC values, using five correlative modeling techniques on eight species, were above 0.77. Consistent with this moderate AUC value, the training dataset model did not predict occurrences of the studied species in certain places where these are known to occur (Fig 1).

*b) Specificity*

A comparison of specificity in all five models, based on the test data under three different thresholds, shows relatively comparable values for *Asparagus asparagoides*, *Fusarium oxysporum*f. spp., *Gossypium, Lantana camara* L.,*Opuntiarobusta, Phoenix dactylifera* L., *Triadicasebifera* and *Triticumaestivum* L. (Fig 1). For example, specificity values under default threshold for *Triticumaestivum* L. and *Fusarium oxysporum*f. sppfor Bioclim, BRT, GLM, MaxEnt and RF were 1, 0.79, 0.76, 0.87, 0.91 and 1, 0.72, 0.07, 0.00 and 1respectively. Similar comparison on specificity values under "sensitivity = specificity" threshold for *Triticumaestivum* L. and *Fusarium oxysporum*f. sppfor Bioclim, BRT, GLM, MaxEnt and RF were 0.68, 0.68, 0.70, 0.68, 0.74 and 0.67, 0.60, 0.51, 0.59 and 0.98 in turn. Finally, a comparison of specificity values under "maximum sensitivity + specificity" threshold for *Triticumaestivum* L. and *Fusarium oxysporum*f. sppfor Bioclim, BRT, GLM, MaxEnt and RF were 0.63, 0.47, 0.52, 0.73, 0.74 and 0.74, 0.60, 0.88, 0.93 and 0.99 in that order. Results also show that the mean specificity values under different thresholds, using the five modeling techniques on the eight specieswere above 0.78 (Fig. 1).

*c) Sensitivity*

Sensitivity presented variable results for most models under different examined thresholds. For example, sensitivity values for *Phoenix dactylifera* L. under default threshold were 0.00, 0.38, 0.85, 0.23, and 0.00 for Bioclim, BRT, GLM, MaxEnt and RF, respectively. Sensitivity values for this species under threshold of "sensitivity = specificity" were close to each other while values of sensitivity under threshold of "maximum sensitivity + specificity" were 0.91, 0.17, 0.85, 0.21, and 0.21 for Bioclim, BRT, GLM, MaxEnt and RF, respectively. Similar variations on sensitivity values under default threshold for *Opuntiarobusta* on Bioclim, BRT, GLM, MaxEnt and RF were 0, 0.23, 0.64, 0.19, and 0 respectively. Similar contrast on sensitivity values under "sensitivity = specificity" threshold for this speciesfor Bioclim, BRT, GLM, MaxEnt and RF were 0.02, 0.66, 0.76, 0.80, and 0.00 in turn. Finally, an assessment of sensitivity values under "maximum sensitivity + specificity" threshold for *Opuntiarobusta* for Bioclim, BRT, GLM, MaxEnt and RF were 0.02, 0.66, 0.76, 0.88, 0.00 in that order(Fig. 1).

*d) TSS*

More realistic value can be seen between the TSS index obtained under different thresholds and/or most of the SDMs output. For example, TSS values for *Triticumaestivum* L.under default threshold were 0.37, 0.36, 0.27, and 0.23 for BRT, GLM, MaxEnt and RFrespectively, which indicates better consistency with areas projected as climatically suitable for the species. TSS values for this speciesunder threshold of "sensitivity = specificity" were 0.37, 0.36, 0.40, 0.25, and 0.28 for Bioclim, BRT, GLM, MaxEnt and RF respectively. Similar consistency for this species were also found under threshold of "maximum sensitivity + specificity" on BRT, GLM, MaxEnt and RF. It should be mentioned that some variation were also seen under different thresholds for this species on Bioclim. Similar consistency was shown for *Fusarium oxysporum*f. spp., *Gossypium, Lantana camara* L.,*Opuntiarobusta, Phoenix dactylifera* L., and *Triadicasebifera* (Fig. 1).



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## IV. Discussion

In this study, the five correlative modeling techniques under three different thresholds were examined through extrapolation (Fig 1). The assessment of SDM correlative and envelope performance, based on AUC, Sensitivity, Specificity and TSS in modeling eight species under threshold selections of *i)* maximum sensitivity + specificity, *ii)* sensitivity = specificity and *iii)* default, indicates that TSS gives varying, but more realisticvalues (Fig 1), in comparison with specificity which represents the probability of correct classification of absence by the model. Caruana and Niculescu-Mizil (2006) note, however, that some researchers have attempted to explain the tests' relative performances and their sensitivity to data characteristics, but movement toward the establishment of a comprehensive assessment toolbox has been hindered by disagreement on the valid applicability of some statistics. SDM evaluation measurements could benefit from the identification of techniques useful in other fields, and from more concentration of research on topics such as the analysis of spatial patterns in errors, dealing with uncertainties, and assessment performance in the context of specific applications, including decision making (Austin, 2007).

We believe that the utilized method to generate absence or background points in the study was appropriate as this method is recommended by Elith et al. (2010) for species which have been presented in different portions of the range for different periods of time. In contrast, the recognized best practice when using museum data is to use what has been termed the 'target group background' approach (Phillips et al., 2009). It should be highlighted that although one of the examined threshold was the default one (0.5)it does not mean that we are suggesting this threshold as the best one.

We believe that use of a combination of distribution modeling techniques such as Bioclim, MaxEnt, BRT, RF and GLM in a complementary method, together with species accuracy estimators, allows us to better represent the geographical distribution of species and the species composition at localities, including a measure of its accuracy. However, it is necessary to assess and evaluate accuracy of species distribution modeling with different techniques as there are biases and limitations in representation of the results purely based on one modeling technique or one accuracy method. Using a combination of methodological approaches as executed in this study facilitates identification of an overall pattern, provided by all of the individual model predictions, that represent the geographical patterns of richness and composition of species, regardless of the degree of accuracy of the predictions by each individual model for each species.

Accurate projection of a dynamic phenomenon such as the richness of the distribution of a species is extremely complex. It has been shown that the results of SDMs are unreliable projections of the range of a species. Rather, they produce a provisional description of ranges, which require continuous updating as new data becomes available or environmental factors alter. Species distributions predicted by the relating of biological data to environmental variables showed a tendency toward overestimation of the actual range extents, due in part to the limitations of using only the environmental conditions as model predictors for the sites where the species has a known presence. Where absences due to historical, dispersal or biotic factors (Pulliam, 2000) are not accounted for, model predictions willinevitably tend toward the potential distribution of species (i.e. sites of environmental suitability in which a species could occur, based on a group of environmental variables; see (Jiménez-Valverde et al., 2008)). Under such circumstance, a set of errors and biases will result when predictive distribution maps are overlaid to create a representation of the richness of a species, producing an unrealistic representation (Hortal et al., 2007). Thus, the creation of a valid representation of species richness demands a deeper analysis of results, in order to detect areas with notable levels of omission, as well as account for presences located in areas where no representation was predicted.

Why not AUC? SDMs are invaluable for addressing questions and issues in biogeography, as well as evolutionary and conservation biology. Understanding performance, assessment of correlative and mechanistic models is essential to their valid application (Guisan and Thuiller, 2005). AUC is a frequently used technique for measurement of model performance (Lobo et al., 2008; Manel et al., 2001; Thuiller et al., 2005), proven to be independent of prevalence, in theoretical (Hanley and McNeil, 1982; Zweig and Campbell, 1993) and empirical applications (McPherson et al., 2004). In performance measurement, AUC is threshold independent and thus suitable for evaluating performance in ordinal score models, like logistic regression with true presence-absence data. However, in practice, absence data is often unavailable and only the presence data is accessible. Under such circumstances, envelope (eg. Bioclim) or distance-based models (e.g. Domain or Mahalanobis) are the SDMs of choice (Farber and Kadmon, 2003). However, in practice, a comparative prediction of presence-absence is often necessary, thus necessitating a threshold application for transforming the probability/ suitability scores into presence–absence data. For most reverse selection algorithms, presence–absence data of composition of species in specific locations is necessary (Tsuji and Tsubaki, 2004). As available data is frequently not complete, SDMs are often used to predict presence or absence in a potential locality for a

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particular species (Sánchez-Cordero et al., 2005). Biodiversity hotspot estimations are also frequently based on presence–absence predictions (Schmidt et al., 2005). Assessing impacts at community level of global change could be achieved by stacked binary SDM species assemblage prediction (D'Amen et al., 2015; Guisan and Rahbek, 2011). Presence–absence predictions exclude ROC plotting and, thus, AUC is not a technique for evaluating accuracy of the predictive maps used in such applications. The results in Figure 1 indicate that the high values of AUC for each species and model is no guarantee of output accuracy. Further, MESS (Multivariate Environmental Similarity Surface) maps do not specify changes in correlations between variables, and tests for these are also essential because parameters are estimated on the structure of correlations between training data predictors. Generally in SDMs, predictions will be unreliable for areas with substantial variance in correlations of important variables (Harrell, 2001). When available predictors have only indirect relationships to distributions of species, this is particularly problematic (Austin, 2002). While the selected set of variables might reasonably well represent the unmeasured directly influential variable, if inherent correlations change in new areas, there will be compromises in predictions.

Regarding the necessity of producing presence/absence predictions from SDMs, evaluating this binary prediction using confusion matrix and classification accuracy criteria should be taken into account. However, the selection of an optimal threshold is a critical issue, raisinga literary criticism(Liu et al., 2005). How well a binary prediction can classify presence and absence observations, which is called as sensitivity and specificity, respectively, is the cornerstone of the classification accuracy evaluation. Although,these metrics have been solely used for evaluating binary predictions(Ahmadi et al., 2013), they show an inherent inconsistency. For examples models with ahigh value of sensitivity donot necessarily show high specificity. It seems that models capability for extrapolation and/or interpolation compromise the resulting values of sensitivity and specificity(Franklin, 2010; Merow et al., 2014). This can be seen in our case where for almost all species RF results in the lowermost probability of occurrence in the independent area, and accordingly, high values of specificity but low values of sensitivity. Furthermore, the niche shift, the tendency of the species to establish in areas beyond the native niche in out-of-sample areas (e.g. independent area), also affects the prediction performance of the SDMs [34].In this situationTSS (i.e. sensitivity + specificity – 1) through combining the capability of correctly predicting both presence and absence (e.g. background points) observations, and therefore, taking into account both omission and commission errors, provides a reasonable viewpoint of the models performance.

Comparison of the initial distributions of species richness from model predictions with the observed ones and the analysis of errors are the successive phases for adjustment of predicted distributions of a species subset, thereby refining the picture of species richness. Reductions in the errors of omission or commission can be executedby prioritizing either sensitivity or specificity (Fielding and Bell, 1997a). The accuracy of a model must be always interpreted in terms of its intended purpose (Araujo and Guisan, 2006) by differential weighting of false-positives and false-negatives. In our study, the impact of omitting observed species was assumed to be greater, and we thereforeminimized errors of omission. Both commission and omission errors need consideration, however, from the perspective of conservation, ignoring a species where it is present may lead to the underestimation or minimization of the conservation needs of an area, while erroneously including a species in a particular locality might result in unnecessary or wasted conservation efforts and resources(Rondinini et al., 2006). A specific strategy is demanded, based on the need to reduce commission or omission errors.

Choosing a threshold is required when assessing model performance using the indices derived from the confusion matrix, which also facilitates the interpretation of modeling outputs, and in line with this matter we refer to Liu et al.(Liu et al., 2005) who reviewed different threshold determination approaches. Furthermore, refer to Bean et al.(Bean et al., 2012) who investigated the effects of small sample size and sample bias on threshold selection and accuracy assessment of species distribution models. In line with their finding, and based on the results of this study, selecting an arbitrary default threshold (for example predicted probability of 0.5) may underestimate the performance of the model to classify presence/absence areas. In such situations, taking into account the behaviour of the model to characterize presence and absence points, for example where sensitivity of the model equals to specificity or their summation reaches maximum, is more reasonable for selecting thresholds and producing binary presence/absence maps.

In this study attempts were made to answer the question "*in the use of species distribution models, should we rely on the result of a single accuracy method or a single species distribution method?"* through evaluating AUC, Sensitivity, Specificity and TSS performance accuracy methods based on the application of five types of bioclimatic models under three different thresholds to predict the distributions of eight different species in an independent area. As discussed earlier, SDMs are based on different algorithms and thus they perform differently; and for the users, the decisions at the commencement of the process is which of these is most appropriate is complicated; and the situation would become more



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challenging if the users rely on in appropriate accuracy measure methods. Our findings show that evaluating performance of accuracy gives different results among different techniques and the TSS method is better compared to the other three examined methods. We note that this study adds to one undertaken by Allouche et al. (2006) who assessed the accuracy of species distribution models through prevalence, kappa and TSS.

## V. Conclusion

The extensive array of methods, data types and novel research questions imply the need for many modeling decisions. Different modeling techniques (e.g., DOMAIN, CLIMEX, MaxEnt, BRT, RF, Bioclim) and different methods of measuring accuracy (e.g., AUC, Sensitivity, Specificity, the True Skill Statistic)have different requirements. In selecting the most appropriate method of measuring accuracy, knowledge is required in terms of which method is most appropriate for the data available and its intended application. However, the information facilitating an informed choice of method is currently scattered throughout the modeling literature and incomplete, making it problematic for most users to make decisions on the adoption of newer methods, and for newcomers to know where to begin. Knowledge of a particular algorithm gives insight into the features and limitations of its predictions, and why particular patterns occur. As Bioclim, GLM, MaxEnt, BRT and RF provided slight variances in projections of the same group of species, it may be more expedient to use TSS as an intuitive method for measuring the performances of species distribution models, in comparison with the area under the ROC curve (AUC), Sensitivity and Specificity.

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*Author contribution statement:*
Conceived and designed the experiments: FS LK MA.
Performed the experiments: FS, MA.
Analysed the data: FS, MA.
Contributed reagents/materials/analysis tools: FS, MA.
Wrote the paper: FS, LK, MA.

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## Figure Caption

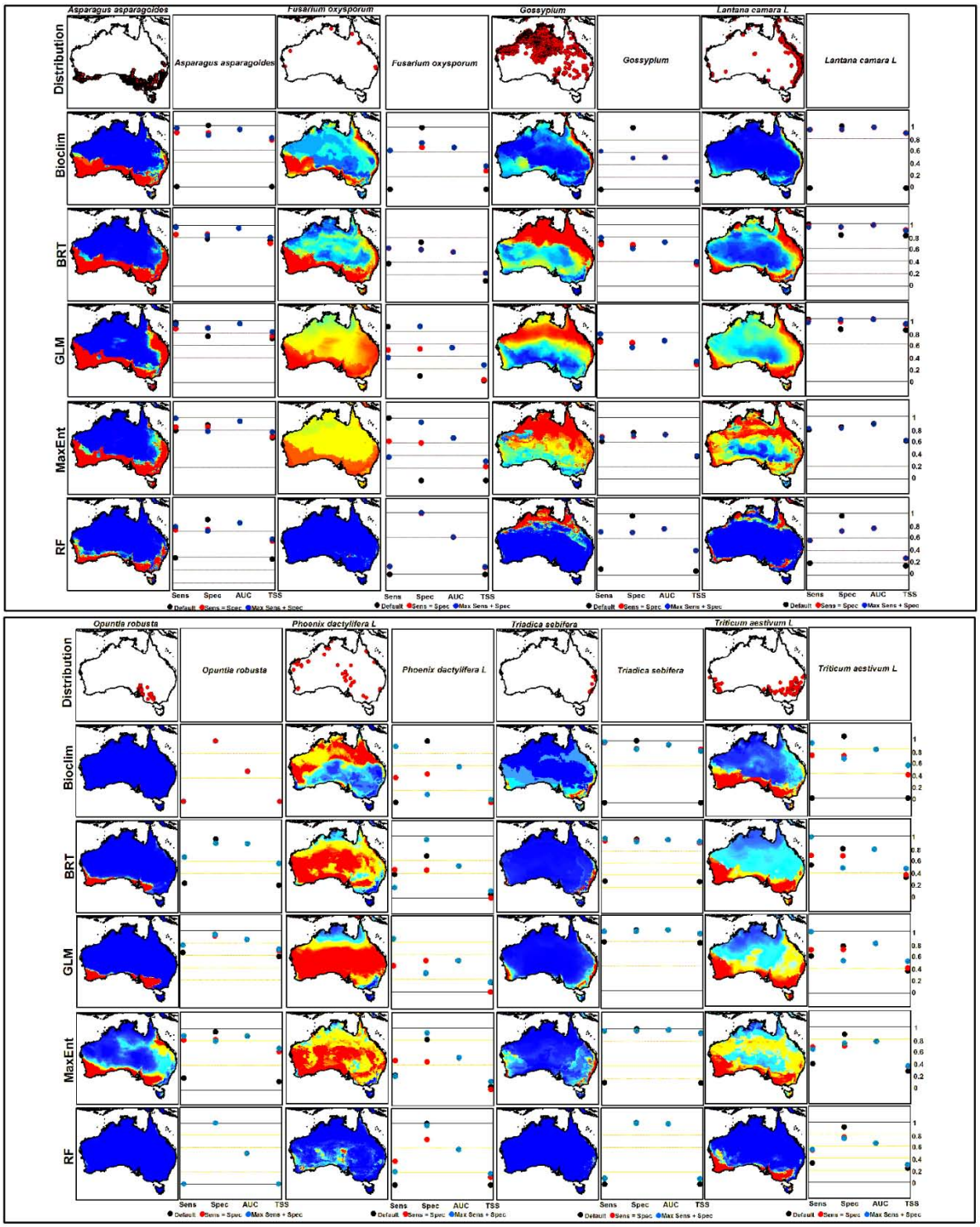


*Figure 1:* Projections of an independent area for the potential distribution of eight species using five different correlative niche models and the area under the ROC curve (AUC), Sensitivity, Specificity and the True Skill Statistic (TSS) values. Warmer colors show areas with better-predicted conditions. The top row of maps, shows the distribution of species. This map was generated by ArcMap 10.2. Available at http://www.esri.com/arcgis/about-arcgis. The dot graphs show the performance of the different accuracy methods tested by different threshold selection.

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# Integrated Ecological Approach as Paradigm Shift towards Sustainability: Current Efforts and Challenges

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*Abstract-* Currently ecosystem degradation is become the main challenges of human being. Conservation of resource and traditional restoration is not sufficient because of high consumption rate and limited resource left on the earth. Consequently, Ecological restoration become the prime option. It is scientific application of restoration ecology and deals with restoring the function, structure and process of ecosystem. It is holistic approach with the consideration of important factors of ecological, social, cultural, economic and policies. Though, different scholars attempt to describes integrated approach in Ecological restoration by combining different factors, still it is marginally addressed and successful practical implementation of ecological restoration also lack. This review aims to fill this gap by consider integrated ecological restoration as a paradigm shift to sustainability. This paper proposed a framework by reviewing and insight 118 scientific papers. The considered factors were scientific basis in restoration practice, flexible plan and management action, landscape perspective, socioeconomic and policy dimension, and Inter and Trans disciplinary approach. Integrated ecological restoration is a mechanism to address ecosystem resource degradation sustainably.

*Keywords: ecology; ecosystem degradation; integrated ecological restoration; paradigm shift; sustainability.*

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# Integrated Ecological Approach as Paradigm Shift towards Sustainability: Current Efforts and Challenges

Hamere Yohannes [α], Teshome Soromessa [σ] & Mekuria Argaw [ρ]

*Abstract-* Currently ecosystem degradation is become the main challenges of human being. Conservation of resource and traditional restoration is not sufficient because of high consumption rate and limited resource left on the earth. Consequently, Ecological restoration become the prime option. It is scientific application of restoration ecology and deals with restoring the function, structure and process of ecosystem. It is holistic approach with the consideration of important factors of ecological, social, cultural, economic and policies. Though, different scholars attempt to describes integrated approach in Ecological restoration by combining different factors, still it is marginally addressed and successful practical implementation of ecological restoration also lack. This review aims to fill this gap by consider integrated ecological restoration as a paradigm shift to sustainability. This paper proposed a framework by reviewing and insight 118 scientific papers. The considered factors were scientific basis in restoration practice, flexible plan and management action, landscape perspective, socioeconomic and policy dimension, and Inter and Trans disciplinary approach. Integrated ecological restoration is a mechanism to address ecosystem resource degradation sustainably.

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## I. Introduction

Currently, many ecosystems are at risk due to intensive exploitation of resources. This have an impact on the service they provide for human being such as food and fibre production, water provision, climate regulation and wildlife habitat [1]. It is estimated that 86% of the world's population live in countries that require more from nature than their ecosystems can provide [2]. Our consumption rates already exceed the supply of many resources crucial to human health, and few places on Earth do not bear the stamp of human impacts [3]. Over the last 50 years, 60% of worldwide ecosystem services have degraded due to increases in the global population and economic growth [4]. As these impacts increasingly compromise biological diversity, human health and food security. Therefore, policy makers and managers started to push to investment in ecosystem restoration [5].

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Long-term solutions to current environmental problems involve not just conservation of the natural world, but increasingly the restoration of ecologically healthy landscapes and communities [6]. Ecosystem or ecological restoration defined as an intentional activity that initiates or accelerates the recovery of a degraded, damaged, or destroyed ecosystem with respect to its health, integrity, services, and sustainability. The damage may have been caused or aggravated by natural events such as wildfire, floods and storms or, caused as the direct or indirect result of human activities [7].

Ecological restoration is important to enhance ecosystem services and biodiversity, mitigate and adapt climate change, slow biodiversity loss, and contributes to the improvement of human well-being and humanity's relationships within nature [6]. The main goal of restoration is to create self-supporting ecosystem which do not need further assistance to develop mature characteristics [7] [8]. Though, ecosystem based management is powerful and effective, it is costly and time demand action [9]. Ecological restoration requires multiple efforts, long-term commitment, and thoughtful deliberation [10].

In general, the field of ecological restoration has thus received increasing attention worldwide and has experienced tremendous advancement over the past 30 years and is now widely recognized as an essential component of the fields of conservation and sustainability [1].

### *a) Gaps identified from critically evaluated literatures*

Traditional management of ecological systems focuses on specific products or services desired by people, with emphasis on marketable commodities. Resource managers learn just enough about ecosystems to maximize the production of these commodities. As a result, ecosystems are overused and poorly understood [11]. Similarly, Ecological research on restoration has largely focused on community ecology and ecosystem ecology, with particular attention to plants [12]. Nevertheless, an ecosystem perspective on land and resource management means thinking about land-its soils, waters, air, plants, animals, and all their relationships-as whole units that occur in a hierarchy of nested places [13]. Therefore, researches



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and management practices works on restoration of degraded ecosystem should focus in integrated ecological restoration.

Over the last decade, there has been an observation that shows the clear gap between knowledge generated by the researchers and practical application by restoration practitioners in ecological restoration [14] [15]. Though, the need of ecological restoration concept is widely discussed [6] [1], there is still a gap in successful implementation on the ground and report. And this issue is marginally addressed in scientific literatures [11].

In addition, Though, there are different literature, that shows the efforts to explicit integrated ecological restoration by considering different factors for instance the integration of, ecological knowledge, management action and social dimension [16]; multi-functionality, transdisciplinary, participation, complexity, and sustainability [17]; ecological theory with practice and restoration ecology trans-disciplinary framework [18]. Still there is a gap to explore more factors of integrative approaches in ecological restoration in depth. Here in this paper an integrated approach to managing natural resource is not introduced as a new concept, here try to refined through multiple integration such as incorporating landscape perspective; transdisciplinary link, socioeconomics and policy dimension with restoration, scientific based practice and flexible plan and management, because restoration ecology needs to adopt a more integrated approach which will make it a more useful science for sustainability as we progress further in to the twenty-first century. Therefore, this paper shows the possible factors could be integrated in ecological restoration as approach to progression of ecological sustainability. This paper tries to fill the gap by review scientific literatures to overview the current status of ecological theories and principles implementation in ground and the main challenges and propose conceptual framework to apply integrated ecological restoration.

*b) Objective of the Review*

- Review the experience of ecological restoration practice and main challenges,
- Explore the components of integrated ecological restoration and propose conceptual basis.

*c) Review Methodology*

This paper is prepared from various review of scientific articles, books, reports published from 1987 up to 2017. The overall process of preparing this paper was done by following the main steps adopted from [19], deine the topic, obejecvtive formulation, select key words for searching, identify the key databese and criricall review the publication. The databases used included Google Scholar, Web of Science, science direct, Scopus and others which were searched in June and July 2017 by using the key searching terms. Accordingly, 118 scientific papers were critically evaluated and included in this seminar review as per to the requirement of the main topic. The main journals reviewed were Ecology and Society, Restoration Ecology and Journal of Ecology. And mostly SER and CBD secretariat reports were used in this paper.

During the review, the focus was collecting concepts and practices for integrated ecological restoration approach to become a paradigm shift for sustainability. Therefore, social, environmental and economic issues were duly incorporated.

## II. Review of Related Literatures

*a) A Brief History of Ecological Restoration and Paradigm Shifts*

The idea of restoring the land dates back centuries, practiced in the different forms, such as erosion control, reforestation, and habitat and range improvement [20], but modern restoration ecology and its practice began in the early 1900s when people such as famous conservationist Aldo Leopold (a forester) began promoting the movement [12]. Restoration ecology is the science on which ecological restoration is based. It emerged as an academic field in the 1980s [16]. Science of restoration ecology has become a strong academic field [20].

Gaining momentum in the latter half of the twentieth century, restoration ecology is now established as a science and studied in many research institutions. International societies and journals, such as the Society for Ecological Restoration (SER) (established in 1988). There has been a strong push to formalize the science and practice of restoration, linking it explicitly with ecological theories [12] [21]. In addition, since the publication of the Millennium Ecosystem Assessment in 2005 there has been a surge of interest in ecological restoration to recover biodiversity, re-establish ecosystem functioning and connectivity, and reactivate the delivery of ecosystem services [22].

As [23] stated "*the next century will, I believe, be the era of restoration in ecology*". Over the last 30 years, ecological restoration has emerged as the central new promise for the reconciliation of societal well-being and biodiversity conservation in a human-dominated world [24]. During this period, many paradigm shifts in restoration ecology develops. The foremost paradigm shift was the emergence of ecosystem based management in 1980's to provide best alternatives for traditional resource management approaches. In 2000, CBD adopted this approach and develop 12 principles for the implementation. [25] [26].Though [27], argue that Ecosystem Based Management cannot be considered as new paradigm shift, because since Leopold's effort of restoration in 1930's there was ecosystem management, although he never actually used the term



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ecosystem management, his career testifies that he recognized the need to protect or restore ecological components, in order to sustain resources. According to [4], By the early 2000s, EBM was the dominant paradigm, at least in theory, for managing natural resources around the world, in both marine and terrestrial systems. [28], identified 17 different criteria that are commonly used to define ecosystem-based management.

In the mid-1980's, there was a paradigm shift with the promotion of more holistic approaches originating from within the conservation community and the emergence of the scientific discipline of landscape ecology [29]. Consequently, since mid-1990's, the paradigm of restoration with landscape perspective thus goes beyond restoring pieces of land or even restoring large area, while ignoring the influence of the landscape structure was raised. Many literatures stated that we need to move from small-scale "environmental gardening" to large scale restoration based on landscape ecology principles [30][17] [31].

The other fundamental paradigm shift was from ''backward-restoration'' to ''forward-restoration'', in which never-seen futuristic designer ecosystems may be the best option to attain self-sustaining ecosystems for the future [32][33]. For the first time, Aldo Leopold, recognized that the practice of ecosystem health required reference points - healthy, intact ecosystems. A reference ecosystem is a model adopted to identify the particular ecosystem that is the target of the restoration project [34]. It can be an actual site (reference site) or a conceptual model synthesised from numerous reference sites, field indicators and historical and predictive records [1]. Restoration of past ecosystems is possible when climatic conditions suit the species that once were present [10]. However, the [35] reported that *global warming of 1.5°C above pre-industrial levels and no sign of temperature reduction. This shows that there is no much chance going back. [36],* also argue that restoration should follow nature's lead, not in order to recreate an 1850's ecosystem, but to restore an ecosystem's ability to respond to change. [10] pointed out historical information is a useful guidance but should not be a 'straight jacket' for projecting restoration goals and trajectories in the future. According to [3], A restored ecosystem will not necessarily recover its former state, however since contemporarily constraints and conditions can cause it to develop along an alternative trajectory [34]. Therefore, we should intervene with an eye to the future and toward managing for future change [37][38]. Therefore, forward restoration become a major paradigm shift.

[18] reported the two recent paradigm shifts in ecological restoration, the first one is moving towards more scientific foundation to unite science with practice and the second is to locate restoration firmly in the transdisciplinary arena. In general, Restoration ecology has historically emphasized the management actions and interventions associated with recovery of damaged ecosystems, sometimes referred to as the "restoration toolbox" [39]. But in recent years, the field has seen a paradigm shift toward stronger scientific foundation and better inclusion of socioeconomic, political, economic, cultural, regulatory frameworks, and taking account of the past and future for sustainability [40]. This could lead as to more holistic and integrated ecological restoration approach.

*b) Ecological Restoration in Practice*

Through ecological restoration theories are translating to practice. Most countries have suffered degradation and forest loss and have opportunities for restoration. According to [41], rough estimation, more than two billion hectares worldwide offer opportunities for restoration. Most of these lands are in tropical and temperate areas.

From a global perspective, restoration work generally is not taking place in the countries where it is most needed. Most ecological restoration research come out from high income countries classified and the work mostly focuses on forest and aquatic ecosystem [42]. For instance, Vast deforested areas in Europe and North America have regrown forests. In contrary, though, tropical regions have the largest need for restoration efforts, the practice is limited [41]. Ethiopia has 82 million ha of potential for tree based landscape restoration, varying with short and long term [43].

Win-win projects that result in both conservation and economic gains are not easy to implement, although they are a commendable goal [44]. Consequently, according to [28], there are relatively few case studies of successful implementation, and the extent to which the ecosystem based management principles in restoration, for instance Restoration in Kissimmee River, is considered as the most successful project which includes ecological evaluation and adaptive management till date [45].Atlantic Forest Restoration Pac program in Brazil and Sloping land conversation program in China (restoration in Yellow and Yangtze river) also has good progress in ecological restoration. South Korea and Costa Rica have embarked on successful forest restoration strategies [41].

Though, [21], pointed out that the number of empirical evaluations has increased during recent Years, a recent review of restoration in the Nordic countries indicates that ecological restoration projects in the region often completely lack formal evaluation [46]. Other studies also show this to be the case in other parts of the world [47] [48]. In addition, [49], found that from 10 case studies in Northern Hemisphere countries, most evaluations were short-term and only some parts of them were properly documented, which affects adversely the efficiency of restoration process, since inefficient methods were implemented. They suggested



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that perform continues evaluation, disseminate the finding both successes and failures. The case in Ethiopia is the same, there are very few examples of successful implementation of restoration and no proper documentation[50], For instance, Humbo forest restoration landscape and Tigray region restoration experience (Abreha Weatsbeha, Geregera, Mossa and Kihenwatersheds) [51]. There is also ongoing effort in Bale mountain, with Participatory Forest Management (PFM) and the newly launching program to conserve biodiversity and ecosystem functions and services. As compared to the current land degradation status, that is about 33,193,3903.14 ha (30% of total land) of land is degraded in Ethiopia [52], These efforts are not adequate.

On the other hand, [53], reported that Ethiopia is rising as a leader in restoration, though the country passes the long difficult road. In the past, 97% of Ethiopia native forest was lost and 1984-85 famine. Over the last decade, Ethiopia put tremendous effort to rehabilitate and restore degraded lands by using Sustainable Land Management (SLM) tool.

*c) Challenges/ Barriers to implement Ecological Restoration*

Since ecosystem is more complex process, there might be challenges raised from timing, capacity, communication, and collaboration challenges [53].

i. *Sever land degradation*

In many of severely degraded production landscapes, which loss of habitat and biodiversity, changes in hydrological processes, loss of soil and altered nutrient levels. Restoration to a former state is not viable, and they will be targets of ecosystem repair to improve levels of ecosystem function and services, using native species where possible [37]. According to [54], where the hydrological components like wetland completely drained, soil nutrient and microbial severely degrade, plant and animal communities completely lost and the whole landscape fragmented, restoration become really challenging.

ii. *Cost and Time Constraint*

The areas of degraded land now present in various parts of the world are large. Some systems are severely degraded and will be costly to repair [55]. There is lack of attention to the cost of restoration in research and literatures due to different factors such as economists and ecologists have traditionally approached the cost in different disciplinary perspective; restoration and economics are viewed as opposite force and the consultants who is responsible to guide and publication the whole process may not make the data available. Despite these obstacles, it is essential to integrate ecology and economy in restoration effort [56]. Later, different literatures try to integrate the broad sets of socioeconomics and ecological objectives and criteria when planning and evaluating restoration projects [42][57]. Although progress has been made conceptually, too few practical applications have been achieved during the last 15 years, especially in the crucial areas of valuation and financing [58]. Concurrently, there has been far too little work on how to actually measure and monitor the economic effects of restoration [59], However, Restoration feasibility depends also on restoration costs [60].

In high latitude and high elevation areas, ecosystem often require decades or centuries to recover as a result of short growing season in these areas [61]. Furthermore, in some natural ecosystems require a longer time to develop their mature character. Mostly, it is difficult to determine how long the ecological restoration takes to reach endpoints and even it is hardly to determine the exact time [62]. Typically, if the ecosystem is highly endangered, the responsible bodies fail to commit for the restoration as a result of recovering this kind of ecosystem become time consuming and costly [63].

iii. *The issue of trade-offs in restoration*

Restoration actions focusing on a particular ecosystem service could lead to negative impacts on biodiversity or provision of other services, which will need to be considered during the planning process, leading to conflicts and trade-offs [24]. As restoration of one ecosystem service may come at a cost to another, one particular challenge is how to ensure multi-functionality in both the short and long term. For instance, although planting a few short-lived but fast-growing species is a common approach for carbon offsets, these plantations do not approach the diversity of naturally occurring tropical forests and can have a high rate of failure [64]. [65], also found that vegetation restoration can produce positive effects on Net Primary Productivity, but negative effects on Water Yield. A carefully chosen balance between the aimed biodiversity benefits and the unwanted side-effects is likely to be highly context-specific, where local and national rules and regulations and public opinion provide inputs [66]. The good thing is trade-offs between biodiversity and ecosystem services may change through time after restoration starts [24]. Navigating the trade-offs between provisioning, regulating, cultural, and supporting ecosystem services, as well as maintaining natural capital that is critical to generate future services, is essential for achieving sustainability [67].

iv. *Social Conflict*

Often it may be impossible to choose the optimal sites for restoration due to unwillingness of the land owners [60][57]. Furthermore, it may prove problematic to find areas large enough to host and maintain restoration objectives, especially in densely populated areas characterized by highly fragmented forests and diversified forest ownership. Many of

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degraded ecosystems are still being used by people and many of these people are poor, which could worsen the degradation level [55]. Some research done in Latin America reported that social perceptions towards restoration effort and expectations of several stakeholders could be one of the main challenges of most restoration project in Latin America countries [68][57].[9] also reported that social understanding and need difference could rise to conflict.

v. *Limited Information and Knowledge*

Often, there is little information about the past ecosystem composition and structure, because ecological restoration is relatively recent decade science, in this situation, it become difficult to evaluate the success of restoration [48]. Information access within and among countries still needs improvement. Sometimes, scientific knowledge is not available to practitioners. Much information and knowledge are not produced in scientific arena and are incompletely communicated. In many cases, they are housed in theses, technical publications, forums, and other media products. Knowledge of the whole ecosystem process and function and skill to implement ecological restoration practice also limited [69]. It is necessary to consider and have knowledge about the resilience of the ecosystem, past land use, and the matrix of the surrounding landscape to define restoration approaches in a socioecological perspective [57].

vi. *Lack of Standard Criteria*

There is limited success in many projects due to inappropriate planning and implementation. There has been a growing need for a clear set of standards to establish benchmarks for the technical application of restoration treatments across ecosystem types, and to maximize ecosystem recovery within a framework that engages stakeholders and respects socio-cultural realities and needs. Practitioners, operational personnel, planners, managers, funders, and regulators need standards to help them develop high quality plans and achieve acceptable ecosystem recovery outcomes [69]. [70] reported that there are no standard criteria to assess the restoration success in Ethiopia. Only in recent year (2016), SER release international standard for ecological restoration. These international standards follow pioneering efforts of SER Australasia to develop 'National Standards for the practice of ecological restoration in Australia'. And it became the first such initiative anywhere in the world. Still now no information about its adoption and applicability in local scale in other countries[69]

vii. *Funding*

Most restoration projects lack adequate funding for monitoring [71]. According to [72], Funding for restoration effort and monitoring of its effects is often granted for short periods, and granting is more politically than scientifically motivated. Amount of incentives; amount of resources invested; number of institutions involved; presence or absence of incentives; subsidies or fines to stimulate or discourage restoration activities [60]. Without sufficient funding, the success of our efforts will be difficult to assess, or have the option to revise actions if necessary [66].

*d) Integrated Approach in Ecological Restoration*

An integrated ecosystem approach is perhaps the only way to tackle the challenges of climate change, habitat loss, and the sustainable use of natural resources. Ecological restoration and biological conservation are the logical pillars upon which we can build an innovative approach to maintaining and restoring the ecosystems that we, and all life, depend on [73]. Restoration ecology is an integrated science, because it adds political engagement, economic basic conditions, education of people, and even cultural aspects [32]. Different authors [18][17][74][16] address integrated ecological restoration by considering different factors, these all efforts revealed that the progress of ecological restoration towards sustainability. According to [53], early integration starting from restoration planning, provides opportunities for efficiency opportunities for improved and productive collaboration and coordination which bring cost-savings in monitoring and adaptive management. Here in this paper, the following components are proposed as a part of integrated ecological approach to meet sustainability, which could increase the success of ecological restoration. These are scientifically based restoration practice, consideration of landscape perspective in restoration, multidisciplinary approach, socioeconomic and policy framework and flexible plan and management actions. Though it is well known in some cases to address all the factors, it is a way of achieving sustainable management.

i. *Combine scientific basis to restoration practice*

The science and practice of ecological restoration have advanced rapidly in the last decade, creating a wealth of guidance, tools and technologies [75]. [10], noted that ecological restoration until recently has been viewed as more of as art rather than science. In addition, [1]) reported that, to date, many of the restoration actions are based on gut feeling rather than on scientific evidence. In fact, the practice of restoration has developed more through trial and error than by the application of any scientific framework [76].According to [18], including scientific basis for restoration practice is one of the paradigm shift. Thus, ecological theory is highly relevant to the practice of restoration ecology. Ecological restoration is applied science and derives from the science of restoration ecology, it means restoration ecology is the science on which ecological restoration is based. Restoration ecology ideally provides clear concepts, models, methodologies and tools for practitioners in support of their practice [34][7].



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Restoration ecology is rooted in ecological principles, such as successional theory, assembly, life histories, recruitment limitation and landscape ecology [77] [8]. [78] stated that ecological restoration should be an acid test of ecological understanding. According to [32], Ecological restoration still can be considered as an acid test, but for our understanding of the interaction of people with their environment, rather than for pure ecology. During this test, restoration ecology can develop new theory specifically to repair damaged ecosystems [7].

Ecological restoration is a knowledge and practice based undertaking [80] [38]. Restoration plans must be based on the best available science [81] with clear goals. Science-based restorations follow: (1) explicitly stated goals, (2) a restoration design informed by ecological knowledge, (3) quantitative assessment and data collection of system responses employing pre- and post-restoration (4) analysis and application of results to inform subsequent efforts, based on adaptive approach [82]. Although, ecological restoration has scientific foundations, the integration of ecological theory and restoration has been uneven, despite recognition that the practice could be enhanced by such integration [20] [1].

ii. *Landscape perspective in ecological restoration*

The first decades of ecological restoration practice were dominated by small-scale initiatives not integrated at the larger scales [30]. In recent year, it is becoming increasingly clear that ecosystems do not function independently from their surroundings and their spatial relations is important [83]. And restoration sites are not isolated compartments; rather they are linked to their surroundings [32]. In addition, the extent of current environmental degradation and the increasing call for large-scale restoration necessitates approaches that can be applied over much larger areas. Ecological restoration can occur at a variety of spatial scales but for maximum benefits should be approached from a landscape perspective [84].

Landscape ecology perspective in restoration mainly consider mosaic ecosystem or the improvement of landscape structure, functions or dynamics, as well as local restoration actions that consider the influence of the surrounding landscape structure on restoration outputs [30]. According to [85], study in Boral forest, Landscape context considerably affects the success of ecological restoration. Similarly, [86], stated that landscape context or surrounding matrix is one of the factor that should be considered during management planning like ecological restoration, because the surrounding land use matrix affects recovery because it serves as an important source of propagules, as well as potential disturbances.

Considering landscape approach is becoming a driving paradigm in the international environmental and development community [17]. [87], also proposed a landscape ecological paradigm shift in resource management design. Thus, Recently, many large-scale restoration programs have arisen across the world. It became induced by other forces such as payments for ecosystem services (PES) schemes [39], the production of timber and non-timber forest products from native species [88], and biodiversity offsetting policies [89]. These programs integration in restoration project could serve as to compensate the highest cost of restoration in landscape scale [86]. But, project that links restoration and these programs are very few [42]. In this context, restoration ecologists and practitioners, as well as policy makers, will certainly have to be prepared to adopt new approaches for inducing, planning and implementing restoration programs. According to [57], Restoration approaches should be based at national levels, but adapted to local-regional levels, in a bottom-up perspective.

iii. *Flexible plan and management actions*

Flexible plan in ecological restoration identifies a probabilistic range of possible outcomes instead of a single reference condition. [90] states that there is a need to identify multiple probabilities and trajectories of outcome to restoration rather than expecting the emergence of a site resembling a single reference system. According to [69], full recovery is not possible or appropriate everywhere. In many cases where restoration has been assumed by some to be impossible (if the system passes its allowable thresholds), it would be sensible to modify the goal.[91] also reported that if the area is highly degraded due to intensive disturbance, creation of new ecosystem (novel) and enhancement will be an option.

The emergence of the novel ecosystems concept is reshaping the field of ecological restoration. In the context of past and ongoing local and global changes, many ecosystems are being transformed into new, non-historical configurations [92], it allows more flexible goal for restoration for the changing environment. Because of these changes, historical restoration targets will often be unsustainable in coming decades [93][37][38] [94].

On the other hand, [80], suggested that the introduction of novel ecosystem together with restoration target may not be important in protected area since some protected areas may be relatively resistant to change and restoration with a focus on historically determined goals will still make sense. According to [93], ecological restoration primary aim is to restores historical ecosystem where possible. Meanwhile, the project need to be ready for the emergence of novel ecosystem. Though the issue is still a debate [95] suggested that in the 21st century the restoration priorities should be broadening the restoration framework to include the emergence of novel ecosystem.



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According to [96], ecosystem management (here restoration) involves decision making within extremely complex natural and social dynamics, the outcomes of management actions are highly unpredictable. In addition, each restoration project has its own uncertainties and surprises, and each requires flexibility. Adaptive management is a way to remain flexible and cope with surprises while making necessary management decisions. It is an approach to ecosystem restoration that recognizes uncertainties, embraces multiple problem-solving strategies, and allows for adjustments to be made along the way in smart way [97]. It promotes flexible decision-making to modify existing activities or create new activities if new circumstances arise or if projects are not meeting their goals [98]. Most literature reported that integrating adaptive management in resource management is very important and useful, however, practical implementation and reporting is still behind, particularly in large scale [99]. Scientific based restoration should include adaptive management, the corrections that are made to the restoration process should be guided by sound theory and experimentation, not just trial and error [82] [100]. Natural resource restoration is complex management systems, we must manage them adaptively and in an integrated manner [101]. In short, flexible adaptive management is one of the general principle ecosystem based restoration [73].

iv. *Socioeconomic and policy dimension in ecological restoration*

During the last few decades, the interest in ecological restoration has increased rapidly [75]. In earlier time, restoration emphasized on ecological sustainability, but in recent past decade, the importance of human benefits from the management become dominantly important through the concept of ecosystem service integrity in restoration efforts, which could bring social sustainability [102]. The practice of ecological restoration seeks to transform humanity's role from agents of degradation to act as conservators and healers of indigenous ecosystems [103]. Although ecological restoration deals with scientifically based practical alterations of ecosystems, it is not only a technical task. Instead, it has an important human element, with strong social and political associations that are increasingly acknowledged in ecological restoration to reach the goal [104]. Therefore, Restoration is carried out to satisfy not only conservation values but also socioeconomic values, without considering these values, particularly relationships between a site and its stakeholders, a restoration project may not gain the social support needed for success and may fail to deliver important benefits to ecosystems and to society [69].

Above all, still there is a gap in addressing practically, all social attributed in restoration effort, for example, [42] did comprehensive review on socioeconomic aspects of ecological restoration, and the most tangible and concrete socioeconomic contributions of restoration to society are underemphasized, or often ignored altogether. [21] also found that very few papers looked at socioeconomic attributes of restoration, but understanding the socioeconomic benefits/impacts of restoration is necessary to support the adoption of ecological restoration in natural resource management. Ecological restoration should also be recognized as an important element of sustainable socioeconomic development particularly for developing countries [42].

Nowadays, there is emphasis on the importance of restoration for addressing global environmental change [105]. It became integrated in global and regional biodiversity policies [75], sustainable policies [58], United Nations Framework Convention on Climate Change (UNFCCC), land degradation neutrality under the United Nations Convention to Combat Desertification, the wise use of wetlands under the Ramsar Convention on Wetlands and Bonn challenge [106].For instance, in achieving the 2020 Biodiversity Targets, the so-called Aichi Targets (including restoration of at least 15 per cent of degraded ecosystems), including by the European Union, UNEP, World Bank. More recently, the United Nations adopted its 2030 Agenda for Sustainable Development, including Sustainable Development Goal (SDG)15 to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" [24][107]These and other international organization also coming to the realization that ecological restoration should receive high priority from society in socioeconomic as well as ecological perspectives [42].

Practically, the two large-scale ecological restoration programs examples are the Atlantic Forest Restoration Pact (AFRP), which aims to restore 15 million ha of degraded lands in the Brazilian Atlantic Forest by 2050 [108], and the Sloping Land Conversion Program (SLCP) in China, in which steeply sloping and marginal land has been retired from agricultural production since 1999 in order to promote forest and grassland cover [109]. These initiatives align with Aichi Targets [110].

In parallel, the Bonn Challenge (2011), which is global commitment to restore 150 million hectares of land around the world by 2020 and the New York Declaration on Forests, which seeks to restore 350 million hectares by 2030 were launched by international organizations such as the World Resources Institute (WRI) and the International Union for Conservation of Nature (IUCN) at a governmental scale. After the Convention of the Parties in Lima, initiative 20x20 is a country-led effort to bring 20 million hectares of land in



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Latin America and the Caribbean into restoration by 2020 [57]. The Bonn Challenge is leading to real progress on the ground. In many countries, restoration opportunity assessment is undertaking and restoration programs stats to be included in national plans and strategies. In general, thought restoration included in many conventions, agreements, policies, strategies and article recommendations, practically, there is no much report on policy impacts or implications of the restoration work [42].

v. *Inter and Trans disciplinary in ecological restoration*

Similar to the broader field of ecology, restoration ecology is an integrative discipline [76]. In current global situation, integrative discipline is essential in ecological restoration, because the goal of restoration is beyond environmental gardening [10]. The broadening of focus of restoration suggests both that ecological aspects need to be considered in a wider socioeconomic context and that an interdisciplinary or even transdisciplinary approach is needed [38]. Interdisciplinary approaches focus more on linking different research disciplines together, such as microbiology, seed science and pollination ecology [10][9]. Biodiversity-Ecosystem Functioning (BEF) experiment is one of interdisciplinary approach which is necessary for better projection and understand of restoration outcomes [10]. It is recent emerging attempt to uniting community and ecosystem by using BEF experiment [111]. According to [112], there is an attempt in forest sector is to adopt the BEF framework in setting up large experiments where the effects of tree species richness on ecosystem functions are evaluated. In the last decade, the relationship between biodiversity and ecosystem function become a central issues and ecologist widely considered it as one of the paradigm shift in ecology science [113][114].

On the other hand, transdisciplinary is about cross-sectoral approaches are based on multi-stakeholder processes relating more to practice [17], such as agronomy, engineering, sociology and landscape architecture, soil science and hydrology [76]. Transdisciplinary restoration thus involves an entirely new type of knowledge, leading to new relationships between researchers, professionals, and practitioners involved. The current transdisciplinary science creates a new way to solve complex biological hydrology and human ecological relationship [115]. It is about broadening our conceptual and methodological scope from the natural sciences to the humanities, from strictly bio ecological issues to much more complex human ecological issues [116]. Similarly, when restoration practice planned to be large, transdisciplinary approach is needed beyond interdisciplinary approach [38]. According to [18], Transdisciplinary arena in restoration is one of the paradigm shifts to unite natural with social science. For example, including political and socioeconomic issues with restoration rather than applying multifaceted aspects of applying ecology to restoration. Though, challenges occur in integrating expertise from various disciplines and multiple, sometimes divergent interests and goals [53], it is important for successful ecological restoration.

e) *Framework of Integrated Ecological Restoration for Sustainability*

Integrated ecosystem approach is the principal method to solve the current climate change, habitat loss and misuse of resources in the world [73]. Thus, Ecological restoration is often a primary component of ecosystem management, conservation, and sustainable development programmes throughout the world. Rehabilitation and restoration are now often a prerequisite to sustainable use [58]. It is now well recognised that science for sustainability will require integrated problem-focussed research [117]. Ecological restoration has as its goal an ecosystem that is resilient and self-sustaining and supporting sustainable livelihoods. A realistic restoration goal has to be ecologically sound, economically feasible and socially acceptable, as any other sustainable practice [32][10]. According to [70], inherently ecological restoration is multidisciplinary, multi-scalar and multi-sectorial activity, so it need good governance. Now, we can see the link of ecological restoration and sustainability issue., even the 17 UN Sustainable Development Goals (SDGs) which come into force in 2016to guide the post-2015 development agenda clearly stated that the importance of restoration to meet their sustainability goal particularly at goal number 15, and many other goals also related to landscape (ecosystem) restoration. These goals explicitly emphasize in the importance of 'holistic and integrated approaches to sustainable development' are required [118]. Furthermore, [117] suggested that landscape ecological restoration as paradigm for sustainability. [109], reported that in sustainability science cannot be addressed through un-coordinated studies of individual components by isolated traditional disciplines; instead, a new kind of interdisciplinary science is needed to build an understanding of social–ecological systems.

Based on the above discussed concepts in this paper the following conceptual basis is proposed to attain sustainability in holistic or integrated ecological restoration. The central idea is when degradation occur in the ecosystem, the whole ecosystem should be assessed to know the problem extent, because there is no single isolated piece, then plan, design and act in integrated fashion to obtain sustainable result. To attain this, by incorporating key elements such as integrate scientific base in restoration practice, consider landscape perspective to boost the restoration outcome, act with flexible plan and management with



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the awareness of the current rapid environmental change, incorporate social and policy framework as integral part of restoration to obtain active community involvement and sustain their livelihood and finally acknowledge multidisciplinary nature of restoration and emphasize on transdisciplinary field of study to produce holistic outcome.

## III. Conclusion

Over the last 50 years, ecosystem is highly exploited by human activities globally and ecosystem become unable to provide valuable services including biodiversity maintenance. This has severe impact on human well-being as well as food security. Restoration recognized by the international community as an important way of enhancing both biodiversity and ecosystem services. Recently, ecological restoration gains momentum attention by resource managers, policy makers and researchers and considered as the prime option for the current rapid changing environment, loss of biodiversity and ecosystem fragmentation. It is about restoring the whole ecosystem by using basic principles, realistic plan and adaptive management. In short, it follows holistic or integrated approach to sustain the management.

Though, integrated approach in ecological restoration is important, there is a gap of addressing the issue in literature as well as in practice. Practically, there are few model efforts of ecological restoration in large scale such as Atlantic Forest Restoration Pact in Brazil, Kissimmee river restoration in Florida and Chinese Sloping Land Conversion Program are among the successful projects. Most of the restoration efforts are done in developed countries (Europe and North America), but developing countries are the most severely degraded are in need of restoration still. There are different challenges while restoration implementation such as cost and time constraint, severe level of degradation, social restriction, trade-off issues, limited information and knowledge and lack of standards and funding constraint. These challenges limit the application of restoration widely. These challenges could be also minimized through integrated ecological restoration approach.

Principally, to address Integrated ecological approach, the following conceptual basis is very vital such as restoration practice on the basis of scientific fact; consider the connection of the restoration project with the surrounding matrix; design and manage in flexible manner to tackle any uncertainty; ecological multidisciplinary approach and active community engagement to sustain the restoration practice by providing human health, keep cultural value and economic returns through different incentives such as income generation through different production, at large incentives from PES (CDM, REDD+), biological corridor, in addition, political support through different policy setting also very important to acknowledge the importance of ecological restoration and work to achieve that.

## IV. Recommendations

Based on the reviewed paper, the following suggestion are forwarded;

- To tackle current rapid environmental change, integrated ecological restoration should be a priority option.
- Since integrated ecological restoration become widely known as a precondition for sustainability; Therefore, research as well as restoration practice should consider it,
- There are few good examples of ecological restoration, therefore, these efforts should be Adopt to other areas with improvement through Integrated Ecological Restoration.

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# Determinant of Biogas Technology Adoption and its Implication on Environmental Sustainablity: A Case of Aletawondo Woreda, Sidama Zone, South Ethiopia

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*Abstract-* The study aims to assessing the role of biogas technology in saving biomass, mitigating green-house gases (GHG) emissions, and maintaining environmental sustainability in Aleta wondo woreda. The sample size, 196 households were selected and interviewed in systematic random sampling techniques. Data was analyzed using descriptive statistics and binary logit with the aid of STATA. Adoption of biogas technology significantly determined by proximity to water, access to credit, cattle size, availability of trained mason, land size and annual income. On average 1066.80kg biomass and 25.2 liter kerosene reduced; 2160.93kg $CO_2$equivalent GHG emissions to the atmosphere mitigated annually per adopter households in the study area.

*Keywords: biogas, biomass, health, GHG, environment.*

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Gosaye Shegenu [α] & Abrham Seyoum [σ]

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## I. Introduction

Biomass energy in the form of firewood, charcoal and crop residues plays a vital role in the basic welfare and economic activities in many Sub Saharan Africa (SSA) households, where they meet more than 90% of household energy needs (EIA, 2010; KIPPRA 2010). According to the US department of energy, about 75% of total wood harvested in SSA is used for cooking. In developing countries, over 500 million households still use traditional biomass for cooking and heating (UNEP, 2009).

In Ethiopia, biomass accounts for 92% of the total national energy consumption in 2010. Petroleum fuels and electricity met merely 7.6% and 1.1% of the national energy consumption, respectively. The household sector accounts for 89% of total final energy consumption (74% by rural and 15% by urban households). The growing population requires more fuel wood and more agricultural production which increase needs for new farmland, which accelerates deforestation and forest degradation. It is estimated that unless action is taken to change the traditional development path, an area of 9 million ha might be deforested between 2010 and 2030. Over the same period, annual fuel wood consumption will rise by 65% with large effects on forest degradation (World Bank, 2012 and Government of Ethiopia, 2012). The current forest cover of Ethiopia became increasing to 12.4% (World Bank, 2012).

Biogas technology is an integrated waste management system that is a clean, renewable, naturally produced and underutilized source of energy. Methane is produced through an anaerobic biological process of conversion, using any available organic material which is used for cooking, lighting and organic fertilizer. It is reviewed as a promising sustainable solution for farm households because it can help to solve major environmental problems such as soil degradation, deforestation, desertification, CO2 emission, indoor air pollution, and reduce GHG emission by replacing firewood and agricultural residue fuels, Karthik Rajendran; 2012. Socioeconomic factors such as household income, fuel wood and kerosene cost, land ownership, livestock practice, and land size have a significant effect on the adoption of biogas technologies (Walekhwa et al, 2009).

Substitution of traditional fuels by biogas is expected to result in generally positive impacts on household health due to reduced exposure to smoke and improved management of waste, Mekonnen Lulie, 2009). Given the inter-related challenges of environmental deterioration and energy demand, climate change, indoor air pollution and human health, accelerated and large-scale dissemination of biogas technology is therefore now necessary more than ever before. The key energy challenges facing the study area and the region is how to affordably produce high quality cooking gas and also how to widely disseminate biogas energy technologies.

### *a) Statement of the Problem*

Replacing firewood with biogas would have a positive effect on deforestation, which would improve the local environments, ecosystems, problems with erosion and mitigate GHG, Bajgain, Shakya, 2005. Management of animal dung and human excreta also prevents methane gas emission. When dung is naturally digested methane gas is produced and released in to the atmosphere. If instead these substrates are digested in a biogas plant the methane gas is collected and thus

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avoiding release in to the atmosphere. Some researchers such as Muriuki; 2014, Zerihun; 2014, Bekele; 2011 and Anushiya; 2010 have analyzed the role of biogas energy for environmental protection, climate change mitigation and poverty alleviation, especially in rural areas where agriculture is the main source of income.

Biogas as an alternative to the use of biomass for energy was introduced in Ethiopia since 1979. Households directly benefit from domestic biogas; reduced use of fuel wood, improved living conditions and improved soil fertility through the use of bio-slurry. Additionally biogas contributes to the reduction of greenhouse gases and to job creation (PID, 2008). As an effort to counteract environmental, indoor air pollution and social problems arising from wood fuel combustion and use, and waste management, numerous efforts by several development organizations in Ethiopia through the Ministries of water & energy and Environmental protection, to introduce and disseminate biogas technology in the area, to provide affordable, clean and sustainable domestic biogas to the residents is very low (NBPE, 2013). According to report by National Biogas Programme Ethiopia, 2013; the dissemination of biogas technology to rural household was 8608 domstic biogas at national level and only 250 in the study area. Eventhough these efforts, it is not clear why some households in the study area adopt the technology while many others do not adopt. It is also not examined how biomass energy use affects the quality of environment in general, indoor air pollution in particular and how biogas technology as alterative use of energy and contributes for environmental sustainability.

Therefore, the purpose of this study was to identify factors which influence adoption of biogas technology in typical households, the role of biogas use on mitigating green house gass emissions, and assess the effect of biogas energy on environmental sustainability in the study area.

*b) Research Objectives*

The general objective of this study is investigating the determining factors that influence the adoption of biogas technology and its implication on environmental sustainability by households in the study area.

The specific objectives are:

1. To estimate biomass (fire wood & crop residue) saved and forest conserved by use of biogas energy by farm households.
2. To analyze the role of biogas for greenhouse gas emission reduction in the study area.
3. To investigate the determinants for biogas technology adoption by farm households.

## II. Methodology of the Study

*a) Description of the Study Area*

The study was carried out in Aleta – wondo woreda which is located in the South Eastern part of South Nation Nationality and People's Regional state at 64km and 337 km from regional capital city, Hawassa and Ethiopia capital city, Addis Ababa respectively. Aleta-wondo wereda has a total area of 27,823 hectare which is divided in to 28 administrative kebeles.

The total population of the Wereda is 188,932 of which male 96624 and female 92208. The average household size is 5.6 persons including heads of household which is larger than the corresponding figures in official statistics for rural HHs in the country (4.9 persons) and SNNPR (4.9 persons). Hence, the total number of households is 33,738 of which 2,815 (8.3%) are female headed and the occupational status 96% of the population lives by farming (CSA, 2007). The altitude of the Wereda ranges between 1,750 to 2,600m and its temperature lies between 10°c to 23°c and the average annual rain fall is 1,400 mm. The Woreda covered with forest is estimated to be 1, 170.85 hectare (4.2%). The Wereda's total cattle population is 99,082, and there are 9,409 goats, 18,361 sheep and 69,761 local and 1,576 improved breed poultry and there are also 14,789 bee hives (A/Wondo Woreda Baseline Survey Report, 2011). Regarding the energy supply, the Wereda's population mainly depends on biomass source of energy utilization. The main type of biomass fuel in the Wereda is fuel wood followed by crop residue and charcoal (Woreda Energy Baseline Survey Report, 2011). There is biogas program in 13 kebeles from the total of 28 kebeles. Around 250 domestic biogas technologies were introduced and disseminated to farm households since 2010, WWMEO annual report, (2014).

*b) Sources of Data*

Sources of data for the study were generated through both primary and secondary sources. As the primary sources, information was collected from four categories of sources; household interview schedule, key informant interview, focused group discussion and field observation. Secondary data were gathered from documents, reports, journals, proceedings, bulletins, internet, periodicals, various books and other relevant materials.

*c) Sample Size and Sampling Procedures*

The sample size was determined by using Arkin and Colton's formula (1963) at 95% level of confidence and 5% level of significance and level of precision is 7% (0.07) which is given by:- n= N z2 P (1-P)/ ((N) d2 +Z2) P (1-P): Where, n= Sample size, Z= the value of standard variant (at 95% of confidence level), Z= 1.96, P= estimated population proportion (0.5), d= standard error or level of precision (0.07). The 196 sample households were selected through multi stage sampling



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techniques, which is commonly used probability sampling technique in a situation where the ultimate unit of selection requires certain series of stages in this study. Five kebeles from 13 biogas program implementing kebeles of Aletawondo were selected, which had enabled the researcher to collect the data related to biogas users and non-users experiences.

*d) Method of Data Collection*

Both primary and secondary data were instrumental in informing this study. Primary data was collected through observation, structured personal interviews with household heads and key informants, and focus group discussions. Household's survey interview questionnaire consisted of both open and closed ended questions, which were employed to collect primary data their existing situation of biogas technology adoption and utilization as well as biomass consumption. The primary data collection included socio-economic and demographic characteristics of households (age, gender and education of household head, household size, proximity to water, access to credit, proximity to cement, sand and stone market), and detailed biomass use; fire wood and crop residue consumption patterns and biogas technology benefits. Prior to data collection, four data collectors were recruited and hired who have minimum of Bachelor Degree and are able to understand English and speak local language.

*e) Data Presentation and Analysis*

i. *Descriptive Statistics*

Descriptive such as frequencies, mean, standard deviations and cross tabulations were used to display the data before detailed analysis with the use of SPSS. Tests of significance, specifically t-tests and chi-square (X2) were used. The pvalues were instrumental in informing the results of this study and the significance difference was set at $p<0.05$. SPSS, STATA and Excel computer software were used to analyze objectives one and two. These were made and guided through some accepted conversion factor for the execution of the data analysis in this research.

ii. *Econometric Model*

The most commonly used econometric models in adoption studies are the limited dependent variable models such as logit and probit (Bekele and Drake, 2003) and both are well established approaches in studies on technology adoption (Burton et al., 1999). The choice of whether to use a probit or logit model, both widely used in economics, is a matter of computational convenience (Greene, 1997). Logistic regression has been used when the dependent variable is a dichotomy and the independent variables are of any type and it applies maximum likelihood estimation after transforming the dependent into a logit variable, Garson, 2008.

The conventional model, LPM, though having citable advantages, has meaningful limitations, such as generation of predicted values outside the 0-1 intervals (which violets the basic principles of probability), the heteroscedastic nature of the variance of the disturbance term, and the non-reasonability of assumption of normality in the disturbance term (Greene, 1991).

With such drawbacks of LPM, a non-linear probability models (logit and probit), are suggested to satisfy the limitations of the former (Amemiya, 1981 and Maddala, 1983). However, the choice of logit model over the probit is that the former is easy and extremely flexible to manipulate, leads to meaningful interpretation (Hosmer and Lemeshow, 1989), and simpler in estimation than the probit model (Pindyck and Rubinfeld, 1981). That is to say, the conditional probability p approaches zero or one at a slower rate in logit than in probit.

As a result, a binary logistic regression model was used to analyze farm households' biogas technology adoption in the study area. Thus, to achieve specific objective three in this study, logistic model were used to investigate the factors which influences biogas adoption and utilization. The variables often considered in biogas energy adoption decision include age, educational status, income level, household size, gender of the household head, size of land owned by the household and the cost of alternative fuels (Somda et al., 2002).

Following Gujarati (2003), the logistic distribution function for the biogas adoption decision by household can be specified as: $P_i = \frac{1}{1+e^{-z(i)}}$, where $Z_i = \beta_o + \sum \beta i X_i + \varepsilon_i$.

iii. *Definition of Variables and Expected Hypotheses*

*Biogas Adopter Households (HHADOPT):* household decision for biogas adoption is dependent variable in binary logit model and it is a dichotomous nature that takes a value of 1 if the household adopter; and 0, otherwise. It is to identify the potential explanatory variables and to formulate hypotheses regarding their possible effects on the dependent variable.

*Table 3.1:* Explanatory variables and expected hypothesis

| Variable | Description | Variable type | Value | Expected sign |
|---|---|---|---|---|
| Hhage | Age of household | Discrete | Measured in years | (+/-) |
| Hhgender | Gender of household | Dummy | 1 = male, 0 = female | (+/-) |
| Famsize | Family size of household | Discrete | Measured in number of household members | (+) |



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| | | | | |
|---|---|---|---|---|
| Hheduca | Education of household | Discrete | Measured in year of schooling | (+) |
| Landsize | Land size of household | Continuous | Measured in hectare | (+) |
| Catlsize | Cattle size of household | Continuous | Measured in number | (+) |
| HHINCOME Monthly Income Of Household Continuous | Measured in ETB | HHINCOME Monthly income of household Continuous | Measured in ETB | (+) |
| Credaces | Access to credit | Dummy | 1= accessible, 0 = not-accessible | (+) |
| Watacces | Proximity to water | Continuous | Measured in kilometer | (-) |
| Masnavai | Availability of trained mason | Dummy | 1 = available, 0 = not-available | (+) |
| Sanacces | Proximity to sand market | Continuous | Measured in kilometer | (-) |
| Stonaces | Proximity to stone market | Continuous | Measured in kilometer | (-) |
| Cemacces Proximity To Cementmarket Continuous | Measured in kilometer | CEMACCES Proximity to cement market Continuous | Measured in kilometer | (-) |

*Source: Own survey data, 2016*

iv. *Model Specification Tests*

*Likelihood Ratio Test:* A likelihood ratio test was a statistical test used to compare the goodness of fit of two models (the null model and the alternative model). Hence, prior to running a binary logistic model, the model adequacy were tested and checked by likelihood ratio test.

*Goodness – of – Fit Test:* The goodness-of-fit of the logit model was measured by the McFadden (2002) with likelihood ratio statistics as the basis of inference with a chosen significance at 10%, 5% and 1% probability level. The adequacy of binary logistic model was examined by goodness-of- fit test for the purpose of whether the fitted model adequately describes the observed outcome of biogas adoption in the data through Hosmer–Lemeshow goodness-of-fit test.

*Multicollinearity Tests:* Pair wise correlations were computed from survey data to check the existence of high degree of association problem among dummy independent variables. A value of 0.75 or more indicates stronger relationship b/n dummy independent variables (Maddala, 1992). The decision rule for pair wise correlation coefficients says that when its value approaches 1, there is a problem of association between independent dummy variables.

Variance Inflation Factor (VIF) was also checked for continuous variables using STATA 12.0. According to Maddala (1992), VIF can be defined as: VIF (xi) = , the larger the value of VIF, the more will be the collinear of variable xi. The rule of thumb is that if VIF for each variable in the model (VIF) is ☐10, there is a problem with multicollinearity, and therefore adjustment methods need to be applied.

## III. Results and Discussions

a) *Econometric Model Results*

Model Specification and Test Results; goodness-of-fit tests, none of them show a significant difference – the regression model was adequate. The results of goodness-of-fit test shows that the model was significantly adequate to fit the observed data at X2 = 4.81, p = 0.78. The model with more variables fits significantly better and the result for nested model -1 in model-2 were found significantly adequate at X2= 34.42, p = 0.0000. The VIF values were less than 10 and it shows that all the continuous independent variables have no multi co linearity problem. In pair-wise correlation test there is no a problem of high degree of association among independent dummy variables.

b) *Factors Influencing Biogas Technology Adoption in the study area*

In informing and interpreting, econometric model result, marginal effect was instrumental and employed for this study.

Cattle size, access for credit, land size, availability of trained mason, annual income, proximity to water point, proximity to sand and stone market and gender of household head were found factors influencing biogas technology adoption decision in the study area.

The study result shows that households' home distance to water point was statistically significant and negatively affects biogas adoption at 1% significance level. Cattle size, access for credit and availability of trained mason variables were statistically significant and positively influences adoption decision at 5% significance level. Besides, land size and annual income were statistically significant and positively affects adoption decision at 10% significance level. And household's home distance to sand & stone market and gender of household head were significantly affects to adopt biogas technology at 10% significance level in the study area.



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*Table 3.2:* Logistic regression estimates factors affecting households' biogas adoption decision

| Variables | B | S.E. | M.E |
|---|---|---|---|
| CATLSIZE | 0.954 | (0.392)** | 0.1492938 |
| CEMACCES | 0.011 | 0.177 | 0.0017677 |
| CREDACES | 3.353 | (1.329)** | 0.3754223 |
| FAMSIZE | 0.327 | 0.670 | 0.0511745 |
| HHAGE | -0.153 | 0.110 | -0.0240017 |
| HHEDUCA | 0.054 | 0.197 | 0.0084202 |
| HHGENDER | -1.221 | (0.707)* | -0.2309339 |
| HHINCOME | 0.0003 | (0.0002)* | 0.0000503 |
| LANDSIZE | 2.170 | (1.254)* | 0.3395644 |
| MASNAVAI | 5.916 | (2.293)** | 0.6406308 |
| SANACCES | -0.073 | (0.043)* | -0.0114235 |
| STONACES | -0.335 | (0.197)* | -0.0523826 |
| WATACCES | -4.005 | (0.892)*** | -0.6266359 |
| _CONS | -3.408 | 3.875 | |
| Number of observations = 196 | | Wald Chi$^2$ (13) = 56.18 | |
| Log likelihood function = 26.186761 | | Prob. >-chi$^2$ = 0.0000 | |
| M.E: Marginal Effect | | Pseudo R$^2$ = 0.8072 | |
| ***, ** and * indicates Significance levels at 1%, 5% and 10% respectively. | | | |

*Source: Own Survey data, 2016*

*c) Biogas Technology Implications in the Study Area*

i. *Benefits of Biogas for Replacing Fuel wood, Crop residue and Kerosene*

In Aleta-wondo woreda, non-adopter households consumes on average 2058kg biomass (fire wood and crop residue) annually but for adopter households is 991.20kg per household. There was a considerable saving adopter over non-adopter households by 1066.80kg (51.8%) of biomass (fire wood and crop residue) per year per household. Concerning kerosene, per non-adopter households consumed on average 25.68 liter of kerosene annually and the average annual kerosene consumption for adopter households is 0.48 liter per household. There is a considerable saving of 25.2 liter (98.1%) of kerosene per year per household in the study area.

In monetary value biomass costs 1955 ETB by non-adopter and 941 ETB by adopter, and kerosene 341 ETB by non adopter and 6 ETB by adopter per household per year. A considerable saving of moneny from biomass and kerosene is about ETB 1249 by adopter per household per year in the study area.

ii. *Biomass and Kerosene Consumption Vs GHG Emission*

In Aletawondo woreda, average annual GHG emissions by adopter households are 1929.86kg, 1.17kg and 15.06kg CO2equivalent of biomass, kerosene and biogas respectively; whereas the average annual GHG emission by non-adopter households are 4006.92kg, 62.6kg and 37.5 kg CO2equivalent from biomass, kerosene and raw manure respectively. In aggregate the average annual green house gas emission by adopter households is 1946.09kg, whereas by non-adopter is 4107.02kg CO2eqv. There was a considerable reduction of GHG emission by 2160.93kg CO2equivalent (52.6%) of GHG emission per year per household.

iii. *Benefits of Biogas for Manure Management*

In the study area the production of manure and utilization are properly managed through biogas plants by adopter households. On average 11.55 tons of dung were produced and utilized for biogas per year per adopter households; and on average 7.09 tons of dung was produced by non-adopter households and 2.13 tons, 2.84 tons and 2.13 tons are utilizing for composting, directly apply on farm and leave on field respectively.

iv. *Benefits of Biogas for Chemical Fertilizer Substitution*

Bio-slurry is a good organic fertilizer that can replace or reduce the application of chemical fertilizer. Adopter households were utilized 47.19kg DAP and 47.19kg Urea before biogas installation and 14.69kg DAP and 14.69kg Urea after biogas installation; non-adopter households were utilized 47.77kg DAP and 47.77kg Urea (Table 4.18). This result shows, a considerable savings and substitutes chemical fertilizer



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is 32.5kg (68.9%) DAP & Urea due to installation of biogas technology.

v. *Biogas Benefits Analysis, Health and Sanitation*

Of the interviewed respondents, with statistics distributions 23.5%, 18.4%, 83.7%, 84.7%, 82.7% for adopter households and 67.3%, 61.2%, 16.3%, 25.5%, 19.4% for non-adopter households gives answers as cough & itchy eye problem, headache problem, smoke free, had clean kitchen, reduces burning respectively.

vi. *Implication of Biogas on Environmental Sustainability*

*Substitution for Biomass and Kerosene Fuels:* when biomass is obtained from renewable sources (fire wood, dungcakes) the produced carbon-dioxide is assumed to be absorbed by the vegetation from which they originate. Thus, in the study area, each biogas adopter household had saves and can replaces 1066.80kg biomass (fire wood and crop residue) and 25.2 liter kerosene annually due to installation of biogas.

*GHG Emission Reduction:* The average annual GHG emissions are 1929.86kg, 1.17kg and 15.06kg CO2 equivalent biomass, kerosene and biogas consumption for adopter households respectively and the average annual GHG emission are 4006.92kg, 62.6kg and 37.5kg CO2equivalent from biomass, kerosene and raw manure for non-adopter households respectively. There is a considerable reduction of GHG emission by 2160.93kg CO2 equivalent (52.6%) per year per household.

*Health and sanitation:* The change in sanitation and cleanliness had been a matter of great satisfaction brought about by biogas and biogas induced way of toilet construction. On the other hand, health problems, such as, cough & itchy eye problem, headache problem, smoke free, clean kitchen and reduced burning when cooking and lighting are the major benefits of biogas technology gained by adopter households in the study area.

*Manure Management:* The problem of manure exposing on fields were alleviated by installation and utilization of biogas technology. Thus, adopter households were best actors for manure management, and contributing for environmental sustainability.

*Bio-slurry utilization:* Adopter households are utilized 47.19kg DAP and 47.19kg Urea before biogas installation and 14.69kg DAP and 14.69kg Urea after biogas installation. The substitution effect of bio-slurry for chemical fertilizer results in high contribution for maintaining of soil micro-nutrients and soil structure and thereby keep healthy and sustainable environment in the study area.

*Forest Conservation:* The reduction in fuel wood consumption saves the forest resources and ultimately the bio-diversity becomes conserved. In the study area, each biogas plant saves 1.067 tones fire wood annually per year. The saving of trees from the saved fire wood could directly be attributed to biogas installation. The ongoing installation of biogas technology was the best measures for alleviating the problems, and the study result shows biogas technology can replacing fuel wood and fossil fuel and thus, much contributing for environmental sustainability.

## IV. Conclusion

The purpose of this study therefore is to identify the factors that influence adoption of biogas technology and its implication on the household's health and environmental sustainability in the study area.

The sample size was determined statistically giving equal chance for adopter and non-adopter households and a total 196 sample households were selected through multi stage sampling techniques. Data was collected and analyzed using descriptive statistics with the aid of SPSS_20 and econometrics model; binary logistic regression was employed with the aid of STATA -12. Prior to running binary logit model for the estimation of explanatory variable coefficients and related parameters, goodness of fit, likelihood ratio and multicollinearity problem were tested and checked whether or not the model adequate for the survey data. Most of households highly depends on biomass source of energy and then environmental degradation has becomes a cross cutting issue that could be mitigated. The study result shows that the probability of a household adopting biogas technology increases with proximity to water or proximity to water sources, access to credit, cattle size of the household, availability of trained mason, land size, annual income, gender, and proximity to sand and stone market.

The empirical findings shows that; the average annual per capita biomass (fire wood and crop residue) and kerosene consumptions are 2058kg and 25.68 liter by non adopter and 991.20kg and 0.48 liter by adopter households respectively.

From this there was a considerable savings of 1066.80kg (51.8%) and 25.2 liter (98.1%) biomass (fire wood and crop residue) and kerosene respectively per year per household per biogas plant. In monetary value a considerable saving of moneny from biomass and kerosene is about ETB 1249 by adopter per household per year. The annual average GHG emissions are 4107.02kg CO2equivalent from non-adopter households and 1946.09kg CO2equivalent from adopter households and it has a considerable emission reduction is 2160.93kg CO2equivalent (52.6%) of GHG emission per year per household in the study area.

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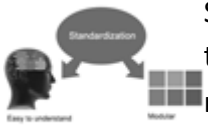


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It is mandatory to read all terms and conditions carefully.

# AUXILIARY MEMBERSHIPS

## Institutional Fellow of Open Association of Research Society (USA) - OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).



The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

*The Institute will be entitled to following benefits:*

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.





The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.




The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.




After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

**The following entitlements are applicable to individual Fellows:**




Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.



Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

**Other:**

**The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:**

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

**Note :**

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

# 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.

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**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**

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## 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 Social Science Research Paper

Techniques for writing a good quality homan social science 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 homan social science 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.



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***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.
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.

***19. 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.

***20. 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.

***21. 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.

***22. 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.

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## 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.



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*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:**

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- 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.



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**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.

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| ***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 |

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