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

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# Assessment of Urban Heat Island (UHI) using Remote Sensing and GIS

By Aneeqa Azeem, Muhammad A Butt , Khadija Nisar & Huma Anwar
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*Abstract-* This study assesses the Urban Heat Island (UHI) effect and evaluates the impact of urban/suburban areas in Lahore District on its land surface temperature using Remote Sensing and GIS techniques. The satellite brightness temperature information derived from the medium resolution satellite LANDSAT 5 (Thematic Mapper) is analyzed and compared with the land use/land cover types acquired by classifying the image. The results reveal that urban heat island in Lahore District is significant, with average Land surface temperature values ranging from 23°C to 44°C, and maximum urban/non-urban temperature difference reaching 5°C. The high built-up area exhibits the maximum surface temperature ranges from 31 to 44°C compared to other land use types. The relationship between thermal behavior and NDVI is also analyzed and negative correlation is identified by the results from the extracted surface temperature and NDVI from Landsat. This suggests that vegetation is the primary determinant controlling the spatial distribution of land surface heat. An effort to compare the population density and air pollution parameters with surface temperature is also made and the air pollution concentration is considered in relation with urban areas of high temperature and high population density.

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# Assessment of Urban Heat Island (UHI) using Remote Sensing and GIS

Aneeqa Azeem [α], Muhammad A Butt [σ], Khadija Nisar [ρ] & Huma Anwar [ω]

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## I. Background

Approximately 2% of the Earth's land surface is covered by urban regions, contains about half of the human population (UNDP, 2001). The increased urbanization trend has various environmental impacts and it seems to be never ending with a continuous and rapid increase throughout the last century and still projected to increase even faster. Developing and improving urban infrastructure is important for human welfare but it has somehow hindered the natural eco-system especially within the urban areas.

More and more people move from rural to urban areas in order to provide themselves with better opportunities for progress. This rural urban migration is inevitable and has implications on economic growth and development. But as population influx in the urban areas increases, it puts a burden on the localized urban environment and somehow this development is accompanied by environmental deterioration.

Consistent development of urban areas results in the formation of more and more impervious surfaces which has been considered as a predominant driving force towards the alteration of the natural eco-system (Zhou et al., 2004). These unreceptive surfaces seal soil surface that results in elimination of rain water penetration (infiltration) and ground water recharge. This enhances ground water runoff which ultimately plays a part in natural catastrophes like floods. When this heat is released, it increases temperature thus increasing energy consumption within urban areas to modify the environment.

Quality of urban life and energy cost are mainly affected by Urban Heat Island. With each degree temperature the power used for air conditioning is enhanced. The level of atmospheric temperature elevates due to the subsequent increased use of electricity for cooling. The earth's rising temperature are the hot issues today in the world. Since the industrial revolution the temperature of the planet has been increased. Today the main cause of $CO^2$ level rise is due to increased energy use. (Irfanet al, 2001).

The knowledge of urban heat island is important for a range of issues and themes in earth sciences and also in planning and management practices as the impact of urbanization is huge and affects the natural ecology.

## II. Objectives

The research analyses and verifies the spatial pattern of surface temperature with urban spatial information related with landuse/cover and NDVI using remotely sensed data and GIS.

The main objectives of the research are listed below:

- To estimate the urban heat Island Effect using remote sensing data.
- To analyze the relationship between LST and Vegetation Density in urban area.
- Evaluate the connection between LST and other urbanization parameters. (Population Density, Air Pollution, etc)

## III. Study Area

*Lahore District* is the Capital of Punjab province and is the second largest city of Pakistan. It is located within the geographic extents of 31°34' North latitude and 74°22' East longitude at the left bank of river Ravi, one of the five rivers of the Punjab province. The dimensions of the area are 31°15 and 31°45 latitude and

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74°01' and 74°39' longitude. Figure 1 highlights the study area location in Pakistan.

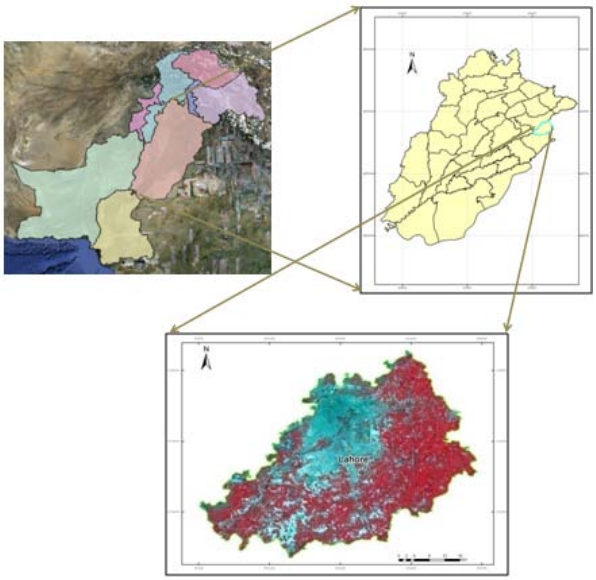

*Figure 1 :* Study area

## IV. Material and Methods

The adopted methodology for this research was dependent on the needs and demands of the researcher to achieve research objectives and does not follow any particular school of thought. However it consisted of the following steps:

- Data collection
- Data processing
- Data analysis

*a) Datasets Used*

The data collected for study was obtained from different sources. The boundary of the study area was obtained from The Urban Unit on request. The respective city boundary was then overlapped with the obtained satellite imagery to identify the study areas.

In general the data used for analysis comprises the following combined Satellite images and secondary data:

- Landsat 5 (Thematic Mapper) Image
- Population Density data
- Air Pollution data

i. *LANDSAT Thematic Mapper*

Landsat TM images dated June, 14, 2011 were acquired from the Earth Explorer to locate and analyze the Spatial distribution pattern of LULC types (classes and LST (Land Surface Temperature). For this purpose, the image was given a geographical reference by rectifying it to Universal Transverse Mercator (UTM) WGS84. Later on, the image was resampled to its spatial resolution with the help of the algorithm of nearest neighborhood.

The TM data is captured in seven spectral bands simultaneously. Band 6 is thermal band that senses infrared radiation. (NASA 2011)

Technical detail of the TM sensor is as follows:

- Spatial Resolution: 30m (120m - Thermal)
- Spectral Resolution: (0.45 – 12.5) $\mu$m
- Temporal Resolution: 16 days
- No. of Bands: 7
- Image Size: 185Km X 172Km
- Swath Width: 185 Km
- IFOV: 30m$^2$ & 120 m$^2$band 6

The TM band list is given in Table 1.

*Table 1 :* TM Bands List

| Wavelength Region | Band Number | Wavelength ($\mu$m) | Resolution |
|---|---|---|---|
| Visible | 1 | 0.45-0.515 | 30 m |
| | 2 | 0.525-0.605 | 30 m |
| | 3 | 0.63-0.69 | 30 m |
| NIR | 4 | 0.75-0.90 | 30 m |
| SWIR | 5 | 1.55-1.75 | 30 m |
| | 6 | 10.4-12.5 | 120 m |
| TIR | 7 | 2.09-2.35 | 30 m |
| Pan | 8 | 0.52-0.9 | 15 m |

*Source: NASA 2011*

Band 6 of TM is basically analyzed and examined for extracting the surface temperature, whereas all other bands helped in classification of landcover for Lahore.

The individuals images/bands are stacked using Erdas Imagine software and then clipped based on the area of interest. (Figure 2).

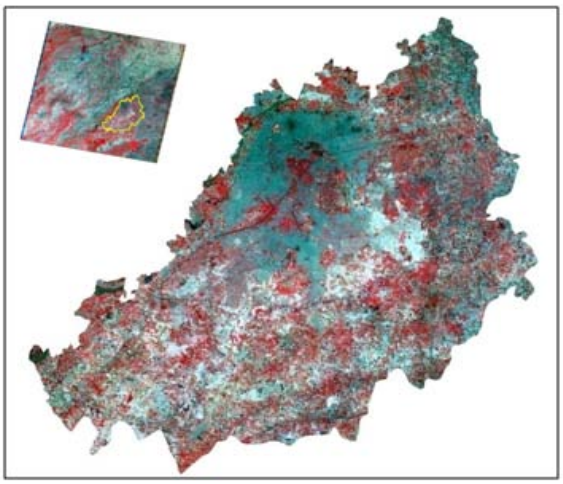

*Figure 2 :* Clipped Image of Lahore with Band Combination (4,3,2)

*b) Land Surface Temperature Estimation*

An algorithm adopted from (Saleh S, 2002 & Zhao-ming et al) has been used to retrieve LST. The flow chart (Figure 3) below shows the major steps of algorithm for obtaining LST and the calculated land surface temperature of Lahore, using band 6 of Landsat has been shown in Figure 4.

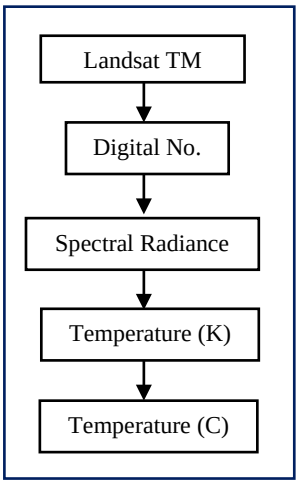


*Figure 3 :* Major steps obtaining LST

i. *Conversion of the Digital Number (DN) to Spectral Radiance (L)*

LANDSAT 5(TM) data are acquired as the 8-bit grey scale imagery in Level 1G product. The equation and constants (see in Table 2 below) for converting the 8 bits digital number of the image data into the spectral radiance is as follows:

$$L = L_{MIN} + (L_{MAX}-L_{MIN}) * DN/255$$

Where

L = Satellite Spectral radiance

$L_{MIN}$= 1.238 (Spectral radiance of DN value 1)

$L_{MAX}$= 15.600 (Spectral radiance of DN value 255)

DN= Digital Number

Group scaling parameters' which shows what the upper/lower bounds for radiance are in each band. $L_{MIN}$ and $L_{MAX}$ values for each thermal scene can find in the satellite header file.

*Table 2 :* TM Spectral Radiance

| TM Spectral Radiance Range in ($Wm^{-2}sr^{-1}\mu m^{-1}$) | | |
|---|---|---|
| Band Number | Lmin | Lmax |
| Band 1 | -1.52 | 193.0 |
| Band 2 | -2.84 | 365.0 |
| Band 3 | -1.17 | 264.0 |
| Band 4 | -1.51 | 221.0 |
| Band 5 | -0.37 | 30.2 |
| Band 6 | 1.238 | 15.303 |
| Band 7 | -0.15 | 16.5 |

ii. *Conversion of Spectral Radiance to Temperature in Kelvin*

The radiance is converted to the temperature in Kelvin using following formula:

$$T_B = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda}+1\right)}$$

Where

$K_1$= Calibration constant 1 (607.76) for TM

$K_2$= Calibration constant 2 (1260.56)

$T_B$= Surface Temperature

$L_\lambda$ = Spectral Radiance in $Wm^{-2}sr^{-1}\mu m^{-1}$

| | *TM* | *ETM+* |
|---|---|---|
| $K_1$ | 607.76 | 666.09 |
| $K_2$ | 1260.56 | 1282.71 |

For Landsat-5 TM,

$K_2$ = 1260.56, and $K_1$ = 607.76mW cm_ 2 sr_ 1 Am_ 1.

Landsat TM Spectral Radiance $L_{MIN}$ and $L_{MAX}$ offset gains range for band 6 is:

| Band | Lmin | Lmax |
|---|---|---|
| 6 | 1.238 | 15.303 |

iii. *Conversion of Kelvin to Celsius*

$T_B = T_B$-273

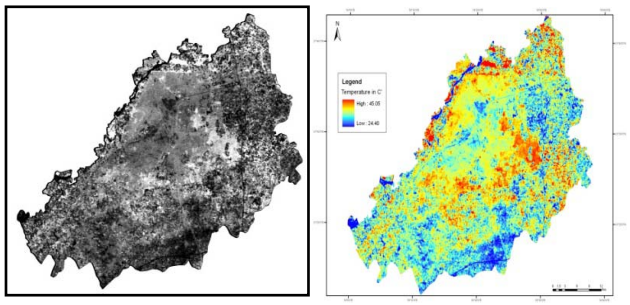

*Figure 4 :* Surface Temperature Images

*c) Normalized Difference Vegetation Index (NDVI)*

The derivation of Normalized Difference Vegetation Index (NDVI) is a standard procedure and has already been enlightened in the literature. The study adopted this standard mathematical formula for NDVI as below:

$$\frac{R_{NIR}- R_{RED}}{R_{NIR}+R_{RED}}$$

where

$R_{NIR}$ = Reflectance in near infrared band

$R_{RED}$ = Reflectance in red band

The 5 shows the NDVI images retrieved using above formula.

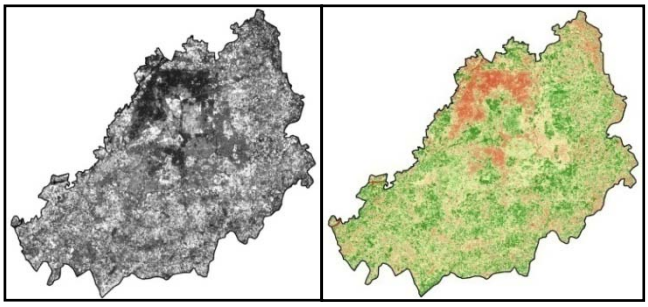

*Figure 5 :* NDVI Images

*d) Definition of Urban and Non Urban Spaces*

In order to understand the relationship between temperature and typical land cover types, correlation was performed between temperature and NDVI images on a pixel to pixel basis. Supervised image classification was also performed to get landuse categorizations.

## V. Results and Conclusions

In case of Lahore, after examining the temperature distribution maps, it was found that maximum temperature values mostly existed with in the central part of the urban area also called the old city typically characterized by densely built-up commercial areas with deep street canyons.

The urban and suburban areas have experienced maximum temperatures ranging between within 30°C and 44°C. In addition due to the building geometry, wind circulation in urban areas is limited. So a human body experiences discomfort and requires air cooling with these temperatures. More heat is released and temperatures increase further because more air conditioners are used for cooling purpose. On the contrary, the LSTs are usually lower in suburban and rural areas where there is agricultural land.

*a) Analysis of Land use/ Land cover*

The land use classified image of Landsat-5 TM is shown in Figure 6. The image is classified using Maximum likelihood classification that used the nearest neighbor algorithm to resample the pixels in order to make different classes. The classification helped to study the relationship between land cover change and temperature. The accuracy of the classification images was gauged by comparison against the actual LST and NDVI images and it was clear that higher temperature values corresponded to more developed areas while lower values exhibited the rural areas.

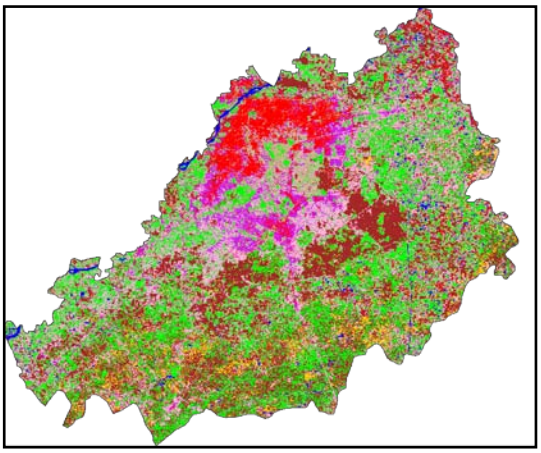

*Figure 6 :* Land use Classification of Lahore

*Table 3 :* Supervised land use Classification statistics

| Class No. | Class Name | No. of Pixels | Percentage (%) |
|---|---|---|---|
| 1 | Vegetation | 963102 | 48.03 |
| 2 | Built-up High | 155560 | 7.75 |
| 3 | Built-up Medium | 55822 | 4.78 |
| 4 | Built-up Low | 181778 | 9.06 |
| 5 | Bare Soil | 256811 | 12.80 |
| 6 | Water | 14179 | 0.70 |
| 7 | Sand | 377704 | 18.83 |

*b) Analysis of Surface Temperature*

NASA model is used to estimated the surface temperature.

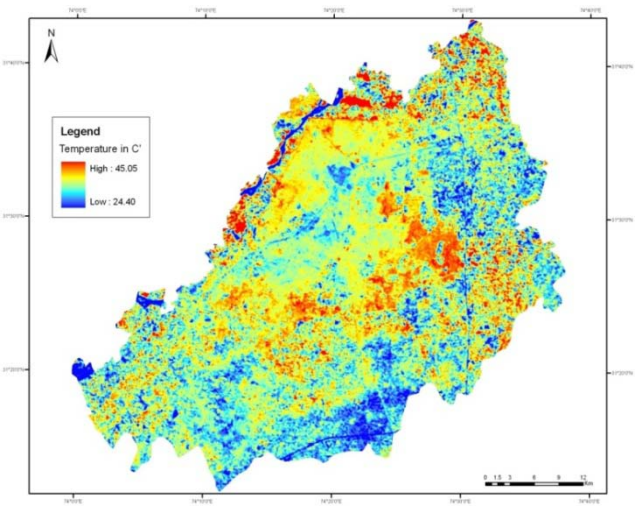


*Figure 7 :* Spatial Distribution of Temperature in Lahore

The estimated surface temperature ranges (figure 7) from 23.16 to 43.58°C (mean temp. 33.37°C). It is observed that the upper left part shows maximum surface temperature range that corresponds to high built-up areas (30.73 to 43.58°C). Whereas the low

dense built-up ranges from 29.91 to 38.11°C. Water bodies exhibit minimum surface temperature compared to other land use/land cover features (23.16 to 33.32°C). Table 4 shows the surface temperature statistics, followed by vegetation (27.30 to 37.21°C). Hence Water bodies and sparse vegetation is cooler as compared to other land use/land cover features.

*Table 4 :* Temperature statistics per land cover/ land use classes

| Class No. | Class Name | Temperature | | |
|---|---|---|---|---|
| | | Mean | Min | Max |
| 1 | Vegetation | 32.00 | 27.30 | 37.21 |
| 2 | Water | 28.08 | 23.16 | 33.32 |
| 3 | Built-up High | 37.15 | 30.73 | 43.58 |
| 4 | Built-up Medium | 35.30 | 31.95 | 38.66 |
| 5 | Built-up Low | 33.95 | 29.91 | 38.11 |

c) *Analysis of Normalized Difference Vegetation Index (NDVI)*

A NDVI image was computed (see figure 8) from red and near infrared (NIR) bands of landsat 7 ETM+, using the formula:

$$NDVI = TM\ 4 - TM\ 3 / TM\ 4 + TM\ 3$$

The NDVI image has been transformed into image of 8bit (0-255) value from the original values ranges between -1 to +1. The land use/cover change and surface temperature map extracted from landsat image was correlated with the resultant NDVI image to study how all these changes have interacted.

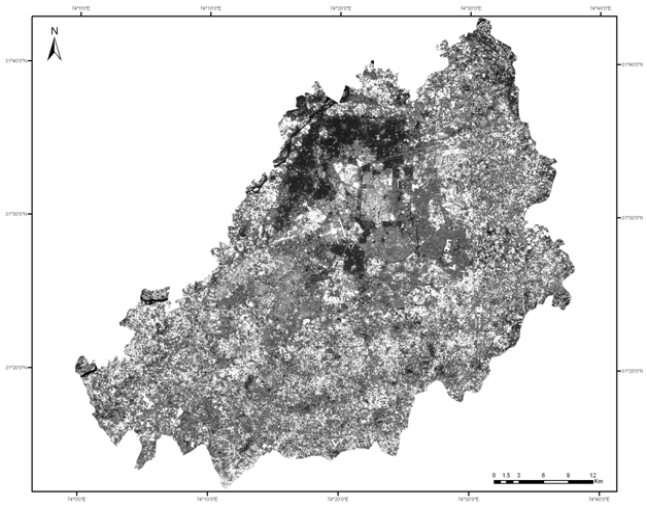

*Figure 8 :* NDVI image for Lahore District

*Table 5 :* Average NDVI per land cover/ land use classes

| Class No. | Class Name | Mean NDVI Value | STD. |
|---|---|---|---|
| 1 | Vegetation | 139.31154 | 28.134737 |
| 2 | Water | 63.036182 | 16.571907 |
| 3 | Built-up High | 55.151108 | 8.636002 |
| 4 | Built-up Medium | 69.333649 | 10.100005 |
| 5 | Built-up Low | 86.761292 | 14.734277 |

As shown in the table 5vegetated area has the highest NDVI value 139.31, while High Built-up area has the lowest NDVI value (55.15) Medium and Sparse residential areas have comparatively low NDVI value of 69.33 and 86.76 respectively, because these areas have few green spaces.

d) *Relationship between Surface Temperature and NDVI*

For each land cover type the relationship between surface radiance temperature and NDVI was investigated through correlation analysis. Table 6shows the analysis between surface temperature and NDVI with respect to land cover/use type.

From the table it is apparent that surface temperature values negatively correlate with NDVI values for all land cover types. This relationship can be visualized by the plot 1 which shows the relation between mean surface temperature values for all land cover types with NDVI.

*Table 6 :* Surface temperature, NDVI per land use classes

| Class No. | Class Name | Mean NDVI Value | Average Temp |
|---|---|---|---|
| 1 | Vegetation | 139.311 | 32.00 |
| 2 | Water | 63.036 | 28.08 |
| 3 | Built-up High | 55.151 | 37.15 |
| 4 | Built-up Medium | 69.333 | 35.30 |
| 5 | Built-up Low | 86.761 | 33.95 |

Strong negative correlation has been observed between surface temperature and NDVI which implies that a land cover that has higher biomass exhibits lower surface temperature. Because of this relationship between surface radiance temperature and NDVI, land use/cover changes have an indirect impact on surface temperatures through NDVI.

*e) Population Density Vs Surface Temperature*

The Figure 9 shows the Population density (persons/acres) distribution for Lahore.

It is obvious from the map that urban areas have high population density which lowers towards the south side towards rural areas.

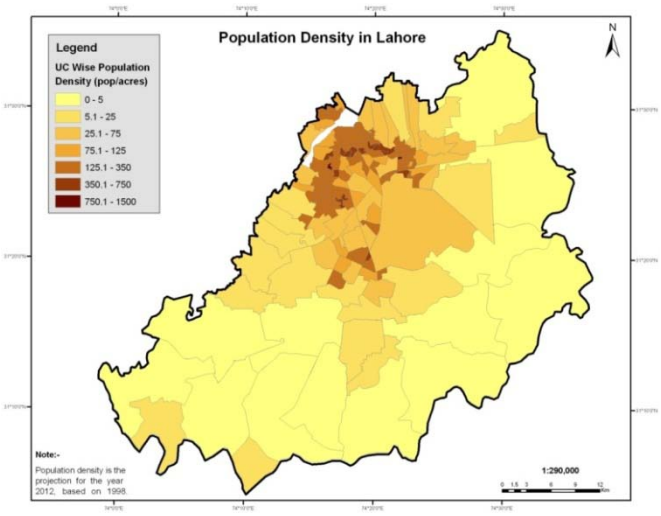


*Figure 9 :* Population density distribution in Lahore

*f) Analysis of Air Quality*

There is positive relationship between air pollutants, urban density and increased temperatures in urban areas as showed from results (Figure 10, 11). The air quality points are taken at different location in urban areas of Lahore as urban areas are associated with high temperatures and population density (obvious from table 7 and figure 11).

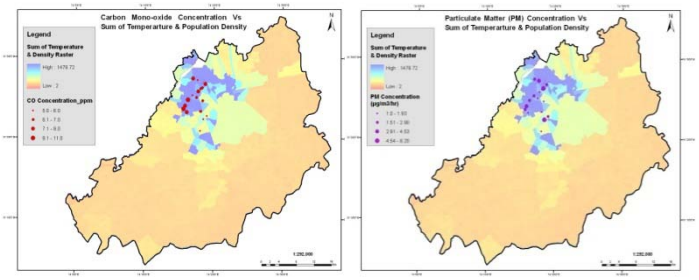


*Figure 10 :* Concentration of CO & $NO_2$

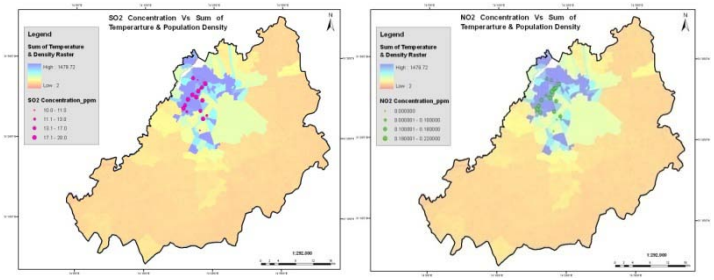


*Figure 11 :* Concentration of $SO_2$ & PMs

*Table 7 :* Statistics for Air Quality parameters vs Population density & Temperature

| Stop # | Population Density (Pop/acre) | Temp 'C | Air Quality | | | |
|---|---|---|---|---|---|---|
| | | | CO (ppm) | $SO_2$ (ppm) | PMs ($\mu g/m^3/hr$) | $NO_2$ (ppm) |
| 1 | 159 | 35.544 | 5 | 20 | 2.76 | 0.1 |
| 2 | 307 | 35.937 | 8 | 16 | 2.365 | 0.08 |
| 3 | 62 | 35.544 | 5 | 20 | 8.17 | - |
| 4 | 277 | 36.330 | 7 | 17 | 7.6 | 0.17 |
| 5 | 277 | 35.937 | 7 | 12 | 1.111 | 0.2 |
| 6 | 34 | 35.544 | 6 | 12 | 2.208 | 0.15 |
| 7 | 274 | 36.330 | 5 | 10 | 4.532 | 0.1 |
| 8 | 197 | 35.544 | 7 | 15 | 1.428 | 0.15 |
| 9 | 112 | 35.937 | 9 | 18 | 1.385 | 0.2 |
| 10 | 347 | 36.330 | 10 | 20 | 1.93 | 0.18 |
| 11 | 223 | 37.111 | 11 | 18 | 2.381 | 0.22 |
| 12 | 43 | 35.544 | 7 | 18 | 1.04 | 0.15 |
| 13 | 335 | 36.330 | 9 | 15 | 3.607 | 0.17 |

*Source : Lahore urban transport master plan 2011, Volume II*

Table 7 describes the values of CO, $SO_2$, $NO_2$, Particulate matter and corresponding statistics of surface temperature and population density for each stop.

## VI. Recommendations

The methodology applied in this study gives an alternative, easy and most updated way against the traditional empirical analysis using the available updated data for environmental studies. This methodology should be applied to other regions in Pakistan that undergo a rapid urbanization.

Much Higher resolution imagery should be used for the classification and quantification of land use/land cover type, so that different classes could be easily distinguished and pixel based analysis would give more

accurate and precise results. More improvement in temperature estimation will occur by using Landsat 7 with resolution of 60m thermal sensor.

Several atmospheric effects (e.g., partial water vapor absorption), variable surface emissivity, sub-pixel variation of surface temperature and urban geometry affects the measurement of Land surface temperature. Therefore, these factors should be considered in computing actual LST in future.

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# An Analysis of Health Situation of Women and Children at the Char of Gangachara Upazilla: A GIS based Case Study

By Mehjabin Elahi, Dr. Shahedur Rashid & Dr. Prosannajid Sarkar
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*Abstract-* Every year in Bangladesh substantial life of women and children are lost through various diseases. The study area of Gangachara is one of the monga-prone areas in Bangladesh. The river, Tista has a big influence on the livelihoods of the people of Gangachara. Healthcare situation in the chars is poor. But health is a basic requirement to improve the quality of life. Floods and erosion disrupted the lives of char dwellers. The victims of erosion lose their settlements, agricultural lands and employment and are forced to move elsewhere sometimes on a yearly basis. Bangladesh is still lagging behind in the field of environmental health. The Level of morbidity remains very high in Bangladesh. Much of the sickness, ill health and resultant deaths in this country are due the overall degradation of the environment. More than 80% population in Bangladesh live in rural areas and environmental problems are more acute in the rural areas of the country.

*Keywords: women, children, health situation, gangachara, GIS.*

*GJHSS-B Classification : FOR Code: 059999p*


*Strictly as per the compliance and regulations of:*

# An Analysis of Health Situation of Women and Children at the Char of Gangachara Upazilla: A GIS based Case Study

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*Abstract-* Every year in Bangladesh substantial life of women and children are lost through various diseases. The study area of Gangachara is one of the monga-prone areas in Bangladesh. The river, Tista has a big influence on the livelihoods of the people of Gangachara. Healthcare situation in the chars is poor. But health is a basic requirement to improve the quality of life. Floods and erosion disrupted the lives of char dwellers. The victims of erosion lose their settlements, agricultural lands and employment and are forced to move elsewhere sometimes on a yearly basis. Bangladesh is still lagging behind in the field of environmental health. The Level of morbidity remains very high in Bangladesh. Much of the sickness, ill health and resultant deaths in this country are due the overall degradation of the environment. More than 80% population in Bangladesh live in rural areas and environmental problems are more acute in the rural areas of the country.

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## I. Introduction

The riverine sand and silt landmasses known as char in Bengali are home to over 5 million people in Bangladesh. These areas are highly vulnerable to sudden and forceful flooding as well as erosion and loss of land, which makes living in the chars both hazardous and insecure. Many char dwellers struggle to produce or buy enough food to eat and malnutrition and micronutrient deficiencies are more common than elsewhere in the country. The chars- some midstream islands and others attached to the mainland–are created from river sediment and are in a constant state of formation and erosion. Emerging chars create new areas for settlement and cultivation, an important resource in a land scarce country such as Bangladesh. However, a constant threat of riverbank erosion and flooding, combined with a lack of physical infrastructure, government services and employment opportunities in the chars, makes for a vulnerable, difficult and fragile way of life. Char dwellers are considered poorer than the mainland population and are increasingly becoming the targets of efforts to reduce property. Nevertheless, there is still very little quantitative information on the health, nutrition, and food security of these vulnerable people, partly because they are highly mobile and access to the chars is physically difficult. Floods damage or destroy crops, homes, water and sanitation facilities and other assets and hinder access to food, medical care, schools and work. The victims of erosion lose their settlements, agricultural land and employment and are forced to move elsewhere, sometimes on a yearly basis. The main concern of this study is to assess the health situation of women and children at the chars of Gangachara Upazilla. It will also focus on the present problems of healthcare system to provide the char dwellers a better health care system.

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## II. Statement of the Problem

Every year in Bangladesh substantial life of women and children are lost through various diseases. Gangachara, the study area, is one of the monga-prone areas in Bangladesh. The river Teesta has a big influence on the livelihoods of the people of Gangachara. Name of the major chars of Gangachara are Binbinia char, Motukpur char, Kolkond char, kholair char, Nohalir char and Malai char. Healthcare situation in all the above mentioned chars is poor. But healthy is a basic requirement to improve the quality of life. A national economic and social development depends on the state of health. A large number of Bangladesh's people, particularly in char areas, remained with no or little access to healthcare facilities. Gangachara Upazilla has an area of 9.86 sq. km. The town has a population of 12,600 out of which 52.02% is male and 47.98% is female. Only 15.1% female are literate. There are ten family planning centre, two satellite clinics and a health complex. This study will determine the health situation of women and children at the major char areas of Gangachara Upazilla.

### a) *Aim of the Study*

- To demonstrate the present health situation of women and children at the char areas of Gangachara Upazilla.

### b) *Objectives of the Study*

The objectives of the study are:

- To know about the health problems and facilities of study area.

- To know about the consciousness level of women and children health of study area.
- To know about the environmental effect on women and children health of study area.
- To analyze related aspects of concern areas from maps and satellite images by using GPS.

*c) Study Area*

Study area is uttar kolkanda mouza located in Gangachara upazila of Rangpur district, Bangladesh. Gangachara upazila was established in 1917 and consists of 9 union parishads, 93 mouzas and 149 villages. Total area of Gangachara Upazila is 209.61 sq km. Gangachara (Town) consists of two mouzas. It has an area of 9.86 sq km. The town has a population of 12600; male 52.02%, female 47.98%. The density of population is 1278 per sq km. Literacy rate among the town people is 28.6%. Gangachara is noted for tobacco production.

*Table 1 :* Unions of Gangachara Upazila

| Union Name | Number of Mouza | Number of Villages | Area (Acres) | Number of Household | Population | Literacy (%) |
|---|---|---|---|---|---|---|
| Betgari | 10 | 14 | 6029 | 5309 | 23065 | 31.11 |
| Kholeya | 6 | 12 | 5936 | 5430 | 23749 | 34.89 |
| Borobil | 8 | 10 | 8543 | 7758 | 32446 | 35.65 |
| Kolkanda | 10 | 9 | 8558 | 5428 | 24415 | 32.61 |
| Laxmichari | 8 | 11 | 6703 | 4095 | 17379 | 30.66 |
| Gojghota | 9 | 9 | 4761 | 4244 | 28018 | 45.99 |
| Mornea | 13 | 26 | 5106 | 5869 | 25176 | 37.07 |
| Nohali | 7 | 7 | 7667 | 5276 | 21428 | 20.78 |
| Alsabadchar | 13 | 13 | 7175 | 7820 | 30983 | 28.19 |
| Gangachara | 93 | 149 | 66638 | 60674 | 259856 | 32.95 |

*Source: Upazila Statistical Office*

*Table 2 :* Various mouza of Kolkanda Union

| Mouza Name | JL No | House Hold | Total Population |
|---|---|---|---|
| Chilakhal | 1 | 453 | 2075 |
| Matukpur | 2 | 659 | 3397 |
| Kismat Matukpur | 3 | 469 | 1804 |
| Jitpur Sreeram | 4 | 1722 | 7719 |
| Binbina Char | 5 | 16 | 63 |
| Kuribisha | 9 | 109 | 460 |
| Uttar Kolkanda | 7 | 1188 | 5383 |
| Arazi Sreeram | 6 | 360 | 1582 |
| Ale Kismat | 8 | 452 | 1932 |
| Kolkanda Union | 8 | 5428 | 24415 |

*Source: Upazila Statistical Office*

*d) Binbinia Char and Motukpur Char*

These two char is located in kolkanda union. These are one of the most deprived areas in the northern Bangladesh. Most of the people of these areas are landless and marginal farmer. In different times their land property was taken away by river bank erosion and river channel shifting. Binbinia char and Avazi Sreeram are situated to the east of this mouza and Ale kismet Mouza is situated to the west, top part of this mouza touched with Motukpur mouza. Location of study area-

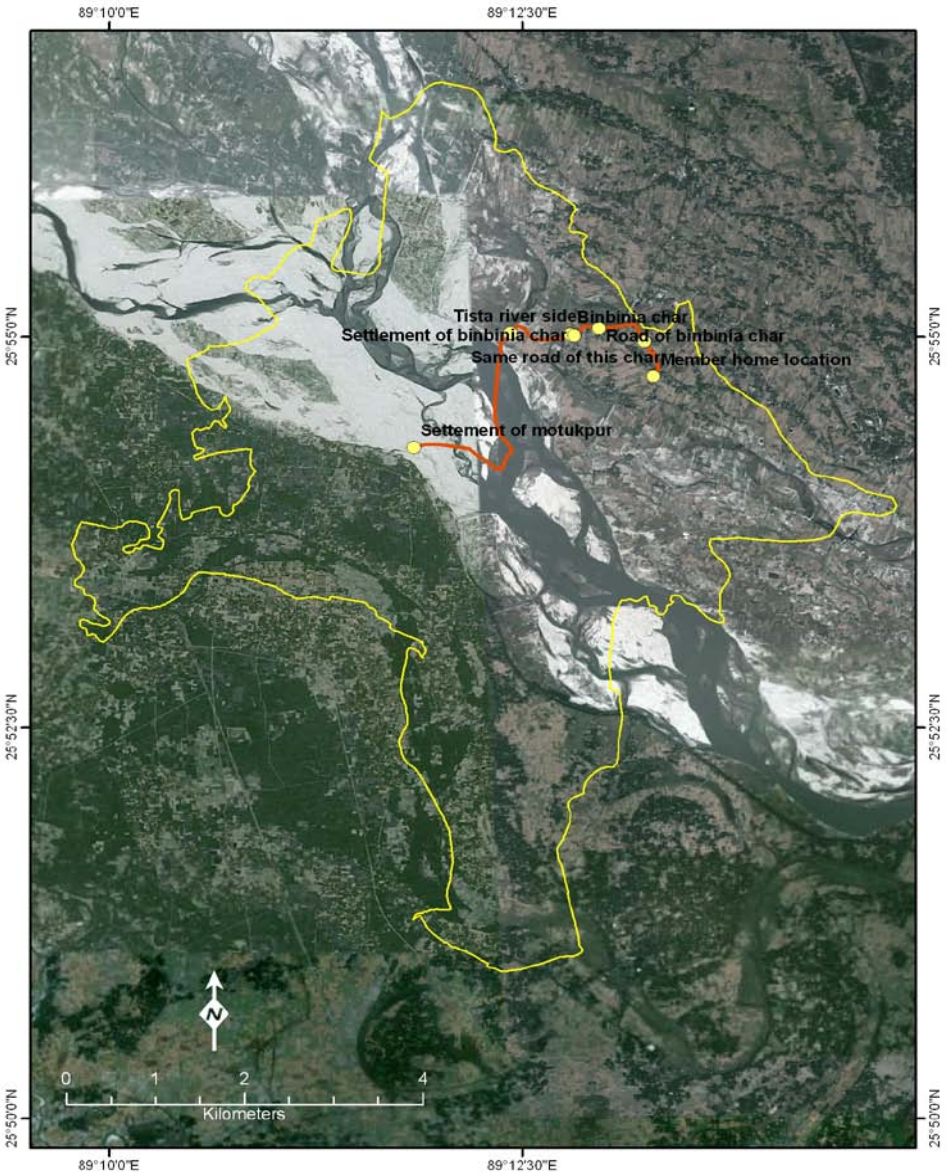



*Figure 1 :* Location of study area

## III. Research Methodology

Systematically sampling has taken to collect social data or information. To have performed the analysis on the data sets and derived the findings, GIS, as usual descriptive statistical tools and techniques have been applied in the study. Here, two types of primary data (socio-economic and geographical) are collected from the field by conducting questionnaire survey, FGD and GPS device etc. Major primary sources which will be conducted in four ways-

(i)In-situ Observation, (ii) Formal Questionnaire Survey, (iii) FGD, (iv) GPS Survey.

Here, noted, The GPS technology has tremendous amount of applications in GIS data collection, surveying, and mapping.

The source of secondary data is publication of Government Agencies, Publication of Related NGOs and Satellite Images. Satellite image is collected from Google Earth.

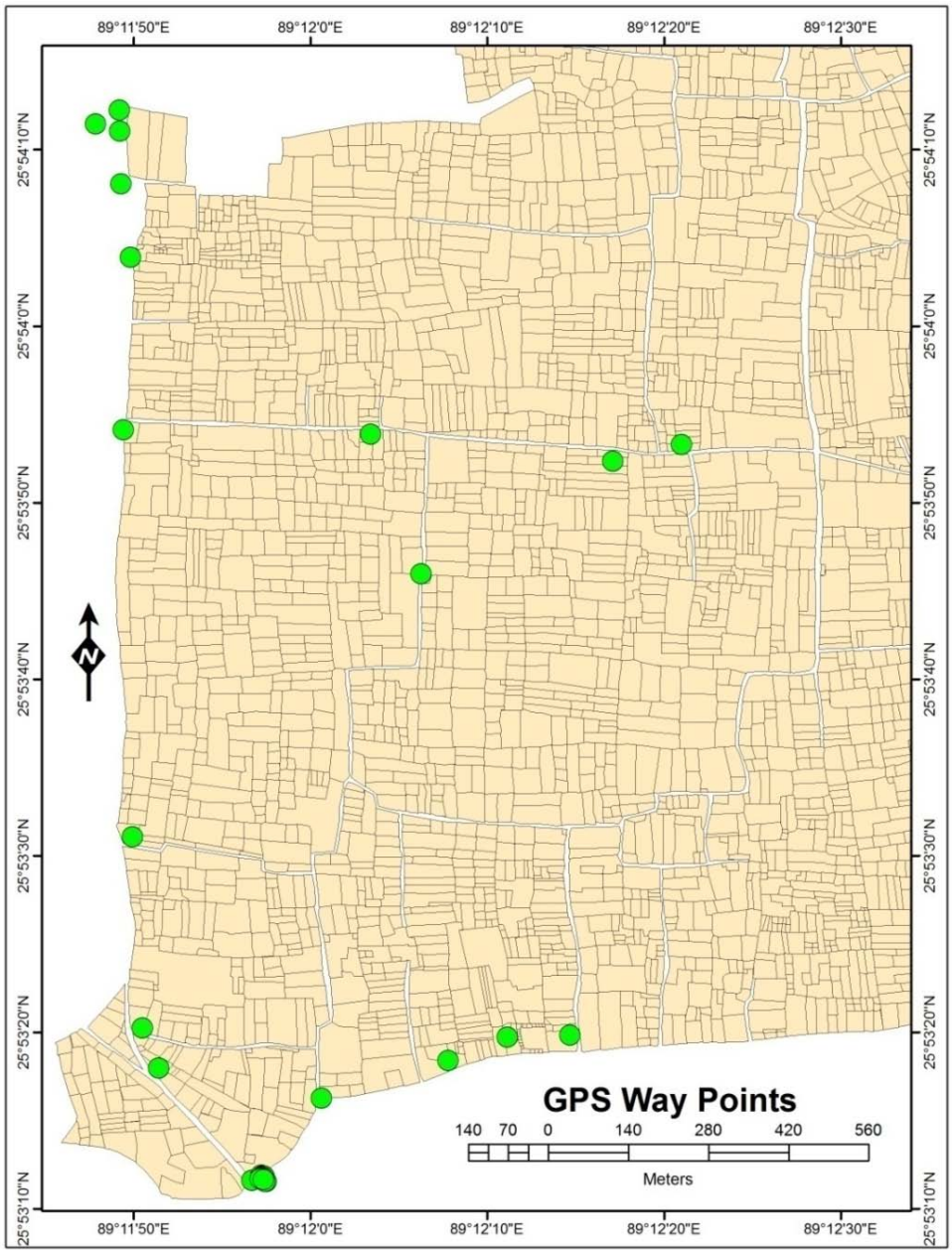



*Figure 2 :* GPS Data (way pints) of the study area

GPS survey was conducted to get some points for geo-referencing maps and images. I have collected 15 reference points including my study area.

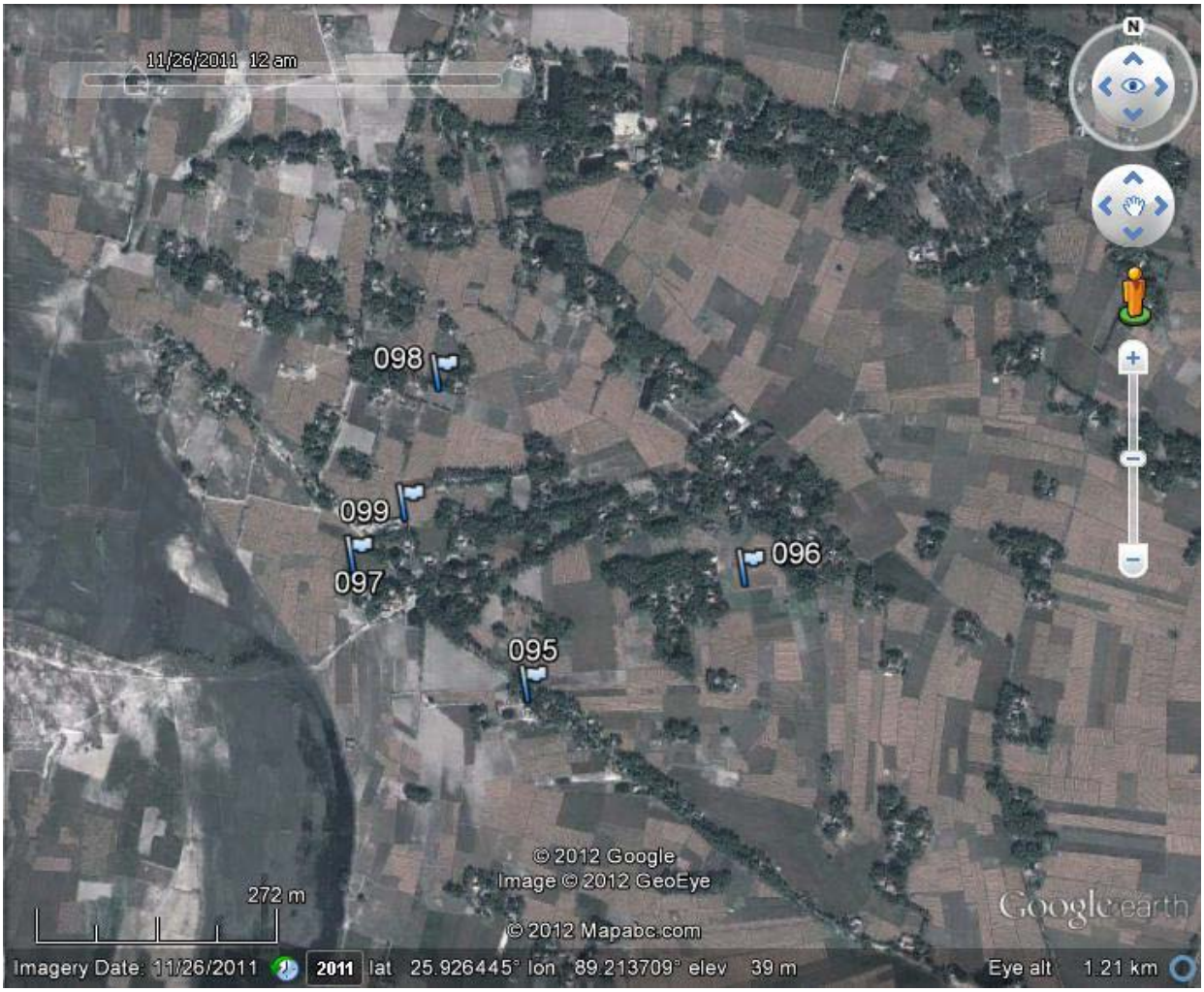



*Figure 3 :* Way points of study area

So, I made a questionnaire field survey in this char on selected women and children and collected primary data. There have 148 household in this mouza. The sample was selected randomly from this and the sample size was 148. The personal interview of members of union, Upazilla and others was also conducted during field investigation.

The collected satellite image 'Spot Image' and the spatial resolution of this image is 5m×5m.


*Figure 4 :* Satellite Image of the Study Area

Through questionnaire survey: The questionnaire was designed considering following four variables, this are-independent, dependent variable, controlled variable, uncontrolled variable. The questionnaire tried to collect five different types of information from the study area. Such as-General Information, Social/Economic Information, Land Related Information, Physical and Environmental Information, Land Management and Legal Information.

## IV. Data Analysis Tools

*a) Major data analysis tools were-*

- Microsoft Excel and SPSS for numerical data analysis;
- Arc GIS, Arc View and Erdas Imagine for Raster Data analysis.

*b) Image Analysis Software*

Various software is used for image analysis. Some are used for collecting image and joining and others for creating shape file and calculating geometry of various features. The software are used for image analysis is mentioned below with their function.

*Table 3 :* List of used software for image analysis

| S.N | Software | Functions |
|---|---|---|
| 1 | Google Earth | Image Collection |
| 2 | Adobe Photoshop | Image Joining (Manual) |
| 3 | Auto Stitch | Image Joining (Automatic) |
| 4 | Arc View 3.3 | Database management |
| 5 | Arc GIS 9.2 | Georeferencing, DBM, Projection, Creating features, calculation of geometry etc. |

*c) Image Processing*

Image processing means set of techniques such as- image collection, geo-referencing and geo-correction of image, defining projection, digitization etc. Image processing techniques used in this research is briefly mentioned below:

i. *Geo-referencing*

GIS users analyze relationships among real-world objects. Features in a GIS must be georeferenced so data can be correctly related to locations on the earth's surface. Georeferencing data is accomplished by assigning a coordinate system—a reference system used to locate geographic features on a two- or three-dimensional surface. *(Canserina Kurnia, ESRI).*

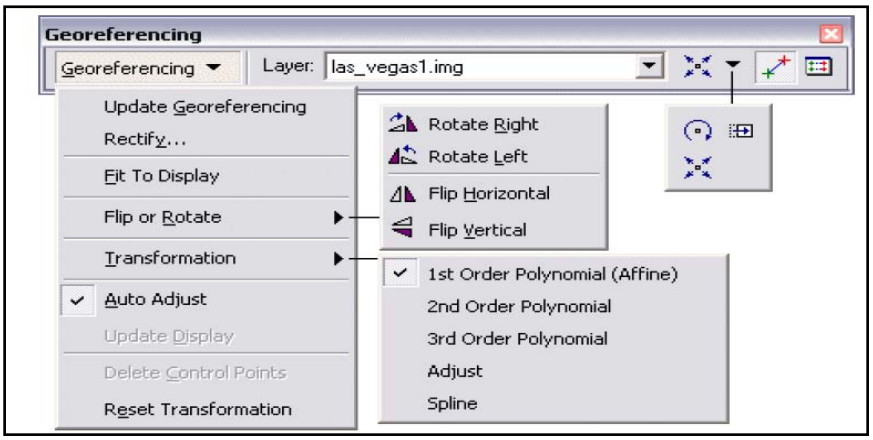



*Figure 5 :* Geo referencing Tool in Arc GIS 9.2

Geo referencing is a very important part of image analysis. Without spatial reference any kind of image analysis is impossible.

## V. Literature Review

Review of previous studies is one of the important parts of any scientific research and serves a number of academic purposes. It is a task, which deal with previous research to find more information gaps for the designed research. By examining published documents, professional journals data achieves and library sources. The researcher may find the desired portion of the data needed in a particular study. Many literature reviews are available on this issue. Some of these have been studied for this research and important aspects are discussed here.

*Akhter and Hunter (1991)* defined the term medical geography as well as health. They indicated that the basic differences between medical geography and epidemiology. An in depth discussion was also made on disease ecology and health cure in the developed and under developed countries. *Learmonth (1991)* explained the term disease ecology and focused on the ecology of yellew fever. An attempt was also made to discuss the diffusion of this disease.

*Khan (1995)* observed that besides non availability of medical services, many other factors such as precarious nutritional status, lifelong inadequate food intake, poor sanitation and lower health status of women had affected the overall health status. It was observed that, women faced poorer environmental sanitation that gave them lower resistance capacities.

*Hoque and Hoque (1994)* indicated that environment and health together are such a vast and complex topic that any effort to describe them is bound to be incomplete.

*Sarwar(1992)* focused on malnutrition which affects the mental and physical development of children and reduces their ability to resist the disease. *Jahan and Saadia (1989)* traced that nutritional blindness among preschool age children in Bangladesh is near highest levels in the world.

*Samir (2010)* pointed – the world is facing increasingly frequently and intense disasters, both natural and man-made, with devastating impacts. Women play a vital role in providing economic and mental assistance to the family and community in past disaster rebuilding activities and at the same time actively participate in disaster deterrence programmes. Post disaster recovery projects often fail to understand the significant of gender relations in people's lives in a society and formulate policies without appreciating local, cultural practices and institutions, resulting in loss of traditional sources of status power of women.

*Skoda et al. (1979)* traced out the effects of various natural and socio economic factors like sanitation, water usage etc. in Bangladesh.

Skin diseases are common in Bangladesh. *Ahmed et al. (1977)* observed that skin diseases were related to location of residence, seasonal variations, age and site involved with skin diseases. Acute respirations Infection (ARI) is one of the major causes of morbidity and mortality among children in Bangladesh.

*Parvez (2009)* pointed- In fact women and children are worst sufferers during flood and any natural calamity. They face countless difficulties, live inhumanly and struggle to survive even at the cost of one's lives. The bitter truth is that in such distressing situation some of the poor girl/women are enticed by pimp. Traditional gender specific work naturally becomes too difficult for them. For lack of resources poor women face more problems than women belonging to middle class and rich household. For those types of important reasons relief and rehabilitation facilities should be promised for women and children, especially those who are so helpless and distressed.

*Khanom (1995)* in a study observed that the government supplying the services is inadequate. Besides, all the places of rural area do not get equal services. NGO's also are not serving equally all over the country. Different

NGO's working in different areas. Some areas are having services from more than one NGO on the country; some areas do not have any access to any kind of services. This study also indicated that insufficiency of doctor's, especially female doctor is a major problem in rural area. As a result, different maternal complicacies do not get treatment. Besides for 'Pardah' tradition, women do not want to see a male doctor in some casas any doctor at all. This study further noticed that the services of the government health workers are not regular in some places.

The above studies have addressed health-related issues of Bangladesh from the perspective of health practitioners. Very few studies in that past have focused on the spatial variation of mortality and morbidity in Bangladesh (Huq, 1996). He focused on the spatial epidemiological aspect of child health in a small area (Savar thana, Dhaka) of Bangladesh using GIS tools. He observed that both social and physical environments played significant roles on the morbidity and mortality of the children aged (0-5) years.

*Kingham et al. (1995)* outlined spatial clustering of health events using environmental epidemiological data in a study on the child health situation in Lancashire in England. This study examined spatial clustering problems of disease with the aid of GIS (quoted in Huq, 1996).

*Twigg (1990)* in a study on health care indicated that GIS has much potential in hhealth care planning and further argued that although Gis offers much potential, its use in the health service is crucially dependent upon the availability of geo referenced, accurate and up to date data.

## VI. Results and Discussions

*a) Women and Children Health Condition of Char Area*

Binbinia and Motukpur char of Gangachara Upazilla is one of the most flood vulnerable areas which are affected by flood and riverbank erosion almost every year. To assess the health situation of women and children of this area, field survey is needed to acquire the real picture. So, I made a questionnaire field survey in this char on selected women and children and collected primary data. There have 148 household in this mouza. The sample was selected randomly from this and the sample size was 148. The personal interview of members of union, Upazilla and others was also conducted during field investigation. Those collected data are needed to analyze and arrange to find out the problem and there coping and adapting strategies. The analyzed data are given below:

*Table 4 :* Women and children health condition (Food, Water, and Sanitation)

| Questions | Total Respondents | Number of Respondents | |
|---|---|---|---|
| | | Yes | No |
| Can you manage the right proportion of food materials for your family members | 148 | 49 | 99 |
| Do you face scarcity of water | 148 | 69 | 79 |
| Do you face any sanitation problem | 148 | 32 | 116 |
| Do you think your sanitary system is hygienic? | 148 | 31 | 117 |
| Do you think women and children need extra privacy and protection in any form like time of bathing, using latrine, collecting water and others | 148 | 148 | 0 |

*Source: Field Survey, 2012*

i. *Comments*

Those women and children stay in char area; they also have to face different kind of difficulties than the male person. Women cook their food in their house but for this they have to face various kinds of problems such as deficiency of food materials, scarcity of drinking water and sufficient fuel. Moreover maximum women families sanitary system are non hygienic.

*Table 5 :* Women and children health condition of char area

| Questions | Total Respondents | Number of Respondents | |
|---|---|---|---|
| | | Yes | No |
| For pregnant women has there any special facilities in your area | 148 | 0 | 148 |
| Ever you and your children attacked by water born diseases | 148 | 72 | 76 |
| Do you get any doctors facility in your area | 148 | 25 | 123 |
| Do you get any private organization or govt. free medical facilities | 148 | 37 | 111 |

*Source: Field Survey, 2012*

ii. *Comments*

Women and children face different kinds of health problems. Specially, pregnant women do not get any kinds of facilities in the study area. They are also affected with several kinds of water born diseases and they do not get any doctoral facility.

*Table 6 :* Women and children health condition (Harassment in different sectors)

| Questions | Total Respondents | Number of respondents | |
|---|---|---|---|
| | | Yes | No |
| Do your children go to school? | 148 | 107 | 41 |
| If yes, are they facing problems or obstacles to go school? | 148 | 80 | 27 |
| Did your girls face any harassment at this time? | 148 | 79 | 69 |
| Do you face any types of violence from your husband | 148 | 36 | 112 |
| Do you face any transportation/ communication problem? | 148 | 122 | 26 |
| Do you get any extra facilities in the transport vehicle as women? | 148 | 19 | 129 |
| Is there any awareness programmed arranged? | 148 | 43 | 105 |

*Source: Field Survey, 2012*

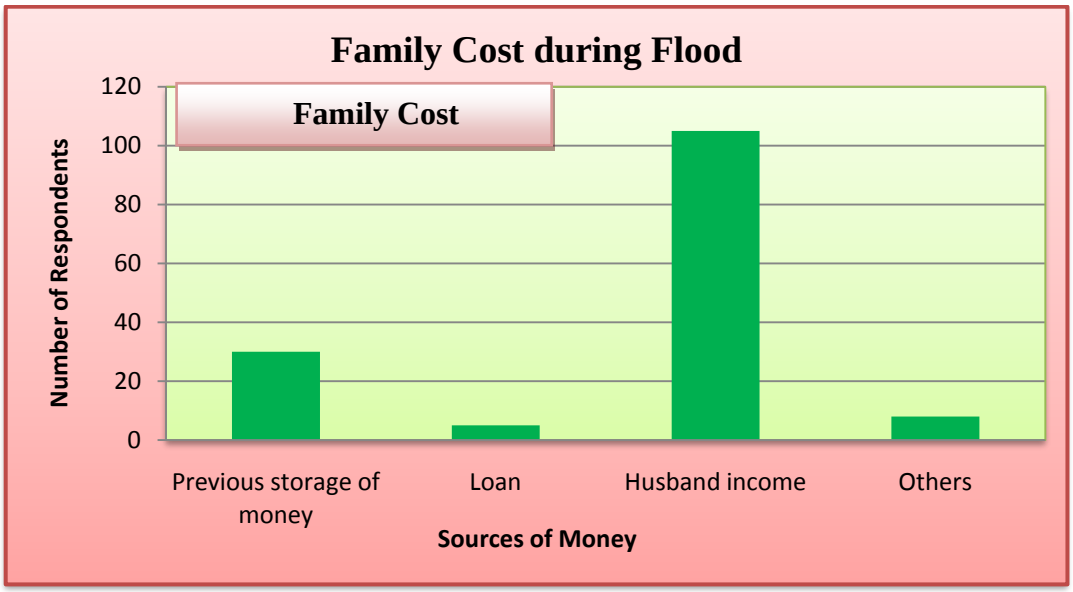
iii. *Comments*

Women and children also face transport problems and harassment in the study area. Their children go to school though they face obstacle in the prior of going school. There are no extra facilities of women in the vehicle in the study area.

*b) Some Others Problems Women Face in Char Area*

i. *Family Cost*

Women have to maintain families internal some work and for this money are needed. In this case, maximum women take the necessary money from their husband to maintain the family works which number is 105 out of 148 respondents in the study area. Some women also use previous storage money or take loan from others and which number is low. (Figure 5)

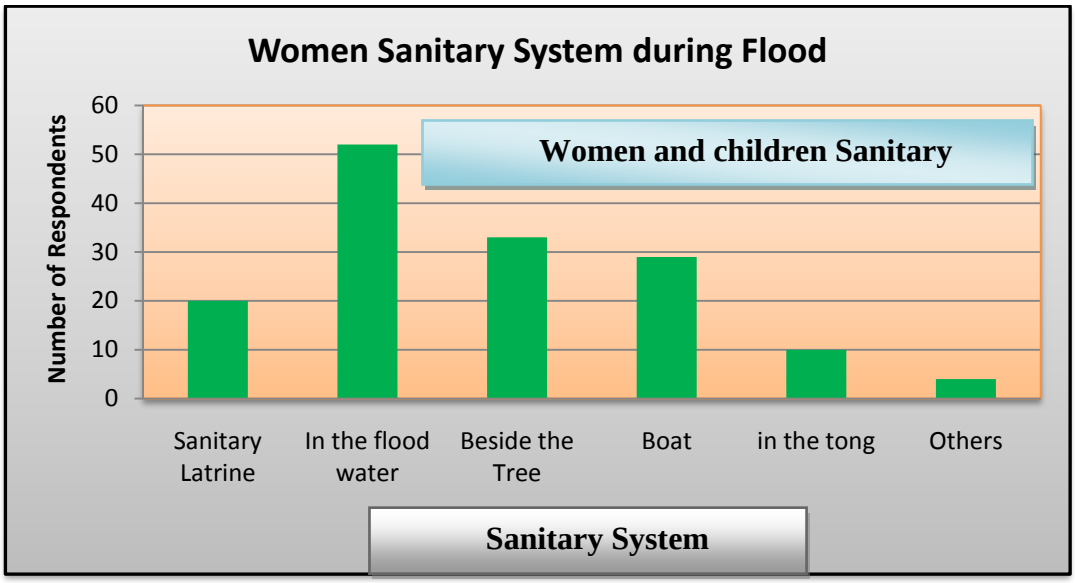



*Source: Field Survey, 2012*

*Figure 6 :* Family Cost

ii. *Women and children Sanitary System*

Women and children are great sufferer in the char area in the case of sanitary system than male person. From above chart and table it can be said that 52 respondent of the study area complete sanitary work in the flood water, 33 respondents beside the tree, 29 respondents in boat and very low number respondent use the sanitary latrine out of 148 respondents. (Figure 6)

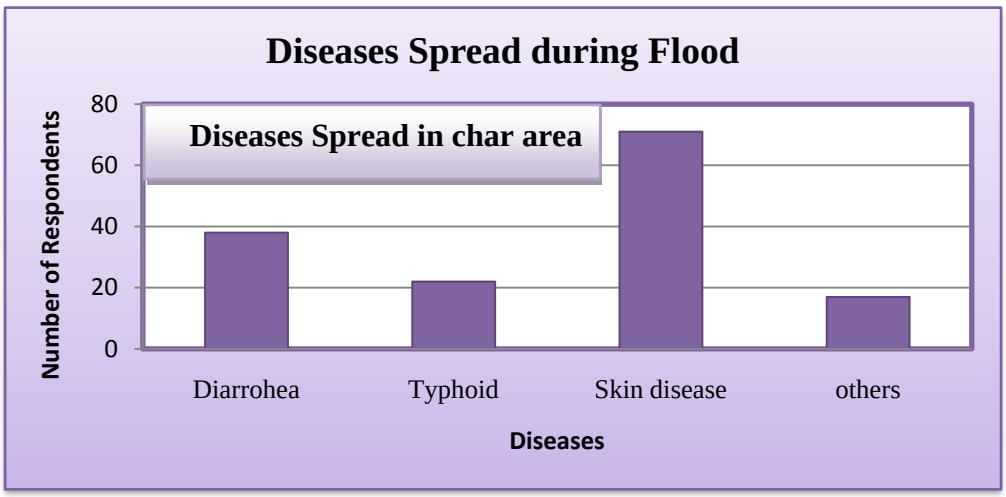



Source: Field Survey, 2012

*Figure 7 :* Women and children Sanitary System

iii. *Diseases Spread in char area*

Different kinds of disease are spread in the char area. From above chart and table it can be said that among them most of the women and children are affected by skin disease which number is 71 out of 148 respondents. Some are also affected by typhoid, Diarrhea etc related diseases in the prior of flood. (Figure 7)

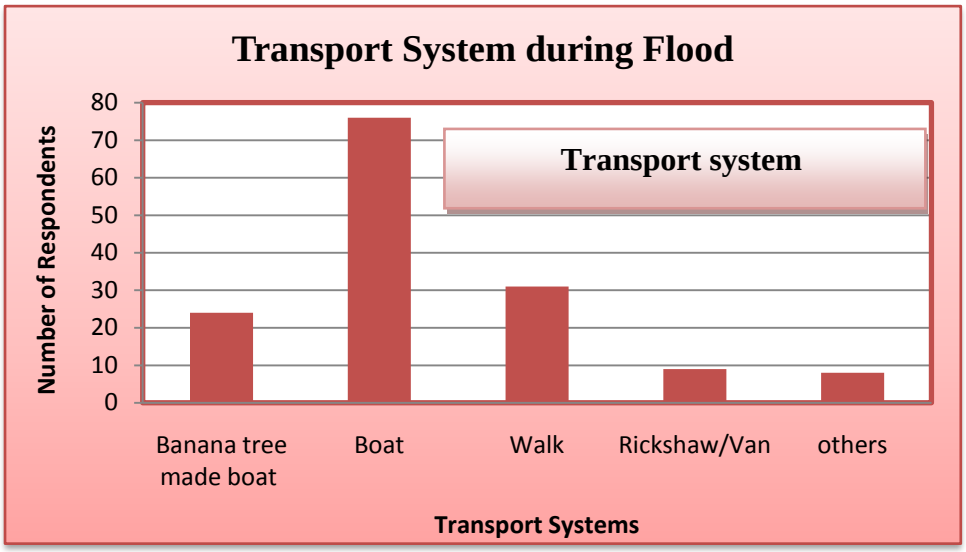



Source: Field Survey, 2012

*Figure 8 :* Diseases Spread in char area

iv. *Transport system in char area*

From below data chart (Figure 8) it is found that maximum women use boat as a mode of transportation in the study area which number is 76 out of 148 respondents where as 31 respondents go to their destination on foot.




*Source : Field Survey, 2012*

*Figure 9 :* Transport systems in char area

v. *Position of Women and Children in Bangladesh*

Specific social features in Bangladesh include seclusion and limited mobility of women & children, and the exclusive nurturing role assigned to them in the gender division of labor. Cultural values, religious norms, and social structures force women and children to be dependent on men. Most of the value systems in almost all Bangladesh societies believe in the need for protection of a male for women to carry on with life. At the same time, the social pressures arising out of the same value systems force the poor towards action such as female infanticide.

According to the socio-economic indicators, the illiteracy of the overall population is considerably high and the gender disaggregated data points out that female illiteracy is always higher than male. The ownership of assets shows a similar pattern where women own fewer assets, since most societies follow a patriarchal system of ownership of property.

Some of the key factors contributing to women's 'double edged' vulnerability owing to poverty and other social disadvantages in the Bangladesh context can be stated as follows:

- Very high illiteracy levels
- Low ownership of assets such as land, and other property (often inheritance laws are male oriented)
- Minimum work opportunities outside home
- Limited mobility out of home and out of their own locality
- Low social status
- Socially constructed dependency on male relatives

All these factors, the dynamics between them and the processes arising from the inter-relationships between them has resulted in women becoming an extremely vulnerable group in Bangladesh.

vi. *Women and Children: Disaster*

As mentioned the socio economic, cultural and religious values in Bangladesh have resulted in its women and female children in particular to be more vulnerable to adverse situations in comparison to men. These dynamics form into vicious cycles, where women and their children get trapped. Therefore, it is nearly impossible for women belonging to already poor and vulnerable groups to bounce back once hit by extreme events. The result in the worst scenario is often women becoming destitute with their children. In many societies, vulnerability to (natural) disasters differs for women and men. Women are often more vulnerable to disasters than men through their socially constructed roles and responsibilities, and because they are more poor. Disasters do not just happen. The social structure of most societies formally relegates women to inferiority and dependency, increasing their vulnerability through their disempowerment .Women is integral parts of functioning societies, with established roles and rule Adolescents, pregnant women, lactating mothers, the disabled, and the aged make up particularly vulnerable groups in emergencies. In the course of determining the impact of both natural and conflict induced disasters.

vii. *Problem of Food, Clothing and Shelter*

Poor people suffer from lack of food, clothing and shelter. At the time of flood many families/women become homeless. It is sometimes impossible or not acceptable for a girl of marriageable girl to seek shelter in somebody's house. Unemployed men often sit idle or move elsewhere leaving their households members behind. Poor women and children have to wait all through the day and night for some food. Poor women with only one "shari" are often oblige to remain in wet clothe for most of the day for lack of the private place to dry off. Women's life also falls at risk, especially while

travelling during floods the shari become a death trap for women. An increase in the number of female-headed households (because of male out-migration) also amplifies women's responsibilities and vulnerabilities during natural disasters. After a disaster hits there are often inadequate facilities available for women to cope with their household tasks or to get shelter.

viii. *Problem of Sanitation*

Women and children face countless difficulties using latrines than men during flood. It is impossible for women and children to disagreed their inhibitions and go to latrines, which are open to all. Women sometimes have to wait till dark/night to ensure privacy to respond to calls by nature, even changing clothes/sanitary pad which are really discomfortable to sufferer women. In the flood shelter they have also problem to share toilet with others.

*Figure 10 :* Sanitary system

ix. *Impact on women's economic livelihoods*

When poor women lose their livelihoods, they slip deeper into poverty and the inequality and marginalization they suffer from because of their gender division increases. Therefore, flood presents a very specific threat to their security. Floods damage livestock -cows, goats, buffaloes, and poultry -chickens, ducks, fisheries, trees, crops-rice, wheat, nuts, chilies, lentils, seeds and animal fodder. Sand deposition as a result of flood and river erosion affects production of crops such as nuts. During and after flood, the lack of fodder for livestock and poultry results in reduced milk and meat production.

c) *The Impacts of Chars During Floods on the Livelihoods of Women Include*

i. *Crop production loss*

Women, who control homestead-based livelihoods, lose income when crops are blown or washed away.

ii. *Livestock death*

Cows and goats are the most valuable assets of poor people in flood-prone areas. During flooding, collection of fodder for livestock is a significant challenge, particularly for goats that need green grass (which often becomes flooded.)

iii. *Housing and homestead*

The destruction of houses by floods is a common impact in disaster prone areas. Homestead vegetation which is maintained by the female family member is damage by flood and decrease the earning source of women.

iv. *Loss in productivity*

Flood water and sand deposition decreases soil productivity. So, the food insecurity situation has been worsened by the floods.

v. *Supply shortage and price of inputs*

Shortages during flooding leads to increased prices for inputs such as seeds, fertilizers, oil for running irrigation pumps, fodder for animals, transport costs and veterinary fees.

vi. *Loss of income, savings and employment*

Loss in production, lack of storage and destruction of access roads result in assets (e.g. cattle) or products (e.g. milk) being sold at low prices. The selling price decreases while the shortage in supply induced by floods results in increased prices for essential goods. Moreover, flood reduces employment opportunities, especially for women working in agricultural fields. Less income of women means less food at home for children. As a result, there is a net loss in income which, in turn, leads to a loss in savings, thus making it even harder for households to cope with disasters.

vii. *Limited access to market*

With damages to infrastructure and communications systems, women and children cannot

access the market to buy or sell food such as milk, eggs, vegetables or other products. Women are forced to trade within the village or accept lower prices offered by male buyers from other area. Also much another socio-economic impact of chars during flood on women and children are seen in the study area. Among them those mentioned are more common and miserable.

## VII. Research Findings

Through this study, it becomes clear that chars environment create a great impact on women and children life. By studying this, there found some information which can be summarized that-

The negative impact of char's environment is widely seen on live, livelihood, agricultures and health.

- Most of the women lose their livelihoods; they sink deeper into poverty and the inequality and marginalization they suffer from because of their gender division.
- Women who had comparatively less knowledge about their child health and its impact and were dependent on male decision.
- Most of the women have no ability to take steps like, pregnancy time, medicine, child education etc.
- Most of the women and child suffer from physical injury, water born diseases, malnutrition and other health problems than man.
- Woman and children are not get proper health facilities in the health complex only Sunday health worker come and their health facilities are not good.

## VIII. Recommendation

- Create an environment in which women's engagement in adaptation discussion and governance structures is fully supported in order to do so exiting coping strategies and constructing to adaption should be studied.
- Empower women and children as agents of adaptation, and provide women with opportunities to control greater percentages of resources (including land) and services and to make independent decisions.
- Prevent cultural practices from hindering women's capacity to adapt.
- Assist women and their coalitions and networks at community, national and international levels to ensure that recovery and adaptation measures respond to women's needs and concerns.
- Provide training to women's organizations, networks and support groups and opportunities to share experiences—women and their organizations should demonstrate exemplary leadership and serve as gender advocates and credible ambassadors on climate change.
- Acknowledge women's social, economic, physical and psychological vulnerabilities in community-based preparedness and response plans in order to reduce the impact of disasters on women.
- Recognize women's abilities and incorporate them into flood relief efforts with the goal of changing gendered roles and perception of rights.
- Endeavor to ensure that activities are appropriate for women, and that they receive positive encouragement and support for participation.
- Create adaptation finance mechanisms that support livelihood adaptation priorities of poor women, and include gender-disaggregated indicators in adaptation funds for targeting and monitoring the benefits to poor women.
- Safe water supply should be provided immediately in the char areas and public awareness should be increased about the contamination of the water.
- The households who have no toilet facilities should be motivated to dispose human excreta at the proper place and sanitary latrines should be constructed at a safe distance from their sources of drinking water.
- Medical facilities should be made available to the people in remote areas and service of Upazilla health complex and community health complexes should be developed.
- The existing road networks should be developed, so that the people living in the remote areas can easily reach to the health centres.
- Primary health education programmes are to be conducted so as to inform, motivate and help people to adopt and maintain health and hygiene practice and lifestyle.

## IX. Limitation of the Study

This study did not incorporate qualitative data in its methodology. This incorporate of qualitative data in GIS could be more acceptable findings and results. Some of the respondents feel introverted to give answers of some questions related to their personal income, personal savings and security. Despite all the above limitations this study might be a model for further research on health aspects of Bangladesh.

*a) Conflict f Interests*

The authors declare that there is no conflict of interests regarding the publication of this paper.

## X. Acknowledgment

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*a) Copy Right*

All authors declared that the work described has not been published before (except in the form of an

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# A Review of Flooding and Flood Risk Reduction in Nigeria

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*Abstract-* The prevalence of flooding within Nigeria which has been generally attributed to climate change and poor urban planningis an issue of critical importance within the context of national development.Over the period 1985 to 2014, flooding in Nigeria has affected more than 11 million lives with a total of 1100 deaths and property damage exceeding US$17 billion. Although more frequent floods are recorded in Niger, Adamawa, Oyo, Kano and Jigawa states possibly due to the influence of rivers Niger, Benue, Ogun and Hadeja, Lagos state seems to have experienced most of the floods in the country. With rapid population growth and urbanization in the country the risk of flooding to human lives and properties assumes critical dimensions.Critically, poor awareness of the hazard is a major impasse towards its management. This creates a significant gap in the knowledge of how to improve on the current efforts towards addressing the challenges of flooding in Nigeria. Since attempts to tackle the hazard appear to be limited, the present study is driven by the need to identify those limitations in the flood management efforts in Nigeria. Possible way-forward are suggested based on a critical review of flooding and its management in Nigeria, allied with globally acknowledged 'best practices' in flood risk reduction and lessons learned from other countries' experiences of flooding.

*Keywords: flooding, developing countries, nigeria, flood risk, climate change, flood modelling, flood vulnerability assessment.*

*GJHSS-B Classification : FOR Code: 920407, 300899*


*Strictly as per the compliance and regulations of:*

# A Review of Flooding and Flood Risk Reduction in Nigeria

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*Keywords: flooding, developing countries, nigeria, flood risk, climate change, flood modelling, flood vulnerability assessment.*

## I. Introduction

Concerns for flooding has increased in recent times due to climate change (especially in more frequent and severe rainfall events), sea level rise, rapid population growth and urbanization, the level of awareness of flood risk, the limited efforts towards flood disaster risk reduction in many places and the exposure and vulnerabilities of large numbers of human population (Peduzzi et al. 2011, Gill et al. 2004, Action aid 2006, Raaijmakers et al. 2008). The impacts of flooding reported in the last two decades have been significant, amounting to tens of billions of US dollars (Guha-Sapir et al. 2013). Over 3700 flood disasters are recorded in the EM-DAT database, covering the period 1985 to 2014 (EM-DAT 2014). These events were responsible for hundreds of thousands of deaths mainly in Asia (most notably China, Thailand and Bangladesh) and adversely affected billions of people mostly through homelessness, mortality (mainly through drowning), physical injuries, fecal-oral and rodent-borne diseases, vector-borne diseases (mainly in tropical areas) and psychological conditions through depression, anxiety and post-traumatic stress (Ahern et al. 2005, Hunter 2003, Few et al. 2004, Tapsell & Tunstall 2008, Keith, 2013).

In Nigeria, flooding and solutions to its impacts are critical issues (Obeta 2014). With history of devastating floods which affected millions of human populations and caused fiscal losses amounting to billions of US dollars, the importance of exploring more realistic flood risk mitigation measures for Nigeria should be paramount (OCHA 2012). Flooding in Nigeria are fluvial (resulting from rivers overtopping their natural and manmade defences), coastal (affecting mainly the coastal areas) and pluvial (flash, arriving unannounced following a heavy storm) in nature and have been a major cause of concern for rural areas and cities within the country (Houston et al. 2011, Andjelkovic 2001, Bashir et al. 2012, Douglas et al. 2008). Whilst stake holders' efforts towards tackling the hazard have not yielded satisfactory results, they have been criticized as ad-hoc, poorly coordinated, non-generalizable and not well established (Obeta 2014). However, in the light of 'best practices' in flood risk reduction and 'lessons learned' from other countries' experiences of flooding, it can be argued that such stake holders' efforts are limited due to lack of quality data, which are needed to systematically tackle flooding, poor perception of flooding among the general populace, lack of funds and improved technology as well as poor political will power.

The growing number of flood victims and the constrained sustainable development caused by flooding within the country suggest that much of what is known regarding flooding in the country is deficient on remedies. More critical is the subject-matter of Nigeria being one of the most populated countries of the world with population size estimated at over 170 million people (World Bank 2013). Considering the theory that future population growth will drive future flood risk, this population size along with future estimates spurs interest towards building the capacities of human populations to cope with flooding.

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The widespread flooding in Nigeria along with how to deal with associated challenges has received considerable attention, although more discussions focused on local communities, geopolitical regions and states within the country (for examples: Aderogba 2012a, Adeoye et al. 2009, Ali & Hamidu 2012, Bashir et al. 2012, Agbonkhese et al. 2014, Adedeji et al. 2012, Terungwa & Torkwase 2013, Obeta 2014, Ologunorisa 2004, Ojigi et al. 2013, Aderogba et al. 2012, Ogwuche & Abah 2014, Nwilo et al. 2012, Adelekan 2010). In view of the causes of the hazard, climate change, poor urban planning and environmental management along with anthropogenic activities have been generally listed (Adeoye et al. 2009, Aderogba et al. 2012, Adeloye and Rustum 2011). Although the lack of definite measures and capacity to radically tackle the hazard within the country has been arguably overwhelming, concerted efforts in the form of environmental and infrastructural planning, policy directives, social responses, physical intervention and enhanced public enlightenment programmes have been extensively considered (Agbola et al. 2012, Ali & Hamidu 2012, Bashir et al. 2012). Other measures considered are community based early warning systems (Agbonkhese et al. 2014), humanitarian aids from government and private sectors (Adeoye et al. 2009) and appropriate level of preparedness and capacity building (Adedeji et al. 2012). The need for science and technology to embrace environmental education in Nigeria is highlighted (Terungwa & Torkwase 2013) while food hazard mapping as well as assessment of vulnerabilities of lives and properties which play key roles in building community resilience to flooding is considered (Adeaga 2008, Ajibade et al. 2013, Adelekan 2010, Ologunorisa 2004). The importance of reinforcing present strength and capacities of all agencies, including local communities within Nigeria to deal with flood hazard situations is underlined (Obeta 2014).

Despite the attention flooding received in these studies, still the question: "what is the remedy to the recurrent flooding in Nigeria?" remains unanswered. The lack of flood data and other ancillary data which is a major setback towards containing the threats of flooding in the country were raised but not addressed. Attention has solely rested on general knowledge of the causes, impacts and remedies of flooding; suggesting that the broad view of the situation in these studies has been lop-sided and sloppy. The need for more scientific approaches such a flood modelling which drives flood risk management in more developed countries was not highlighted. A general critique, which should provide a nuanced understanding of the strengths and limitations of present efforts to addressing the threats of flooding in the country, is lacking and gaps between increasing flood occurrences and vulnerabilities of local communities were not identified.

For this reason, the present study besides advancing existing knowledge relating to flooding in Nigeria is an attempt to provide answers to key questions with regards to remedy to flood challenges in Nigeria. The importance of flood modelling in flood risk reduction and the need for it to be included in the country's present efforts at reducing the impacts of flooding is emphasized. The study generally is driven by three key issues – (1) to demonstrate the roles more robust and scientific techniques such as flood modelling can play in flood risk reduction within the context of Nigeria, (2) to align the focus of flood risk reduction in Nigeria with the objectives of such a task in more developed countries such as the US, the Netherlands and United Kingdom, and (3) to promote flood risk awareness in the general public as well as to facilitate delineation of more suitable locations for relocation of human populations during flooding in Nigeria. In pursuance of these goals, the study considers the following specific objectives:

- to investigate and summarize evidence of flooding in Nigeria and to critically review efforts towards addressing its threats in the country,
- to identify knowledge gaps relevant to the reduction of flood risk in the country,
- to present flood modelling as a way-forward towards pro-active flood management activities, and
- to make supported recommendations towards building flood resilient communities.

The general concept of flooding and its remedies are presented in section 2. The methodology and data for the research are discussed in section 3 while the study area is described in section 4. Section 5 focuses on general discussions on flooding in Nigeria and present efforts at tackling the challenge. Section 6 presents relevant recommendations towards a possible way-forward while section 7 gives a general conclusion of the study.

## II. Conceptual Framework of Flooding and its Remedies

Flooding along with its severe impacts on human lives, properties and economic activities is globally acknowledged (Keith 2013, Penning-Rowsell et al. 2005). Conceptually, flooding is the result of water overtopping its natural and manmade defences and overflowing places not typically submerged (Smith & Ward 1998). It is also a result of sudden arrival of heavy storms, which overwhelms soil infiltration capacity and urban drainage systems. In the literature, it is claimed that flooding is the most widespread hazard phenomenon on natural environments, accounting for more than 40% (both in frequency of occurrence and potential for losses) of the total disasters globally (Nwilo

et al. 2012, van der Sande et al. 2003). From wave dynamics, flooding is described as a down-slope propagation of attenuated longitudinal wave motion with inundation extent, depth and duration, as well as water flow velocity (Chow et al. 1988). Various forms of flooding can be identified including fluvial, coastal and those resulting from pluvial events which in recent times have threatened many urban areas (Ward & Robinson 2000, Lauber 1996, Hassan 2013).

Arguably, these urban floods are becoming more widespread nowadays and causing significant loss of life and property due to the large number of population exposed within the cities (EA 2007, Gupta 2007, Jha et al. 2012 Chen et al. 2009, Jeffers 2013). In the US, 32.9% of the total natural disasters in 2012 were hydrological with urban floods accounting for the most part, affecting more than 9 million people and causing about US$ 0.58 billion worth of damage (CRED 2013). The same source shows, for that year, more than US$4.7 billion worth of damage recorded for Europe, and about US$0.83 billion and US$19.3 billion damage for Africa and Asia respectively resulting from urban flooding. Four different floods that hit United Kingdom cities in 2012 caused a total loss of $2.9 billion, with many human populations affected (CRED 2013).

Increased frequency and intensity of rainfall drives pluvial floods and is a major cause of concern for urban areas (IPCC 2007). Urban areas are significant in the economic and political development of regions and states (Holton 1998, Sassen 2000, Cohen 2004). However, urbanization is an important anthropogenic influence on climate change especially in forcing increased rainfall intensity and frequency (Kalnay & Cai 2003, Seto & Shepherd, 2009). Impervious surfaces which are extensive in urban areas influence local and regional hydrology by increasing surface water runoffs and causing peak discharge and reduced time of peak (Mujumdar 2001, Hümanna et al. 2011). These are pertinent issues to environmental management, urban planning and flood risk reduction. However, urbanization along with rapid population growth in most places for example the developing countries (DCs) have been unaccompanied by adequate urban planning (Adeloye & Rustum 2011).

Flood risk is linked to exposure of social systems to flood hazards (in the form of flood water depth, extent, duration and velocity of flow) and their vulnerabilities (the propensity to be adversely affected by flooding caused mainly by lack of coping capacity) (Birkmann 2006, Crichton 1999, Balbi et al. 2012). It is also the product of likelihood of occurrence of flood hazard and its consequences identified as possible losses resulting from flooding (Brooks 2003, Smith & Ward 1998, Jeffers 2013). Likelihood of occurrence of flooding can be defined as the percentage probability of flood return period. Within research spheres, the likelihood of flood occurrence is generally delineated by the 100-year flood (EA 2010). Globally, these are key issues which are driving activities towards reducing the risk of flooding across various regions and states (Houston et al. 2011, Agbola et al. 2012, EA 2009, Merz et al. 2010).

Driven by the predictions of worsened flood risk in the future coupled with the notion that floods are inevitable phenomenon which can never be fully constrained within the natural environment (Milly et al. 2002, Nijland 2005, IPCC 2008, Hirabayashi et al. 2013), efforts towards tackling flooding are based on reducing its impacts on human population, development infrastructure and economic activities (DEFRA 2013, UN/ISDR 2004). These efforts have been fundamental to the "living with floods and not fighting them" idea, which dominates key environmental risk research themes (for examples: Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA)) (Balbi et al. 2012, 2004Di Baldassarre & Uhlenbrook 2012), and by improving the awareness of flooding in local communities, provision of data and technical know-how as well as provision of funds towards building a community of human populations who are able live with floods as well as securing critical infrastructure against flood losses, has driven approaches towards addressing the challenges of flooding in places like China, the Netherlands, United Kingdom and the United States (Burby 2000, Kazmierczak & Carter 2010, EA 2009, Merz et al. 2010, Zhu et al. 2011, UN/ISDR 2004, Merz et al. 2010, CEA 2007, CRED 2013).

Flood risk reduction is a multi-disciplinary approach which integrates structural and non-structural measures to achieve the key elements of risk management which are: prevention/mitigation, protection, preparedness, emergency response, recovery and lessons learned (Zhu et al. 2011, EC 2004, Tarlock 2012, UN/ISDR 2007). The realization of these key elements appeared to have undermined structural measures which basically include engineering works aimed at containing water disruptions in rivers, thereby reducing exposure to flooding and susceptibility to flood damage (WMO 2008). On the contrary, non-structural measures do not involve physical constructions; instead focus is on knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training, education and research and include: flood insurance, assessment of vulnerability to flooding which provides information that will enable the classification of a given population with regards to their lack of capacity to cope with the hazard, flood risk/hazard mapping, creating public awareness, relocation of exposed human populations, land-use zoning, flood proofing, flood forecasting and flood early warning systems (WMO 2008, Keith 2013, UN/ISDR 2009 Tate and Cutter 2010 Brilly & Polic 2005, Kundzewicz 2002, Plate 2002).

The success of flood risk reduction can be said to depend to a large extent on knowledge-based decision, robust institutional framework and flood risk communication. Knowledge-based decision uses available information relating to flooding to draw conclusions on possible strategies to be adopted for flood risk reduction. The creation of awareness in stake holders and local communities regarding flooding and its impacts is driven by flood risk communication. Institutional framework includes government response procedures, policies, regulations, guidelines as well as to government agencies engaged in planning and managing flood emergency conditions or in helping victims to cope and recover speedily from extreme flood events (Obeta 2014). Invariably, these three factors require information relating to flood hazard and its consequences which flood risk/hazard maps or some form of graphical representation delineate within an area, as well as public opinion, research findings, empirical results and expert knowledge.

Research has shown that flood characteristics (most notably flood water depth, extent and duration as well as flow velocity) obtained through accurate assessment of flooding are required to produce flood risk/hazard maps (de Moel et al. 2009, Merz et al. 2007). Thus for flood risk/hazard mapping accurate assessment of flooding should not be ignored. Meanwhile, the making of these maps is of scientific significance as it requires critical understanding of the drivers of flood hazard/risk. In the flood risk/hazard assessment literature, flood modelling plays considerable roles. Under the EU commission directive on flood, the United States flood control policy, national flood insurance program (NFIP) and other regionally-based flood risk management policies, the relevance of flood information to both flood risk/hazard mapping and flood risk reduction highlights the significance of flood modelling. For this reason, the key roles of flood modelling can be summarized as follows:

- Description of flow behaviour around groups of buildings and other complex geomorphological features especially in assessment of urban flooding (Bates et al. 2010).
- Ability to provide critical information for strategic planning of flood defence measures and effective flood risk management such as temporal inundation information about the onset, duration and passing of a flood event. (Zerger, 2004, Grimier 2013).
- Leads to an improved understanding of the flood phenomena, provides insight into the causes of flooding and guide through more appropriate measures to be taken to reduce flood damage (Chow et al. 1988).
- Promotes understanding of the complicated nature of flow patterns around floodplain and promotes community's confidence in the process of flood risk reduction (Bedient et al. 2008).
- Serves as the basis for flood forecasting, flood early warning system and flood damage estimation, as well as provides the basis for the decision making of flood risk management (EA, 2007).
- Serves as the basis for producing flood risk/hazard maps that community officials or the general public can use to evaluate their flood risk and analyse possible evacuation procedures (de Moel 2009).

Flood modelling generally predicts flood hazard characteristics such as water flow depth, flow velocity and inundation extent which are required for estimating the likelihood of flood hazard and its impacts required for flood risk/hazard mapping (Moussa and Bocquillon 2009, Chow et al. 1988). Although possible ways of acquiring these data include ground survey methods and remote sensing technology, however, ground survey methods often require enormous field work and keeping of long-term records while remote sensing requires expert knowledge. The cost of acquiring remote sensing data and software for processing them can be overwhelming. Although in a number of investigations, globally available datasets such as Advanced Spec-borne Thermal Emission and Reflection Radiometers Global Digital Elevation Model (ASTER GDEM), Shuttle Radar Topographic Mission (SRTM) and global flood data have been utilized (Ho et al. 2010, Manfreda et al. 2011). However, it can be shown that due to scale and accuracy requirements, these global datasets do not provide realistic estimates of flood assessment and using them as basis for making decision towards flood management can be misleading (van de Sande et al. 2012, Tarekegn et al. 2010).

These challenges and perhaps the recognition of the relevance of data in flood risk reduction further highlight the importance of flood modelling, which is governed by the science and mathematics of hydrology. The prospects of flood modelling in assisting flood risk management in various parts of the world are acknowledged. In the Netherlands, flood modelling, among other roles, supports investigation into estimation of damage caused by flooding (Jonkman et al. 2008, Vis et al. 2003). Within European Union framework, flood modelling plays a considerable role towards flood hazard/risk mapping of the constituting States, as well as development of flood forecasting and early warning systems (EC 2007). Several flood modelling packages exist in the US for tackling fluvial and urban flood through simulation of discharge hydrographs (EA 2010). Several engineering works aimed at constraining floods from River Thames are based on water levels simulated by means of existing flood models (Neil et al. 2011). Many Asian countries, notably China, Vietnam and Bangladesh although having 'not too well' established flood management

policies utilize flood modelling methodologies for flood risk assessment and mitigation (Renyi & Nan 2002, Huong & Pathirana 2011).

Based on ample evidence, the results of flood risk mitigation supported by flood modelling in these exemplar locations have been satisfactory (Van Alphen et al. 2009, Kovacs & Sandink 2013). For this reason and on the basis of effectiveness and robustness as well as enhanced efforts in flood risk mitigation in Nigeria, the present study makes argument in favour of flood modelling. Although, existing flood models are rife with limitations which may constrain their applications in Nigeria, however, developing bespoke flood models for Nigeria can be a priority. This need for flood models was emphasized by the DG of Nigerian Hydrological Services Agency (NIHSA 2013) in a recent mission statement:

*"…in view of flooding in Nigeria, governments at all levels should create awareness on the need for communities to relocate to safer terrain. Moreover, while the current trends in climate variations prevails, the need to develop flood modelling and early warning systems cannot be overemphasized… There is also need to carry out a comprehensive flood hazard mapping for all areas considered at risk of flooding in the country…"*

## III. Method and Data

A search process to identify the body of literature relevant to flooding and efforts towards addressing its threats in Nigeria was undertaken. Combination of terms such as "flooding and management in Nigeria", "flooding and human health in Nigeria", "flooding and modelling in Nigeria" and "flooding and climate change in Nigeria" was applicable to the search. Overall, 429 publications were identified of which 17 focused on the causes of flooding in Nigeria, 132 addressed the impacts, 181 discussed the remedies, 54 looked at climate change issues, 14 discussed public perception of flooding while 31 addressed urban management and planning. These findings are fundamental to discussions presented in this paper. The scientific quality of these papers was assessed based on the publishing journal. This is consistent with academic standard and regulations. Although locally published articles provided most of the information to establish the case in the present study, however, the greater weight was given to articles published by Elsevier, Science Direct, Taylor and Francis, Wiley and sons, ASCE, Nature, Sage, Springer and Copernicus publishers and on International conferences.

The data that provided much of the evidence regarding the prevalence of flooding in Nigeria was sourced from EM-DAT database, Nigerian ministry of Environment and from previous studies.

### *a) Description of the study area*

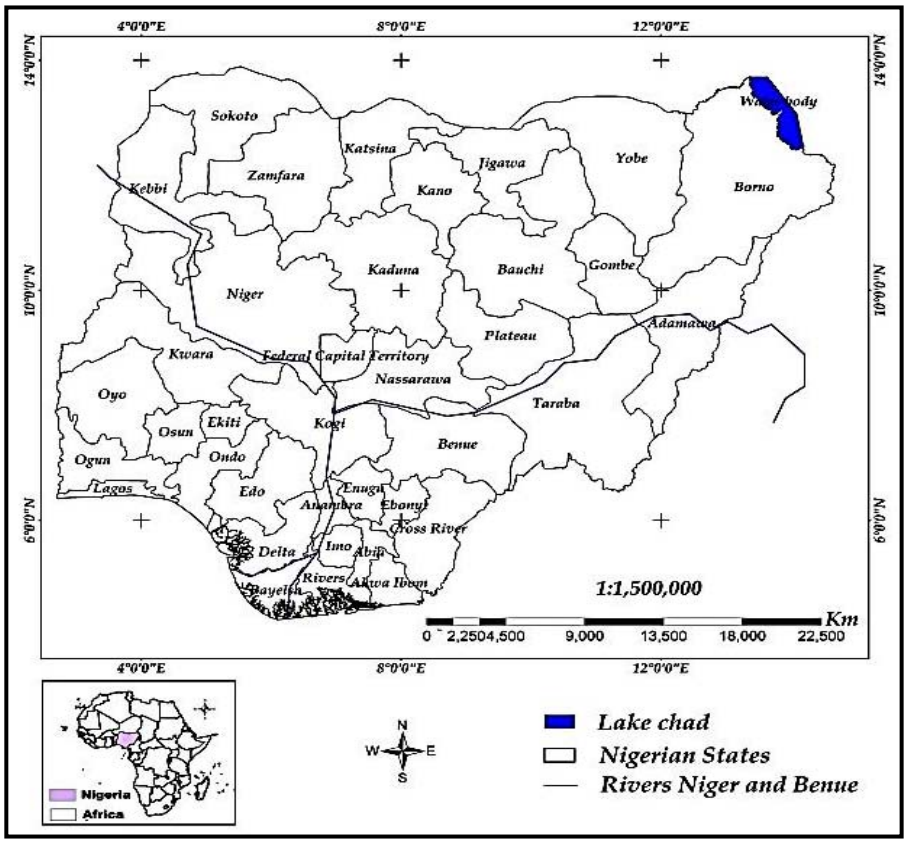
Nigeria, a sub-Saharan West African country, is on the Gulf of Guinea, east of the Greenwich and north of the equator. The country, made up of 36 states including the federal capital territory (FCT), Abuja, lies between latitudes 4° and 14°*N*, and longitudes 2° and 15°*E*, with a total land area of 923,768 $km^2$ (See figure 1), and borders with Republics of Benin and Niger, Chad, and Cameroon. It maintains a large expanse of coastline, over 853 *km* in magnitude, with hydrological features which includes the rivers Niger and Benue, both of which confluence at Lokoja, and flows further southwards through the Niger Delta into the Atlantic ocean.

The 2006 census confirmed over 140 million people in Nigeria, but this population has grown steadily, and is presently estimated at more than 170 million people, making the country the seventh most populous country in the world (NPC 2007, World Bank 2013). According to United Nations projections, Nigeria is one of the eight countries expected to account collectively for half of the total population increase in the world from 2005-2050, and will by 2100, record a population amounting between 505 million and 1.03 billion people (United Nations 2004). Rapidly growing population along with urbanization which appear not to be accompanied by corresponding strategies to support humanitarian needs and anthropogenic activities characterize Nigeria. This concern has not received adequate attention in the literature, especially with regards to the implications of future urban scenarios on environmental sustainability.

## IV. Result and Discussion

### *a) Flooding in Nigeria*

Flooding in Nigeria is generally linked to poor urban planning and climate change (Adeloye & Rustum 2011, Action Aid 2006, Cline 2007, BNRCC 2008). The impacts have been severe and every part of the country's life stream is affected with significant economic losses (mainly through destruction of farmlands, social and developmental infrastructure) and economic disruption (most notably in oil exploration in the Niger delta, traffic congestion in many cities in Nigeria, disruption in telecommunication and power supply) (Ogunbodede & Sunmola 2014, Ologunorisa 2005, Fadairo & Ganiyu 2010). In 2012, the country experienced the worst flooding in more than 40 years as a result of heavy storms that lasted many days. The incidence affected 32 states with 24 considered severely affected (NEMA 2013). The floods lasted from July to October that year and affected 7.7 million people with more than 2 million others reckoned as internally displaced (IDPs). More than 5000 people were physically injured along with over 5900 houses which were destroyed.




Source: Drafted by the authors.

*Figure 1 :* Map of Nigeria showing the 36 states and Rivers Niger and Benue. Inset is Africa showing Nigeria's location

Historically, flooding in Nigeria dates back to the early 1950's with coastal and fluvial floods. Such floods which affected mainly coastal environments were influenced by seasonal interruption of major rivers and water overtopping their natural and artificial defences (Akintola 1994). Fluvial floods account for the majority of the flood threats experienced in locations along the plains adjoining major rivers in the country, including rivers Niger, Benue and Hadeja. The states in Nigeria mostly affected are Adamawa, Kano, Niger, Jigawa, Kaduna, Cross River and Kebbi (Iloje 2005, Agbola et al. 2012). The worst fluvial flood in Nigeria was the Kano state flood disaster of 2006 which affected hundreds of thousands of lives with economic loss worth millions of US dollars (Adebayo and Oruonye 2012). Coastal floods in Nigeria affect the low-lying areas in the southern part of the country (comprising for examples Lagos, Oyo, Ondo, Akwa-Ibom and Bayelsa states). The impacts of such floods have been severe due to the number of human populations exposed as a result of the attractions of coastal areas for economic and social reasons (Adelekan 2010). Globally, Nigeria is ranked among the top 20 countries exposed to coastal flooding based on present population and future scenarios in the 2070s (including climate change and socio-economic factors) (Table 2).

Flooding due to pluvial events which usually occurs annually during rainy seasons, between July and October, ravaging many cities within the country is most frequently experienced. Presently the occurrence of such floods which implicates poor urban planning (in particular inadequate drainage system and the range of urban utilities) is an issue of global significance within the contexts of climate change and flood risk mitigation (Adeloye & Rustum 2011).

From existing literature, it is clear that the impacts of flooding in Nigeria continue to trigger concerns for food security, vulnerability of local communities within the country, humanitarian needs and services, primary health delivery, environmental management, solid waste management, urban development, professionalism in journalism practice and the dynamism or lethargy of Nigerian democracy and political system (Clement 2012, Adelekan 2010, OCHA 2012, Uzochukwu et al. 2014, Ochuko 2014, Obeta 2014, Douglas et al. 2008). Whilst investigating these factors vis-à-vis flood risk mitigation in Nigeria is vital, key features of flooding which influence its level of impacts in the country include flood water depth, inundation extent and duration of inundation. Respectively, flood width, height, annual frequency and duration in Nigeria can measure over 700*m*, 11*m* 10

*Table 1 :* Top 20 countries ranked in terms of population exposed to coastal flooding in the 2070s (including both climate change and socio-economic change) and showing present day exposure

| Rank | Country | Urban Agglomeration | Exposed Population (Current) | Exposed Population (Future) |
|---|---|---|---|---|
| 1 | India | Calcutta | 1,929,000 | 14,014,000 |
| 2 | India | Mumbai | 2,787,000 | 11,418,000 |
| 3 | Bangladesh | Dhaka | 844,000 | 11,135,000 |
| 4 | China | Guangzhou | 2,718,000 | 10,333,000 |
| 5 | Vietnam | Ho Chi Minh City | 1,931,000 | 9,216,000 |
| 6 | China | Shanghai | 2,353,000 | 5,451,000 |
| 7 | Thailand | Bangkok | 907,000 | 5,138,000 |
| 8 | Myanmar | Rangoon | 510,000 | 4,965,000 |
| 9 | USA | Miami | 2,003,000 | 4,795,000 |
| 10 | Vietnam | Hai Phòng | 794,000 | 4,711,000 |
| 11 | Egypt | Alexandria | 1,330,000 | 4,375,000 |
| 12 | China | Tianjin | 956,000 | 3,790,000 |
| 13 | Bangladesh | Khulna | 441,000 | 3,641,000 |
| 14 | China | Ningbo | 299,000 | 3,305,000 |
| *15 | **Nigeria** | **Lagos** | **357,000** | **3,229,000*** |
| 16 | Cote d'ivoire | Abidjan | 519,000 | 3,110,000 |
| 17 | USA | New York | 1,540,000 | 2,931,000 |
| 18 | Bangladesh | Chittagong | 255,000 | 2,866,000 |
| 19 | Japan | Tokyo | 1,110,000 | 2,521,000 |
| 20 | Indonesia | Jakarta | 513,000 | 2,248,000 |

*(Source: Nicholls et al., 2007, OECD, Paris)*

and 25 days respectively (See table 3) (Aderogba 2012). It is shown from EM-DAT database that most floods in Nigeria lasted up to 79 days. Thus based on these features, the dangers posed to human lives and properties by flooding in Nigeria can be appreciated (See figure 2).

The lack of a comprehensive flood record, a gap in knowledge which the present study attempts to address, seems to constrain both a better understanding of the spatial and temporal distribution of the hazard across the country and efforts towards addressing the challenges. Although reports from the media and humanitarian agencies highlight the gravity of flood situation in the country, inconsistency of flood narratives in Nigeria is overwhelming (Olalekan 2013). During flooding episodes in Nigeria, there is often an increase in journalistic and non-quantitative evidence which whilst rife with uncertainties seem to exaggerate the impacts of flooding in the country. However, based on data sourced from EM-DAT, CRED and Dartmouth Flood Observatory (DFO) databases and from previous studies (examples: Adeoye et al. 2009, Adebayo and Oruonye 2012, Agbola et al. 2012, Obeta 2014), the widespread nature of flooding in Nigeria can be investigated

Against this background, the present study brings together available flood data on historical flooding in Nigeria from 1985 till 2014 (see table 4). This move extends recent investigations by Adebayo and Oruonye (2012), Adeoye et al. (2009), Etuonovbe (2011), Agbola et al. (2012) and Obeta (2014). It is believed that this record will give incentive for awareness of flooding among vast human population and local communities, as well as promote future investigations towards predicting probabilistic flooding for the country and formulating more effective ways of addressing the challenges of flooding.

*Table 2 :* observed flood width, depth, frequency and durations for 25 cities and towns in Nigeria. Highest values are 747.00m for mean width, 11.88m for depth/height, 10 times for frequency of occurrence per annum and 25 days for flood duration

| Location | Mean Width (meters) | Highest Experienced Height (meters) | Mean Frequency (Per Annum) | Mean Longest Durations ever lasted (days). |
|---|---|---|---|---|
| Assaba | 125.00 | 7.88 | 6 | 10 |
| Abuja | 163.00 | 6.20 | 5 | 4 |
| Abeokuta | 115.05 | 7.32 | 6 | 8 |
| Aba | 235.00 | 7.54 | 5 | 15 |

| | | | | |
|---|---|---|---|---|
| Ibadan | 521.45 | 9.20 | 3 | 7 |
| Owerri | 124.04 | 8.21 | 5 | 7 |
| Warri | 221.25 | 7.28 | 6 | 16 |
| Benin City | 198.00 | 8.90 | 8 | 12 |
| Jalingo | 115.00 | 7.37 | 4 | 5 |
| Enugu | 147.72 | 7.35 | 5 | 6 |
| Lagos Metropolis | 747.00 | 11.88 | 10 | 25 |
| Kano | 110.00 | 9.72 | 3 | 8 |
| Kaduna | 128.00 | 9.53 | 5 | 12 |
| Katsina | 122.00 | 6.25 | 4 | 11 |
| Sokoto | 114.25 | 7.02 | 6 | 4 |
| Port-Harcourt | 121.21 | 8.12 | 4 | 18 |
| Ondo | 124.75 | 7.80 | 8 | 11 |
| Ogbomosho | 118.00 | 9.55 | 3 | 12 |
| Osogbo | 111.00 | 9.73 | 8 | 13 |
| Onisha | 128.00 | 7.65 | 4 | 4 |
| Calabar | 213.00 | 7.53 | 8 | 11 |

*Source: Aderogba 2012*

*Source: Online images of flooding in Nigeria. www.floodinginnigeria*

*Figure 2 :* Evidence of flooding impacts in Nigeria

*Table 4 :* Spatial and temporal distribution of significant floods in Nigeria from 1985 to 2014

| S/No. | DATE (BEGAN) | CITY (LGAs) | STATE (S) | DURATION (DAYS) | CAUSE (S) | NO OF PEOPLE AFFECTED | MORTALITY | SIZE OF LAND ($KM^2$) | ECONOMIC LOSS (billion US$) | AFFECTED HOUSES |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 13-Sept-2014 | Ibadan and environs | Oyo | 1 | Torrential rainfall | 10000 | 15 | N/A | | Many |
| 2. | 14-Apr-2013 | Various | Southern area | 5 | Torrential rainfall | 81506 | 19 | N/A | | Many |
| 3. | July 2012 | Many* | 32 States in Nigeria | 120 | Heavy rain, dam/levee break, | 7705378 | 363 | Large expanse of farmlands. | 16.9 | Many* Registered IDPs amount to more than 2000000. |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4. | 13-Sept-2010 | Many | Jigawa, Sokoto, Kebbi | 18 | Dam/Leve e break | 1500200 | 40 | N/A | 0.03 | Many houses |
| 5. | 21-Jun-2011 | Many | Kano | 5 | Torrential rainfall | 950 | 24 | N/A | | Farmlands, many houses. |
| 6. | 15-Jul-2011 | Urban areas | Lagos and Katsina | 5 | Heavy rains | 26950 | 20 | N/A | | Damaged urban infrastructure (roads, schools, houses |
| 7. | 20-Oct-2011 | Lagos metropolis | Lagos | 9 | Heavy rains | Thousands | 10 | Nil | | Damaged urban infrastructure (roads, schools, bridges, houses |
| 8. | 26-Aug-2011 | Ibadan and environs | Oyo | Many days | Heavy Rain (Urban flooding) | Thousands | 8 | | | Damaged urban infrastructure (roads, schools, bridges, houses and markets) |
| | 14-Aug-09 | 13 LGA's | Edo | Many days | Heavy Rain (Urban flooding) | Thousands | Nil | Nil | | Damaged urban infrastructure and displaced people. |
| 9. | 20-Oct-09 | Obio / Akpor | Rivers and Delta | 7 | Heavy Rain | 5000 | Nil | 53020 | | 200 |
| 10. | 10-Sep-09 | Gusau | Zamfara | 9 | Heavy Rain | 3000 | Nil | 64200 | | > 5000 |
| 11. | 04-Aug-07 | 50 LGAs* across affected the States were inundated | Plateau, Borno, Delta, Adamawa, Anambra, Bauchi, Yobe, Niger, Taraba, Ebonyi Cross-River, and Bayelsa | 79 | Heavy Rain | 140,000 | 101 | 630,100 | | >18, 859 houses were washed away, with villages and farmlands. |
| 12. | 01-Aug-07 | Ikorodu, Kosofe and Abeokuta | Lagos and Ogun | 15 | Heavy Rain | 5000 | 6 | 5270 | | 5000 |
| 13. | 12-Sep-06 | Obe-ile and Ekiti | Kwara | 2 | Brief Torrential Rain | Nil | 20 | 870 | | Nil |
| 14. | 18-July-06 | Abuja and Maraba | Nasarawa | 3 | Heavy Rain | 40 | 4 | 1851 | | Many* |
| 15. | 15-July-06 | Auchi Township | Edo | 3 | Heavy Rain | 2000 | Nil | 724 | | 500 |
| 16. | 28-Sep-05 | 5 LGAs* | Yobe | 4 | Heavy Rain | 1500 | Nil | 11550 | | >300 |
| 17. | 07-Aug-05 | 8 LGAs* across affected the States were inundated | Jigawa, Bauchi, Taraba, and Yobe | 41 | Heavy Rain | 7 | 3 | 159500 | | 5400 |
| 18. | 21-Aug-04 | 10 LGAs* | Gombe | 3 | Heavy Rain | 3000 | 25 | 20780 | | 1500 |
| 19. | 08-July-04 | 4 LGAs* | Adamawa | 5 | Heavy Rain | 2500 | 65 | 5480 | | 500 |
| 20. | 08-July-04 | Ugheli | Delta | 3 | Heavy Rain | 15000 | Nil | 510 | | 3000 |
| 21. | 22-Jun-04 | 2 LGAs* | Jigawa | 4 | Heavy Rain | 300 | Nil | 8720 | | Farmlands |
| 22. | 17-Jun-04 | Lagos city | Lagos | 2 | Heavy Rain | Nil | Nil | 340 | | Drainages |
| 23. | 22-Sep-03 | 15 LGAs* | Adamawa and Benue | 19 | Heavy Rain | 1000 | 28 | 137700 | | >203 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 24. | 05-Sep-03 | 41 LGAs* | Kaduna, Kano, Niger and Jigawa | 54 | Heavy Rain | 210000 | 16 | 134900 | 0.00257 | >30000 |
| 25. | 08-Aug-03 | 18 LGAs* | Jigawa and Katsina | 17 | Heavy Rain | 16000 | 1 | 19630 | 0.04 | 1500 with farmlands |
| 26. | 05-Aug-03 | 5 LGAs* | Sokoto and Niger | 69 | Heavy Rain | 10000 | 7 | 138900 | | 30000 |
| 27. | 27-July-03 | 3 LGAs* | Benue | 1 | Heavy Rain | 3000 | 2 | 2620 | | 52 |
| 28. | 22-July-03 | 4 LGAs* | Gombe | 3 | Heavy Rain | 160 | Nil | 1520 | | 40 |
| 29. | 23-July-03 | 6 LGAs* | Cross-River | 3 | Heavy Rain | Nil | 5 | 8170 | | Unknown* |
| 30. | 28-July-03 | 3 LGAs* | Kano | 2 | Brief Torrential Rain | 800 | 1 | 790 | | 200 |
| 31. | 07-Jun-03 | 6 LGAs* | Jigawa | 2 | Heavy Rain | 2000 | Nil | 5710 | | 100 |
| 32. | 24-July-02 | Lagos city | Lagos | 3 | Heavy Rain | Nil | 2 | 1650 | | Many* |
| 33. | 27-Aug-01 | 14 LGAs* | Kano and Jigawa | 9 | Dam/Levee break | 80000 | 200 | 14300 | | 60 Villages |
| 34. | Sept 2000 | Pai | Taraba | N/A | Flash | | | | | Thousands of people |
| 35. | 22-July-01 | Talata and Maraba | Zamfara | 1 | Heavy Rain | 3802 | Nil | 1060 | | 3802 |
| 36. | 20-Sep-00 | Lagos city | Lagos | 2 | Brief Torrential Rain | Nil | Nil | 7700 | | Tens of thousands |
| 37. | Aug/Sept-00 | Ibaji-Gurar | Kogi | N/A | Levee break | 150000 | Nil | N/A | | Many* |
| 38. | Sept/Oct-00 | Katsina-Ala | Benue | N/A | Fluvial causes | Nil | Nil | N/A | | Several sizes of farmlands and crops |
| 39. | 26-Oct-99 | 7 LGAs* | Imo | 14 | Heavy Rain | Nil | 50 | 251300 | | Many* |
| 40. | 15-Sep-99 | Not specified | Niger, Sokoto, Kaduna, Adamawa and Borno, with some parts of Ghana and Togo | 27 | Heavy Rain | 396748 | 85 | 862000 | 0.021 | Many*, but worst in Ghana and Togo |
| 41. | 12-Oct-98 | Western area | Kwara | 7 | Heavy Rain | 110000 | Nil | 29090 | | Many*, not specified |
| 42. | 15-Aug-98 | Okunmi | Kano | 2 | Heavy Rain | 5000 | 15 | 39720 | | Many*, not specified |
| 43. | 30-Apr-97 | Ibadan | Oyo | 2 | Heavy Rain | Nil | 5 | 17290 | | Many houses collapsed |
| 44. | 07-Aug-95 | Jos | Plateau | 4 | Heavy Rain | Nil | 30 | 19770 | | 5300 domestic animals killed |
| 45. | 11-Sep-94 | Mai and Agadez | Borno and Niger | 5 | Heavy Rain | 180000 | 142 | 317300 | | Properties up to millions of naira, with foodstuffs and livestock |
| 46. | 22-Sep-92 | Mubi and Madagali | Adamawa and Borno | 2 | Heavy Rain | 13000 | 9 | 42370 | | Roads and Farmlands |
| 47. | 04-Aug-91 | Hadeia | Kano | 2 | Heavy Rain | 10000 | 4 | 22910 | | Farmlands |
| 48. | 16-Sep-90 | Not specified | Edo | 6 | Heavy Rain | 300000 | 6 | 36120 | | Farmlands |
| 49. | 02-Aug-90 | Agbara and Gbakolo | Cross-River | 2 | Heavy Rain | Nil | 100 | 5520 | | Hundreds of farmlands |
| 50. | 03-Jul-90 | Lagos city | Lagos | 2 | Heavy Rain | 3000 | 5 | 3420 | | Many*, not specified |
| 51. | 27-Oct-88 | Kaissama | Bayelsa | 2 | Heavy Rain | 12000 | 10 | 2830 | | 12000 |
| 52. | 21-Sep-88 | Abuja city and 12 ommunities in Anambra | FCT, Niger and Anambra | 15 | Dam/Leve e break | 70000 | Nil | 8880 | 0.001 | Many*, not specified |

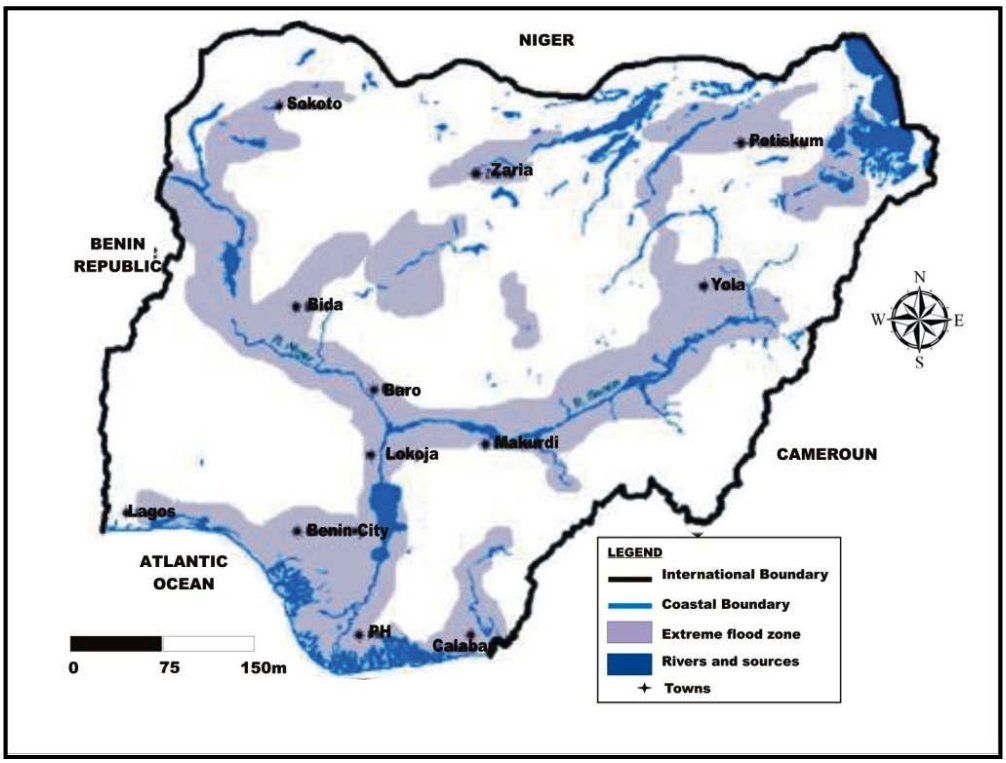
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 53. | 14-Sep-88 | Oshogbo and 76 villages in Sokoto | Oyo and Sokoto | 13 | Brief Torrential Rain | 136000 | 7 | 71960 | | Up to 300000 |
| 54. | 22-Aug-88 | Port Harcourt city | Rivers | 1 | Heavy Rain | 10000 | Nil | 1230 | | 60 |
| 55. | 07-Aug-88 | 15 LGAs* | Kano | 14 | Heavy Rain | 200000 | 53 | 60620 | 0.0142 | Roads and Farmlands |
| 56. | 02-Jul-88 | Lagos city | Lagos | 2 | Heavy Rain | 500 | Nil | 1960 | | Hundreds of inhabitants |
| 57. | 23-Sep-85 | Niger River | Niger | 3 | Heavy Rain | 6000 | Nil | 74620 | | Many*, not specified |

*Sources: Dartmouth Flood Observatory (DFO): available online at http://www.dartmouth.edu/~floods/Archives/index.html, CRED, NEST, EM-DAT, and previous studies.*
**Grouped as the affected LGAs and locations were not specified.*

From table 4, it can be shown that flooding over the period under review has affected more than 11 million people with death toll exceeding 1100 in all. The economic implication of these events has exceeded 17 billion US dollars. Whilst these records are overwhelming in view of the country's gross economic reserve, human resources, environmental management and sustainable development, variations in the frequency of occurrence of floods that appear to vary among individual states are highlighted.

Based on the table, it can be shown that although flooding is common among various states of Nigeria, more frequent floods are recorded in Lagos, Niger, Adamawa, Kano, Oyo and Jigawa states. Whilst Lagos state flooding can be attributed to coastal influence among other key factors, the influence of rivers such as Niger, Benue, Ogun and Hadeja may account for the rest of the states with more frequent floods. These findings are consistent with the result of a recent investigation of flood prone zones in Nigeria (figure 3) carried out by the federal ministry of environment (FME 2012).

Comparing the most devastating floods in the world between 1985 and 2014, it can be clear where Nigeria stands in global and regional perspectives in term of economic and human impacts of flooding. Considering the 2012 floods in Nigeria which are reputed as the worst in more than 40 years, Nigeria ranks third in the world, within the period under review, following Peoples Republic of China and Soviet Union and topmost in Africa, overtaking Mozambique and Algeria in terms of economic loss. This reality should inspire more proactive efforts towards addressing the challenges of flooding in the country.




*Source: Federal Ministry of Environment (2012)*

*Figure 3 :* Spatial distribution of areas affected by extreme floods in Nigeria between 2000 and 2012

Apart from China which presently reputes as the most flood prone country in the world, characterized by recurrent perennial floods due to among other things, the influence of population growth and mainly the River Yangtze (Zhang et al 2006). The fact that other countries with known extreme flooding experience (for examples: Netherlands, the US, Brazil, United Kingdom and many other European countries) are presently ranked below Nigeria suggest among other things that more effective flood risk mitigation measures are presently in place in those countries.

The Netherlands with more than half of the country at or below sea level experienced a severe flood in 1953 which devastated majority of the nation's economic and human infrastructure. The estimated impact of the flood was 1835 deaths and 1 billion Dutch guilders (US$ 558 million). That flood challenged various stake holders, particularly the local communities and Dutch government towards more effective strategies of mitigating the threats of flooding. The result of this is seen in the reduced impacts of flooding in the country in recent times. The flood of 1972 in the US caused 238 deaths, 357 injuries, about 1335 homes destroyed with estimated fiscal loss of over 800 million US$. In the UK, the 1947 floods were considered the worst in recent history with overall impact estimated at merely £4.5 million (USD$ 6.81 million) at current value, with millions of devastated human populations, farm animals and agricultural products (EA 1993). Recent floods in the US and UK have not reached this magnitude in their impacts. For Brazil, compared to the floods of 2010, the flood of 1967 which claimed 610 lives, costing about US$1.2 was considered the deadliest in that country's history.

In view of these analogies, it can be argued with regards to these countries, that considerable progresses have been made at reducing the impacts of flooding especially on human population and critical infrastructure whilst building the resilience of the people and encouraging adaptability strategies. For this reason, Nigeria's position in global and regional perspective requires that various stake holders should focus attention on ways of improving more effective flood reduction measures for the country such as inclusion of flood modelling techniques. This need is more urgent considering climate change scenarios, poor urban planning, along with a number of remote factors such as the topography of the country (most places for example the Lagos metropolis, are almost flat), anthropogenic activities (mainly through indiscriminate disposal of solid waste, concentration of slum developments, non-compliance with regulations, sloppy attitude towards weather warnings and alerts, roadside car washing), poor perception of flooding among local communities, poor legislation and enforcement of regulations, and the presence of large hydrological network (for example rivers Niger and Benue, canals, harbour, lagoons and beaches and the Atlantic ocean) which are influencing flooding and other conditions in Nigeria (Ologunorisa 2005, Aderogba et al. 2012, Aderogba 2012a, Agbola et al., 2012),

*b) Present efforts towards tackling flooding in Nigeria*

The means of tackling flooding in Nigeria include but not limited to structural measures (such as dams, bridges and drainage systems), policy formulation, physical intervention, social measures and research, relocation of human populations and relief assistance to internally displaced persons (Olorunfemi 2011, Odunuga 2008, NIHSA 2013, Obeta 2014). These efforts are driven by institutional approach (including government ministries, departments and agencies), local communities and the general public, humanitarian organizations and international bodies, the media and the academia.

Institutional approach in Nigeria is as old as disasters in the country and generally includes agencies and departments under the Federal Ministry of Environment (FME). For tackling floods in the country, the key institutions include: Federal Emergency Management Agency (FEMA), National Emergency Management Agency (NEMA), State Emergency Management Agency (SEMA), Local Emergency Management Agency (LEMA), National Orientation Agency (NOA), National Environmental Standards and Regulations Enforcement Agency (NESREA) which by 2009 Nigerian Acts supersedes the FEPA, Nigerian Meteorological Agency (NIMET) and Nigerian Hydrological Services Agency (NIHSA) (Ibitoye 2007).

With NEMA as a coordinating body, specific actions towards tackling flooding in Nigeria can be conceived as follows: policy formulation, data collation from relevant agencies, education of the general public on flooding, distribution of relief materials to disaster victims within the states and local government areas (LGAs), protection and development of the environment through enforcement of all environmental laws, guidelines, policies, standards and regulations in Nigeria, as well as enforcing compliance with provisions of international agreements, protocols, conventions and treaties on the environment to which Nigeria is a signatory (key roles of NESREA), provision of reliable and high quality hydrological and hydrogeological services and data on a continuous basis (key roles of NIHSA, which since 2013 has been creating awareness of flooding through the "flood outlook" initiative), flood forecast and weather report along with other meteorological information (NIMET).

Specific actions by local communities and the general public, humanitarian organizations and international bodies, the media and the academia are equally acknowledged (Terungwa & Torkwase 2013, Olalekan 2013, Obeta 2014, OCHA 2012). Co-habitation

among families in Nigeria offers a comparative advantage in the event of flooding as individuals within family setting offer mutual assistance to cope with the hazard and to recover speedily from losses incurred. In many flooding incidences in Nigerian cities, the general public has often converged at the scenes the incidence to offer help to victims, assist in evacuation of those displaced and in protecting property from further damage. Many IDPs easily find shelter and other humanitarian needs from families and friends while awaiting intervention by authorities. However, unlike the developed countries, the vulnerabilities of local communities to flooding in Nigeria may indicate among other factors the overwhelming lack of responsibility towards flooding and ways of addressing its challenges. For examples failure to comply with environmental laws and regulations and to adhere to weather warnings and alerts are possible situations where lack of responsibilities of local communities and the general public is highlighted (Aderogba 2012a). The indifference of most people towards research questionnaires and surveys most likely compounds the situation.

Humanitarian response to flooding in Nigeria has been overwhelming. Almost in all cases of flooding in Nigeria have victims received humanitarian supports with most notably the International Federation of Red Cross (IFRC), United Nations, World Bank, Foreign countries including UK, the United States, China, Japan, France as well as religious organizations including the Catholic, Anglican and Pentecostal churches and missionary societies. The 2012 flooding saw humanitarian response amounting to over US$70 million (OCHA 2012).

Considerable attention has been given to flooding in Nigeria through research and scientific studies. However, the need for science and technology to embrace environmental education in Nigeria has been identified (Terungwa & Torkwase 2013). Similarly, the media have played important roles in reporting flooding in Nigeria, but as argued by (Olalekan 2013), there have been inconsistencies in flood reporting in the country which may be attributed to some disconnect between the media and agencies tackling flooding in the country particularly the NEMA.

Despite these progresses, there are a number of critical issues regarding these present efforts at tackling flooding in Nigeria (Obeta 2014, Agbola 2012, Kolawole et al. 2010). With regards to facilitating the evacuation of victims affected by floods and providing them with urgent humanitarian needs, the level of dissatisfaction and agitations from large numbers of the flood victims, especially the IDPs, queries the effectiveness of these measures. Although it is unjustifiable to claim that the limitation with these present efforts probably leads to more frequent flooding in the country, however, the fact that such measures have not improved the country with regards to the idea of "living with floods" is clearly acknowledged (Adelekan 2010, Adebayo & Oruonye 2013, Akintola & Ikwuyatum 2013).

## V. Recommendations

Based on these critical issues relating to tackling flooding in Nigeria, lessons learned from other countries' experiences of flooding and "best practices" in flood risk reduction (Water UK 2008, Pitt 2008, Sayer et al. 2013), the authors propose that inclusion of flood modelling in the present effort will be a way forward towards a more proactive flood risk reduction within the country. In addition to this proposal, the following recommendations are relevant:

- In view of global focus towards tackling flooding using United Kingdom, the US and the Netherlands as exemplars and considering the specific situation of Nigeria regarding flooding, the nation's academia should focus attention on more scientific investigations. Flooding and climate change concepts should be integrated into curriculum of studies in Nigerian schools. Current issues in flood research such as flood modelling, vulnerability assessment, uncertainty analyses and early warning systems should be promoted.
- From previous studies (for example Nkwunonwo et al. 2015), it is clear that perception of flooding in Nigeria has only received little attention. Due to lack of funds and the indifference of political leaders towards research, a number of researches relating to flooding in the country seem to recycle issues that are well known such as causes and impacts of flooding. To tackle this challenge, we recommend that annual budgeting for Nigeria should be specific and more realistic with funds for research.
- The old English adage *"God created the world, but the Dutch created Netherlands"* is often used to highlight the commitment and responsibilities of the Dutch towards tackling flooding and its challenges. Flood defence in the Netherlands cost each person a few hundred Euros each year and the people rarely flinched at the responsibility (Vis et al. 2003). The high level of adherence to regulations and rules shown by British citizens is highlighted in the conservation of nature and high environmental standards which the country upholds (Pitt 2007). Such positive attitude is also exhibited towards weather reports, disaster warning and alerts informing a significant level preparedness which appears to influence reduced damage following flooding event. Against this background, Nigerians need a change of attitude towards flooding its management. Ideally, Nigerians should participate in matters relating to flooding which most largely affects their lives. This can be done by asking relevant questions, seeking to know and willing to

adapt to individual actions which can potentially influence flood risk reduction within the country. Individuals in politics should ensure that laws which underlie the enforcement of environmental standards and regulations are made. Equally, the general public and local communities in Nigeria should support research through positive and accurate responses to questionnaire and surveys.

- The lack of detailed plan and strategy for disbursing funds and inaccurate information relating to those who have been affected by flooding most probably undermine humanitarian support in Nigeria and account for financial mismanagement. Humanitarian actions in Nigeria are generally for post-disaster and emergency situations suggesting some limitation based on what can be achieved through financial support. Given that most local communities in Nigeria consist of poor human populations, we recommend that the focus and priority of humanitarian supports should be on improving the living condition of the population people whilst not undermining the need for assistance in eventualities. Thus focus will not only ultimately reduce their chances of people being vulnerable to flooding and assist in minimizing financial mismanagement, but also it will boost the credence of humanitarian supports towards natural disasters in general and flooding in particular in Nigeria.
- The European Union framework on flooding requires all constituting States to prepare flood hazard/risk maps (EA 2003). Whilst this policy highlights the relevance of flood modelling, it also underlines strong commitment towards tackling flooding across the region of Europe. A policy of such will benefit West Africa in general and Nigeria in particular. However, whilst a regional policy towards flood risk map may be unrealistic for West Africa in the interim, a strong legislation that requires each state of Nigeria to produce a flood hazard/risk map is recommended for Nigeria. This will to a large extent strengthen existing institutional framework and stimulate increased responsibility towards flood risk reduction among the states in the country.
- Flood risk reduction under the "living with floods" idea is multi-disciplinary indicating that various industries can assist in reducing the impacts of flooding. In UK, evidences of collaboration from various companies and institutions towards addressing flood challenges are undisputable (EA 2010, Water UK 2008, Pitt 2008). Thus, the need for multinationals and banking industries in Nigeria to sponsor research and promote sustainable development within Nigerian cities, as well as augment humanitarian supports to improve the living standards of local communities whilst reducing their vulnerabilities and building their resilience to flooding should not be ignored.
- Flood insurance is a non-structural approach which many property owners have benefitted from in developed countries following flood disasters. To support the roles of flood insurance in Nigeria, it is recommended that the role of FEMA in this regard should be extended to states and whilst encouraging insurance companies to commence sensitization exercises for properties owners to take positive step in this direction.

## VI. Conclusion

Critical issues relating to widespread flooding in Nigeria have been explored with view to charting a more proactive solution towards addressing the challenge within the country. Fluvial and coastal types of flooding are experienced in Nigeria. However pluvial flooding which is a major cause of concern for urban areas within the country appears to be more frequent and arguably unprecedented from the point of view of flood impacts. Over the period 1985 to 2014, the effects of flooding on people, properties and economic activities have been arguably overwhelming. Whilst virtually all states in Nigeria have experienced the hazard, more frequent floods are experienced in Niger, Adamawa, Oyo, Kano and Jigawa states, possibly due to the influence of rivers Niger, Benue, Ogun and Hadeja. Lagos state seems to have experienced most of the floods in the country and this has been associated to poor urban planning and climate change with more frequent and intense rainfall.

Present efforts at tackling flooding in Nigeria appear to be limited and have been grossly criticized as ad-hoc, poorly coordinated and not in line with globally acknowledged 'best practices' in flood risk reduction. Whilst such practices do not seem to be governed by the idea of 'living with floods and not fighting them', which dominates in flood risk reduction literature and many international and regional flood management policies such as the European Union Flood Directive, flood modelling approaches are evidently lacking.

Given the relevance of flood risk/hazard mapping within the framework of flood risk reduction, the specific roles of flood modelling are presented. Basically, it is shown that flood modelling simulates flood hazard data (flood water depth, extent, and duration as well as flow velocity) for flood risk/hazard mapping. However, the dearth of these data among other factor constrains efforts at tackling flooding in Nigeria. Although ground survey and remote sensing approaches can be applied to acquire these data, limitations inherent in these approaches undermine their applications in Nigeria.

With flood modelling presented, recommend-dations which the authors deemed relevant towards achieving the key drivers of this study were made. Most importantly, bearing in mind that flooding cannot be constrained within human environment and that it will

worsen in the future, the need for Nigerians to create a society where social systems are resilient to the hazard is recognized.

It is recognized that a major limitation of this study is in the negligence of flood events prior to 1985. This is due to the lack of accurate and well-coordinated historical data for those periods. However the study recommends this for future investigations, especially with regards to developing a repository where various historical flood data can be lodged, irrespective of their magnitudes and return periods. There is urgent need for bespoke flood models for simulating flood hazard in Nigeria in line with the objectives of NIHSA. That way the barriers associated with existing flood models such as copyright restriction, limited calibration and strict insistence on quality data requirement to run the commercial flood models in Nigeria can be overcome.

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# Evaluation of Bio-Engineering for Pollution Prevention through Sustainable Development of Bioenergy Management

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*Abstract-* This communication discusses a comprehensive review of biomass energy sources, environment and sustainable development. This includes all the biomass energy technologies, energy efficiency systems, energy conservation scenarios, energy savings and other mitigation measures necessary to reduce emissions globally. The current literature is reviewed regarding the ecological, social, cultural and economic impacts of biomass technology. This study gives an overview of present and future use of biomass as an industrial feedstock for production of fuels, chemicals and other materials. However, to be truly competitive in an open market situation, higher value products are required. Results suggest that biomass technology must be encouraged, promoted, invested, implemented, and demonstrated, but especially in remote rural areas.

*Keywords: biomass resources, wastes, energy, environment, sustainable development.*

*GJHSS-B Classification : FOR Code: 879899p*

*Strictly as per the compliance and regulations of:*

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## I. Introduction

This study highlights the energy problem and the possible saving that can be achieved through the use of biomass sources energy. Also, this study clarifies the background of the study, highlights the potential energy saving that could be achieved through use of biomass energy source and describes the objectives, approach and scope of the theme.

The aim of any modern biomass energy systems must be:

- To maximise yields with minimum inputs.
- Utilisation and selection of adequate plant materials and processes.
- Optimum use of land, water, and fertiliser.
- Create an adequate infrastructure and strong R and D base.

There is strong scientific evidence that the average temperature of the earth's surface is rising. This was a result of the increased concentration of carbon dioxide ($CO_2$), and other greenhouse gases (GHGs) in the atmosphere as released by burning fossil fuels (Robinson, 2007; and Omer, 2008). This global warming will eventually lead to substantial changes in the world's climate, which will, in turn, have a major impact on human life and the environment. Energy use can be achieved by minimising the energy demand, by rational energy use, by recovering heat and the use of more green energies. This will lead to fossil fuels emission reduction. This study was a step towards achieving this goal. The adoption of green or sustainable approaches to the way in which society is run is seen as an important strategy in finding a solution to the energy problem. The key factors to reducing and controlling $CO_2$, which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. The non-technical issues, which have recently gained attention, include: (1) Environmental and ecological factors, e.g., carbon sequestration, reforestation and revegetation. (2) Renewables as a $CO_2$ neutral replacement for fossil fuels. (3) Greater recognition of the importance of renewable energy, particularly modern biomass energy carriers, at the policy and planning levels. (4) Greater recognition of the difficulties of gathering good and reliable biomass energy data, and efforts to improve it. (5) Studies on the detrimental health efforts of biomass energy particularly from traditional energy users. There is a need for some further development to suit local conditions, to minimise spares holdings, to maximise interchangeability both of engine parts and of the engine application. Emphasis should be placed on full local manufacture (Abdeen, 2008a).

Fossil fuels, especially oil and natural gas, are finite in extent, and should be regarded as depleting assets, and efforts are oriented to search for new sources of energy. The clamour all over the world for the need to conserve energy and the environment has intensified as traditional energy resources continue to dwindle whilst the environment becomes increasingly degraded (Abdeen, 2008b).

Large-scale, conventional, power plant such as hydropower has an important part to play in development. It does not, however, provide a complete solution. There is an important complementary role for the greater use of small scale, rural based-power plants. Such plant can be used to assist development since it can be made locally using local resources, enabling a rapid built-up in total equipment to be made without a corresponding and unacceptably large demand on

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central funds. Renewable resources are particularly suitable for providing the energy for such equipment and its use is also compatible with the long-term aims (Abdeen, 2008c). In compiling energy consumption data one can categorise usage according to a number of different schemes:

- Traditional sector- industrial, transportation, etc.
- End-use- space heating, process steam, etc.
- Final demand- total energy consumption related to automobiles, to food, etc.
- Energy source- oil, coal, etc.
- Energy form at point of use- electric drive, low temperature heat, etc.

## II. Bioenergy Development

Bioenergy is energy from the sun stored in materials of biological origin. This includes plant matter and animal waste, known as biomass. Plants store solar energy through photosynthesis in cellulose and lignin, whereas animals store energy as fats. When burned, these sugars break down and release energy exothermically, releasing carbon dioxide ($CO_2$), heat and steam. The by-products of this reaction can be captured and manipulated to create power, commonly called bioenergy. Biomass is considered renewable because the carbon (C) is taken out of the atmosphere and replenished more quickly than the millions of years required for fossil fuels to form. The use of biofuels to replace fossil fuels contributes to a reduction in the overall release of carbon dioxide into the atmosphere and hence helps to tackle global warming (Abdeen, 2008d).

*Table 1 :* Sources of energy (Omer, 2008)

| Energy source | Energy carrier | Energy end-use |
|---|---|---|
| Vegetation | Fuel-wood | Cooking<br>Water heating<br>Building materials<br>Animal fodder preparation |
| Oil | Kerosene | Lighting<br>Ignition fires |
| Dry cells | Dry cell batteries | Lighting<br>Small appliances |
| Muscle power | Animal power and human power | Transport<br>Land preparation for farming<br>Food preparation (threshing) |

*Table 2 :* Renewable applications (Omer, 2008)

| Systems | Applications |
|---|---|
| Water supply | Rain collection, purification, storage and recycling |
| Wastes disposal | Anaerobic digestion ($CH_4$) |
| Cooking | Methane |
| Food | Cultivate the 1 hectare plot and greenhouse for four people |
| Electrical demands | Wind generator |
| Space heating | Solar collectors |
| Water heating | Solar collectors and excess wind energy |
| Control system | Ultimately hardware |
| Building fabric | Integration of subsystems to cut costs |

The biomass energy resources are particularly suited for the provision of rural power supplies and a major advantage is that equipment such as flat plate solar driers, wind machines, etc., can be constructed using local resources and without the high capital cost of more conventional equipment. Further advantage results from the feasibility of local maintenance and the general encouragement such local manufacture gives to the build up of small scale rural based industry. Table 1 lists the energy sources available. Currently the 'non-commercial' fuels wood, crop residues and animal dung are used in large amounts in the rural areas of developing countries, principally for heating and cooking; the method of use is highly inefficient. Table 2 presented some renewable applications. Table 3 lists the most important of energy needs. Table 4 listed methods of energy conversion.

*Table 3 :* Energy needs in rural areas (Omer, 2008)

| | |
|---|---|
| Transport | e.g., small vehicles and boats |
| Agricultural machinery | e.g., two-wheeled tractors |
| Crop processing | e.g., milling |
| Water pumping | e.g., drinking water |
| Small industries | e.g., workshop equipment |
| Electricity generation | e.g., hospitals and schools |
| Domestic | e.g., cooking, heating, lighting |

Considerations when selecting power plant include the following:

- Power level- whether continuous or discontinuous.
- Cost-initial cost, total running cost including fuel, maintenance and capital amortised over life.
- Complexity of operation.
- Maintenance and availability of spares.
- Life and suitability for local manufacture.

The internal combustion engine is a major contributor to rising $CO_2$ emissions worldwide and some pretty dramatic new thinking is needed if our planet is to counter the effects. With its use increasing in developing world economies, there is something to be said for the argument that the vehicles we use to help keep our inner-city environments free from waste, litter and grime should be at the forefront of developments in low-emissions technology. Materials handled by waste management companies are becoming increasingly valuable. Those responsible for the security of facilities that treat waste or manage scrap will testify to the precautions needed to fight an ongoing battle against unauthorised access by criminals and crucially, to prevent the damage they can cause through theft, vandalism or even arson. Of particular concern is the escalating level of metal theft, driven by various factors including the demand for metal in rapidly developing economies such as India and China (Abdeen, 2008e).

*Table 4 :* Methods of energy conversion (Omer, 2007)

| | |
|---|---|
| Muscle power | Man, animals |
| Internal combustion engines | |
| Reciprocating | Petrol- spark ignition<br>Diesel- compression ignition |
| Rotating | Humphrey water piston |
| Heat engines | Gas turbines |
| Vapour (Rankine) | |
| Reciprocating | |
| Rotating | Steam engine |
| Gas Stirling (Reciprocating) | Steam turbine |
| Gas Brayton (Rotating) | Steam engine |
| Electron gas | Steam turbine |
| Electromagnetic radiation | Thermionic, thermoelectric |
| Hydraulic engines | Photo devices |
| Wind engines (wind machines) | Wheels, screws, buckets, turbines |
| Electrical/mechanical | Vertical axis, horizontal axis |
| | Dynamo/alternator, motor |

There is a need for greater attention to be devoted to this field in the development of new designs, the dissemination of information and the encouragement of its use. International and government bodies and independent organisations all have a role to play in biomass energy technologies.

Environment has no precise limits because it is in fact a part of everything. Indeed, environment is, as anyone probably already knows, not only flowers blossoming or birds singing in the spring, or a lake surrounded by beautiful mountains.

It is also human settlements, the places where people live, work, rest, the quality of the food we eat, the noise or silence of the street they live in. Environment is not only the fact that our cars consume a good deal of energy and pollute the air, but also, that we often need them to go to work and for holidays. Obviously man uses energy just as plants, bacteria, mushrooms, bees, fish and rats do. Man largely uses solar energy- food, hydropower, wood- and thus participates harmoniously in the natural flow of energy through the environment. But man also uses oil, gas, coal and nuclear power. We always modify our environment with or without this source of energy (Brain, and Mark, 2007). Economic importance of environmental issue is increasing, and new technologies are expected to reduce pollution derived both from productive processes and products, with costs that are still unknown. This is due to market uncertainty, weak appropriability regime, lack of a dominant design, and difficulties in reconfiguring organisational routines. The degradation of the global environment is one of the most serious energy issues (Abdeen, 2009a).

## III. Energy use and the Environment

The range of waste treatment technologies that are tailored to produce bioenergy is growing.

There are a number of key areas of bioenergy from wastes including (but not limited to) biogas, biofuels and bioheat. When considering using bioenergy, it is important to take into account the overall emission of carbon in the process of electricity production.

In addition to the drain on resources, such an increase in consumption consequences, together with the increased hazards of pollution and the safety problems associated with a large nuclear fission programmes. It would be equally unacceptable to suggest that the difference in energy between the developed and developing countries and prudent for the developed countries to move towards a way of life which, whilst maintaining or even increasing quality of life, reduce significantly the energy consumption per capita. Such savings can be achieved in a number of ways:

- Improved efficiency of energy use, for example environmental cost of thermal insulation must be taken into account, energy recovery, and total energy.
- Conservation of energy resources by design for long life and recycling rather than the short life throwaway product and systematic replanning of our way of life, for example in the field of transport.

Energy ratio (Er) is defined as the ratio of Energy content (Ec) of the food product / Energy input (Ei) to produce the food as in equation (1).

$$Er = Ec/Ei \quad (1)$$

## IV. Combined Heat and Power (CHP)

The atmospheric emissions of fossil fuelled installations are mostly aldehydes ($CH_3CH_2CH_2CHO$), carbon monoxide (CO), nitrogen oxides ($NO_X$), sulpher oxides (SOx) and particles (i.e., ash) as well as carbon dioxide. Table 5 shows estimates include not only the releases occurring at the power plant itself but also cover fuel extraction and treatment, as well as the storage of wastes and the area of land required for operation (Table 6). A review of the potential range of recyclables is presented in Table 7.

Scientific assumptions for a short-term energy strategy suggest that the most economically efficient way to replace the thermal plants is to modernise existing power plants to increase their energy efficiency and to improve their environmental performance (Pernille, 2004). Figure 1 summarises the biomass utilisation cycle concept.

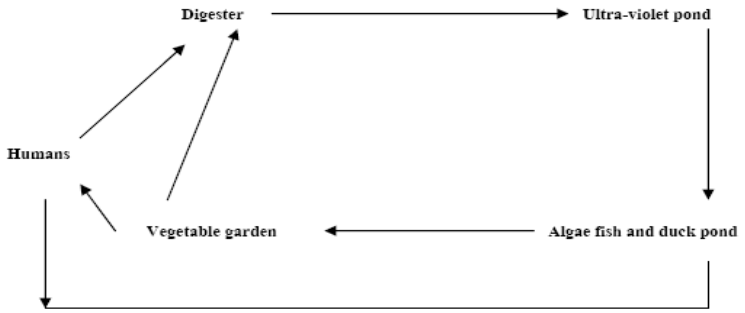


*Figure 1 :* Biomass utilisation cycle concepts (Omer, 2006)

*Table 5 :* Annual GHG emissions from different types of power plants (Robinson, 2007)

| Primary source of energy | Emissions (x $10^3$ metric tones $CO_2$) | | Waste (x $10^3$ metric tones $CO_2$) | Area ($km^2$) |
|---|---|---|---|---|
| | Atmosphere | Water | | |
| Coal | 380 | 7-41 | 60-3000 | 120 |
| Oil | 70-160 | 3-6 | Negligible | 70-84 |
| Gas | 24 | 1 | - | 84 |
| Nuclear | 6 | 21 | 2600 | 77 |

*Table 6 :* Energy consumption per person (Robinson, 2007)

| Region | Population (millions) | Energy per person (Watt) |
|---|---|---|
| Africa | 820 | 0.54 |
| Asia | 3780 | 2.74 |
| Central America | 180 | 1.44 |
| North America | 335 | 0.34 |
| South America | 475 | 0.52 |
| Western Europe | 445 | 2.24 |
| Eastern Europe | 130 | 2.57 |
| Oceania | 35 | 0.08 |
| Russia | 330 | 0.29 |

However, utilisation of wind power and the conversion of gas-fired CHP plants to biomass would significantly reduce the dependence on imported fossil fuels. Although a lack of generating capacity is forecasted in the long-term, utilisation of the existing renewable energy potential and the huge possibilities for increasing energy efficiency are sufficient to meet future energy demands in the short-term (Pernille, 2004).

A total shift towards a sustainable energy system is a complex and long process, but is one that can be achieved within a period of about 20 years. A vision that used methodologies and calculations based on computer modelling can utilised:

- Data from existing governmental programmes.
- Potential renewable energy sources and energy efficiency improvements.
- Assumptions for future economy growth.
- Information from studies and surveys on the recent situation in the energy sector.

*Table 7 :* Summary of material recycling practices in the construction sector (Robinson, 2007)

| Construction and demolition material | Recycling technology options | Recycling product |
|---|---|---|
| Asphalt | Cold recycling: heat generation; Minnesota process; parallel drum process; elongated drum; microwave asphalt recycling system; finfalt; surface regeneration | Recycling asphalt; asphalt aggregate |
| Brick | Burn to ash, crush into aggregate | Slime burn ash; filling material; hardcore |
| Concrete | Crush into aggregate | Recycling aggregate; cement replacement; protection of levee; backfilling; filter |
| Ferrous metal | Melt; reuse directly | Recycled steel scrap |
| Glass | Reuse directly; grind to powder; polishing; crush into aggregate; burn to ash | Recycled window unit; glass fibre; filling material; tile; paving block; asphalt; recycled aggregate; cement replacement; manmade soil |
| Masonry | Crush into aggregate; heat to 900°C to ash | Thermal insulating concrete; traditional clay |
| Non-ferrous metal | Melt | Recycled metal |
| Paper and cardboard | Purification | Recycled paper |
| Plastic | Convert to powder by cryogenic milling; clopping; crush into aggregate; burn to ash | Panel; recycled plastic; plastic lumber; recycled aggregate; landfill drainage; asphalt; manmade soil |
| Timber | Reuse directly; cut into aggregate; blast furnace deoxidisation; gasification or pyrolysis; chipping; moulding by pressurising timber chip under steam and water | Whole timber; furniture and kitchen utensils; lightweight recycled aggregate; source of energy; chemical production; wood-based panel; plastic lumber; geofibre; insulation board |

Figure 2 shows methanol production.

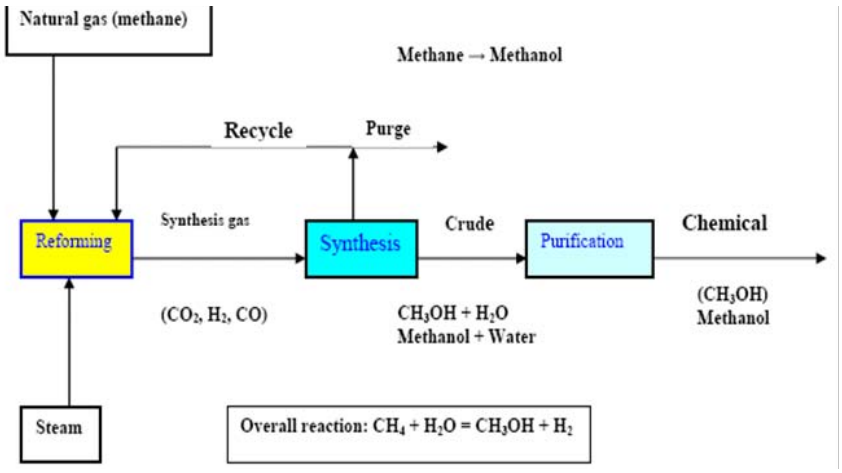


*Figure 2 :* Schematic diagram shows methanol production (Omer, 2006)

In some countries, a wide range of economic incentives and other measures are already helping to protect the environment. These include:

- Taxes and user charges that reflect the costs of using the environment, e.g., pollution taxes and waste disposal charges.
- Subsidies, credits and grants that encourage environmental protection.
- Deposit-refund systems that prevent pollution on resource misuse and promote product reuse or recycling.
- Financial enforcement incentives, e.g., fines for non-compliance with environmental regulations.
- Tradable permits for activities that harm the environment.

The district Heating (DH), also known as community heating can be a key factor to achieve energy savings, reduce $CO_2$ emissions and at the same time provide consumers with a high quality heat supply at a competitive price. The DH should generally only be considered for areas where the heat density is sufficiently high to make DH economical. In countries like Denmark DH may today be economical even to new developments with lower density areas due to the high level of taxation on oil and gas fuels combined with the efficient production of the DH. To improve the opportunity for the DH local councils can adapt the following plan:

- Analyse the options for heat supply during local planning stage.
- In areas where DH is the least cost solution it should be made part of the infrastructure just like for instance water and sewage connecting all existing and new buildings.
- Where possible all public buildings should be connected to the DH.
- The government provides low interest loans or funding to minimise conversion costs for its citizens.
- Use other powers, for instance national legislation to ensure the most economical development of the heat supply and enable an obligation to connect buildings to a DH scheme.

Denmark has broadly seen three scales of the CHP which where largely implemented in the following order (Pernille, 2004):

- Large-scale CHP in cities (>50 MWe).
- Small (5 kWe – 5 MWe) and medium-scale (5-50 MWe).
- Industrial and small-scale CHP.

Most of the heat is produced by large CHP plants (gas-fired combined cycle plants using natural gas, biomass, waste or biogas). The DH is energy efficient because of the way the heat is produced and the required temperature level is an important factor. Buildings can be heated to temperature of 21°C and domestic hot water can be supplied with a temperature of 55°C using energy sources that are most efficient when producing low temperature levels (<95°C) for the DH water. Most of these heat sources are $CO_2$ neutral or emit low levels. Only a few of these sources are available to small individual systems at a reasonably cost, whereas DH schemes because of the plant's size and location can have access to most of the heat sources and at a low cost. Low temperature DH, with return temperatures of around 30-40°C can utilise the following heat sources:

- Efficient use of the CHP by extracting heat at low calorific value.
- Efficient use of biomass or gas boilers by condensing heat in economisers (Table 8).
- Efficient utilisation of geothermal energy.
- Direct utilisation of excess low temperature heat from industrial processes.
- Efficient use of large-scale solar heating plants.

Heat tariffs may include a number of components such as: a connection charge, a fixed charge and a variable energy charge. Also, consumers may be incentivised to lower the return temperature. Hence, it is difficult to generalise but the heat practice for any DH company no matter what the ownership structure can be highlighted as follows:

- To develop and maintain a development plan for the connection of new consumers.
- To evaluate the options for least cost production of heat.
- To implement the most competitive solutions by signing agreements with other companies or by implementing own investment projects.
- To monitor all internal costs and with the help of benchmarking, improve the efficiency of the company.
- To maintain a good relationship with the consumer and deliver heat supply services at a sufficient quality.

Installing DH should be pursued to meet the objectives for improving the environment through the improvement of energy efficiency in the heating sector. At the same time DH can serve the consumer with a reasonable quality of heat at the lowest possible cost. The variety of possible solutions combined with the collaboration between individual companies, the DH association, the suppliers and consultants can, as it has been in Denmark, be the way forward for developing DH in the United Kingdom (Pernille, 2004).

*Table 8 :* Final energy projections including biomass (Mtoe) (D'Apote, 1998)

| Region 2011 | | | | |
|---|---|---|---|---|
| | Biomass (Mtoe) | Conventional Energy (Mtoe) | Total (Mtoe) | Share of Biomass (%) |
| Africa | 205 | 136 | 341 | 60 |
| China | 206 | 649 | 855 | 24 |
| East Asia | 106 | 316 | 422 | 25 |
| Latin America | 73 | 342 | 415 | 18 |
| South Asia | 235 | 188 | 423 | 56 |
| Total developing countries | 825 | 1632 | 2457 | 34 |
| | Biomass (Mtoe) | Conventional Energy (Mtoe) | Total (Mtoe) | Share of Biomass (%) |
| Other non-OECD * countries | 24 | 1037 | 1061 | 2 |
| Total non-OECD* countries | 849 | 2669 | 3518 | 24 |
| OECD countries | 81 | 3044 | 3125 | 3 |
| World | 930 | 5713 | 6643 | 14 |
| Region 2020 | | | | |
| | Biomass (Mtoe) | Conventional Energy (Mtoe) | Total (Mtoe) | Share of Biomass (%) |
| Africa | 371 | 266 | 637 | 59 |
| China | 224 | 1524 | 1748 | 13 |
| East Asia | 118 | 813 | 931 | 13 |
| Latin America | 81 | 706 | 787 | 10 |
| South Asia | 276 | 523 | 799 | 35 |
| Total developing countries | 1071 | 3825 | 4896 | 22 |
| Other non-OECD * countries | 26 | 1669 | 1695 | 2 |
| Total non-OECD* countries | 1097 | 5494 | 6591 | 17 |
| OECD countries | 96 | 3872 | 3968 | 2 |
| World | 1193 | 9365 | 10558 | 11 |

** Organisation for Economic Co-operation and Development.*

## V. Biomass Utilisation and Development of Conversion Technologies

Sustainable energy is energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment. It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years. A great amount of renewable energy potential, environmental interest, as well as economic consideration of fossil fuel consumption and high emphasis of sustainable development for the future will be needed.

Explanations for the use of inefficient agricultural-environmental polices include the high cost of information required to measure benefits on a site-specific basis, information asymmetries between government agencies and farm decision makers that result in high implementation costs, distribution effects and political considerations (Wu and Boggess, 1999). Achieving the aim of agric-environment schemes through:

- Sustain the beauty and diversity of the landscape.
- Improve and extend wildlife habitats.
- Conserve archaeological sites and historic features.
- Improve opportunities for countryside enjoyment.
- Restore neglected land or features, and
- Create new habitats and landscapes.

The data required to perform the trade-off analysis simulation can be classified according to the divisions given in Table 9: the overall system or individual plants, and the existing situation or future development. The effective economic utilisations of these resources are shown in Table 10, but their use is hindered by many problems such as those related to

harvesting, collection, and transportation, besides the sanitary control regulations. Biomass energy is experiencing a surge in an interest stemming from a combination of factors, e.g., greater recognition of its current role and future potential contribution as a modern fuel, global environmental benefits, its development and entrepreneurial opportunities, etc. Possible routes of biomass energy development are shown in Table 11.

The key to successful future appears to lie with successful marketing of the treatment by products. There is also potential for using solid residue in the construction industry as a filling agent for concrete. Research suggests that the composition of the residue locks metals within the material, thus preventing their escape and any subsequent negative effect on the environment (Abdeen, 2009b). The use of biomass through direct combustion has long been, and still is, the most common mode of biomass utilisation as shown in Tables (9-11).

Examples for dry (thermo-chemical) conversion processes are charcoal making from wood (slow pyrolysis), gasification of forest and agricultural residues (fast pyrolysis – this is still in demonstration phase), and of course, direct combustion in stoves, furnaces, etc.

*Table 9 :* Classifications of data requirements (Omer, 2008)

| | Plant data | System data |
|---|---|---|
| Existing data | Size<br>Life<br>Cost (fixed and variation operation and maintenance)<br>Forced outage<br>Maintenance<br>Efficiency<br>Fuel<br>Emissions | Peak load<br>Load shape<br>Capital costs<br>Fuel costs<br>Depreciation<br>Rate of return<br>Taxes |
| Future data | All of above, plus<br>Capital costs<br>Construction trajectory<br>Date in service | System lead growth<br>Fuel price growth<br>Fuel import limits<br>Inflation |

*Table 10 :* Agricultural residues routes for development (Omer, 2006)

| Source | Process | Product | End use |
|---|---|---|---|
| Agricultural residues | Direct | Combustion | Rural poor<br>Urban household<br>Industrial use |
| | Processing | Briquettes | Industrial use<br>Limited household use |
| | Processing | Carbonisation (small scale) | Rural household (self sufficiency) |
| | Carbonisation | Briquettes<br>Carbonised | Urban fuel<br>Energy services |
| | Fermentation | Biogas | Household<br>Industry |
| Agricultural, and animal residues | Direct | Combustion | (Save or less efficiency as wood) |
| | Briquettes | Direct combustion | (Similar end use devices or improved) |
| | Carbonisation | Carbonised | Use |
| | Carbonisation | Briquettes | Briquettes use |
| | Fermentation | Biogas | Use |

Wet processes require substantial amount of water to be mixed with the biomass. Biomass technologies include:

- Briquetting.
- Improved stoves.
- Biogas.
- Improved charcoal.
- Carbonisation.
- Gasification.

*Table 11 :* Effective biomass resource utilisation (Omer, 2007)

| Subject | Tools | Constraints |
|---|---|---|
| Utilisation and land clearance for agriculture expansion | Stumpage fees<br>Control<br>Extension<br>Conversion<br>Technology | Policy<br>Fuel-wood planning<br>Lack of extension<br>Institutional |
| Utilisation of agricultural residues | Briquetting<br>Carbonisation<br>Carbonisation and briquetting<br>Fermentation<br>Gasification | Capital<br>Pricing<br>Policy and legislation<br>Social acceptability |

The increased demand for gas and petroleum, food crops, fish and large sources of vegetative matter mean that the global harvesting of carbon has in turn intensified. It could be said that mankind is mining nearly everything except its waste piles. It is simply a matter of time until the significant carbon stream present in municipal solid waste is fully captured. In the meantime, the waste industry needs to continue on the pathway to increased awareness and better-optimised biowaste resources.

Optimisation of waste carbon may require widespread regulatory drivers (including strict limits on the landfilling of organic materials), public acceptance of the benefits of waste carbon products for soil improvements/crop enhancements and more investment in capital facilities (Abdeen, 2009c).

In short, a significant effort will be required in order to capture a greater portion of the carbon stream and put it to beneficial use.

From the standpoint of waste practitioners, further research and pilot programmes are necessary before the available carbon in the waste stream can be extracted in sufficient quality and quantities to create the desired end products.

Other details need to be ironed out too, including measurement methods, diversion calculations, sequestration values and determination of acceptance contamination thresholds (Abdeen, 2009d).

*a) Briquette Formation*

Charcoal stoves are very familiar to African society. As for the stove technology, the present charcoal stove can be used, and can be improved upon for better efficiency. This energy term will be of particular interest to both urban and rural households and all the income groups due to the simplicity, convenience, and lower air polluting characteristics. However, the market price of the fuel together with that of its end-use technology may not enhance its early high market penetration especially in the urban low income and rural households.

Briquetting is the formation of a charcoal (an energy-dense solid fuel source) from otherwise wasted agricultural and forestry residues. One of the disadvantages of wood fuel is that it is bulky with a low energy density and is therefore enquire to transport. Briquette formation allows for a more energy-dense fuel to be delivered, thus reducing the transportation cost and making the resource more competitive. It also adds some uniformity, which makes the fuel more compatible with systems that are sensitive to the specific fuel input (Jeremy, 2005).

*b) Improved Cook Stoves*

Traditional wood stoves can be classified into four types: three stone, metal cylindrical shaped, metal tripod and clay type. Another area in which rural energy availability could be secured where woody fuels have become scarce, are the improvements of traditional cookers and ovens to raise the efficiency of fuel saving. Also, to provide a constant fuel supply by planting fast growing trees. The rural development is essential and economically important since it will eventually lead to better standards of living, people's settlement, and self sufficient in the following:

- Food and water supplies.
- Better services in education and health care.
- Good communication modes.

*c) Biogas Technology*

Biogas is a generic term for gases generated from the decomposition of organic material. As the material breaks down, methane (CH4) is produced as shown in Figure 3.

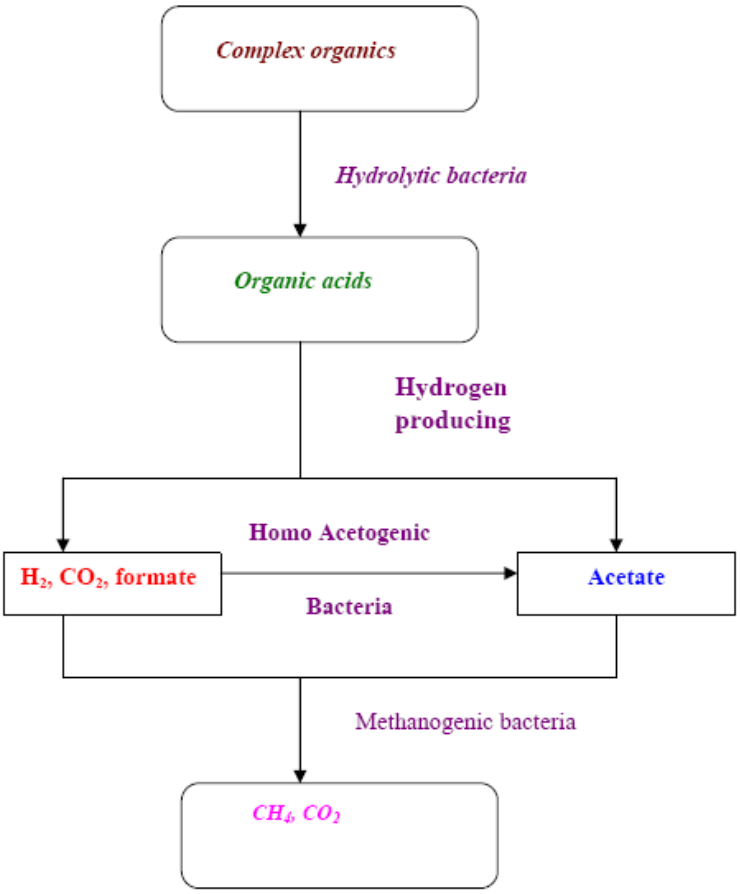


*Figure 3 :* Biogas production process (Omer, 2003)

Sources that generate biogas are numerous and varied. These include landfill sites, wastewater treatment plants and anaerobic digesters. Landfills and wastewater treatment plants emit biogas from decaying waste. To date, the waste industry has focused on controlling these emissions to our environment and in some cases, tapping this potential source of fuel to power gas turbines, and thus generating electricity. The primary components of landfill gas are methane ($CH_4$), carbon dioxide ($CO_2$), and nitrogen ($N_2$). The average concentration of methane is ~45%, $CO_2$ is ~36% and nitrogen is ~18%. Other components in the gas are oxygen ($O_2$), water vapour and trace amounts of a wide range of non-methane organic compounds (NMOCs).

Biogas technology cannot only provide fuel, but is also important for comprehensive utilisation of biomass forestry, animal husbandry, fishery, agricultural economy, protecting the environment, and realising agricultural recycling, as well as improving the sanitary conditions, in rural areas. The introduction of biogas technology on wide scale has implications for macro planning such as the allocation of government investment and effects on the balance of payments. Factors that determine the rate of acceptance of biogas plants, such as credit facilities and technical backup services, are likely to have to be planned as part of general macro-policy, as do the allocation of research and development funds (Hall and Scrase, 1998).

*d) Improved Forest and Tree Management*

Direct burning of fuel-wood and crop residues constitute the main usage of biomass, as is the case with many developing countries. However, the direct burning of biomass in an inefficient manner causes economic loss and adversely affects human health. In order to address the problem of inefficiency, research centres around the world have investigated the viability of converting the resource to a more useful form, namely solid briquettes and fuel gas (Figure 4).

Biomass resources play a significant role in energy supply in all developing countries. Biomass resources should be divided into residues or dedicated resources, the latter including firewood and charcoal can also be produced from forest residues (Table 12). Implementing measures for energy efficiency will increase at the demand side and in the energy transformation sector.

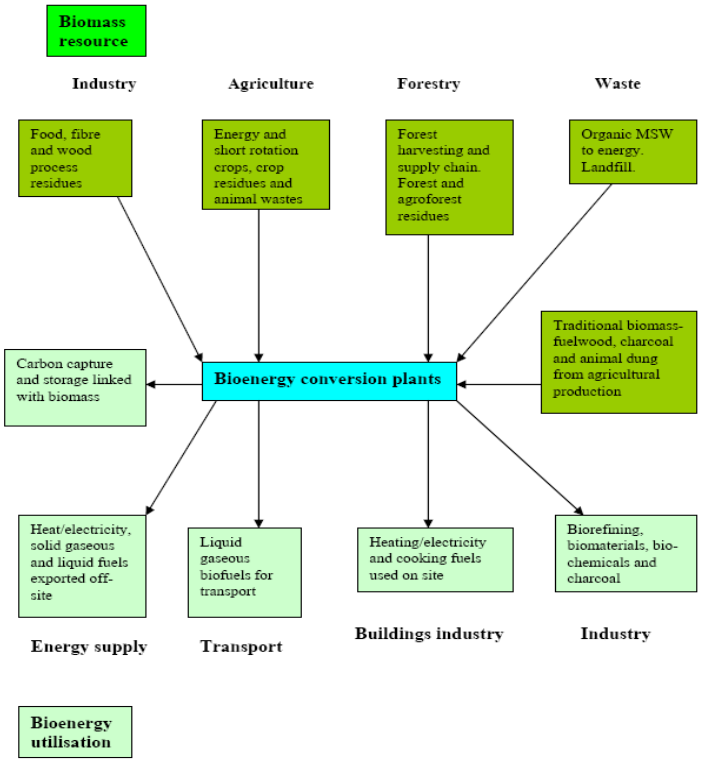


*Figure 4 :* Biomass resources from several sources are converted into a range of products for use by transport, industry and building sectors (Sims, 2007)

*Table 12 :* Biomass residues and current use (Omer, 2007)

| Type of residue | Current use |
|---|---|
| Wood industry waste | Residues available |
| Vegetable crop residues | Animal feed |
| Food processing residue | Energy needs |
| Sorghum, millet, and wheat residues | Fodder, and building materials |
| Groundnut shells | Fodder, brick making, and direct fining oil mills |
| Cotton stalks | Domestic fuel considerable amounts available for short period |
| Sugar, bagasse, and molasses | Fodder, energy need, and ethanol production (surplus available) |
| Manure | Fertiliser, brick making, and plastering |

*e) Gasification Production*

Gasification is based on the formation of a fuel gas (mostly CO and $H_2$) by partially oxidising raw solid fuel at high temperatures in the presence of steam or air. The technology can use wood chips, groundnut shells, sugarcane bagasse, and other similar fuels to generate capacities from 3 kW to 100 kW (Levine, and Hirose, 2005). Three types of gasifier designs have been developed to make use of the diversity of fuel inputs and to meet the requirements of the product gas output (degree of cleanliness, composition, heating value, etc.). The requirements of gas for various purposes, and a comparison between biogas and various commercial fuels in terms of calorific value, and thermal efficiency are presented in Table 13.

*Table 13 :* Comparison of various fuels (Omer, 2003)

| Fuel | Calorific value (kcal) | Burning mode | Thermal efficiency (%) |
|---|---|---|---|
| Electricity, kWh | 880 | Hot plate | 70 |
| Coal gas, kg | 4004 | Standard burner | 60 |
| Biogas, $m^3$ | 5373 | Standard burner | 60 |
| Kerosene, l | 9122 | Pressure stove | 50 |
| Charcoal, kg | 6930 | Open stove | 28 |
| Soft coke, kg | 6292 | Open stove | 28 |
| Firewood, kg | 3821 | Open stove | 17 |
| Cow dung, kg | 2092 | Open stove | 11 |

The organic matter was biodegradable to produce biogas and the variation show a normal methanogene bacteria activity and good working biological process as shown in Figures 5-7. The success of promoting any technology depends on careful planning, management, implementation, training and monitoring. Main features of gasification project are:

- Networking and institutional development/ strengthening.
- Promotion and extension.
- Construction of demonstration projects.
- Research and development, and training and monitoring.

Biomass is a raw material that has been utilised for a wide variety of tasks since the dawn of civilisation. Important as a supply of fuel in the third world, biomass was also the first raw material in the production of textiles.

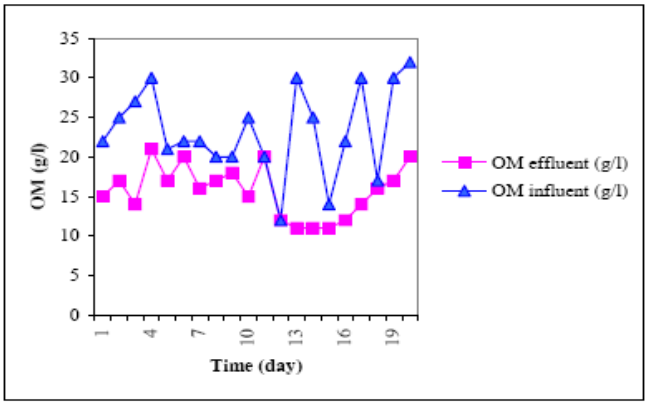


*Figure 5 :* Organic matters before and after treatment in digester (Omer, 2006)

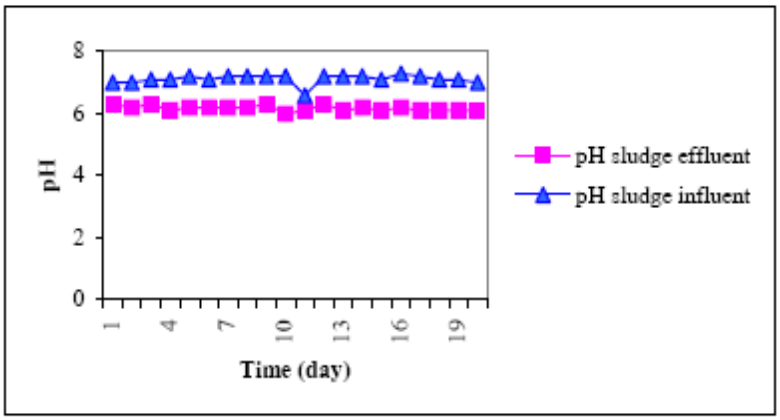


*Figure 6 :* Potential of hydrogen sludge before and after treatment in the digester (Omer, 2006)

The gasification of the carbon char with steam can make a large difference to the surface area of the carbon as shown in equations (2-4). The corresponding stream gasification reactions are endothermic and demonstrate how the steam reacts with the carbon char (Bacaoui, 1998).

$$H_2O\ (g) + C_x\ (s) \rightarrow H_2\ (g) + CO\ (g) + C_{x-1}\ (s) \quad (2)$$

$$CO\ (g) + H_2O\ (g) \rightarrow CO_2\ (g) + H_2\ (g) \quad (3)$$

$$CO_2\ (g) + C_x\ (s) \rightarrow 2\ CO\ (g) + C_{x-1}\ (s) \quad (4)$$

The sources to alleviate the energy situation in the world are sufficient to supply all foreseeable needs. Conservation of energy and rationing in some form will however have to be practised by most countries, to reduce oil imports and redress balance of payments positions. Meanwhile development and application of nuclear power and some of the traditional solar, wind and water energy alternatives must be set in hand to supplement what remains of the fossil fuels.

The encouragement of greater energy use is an essential component of development. In the short-term it requires mechanisms to enable the rapid increase in energy/capita, and in the long-term we should be working towards a way of life, which makes use of energy efficiency and without the impairment of the environment or of causing safety problems. Such a programme should as far as possible be based on renewable energy resources.

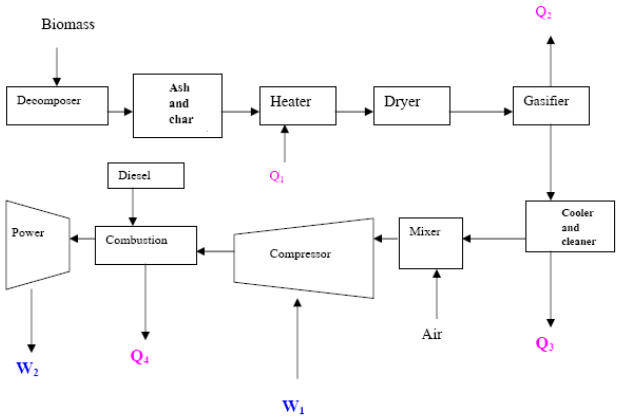


*Figure 7 :* Advanced biomass power with diesel engine (Omer, 2006)

For hot water and heating, renewables contributions come from biomass power and heat, geothermal direct heat, ground source heat pumps, and rooftop solar hot water and space heating systems. Solar assisted cooling makes a very small but growing contribution. When it comes to the installation of large amounts of the PV, the cities have several important factors in common.

These factors include:

- A strong local political commitment to the environment and sustainability.
- The presence of municipal departments or offices dedicated to the environment, and sustainability or renewable energy.
- Information provision about the possibilities of renewables.
- Obligations that some or all buildings include renewable energy.

## VI. Bioheat

Bioenergy is a growing source of power that is playing an ever-increasing role in the provision of electricity. The potential contribution of the waste industry to bioenergy is huge and has the ability to account for a source of large amount of total bioenergy production. Woody biomass is usually converted into power through combustion or gasification. Biomass can be specially grown in the case of energy crops. Waste wood makes up a significant proportion of a variety of municipal, commercial and industrial waste streams.

*Table 14 :* Biomass conversions to energy (Omer, 2006)

| Feedstock | Crops | Conversion process | End product |
|---|---|---|---|
| Wood-cellulosic biomass | Short rotation forest (poplar, willow), plant species (sorghum, mischantus, etc.), | Direct combustion<br>Gasification<br>Pyrolysis | Heat<br>Methane<br>Hydrogen |
| Vegetable oils<br><br>Sugar/starch | Fibre-crops (cynara, kenaf, etc.)<br>Oleaginous crops (rapeseed, soybean, sunflower, etc.)<br>Cereals, root and tuber crops, grape, topinambour, etc. | Direct combustion<br><br>Esterification<br>Fermentation | Oil<br><br>Heat<br>Biodiesel<br>Ethanol |

It is common practice to dispose of this waste wood in landfill where it slowly degraded and takes up valuable void space. This wood is a good source of energy and is an alternative to energy crops. The biomass directly produced by cultivation can be transformed by different processes into gaseous, liquid or solid fuels (Table 14). The whole process of production of methyl or ethyl esters (biodiesel) is summarised in Figures 8-9.

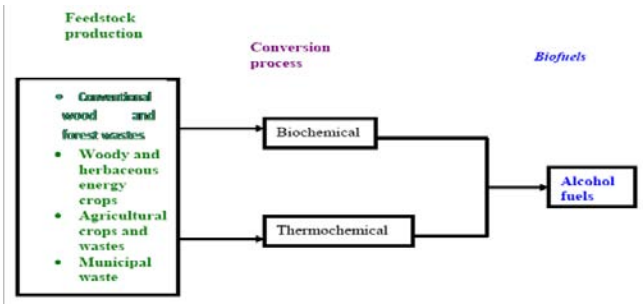


*Figure 8 :* Biofuel pathways for renewable alcohol fuels (Omer, 2006)

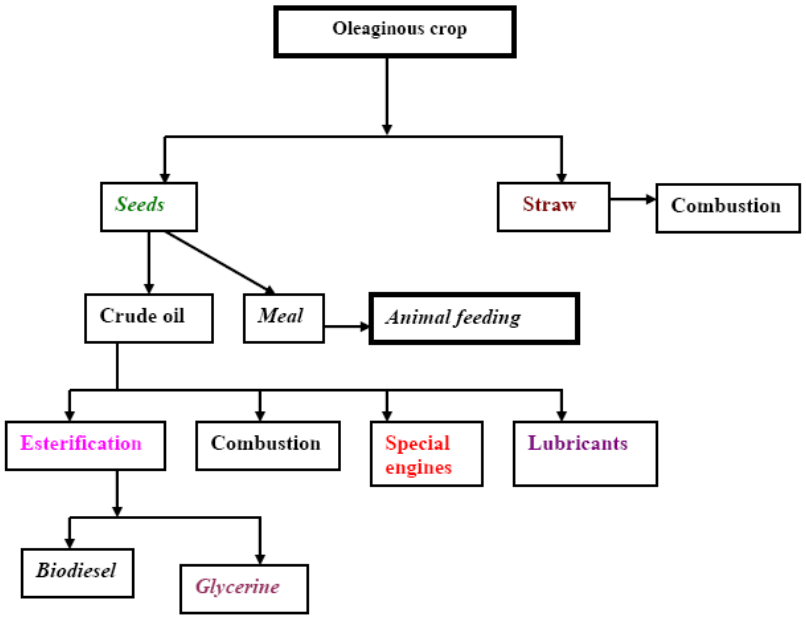


*Figure 9 :* Flow chart of biodiesel production (Omer, 2006)

*a) Waste Policy in Context*

In terms of solid waste management policy, many NGOs have changed drastically in the past ten years from a mass production and mass consumption society to 'material-cycle society'. In addition to national legislation, municipalities are legally obliged to develop a plan for handling the municipal solid waste generated in administrative areas.

Such plans contain:

- Estimates of future waste volume.
- Measures to reduce waste.
- Measures to encourage source separation.
- A framework for solid waste disposal and the construction and management of solid waste management facilities.

Landfilling is in the least referred tier of the hierarchy of waste management options: waste minimisation, reuse and recycling, incineration with energy recovery, and optimised final disposal.

The key elements are as follows: construction impacts, atmospheric emissions, noise, water quality, landscape, visual impacts, socio economics, ecological impacts, traffic, solid waste disposal and cultural heritage (Barton, 2007).

*b) Energy from Agricultural Biomass*

The main advantages are related to energy, agriculture and environment problems, are foreseeable both at regional level and at worldwide level and can be summarised as follows:

- Reduction of dependence on import of energy and related products.

- Reduction of environmental impact of energy production (greenhouse effect, air pollution, and waste degradation).
- Substitution of food crops and reduction of food surpluses and of related economic burdens.
- Utilisation of marginal lands and of set aside lands and reduction of related socio-economic and environmental problems (soil erosion, urbanisation, landscape deterioration, etc.).
- Development of new know-how and production of technological innovation.

## VII. Role of Chemical Engineering

A study (Bacaoui, 1998) individuated on the basis of botanical, genetical, physiological, biochemical, agronomical and technological knowledge reported in literature some 150 species potentially exploitable divided as reported in Table 15.

Turning to chemical engineering and the experience of the chemical process industry represents a wakening up but does not lead to an immediate solution to the problems. The traditional techniques are not very kind to biological products, which are controlled by difficulty and unique physico-chemical properties such as low mechanical, thermal and chemical stabilities. There is the question of selectivity. By the standards of the process streams in chemical industry, fermenter is highly impure and extremely dilutes aqueous systems (Table 16).

*Table 15 :* Plant species potentially exploitable for production of agricultural biomass for energy or industrial utilisations

(Rossi et al, 1990)

| Groups of plants | Number of species |
|---|---|
| Plants cultivated for food purposes that can be reconverted to new uses | 9 |
| Plants cultivated in the past, but not in culture any more | 46 |
| Plants cultivated in other world areas | 46 |
| Wild species, both indigenous and exotic | 47 |
| Total | 148 |
| **Plant product** | **Number of species** |
| Biomass | 8 |
| Sugars and polysaccharides | 38 |
| Cellulose | 17 |
| Hydrocarbons | 3 |
| Polymeric hydrocarbons | 5 |
| Gums and resins | 12 |
| Tannins and phenolic compounds | 3 |
| Waxes | 7 |
| Vegetable oils | 38 |
| Total | 131 |

The disadvantages of the fermentation media are as the following: mechanically fragile, temperature sensitive, rapidly deteriorating quality, harmful if escaping into the environment, corrosive (acids, chlorides, etc.), and troublesome (solids, theological, etc.), and expensive. Thus, pilot plants for scale-up work must be flexible. In general, they should contain suitably interconnected equipment for fermentation, primary separation, cell disruption fractionalises and clarifications, purification by mean of high-resolution techniques and concentration and dry.

*Table 16 :* Typical product concentrations exiting fermenters

(Rossi et al, 1990)

| Product | Concentration ($kg/m^3$) |
|---|---|
| Ethanol | 70-120 |
| Organic acids (e.g., citric) | 40-100 |
| Vitamin B12 | 0.02 |
| Interferon | 50-70 |
| Single-cell protein | 30-50 |
| Antibiotics (e.g., Penicillin G) | 10-30 |
| Enzyme protein (e.g., protease) | 2-5 |



*a) Fluidised Bed Drying*

An important consideration for operators of wastewater treatment plants is how to handle the disposal of the residual sludge in a reliable, sustainable, legal and economical way. The benefits of drying sludge can be seen in two main treatment options:

- Use of the dewatered sludge as a fertiliser or in fertiliser blends.
- Incineration with energy recovery.

Use as a fertiliser takes advantage of the high organic content 40%-70% of the dewatered sludge and its high levels of phosphorous and other nutrients. However, there are a number of concerns about this route including:

- The chemical composition of the sludge (e.g., heavy metals, hormones and other pharmaceutical residues).
- Pathogen risk (e.g., *Salmonella, Escherichia coli,* prionic proteins, etc.).
- Potential accumulation of heavy metals and other chemicals in the soil.

Sludge can be applied as a fertiliser in three forms: liquid sludge, wet cake blended into compost, and dried granules.

The advantages of energy recovery sludge include:

- The use of dewatered sludge is a 'sink' for pollutants such as heavy metals, toxic organic compounds and pharmaceutical residues. Thus, offering a potential disposal route for these substances provided the combustion plant has adequate flue gas cleaning.
- The potential, under certain circumstances, to utilise the inorganic residue from sludge incineration (incinerator ash), such as in cement or gravel.
- The high calorific value (similar to lignite) of dewatered sludge.
- The use of dewatered sludge as a carbon dioxide neutral substitute for primary fuels such as oil, gas and coal.

*b) Energy Efficiency*

Energy efficiency is the most cost-effective way of cutting carbon dioxide emissions and improvements to households and businesses. It can also have many other additional social, economic and health benefits, such as warmer and healthier homes, lower fuel bills and company running costs and, indirectly, jobs. Britain wastes 20 per cent of its fossil fuel and electricity use in transportation. This implies that it would be cost-effective to cut £10 billion a year off the collective fuel bill and reduce $CO_2$ emissions by some 120 million tones $CO_2$. Yet, due to lack of good information and advice on energy saving, along with the capital to finance energy efficiency improvements, this huge potential for reducing energy demand is not being realised. Traditionally, energy utilities have been essentially fuel providers and the industry has pursued profits from increased volume of sales. Institutional and market arrangements have favoured energy consumption rather than conservation. However, energy is at the centre of the sustainable development paradigm as few activities affect the environment as much as the continually increasing use of energy. Most of the used energy depends on finite resources, such as coal, oil, gas and uranium. In addition, more than three quarters of the world's consumption of these fuels is used, often inefficiently, by only one quarter of the world's population. Without even addressing these inequities or the precious, finite nature of these resources, the scale of environmental damage will force the reduction of the usage of these fuels long before they run out (Cheng, 2010).

Throughout the energy generation process there are impacts on the environment on local, national and international levels, from opencast mining and oil exploration to emissions of the potent greenhouse gas carbon dioxide in ever increasing concentration. Recently, the world's leading climate scientists reached an agreement that human activities, such as burning fossil fuels for energy and transport, are causing the world's temperature to rise. The Intergovernmental Panel on Climate Change has concluded that ''the balance of evidence suggests a discernible human influence on global climate''. It predicts a rate of warming greater than any one seen in the last 10,000 years, in other words, throughout human history. The exact impact of climate change is difficult to predict and will vary regionally. It could, however, include sea level rise,

disrupted agriculture and food supplies and the possibility of more freak weather events such as hurricanes and droughts. Indeed, people already are waking up to the financial and social, as well as the environmental, risks of unsustainable energy generation methods that represent the costs of the impacts of climate change, acid rain and oil spills. The insurance industry, for example, concerned about the billion dollar costs of hurricanes and floods, has joined sides with environmentalists to lobby for greenhouse gas emissions reduction. Friends of the earth are campaigning for a more sustainable energy policy, guided by the principal of environmental protection and with the objectives of sound natural resource management and long-term energy security. The key priorities of such an energy policy must be to reduce fossil fuel use, move away from nuclear power, improve the efficiency with which energy is used and increase the amount of energy obtainable from sustainable, and renewable sources. Efficient energy use has never been more crucial than it is today, particularly with the prospect of the imminent introduction of the climate change levy (CCL). Establishing an energy use action plan is the essential foundation to the elimination of energy waste. A logical starting point is to carry out an energy audit that enables the assessment of the energy use and determine what actions to take (Kothari, et al., 2011).

The actions are best categorised by splitting measures into the following three general groups:

i. *High priority/low cost*

These are normally measures, which require minimal investment and can be implemented quickly. The followings are some examples of such measures:

- Good housekeeping, monitoring energy use and targeting waste-fuel practices.
- Adjusting controls to match requirements.
- Improved greenhouse space utilisation.
- Small capital item time switches, thermostats, etc.
- Carrying out minor maintenance and repairs.
- Staff education and training.
- Ensuring that energy is being purchased through the most suitable tariff or contract arrangements.

ii. *Medium priority/medium cost*

Measures, which, although involve little or no design, involve greater expenditure and can take longer to implement. Examples of such measures are listed below:

- New or replacement controls.
- Greenhouse component alteration, e.g., insulation, sealing glass joints, etc.
- Alternative equipment components, e.g., energy efficient lamps in light fittings, etc.

iii. *Long term/high cost*

These measures require detailed study and design. They can be best represented by the followings:

- Replacing or upgrading of plant and equipment.
- Fundamental redesign of systems, e.g., combined heat and power (CHP) installations.

This process can often be a complex experience and therefore the most cost-effective approach is to employ an energy specialist to help.

*c) Policy Recommendations for a Sustainable Energy Future*

Sustainability is regarded as a major consideration for both urban and rural development. People have been exploiting the natural resources with no consideration to the effects, both short-term (environmental) and long-term (resources crunch). It is also felt that knowledge and technology have not been used effectively in utilising energy resources. Energy is the vital input for economic and social development of any country. Its sustainability is an important factor to be considered. The urban areas depend, to a large extent, on commercial energy sources. The rural areas use non-commercial sources like firewood and agricultural wastes. With the present day trends for improving the quality of life and sustenance of mankind, environmental issues are considered highly important. In this context, the term energy loss has no significant technical meaning. Instead, the exergy loss has to be considered, as destruction of exergy is possible. Hence, exergy loss minimisation will help in sustainability. In the process of developing, there are two options to manage energy resources: (1) End use matching/demand side management, which focuses on the utilities. The mode of obtaining this is decided based on economic terms. It is, therefore, a quantitative approach. (2) Supply side management, which focuses on the renewable energy resource and methods of utilising it. This is decided based on thermodynamic consideration having the resource-user temperature or exergy destruction as the objective criteria. It is, therefore, a qualitative approach. The two options are explained schematically in Figure 10. The exergy-based energy, developed with supply side perspective is shown in Figure 11. The following policy measures had been identified:

- Clear environmental and social objectives for energy market liberalisation, including a commitment to energy efficiency and renewables.
- Economic, institutional and regulatory frameworks, which encourage the transition to total energy services.
- Economic measures to encourage utility investment in energy efficiency (e.g., levies on fuel bills).
- Incentives for demand side management, including grants for low-income households, expert advice and training, standards for appliances and buildings and tax incentives.

- Research and development funding for renewable energy technologies not yet commercially viable.
- Continued institutional support for new renewables (such as standard cost-reflective payments and obligation on utilities to buy).
- Ecological tax reform to internalise external environmental and social costs within energy prices.
- Planning for sensitive development and public acceptability for renewable energy.

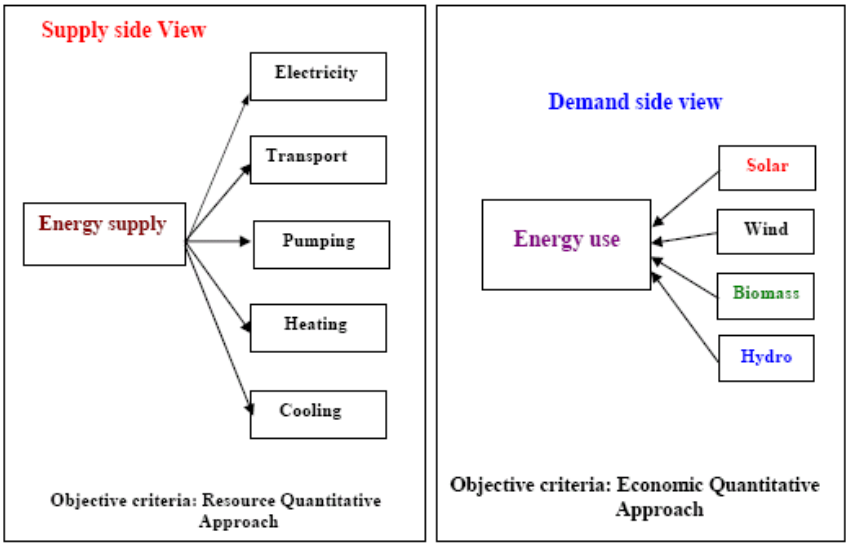


*Figure 10 :* Supply side and demand side management approach for energy (Omer, 2008)

Energy resources are needed for societal development. Their sustainable development requires a supply of energy resources that are sustainably available at a reasonable cost and can cause no negative societal impacts. Energy resources such as fossil fuels are finite and lack sustainability, while renewable energy sources are sustainable over a relatively longer term. Environmental concerns are also a major factor in sustainable development, as activities, which degrade the environment, are not sustainable. Hence, as much as environmental impact is associated with energy, sustainable development requires the use of energy resources, which cause as little environmental impact as possible. One way to reduce the resource depletion associated with cycling is to reduce the losses that accompany the transfer of exergy to consume resources by increasing the efficiency of exergy transfer between resources, i.e., increasing the fraction of exergy removed from one resource that is transferred to another (Erlich, 1991).

As explained above, exergy efficiency may be thought of as a more accurate measure of energy efficiency that accounts for quantity and quality aspects of energy flows. Improved exergy efficiency leads to reduced exergy losses. Most efficiency improvements produce direct environmental benefits in two ways. First, operating energy input requirements are reduced per unit output, and pollutants generated are correspondingly reduced. Second, consideration of the entire life cycle for energy resources and technologies suggests that improved efficiency reduces environmental impact during most stages of the life cycle.

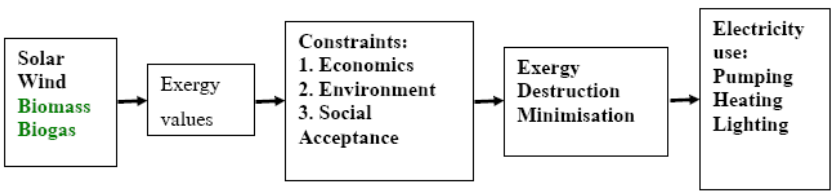


*Figure 11 :* Exergy based optimal energy model (Omer, 2008)

Quite often, the main concept of sustainability, which often inspires local and national authorities to incorporate environmental consideration into setting up energy programmes have different meanings in different contexts though it usually embodies a long-term perspective. Future energy systems will largely be shaped by broad and powerful trends that have their roots in basic human needs. Combined with increasing

world population, the need will become more apparent for successful implementation of sustainable development (Aroyeun, 2009).

Heat has a lower exergy, or quality of energy, compared with work. Therefore, heat cannot be converted into work by 100% efficiency as shown in equations (5-6). Some examples of the difference between energy and exergy are shown in Table 17.

$$\text{Carnot Quality Factor (CQF)} = (1-T_o/T_s) \quad (5)$$

$$\text{Exergy} = \text{Energy (transferred)} \times \text{CQF} \quad (6)$$

where $T_o$ is the environment temperature (K) and $T_s$ is the temperature of the stream (K).

The terms used in Table 17 have the following meanings:

Various parameters are essential to achieving sustainable development in a society. Some of them are as follows:

- Public awareness.
- Information.
- Environmental education and training.
- Innovative energy strategies.
- Renewable energy sources and cleaner technologies.
- Financing.
- Monitoring and evaluation tools.

*Table 17 :* Qualities of various energy sources (Omer, 2008)

| Source | Energy (J) | Exergy (J) | CQF |
|---|---|---|---|
| Water at 80°C | 100 | 16 | 0.16 |
| Steam at 120°C | 100 | 24 | 0.24 |
| Natural gas | 100 | 99 | 0.99 |
| Electricity/work | 100 | 100 | 1.00 |

Improving access for rural and urban low-income areas in developing countries must be through energy efficiency and renewable energies. Sustainable energy is a prerequisite for development. Energy-based living standards in developing countries, however, are clearly below standards in developed countries. Low levels of access to affordable and environmentally sound energy in both rural and urban low-income areas are therefore a predominant issue in developing countries. In recent years many programmes for development aid or technical assistance have been focusing on improving access to sustainable energy, many of them with impressive results (Omer, 2006).

Apart from success stories, however, experience also shows that positive appraisals of many projects evaporate after completion and vanishing of the implementation expert team. Altogether, the diffusion of sustainable technologies such as energy efficiency and renewable energies for cooking, heating, lighting, electrical appliances and building insulation in developing countries has been slow. Energy efficiency and renewable energy programmes could be more sustainable and pilot studies more effective and pulse releasing if the entire policy and implementation process was considered and redesigned from the outset.

New financing and implementation processes are needed which allow reallocating financial resources and thus enabling countries themselves to achieve a sustainable energy infrastructure. The links between the energy policy framework, financing and implementation of renewable energy and energy efficiency projects have to be strengthened and capacity building efforts are required.

## VIII. Results and Discussions

Alternatively energy sources can potentially help fulfill the acute energy demand and sustain economic growth in many regions of the world. Bioenergy is beginning to gain importance in the global fight to prevent climate change. The scope for exploiting organic waste as a source of energy is not limited to direct incineration or burning refuse-derived fuels. Biogas, biofuels and woody biomass are other forms of energy sources that can be derived from organic waste materials. These biomass energy sources have significant potential in the fight against climate change. Recently, there are many studies on modern biomass energy technology systems published (Cihan, et al., 2009, and Bhutto, et al., 2011).

Vegetation and in particular forests, can be managed to sequester carbon. Management options have been identified to conserve and sequester up to 90 Pg C in the forest sector in the next century, through global afforestation (Singh, 2008; Duku, 2009). For efficient use of bioenergy resources, it is essential to take account of the intrinsic energy potential. Despite the availability of basic statistics, many differences have been observed between the previous assessments of bioenergy potential (Bessou, 2009, and Cheng, 2010).

On some climate change issues (such as global warming), there is no disagreement among the scientists. The greenhouse effect is unquestionably real; it is essential for life on earth. Water vapour is the most important GHG; followed by carbon dioxide ($CO_2$). Without a natural greenhouse effect, scientists estimate that the earth's average temperature would be –18°C

instead of its present 14°C (Kothari, et al., 2011). There is also no scientific debate over the fact that human activity has increased the concentration of the GHGs in the atmosphere (especially $CO_2$ from combustion of coal, oil and gas). The greenhouse effect is also being amplified by increased concentrations of other gases, such as methane, nitrous oxide, and Chlorofluoro carbons (CFCs) as a result of human emissions. Most scientists predict that rising global temperatures will raise the sea level and increase the frequency of intense rain or snowstorms (Andrea and Fernando, 2012).

Globally, buildings are responsible for approximately 40% of the total world annual energy consumption. Most of this energy is for the provision of lighting, heating, cooling, and air conditioning. Increasing awareness of the environmental impact of $CO_2$, $NO_x$ and CFCs emissions triggered a renewed interest in environmentally friendly cooling, and heating technologies. Under the 1997 Montreal Protocol, governments agreed to phase out chemicals used as refrigerants that have the potential to destroy stratospheric ozone. It was therefore considered desirable to reduce energy consumption and decrease the rate of depletion of world energy reserves and pollution of the environment. One way of reducing building energy consumption is to design buildings, which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the renewable energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels.

## IX. Conclusion

Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations, as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest – plantation cover, the nation's resource base would be greatly improved. The international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources. Furthermore, investigating the potential is needed to make use of more and more of its waste. Household waste, vegetable market waste, and waste from the cotton stalks, leather, and pulp; and paper industries can be used to produce useful energy either by direct incineration, gasification, digestion (biogas production), fermentation, or cogeneration. Therefore, effort has to be made to reduce fossil energy use and to promote green energies, particularly in the building sector. Energy use reductions can be achieved by minimising the energy demand, by rational energy use, by recovering heat and the use of more green energies. This study was a step towards achieving that goal. The adoption of green or sustainable approaches to the way in which society is run is seen as an important strategy in finding a solution to the energy problem. The key factors to reducing and controlling $CO_2$, which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest – plantation cover, a nation's resource base would be greatly improved. The international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources.

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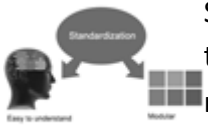


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(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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

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

**Format**

*Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.*

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

**Structure**

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive 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) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

*Abstract, used in Original Papers and Reviews:*

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

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

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin 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 research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

*Acknowledgements: Please make these as concise as possible.*

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

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*Tables: Tables should be few in number, 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. Vertical lines should not be used.*

*Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.*

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. 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.

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## TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

**1. Choosing the topic:** In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

**2. Evaluators are human:** First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

**3. Think Like Evaluators:** If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

**4. 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.

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

**6. Use of computer is recommended:** As you are doing research in the field of Computer Science, then this point is quite obvious.

**7. Use right software:** Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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**9. Use and get big pictures:** Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

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

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

**12. Make all efforts:** Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

**13. Have backups:** When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

**14. Produce good diagrams of your own:** Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

**15. Use of direct quotes:** When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

**16. Use proper verb tense:** Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

**17. Never use online paper:** If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

**18. Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

**19. Know what you know:** Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

**20. Use good quality grammar:** Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

**21. 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 to your topic. You may also maintain your arguments with records.

**22. Never start in last minute:** Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

**24. Never copy others' work:** Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

**25. Take proper rest and food:** No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

**27. Refresh your mind after intervals:** Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

**28. Make colleagues:** Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

**29. Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

**30. Think and then print:** When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

**31. Adding unnecessary information:** Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

**32. Never oversimplify everything:** To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

**33. Report concluded results:** Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

**34. After 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 to 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 in your research.

## Informal Guidelines of Research Paper Writing

**Key points to remember:**

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

**Final Points:**

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of 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 the progression.

**General style:**

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

**Title Page:**

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

**Abstract:**

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing 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 approach 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. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than 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 maintain the initial two items to no more than one ruling each.

- Reason of the study - 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 quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness 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 to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled 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 with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose 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 sound written Procedures segment allows a capable scientist to replacement 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 for the least amount of information that would permit another capable scientist to spare 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 object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text 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:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not 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 - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

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

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part a 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. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise 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 in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to 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 part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

**Discussion:**

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a 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 implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly 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 with prospect, and let it drop at that.

- Make a decision if each premise is supported, 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 the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One 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 available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

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- Do not give permission to anyone else to "PROOFREAD" your manuscript.

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|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
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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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