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MODELLING MULTIPLE RESERVOIR OPERATION SYSTEM FOR AGRICULTURAL AND URBAN WATER USES IN THE SAFARI-IGAVA AREA, MARONDERA DISTRICT, ZIMBABWE

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Abstract

Zimbabwe's land reform in the year 2000 caused huge impacts on agricultural production and management of water resources. In the Safari-Igava area in Marondera District, twenty farms were sub-divided into 600 smaller plots and allocated to new farmers. Reservoirs owned and managed by farmer consortiums were taken over by a state enterprise. In 2004, a new and larger Wenimbi Reservoir, located upstream, was commissioned, mainly for agricultural and water supply to the town of Marondera. The changes brought new water management and farming practices, new water supply and demand characteristics, more water users, more competition, shortages and some conflicts. This study determined the underlying causes of shortages and conflict among irrigators. A spreadsheet-based simulation model was developed and used for analysis of operation of reservoirs and formulation of water management strategies. Quantitative and qualitative data was gathered from institutions managing water, the irrigators, and field measurements. Data was collected on climate, available water, water allocation, reservoir operations, consumptive water use, irrigation practices, crops produced, and topology. Records showed that urban and agricultural water demand was rising, but were below the maximum allocations. Some farmers were expanding area under irrigation, but others experienced water shortages. Regulations for water abstraction from the canals were set up by farmers without outside intervention, checks or controls. Access and distribution rules for water were not changed after the land reform. The model simulation showed that there was enough water to meet all agricultural and urban water demands in the period 2006 to 2012, with shortages likely during peak

demand periods. New water management strategies were required for equity and efficiency in water distribution, as well as minimizing shortages and occurrence of conflict. Regulations enforcement, monitoring of irrigation water abstraction, accurate recording and billing of water abstractions, proper operation and maintenance of infrastructure, were required.

Keywords: Land reform, Irrigation, Reservoir operation, Modeling, Wenimbi River, Wheat, Tobacco

Introduction

Water is a finite resource which is under increasing stress as human population and per capita demands increase through out the world (IWMI, 2000). The demand for water for agricultural, industrial, power generation, domestic use and sanitation, waste collection, treatment and disposal uses on rivers are rising with the growth in world economies. Flows in most rivers of the world are affected by the random and cyclic seasonal fluctuations (Woodruff, 1991; Wurbs and James, 2001). Therefore reservoir storage plays a key role in regulating stream flow fluctuations. To develop reliable water supplies, optimal operation of the reservoirs is crucial (Wurbs and James, 2001).

In hydrological systems that comprised of several interlinked reservoirs and rivers systems, if the water demands and equitable allocation and distribution are complex computer simulation models are used as analysis tools for decision support (van Oel, et al., 2011; Asit, 1976). Simulation models of the hydrological systems are developed and several runs of the simulation models under various scenarios can be used to come up with optimal strategies for distribution and allocation of water (Tarboton, 1992; Wurbs and James, 2001; Ragad and Prudhomme, 2002). Exploited worldwide are ready to use/ commercial or generalized hydrological models designed for application to a range of problems dealing with systems of various configurations and locations, rather than being developed to address a particular problem at a specific site (Wurbs and James, 2001). Commercial models are very important but must be applied carefully and meticulously with professional judgment and good common sense (Wurbs and James, 2001; Savenije, 1995). Understanding both the process that is simulated and the commercial model helps in drawing up useful benefits out of a model.

Alternatives to commercial models are the spreadsheet based models. Savenije (1995) developed a spreadsheet model called WAFLEX for simulation of water resource systems. The cells of the spreadsheet replicate the upstream to downstream flow of water and apply the continuity equation.

The water resource system network can be made up of reservoirs, rivers and their tributaries, and abstraction points. Ground water seepage and

river inflows and direct precipitation are the inflows into reservoirs and river's mainstream which are added fluxes, whereas abstractions, evaporation, overflows and groundwater leakages from reservoirs are fluxes subtracted from the water resources. The spreadsheet based model is simple to use and has been successfully applied in the Save and Thuli catchments (Symphorian et al., 2003; Khosa et al., 2008; Ncube et al. 2011). Also, all over the world all kinds of professionals have become acquainted with spreadsheets, because they have simple data base management facilities and built-in statistical packages (Savenije, 1995). Therefore in this study, the spreadsheet model (WAFLEX) was the decision support tool that simulated the management of water resources in the Wenimbi River basin.

The WAFLEX simulation model was used for analysis of operation of five reservoirs mainly used for irrigation water supply. The study was carried out during the period 2009-2012, but the river flow data used in simulation model was from period 2006 to 2012. Quantitative and qualitative data was gathered for input into the computer model, and for establishing the capacities of available water resources, irrigation water demand characteristics, allocations and underlying causes of shortages and conflict after the land reform. The simulation model was also used to analyse the impact of possible solutions to the shortages and conflicts.

Study Area

The study was conducted in the Safari Igava area, located in the Marondera district, which is part of the Macheke Sub-catchment in the Save Catchment in south eastern Zimbabwe, as shown in Figure 1. Zimbabwe is a country in Southern Africa.

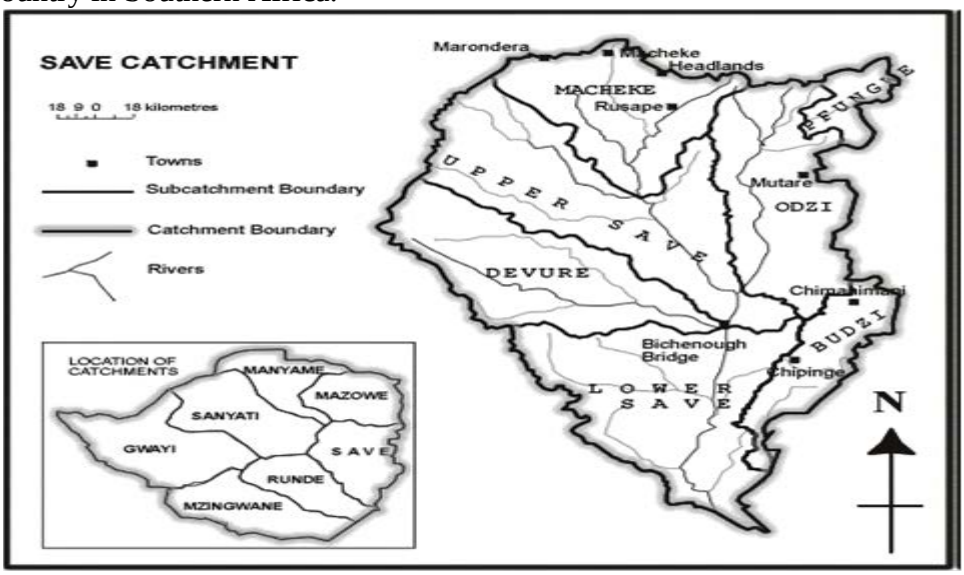

Figure 1: Map of catchments of Zimbabwe and Sub-catchments of Save Catchment

Physiography and Water Resources

Most of the Safari-Igava farming area can be classified as semi arid receiving erratic rainfall with a long term average of 870 mm per annum (Meteorology Department, 2009). The altitude of the area ranges from 1400 to 1600 m above sea level. Two main rivers, Wenimbi and Ruzawi Rivers drain through the area towards the Macheke River. Macheke sub-catchment is located in the Save Catchment (Figure 1). Like most rivers in Zimbabwe, flow in the Wenimbi River is mainly during the rainy season (Mazvimavi, 2003). To mitigate the unreliable rainfall and runoff, five reservoirs were constructed by government and a consortium of large scale commercial farmers to supply water for irrigation and urban water supply (Luxemburg, 1996).

There are four reservoirs on Wenimbi River; the most upstream and largest Wenimbi Reservoir with capacity of 21.3 Mm^3 and downstream is Safari Reservoir with a 10.4 Mm^3 capacity, followed by Eirene Farm 1 Reservoir and the most downstream Eirene Farm 2 Reservoir with capacities of 2.3 Mm^3 and 0.5 Mm^3 respectively. The fifth, Gairon Reservoir with a capacity of 6 Mm^3, is located on Ruzawi River, which originates in the Marondera Town as shown in Figure 2. The town discharges almost half of its wastewater into the Ruzawi River (Zimbabwe National Water Authority (ZINWA), 2009). Safari Reservoir, the main reservoir that supplies the farming community of the Safari-Igava area has two concrete lined canal systems (over 12 km in length), located on riparian and non-riparian farms of Wenimbi River. The two canals and all reservoirs apart from Wenimbi Reservoir were constructed by a consortium of the large scale farmers before the land reform. To ease water supply management on the two canals, some storage reservoirs were built as pumping sites. Interbasin transfer of water from Gairon Reservoir, into the right bank canal was done through pumping. At the end of the canals pipelines were use to convey water by gravity as far as farms numbered 18, 19 and 20 (in Figure 2). A new Wenimbi Reservoir, was built upstream of Safari Reservoir, commissioned in 2004, to supply water to Marondera Town, riparian areas and downstream farmers (Agricultural and Extension Department (AGRITEX), 2005). There are several reservoirs upstream of the Wenimbi Reservoir with a total storage of 5.4 Mm^3 (Government Gazzete, 2006). Figure 2 show the details of the layout of water resources and the farm boundaries. Table 1 and Table 2 summarise the available water resources to the Safari-Igava area.

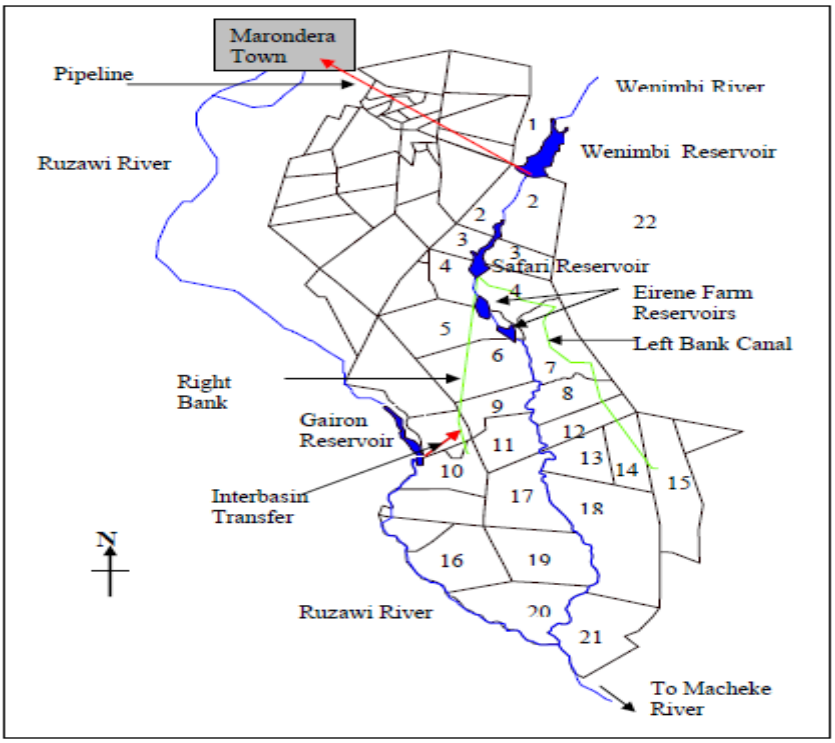

Figure 2: Water Resources and Large Scale Farm Boundaries before Land Reform
KEY: Rivers and reservoirs (blue polygons), farms
(black outlined polygons numbered 1 to 22) and canal (light green).

Table 1: Hydrological Properties and Artificial Reservoirs of the Study Area (ZINWA, 2009; Government Gazette, 2006).

Reservoir Name	Wenimbi	Safari	Eirene Farm 1	Eirene Farm 2	Gairon
River	Wenimbi	Wenimbi	Wenimbi	Wenimbi	Ruzawi
Storage right priority dates (1976 Water Act)	6/4/1993	2/4/1991	24/4/1990	3/1/1990	
Storage(km^3)	21 268	10 400	2 300	500	6 200
Net Storage (km^3)	17 468	9 360	2 170	450	5 680
Catchment Area (Mm^2)	131.45	203.43	216.31	227	7 500
Intermediate Catchment Area (Mm^2)	131.45	71.95	12.88	10.69	7 500
MAR (Mm^3)	140	140	140	140	140
CV	0.9	0.9	0.9	0.9	0.9

Table 2: Water Storage & Allocation from Wenimbi and Ruzawi Rivers for the Safari-Igava Area (ZINWA, 2009; Government Gazette, 2006).

Mean Annual Runoff (MAR) (km^3)	140
Primary Use and Environmental Water Requirements at 10% MAR (km^3)	14
Storage Upstream of Wenimbi Reservoir (km^3)	5400
Total Allocations Wenimbi River system (km^3)	14687

Total Storage in Wenimbi River reservoirs (km^3)	34500
Carryover after exhausting allocations (km^3)	19813
Carryover in Wenimbi River (years)	1.35
Total storage available from Ruzawi &Wenimbi River reservoirs (km^3)	34800
Carryover of reservoirs on Ruzawi & Wenimbi Rivers (years)	1.37

The Legal System and Institutional Arrangements in the Study Area

The Zimbabwe Water Act of 1998 sets the rules for governance and management of water affairs in the Wenimbi River basin. As per government gazette of 26 January 2006, all the reservoirs under consideration in this study were owned by ZINWA on behalf of the government of Zimbabwe. The state owns all water resources; therefore any use of water, except for primary purposes must be approved by the state through ZINWA which issues permits. Access to water from state owned reservoirs for other consumptive and productive uses required an agreement/permit from ZINWA which users apply for through sub-catchment councils. The Macheke sub-catchment council was responsible for operation of Safari, Eirene Farm and Gairon Reservoirs, but during the study period the operation had been delegated to a farmers' committee. Wenimbi reservoir was operated by ZINWA.

Allocation of water for Irrigators and Urban Uses

Every farm had a fraction of water allocated to it from the river flow and the storage reservoirs. The allocation of water was based on water rights that the large scale farmers obtained under the Water Act of 1976, which depended on contribution to construction of reservoirs (for storage rights only) and the priority date system (for storage and flow rights). From the year 2000 to 2006 resettled individual farmers/irrigators were allocated individual permits which they paid for annually. Irrigation requirements were factored at 12 000 m^3 per hectare per year. The quantity of water allocated by a permit on each farm was subdivided among the new farmers so that the total amount of water allocated per farm remained constant and lower than the allocation under the Water Act of 1976. Due to the government gazette of 2006 all the reservoirs were now under government ownership, therefore irrigators required a permit from ZINWA for access.

Farmers/irrigators with access to both the river and canal could abstract from the two sources at the same time. In case of a shortage of water in the Safari Reservoir and Eirene Farm Reservoirs the sub-catchment council and the farmers' committee applied and paid for release of agreement water from the Wenimbi Reservoir. Farmers applied for water releases from Wenimbi Reservoir through the Macheke Sub-catchment council, the manager of the smaller four reservoirs and the intermediator

between farmers and ZINWA. Allocation of agreement water from Wenimbi Reservoir for Marondera urban use was fixed at 4.2 M m^3 per year.

Issues That Arose in the Safari-Igava Area

The land reform of the year 2000 created new 600 plots with minimum sizes of 6 Ha per farmer, on an irrigation system that was designed for 20 large scale farms. The new farmers/irrigators had new crops and agricultural practices, hence new water demand characteristics, and operation of the reservoirs and abstraction from the canals changed. Access was relatively reliable for upstream farmers on both canals, but tail end farmers on the canals faced shortages during periods of high demand; during prolonged dry spells in the summer season and the dry winter season. Farmers pumping directly from the river did not experience shortage problems (AGRITEX, 2005). Irrigators experienced water shortages to the extent that the main reservoir (Safari Reservoir) that supply farmers dried up in the middle of the dry season, the peak period for irrigation water demand. These shortages resulted in conflicts among farmers, and between the water authority (ZINWA) and the farmers (AGRITEX, 2005). The fears of the stakeholders were that the water shortages could escalate when Marondera Town starts abstracting water from Wenimbi Reservoir. Hence careful operation of the reservoirs would be crucial for conflict reduction through judicious management of the water resources.

Methods

Qualitative and quantitative data was collected from government departments, the water authority, the sub-catchment council and farmers. Evaluation of canal leakages was done and the conveyance efficiencies of the two canals were determined. An unstructured questionnaire was used to acquire information from farmers, the water authority (ZINWA), the Macheke sub-catchment council and government departments. The data collected was on climate, water use, area under irrigation since the year 2000, agricultural practices, the number of resettled farmers and water allocation.

The simulation model based on the WAFLEX package was used to mimic the functioning of the Safari-Igava hydrological system, because the model could be used to solve water allocation and reservoir operation (Ncube eta al. 2011). The model was based on the water mass balance equation. The weekly change in storage was due to water inflows, less water losses from the system on a week time step, represented by the equation;

$$\Delta S = R - \left(S_p + E + Y_d\right)$$

Where;

ΔS is change in storage per week

R is sum of runoff flowing into the system, precipitation and ground water contribution into the system (m^3/week),

Y_d is the total abstractions per week (m^3/week),

E is the evaporation (m^3/week) and

S_p is the spillage and ground water outflow from the system (m^3/week).

Inflow excess of full reservoir capacity (FRC) was spilled and added to storage of the immediate downstream reservoir. Utility rule curves (URC1 and URC2) were used for rationing water supply once reservoirs levels had reached defined thresholds. No water was released when reservoir levels were at dead storage capacity (DSC). Water remaining in a reservoir at the end of the seasonal year called "carryover water," was credited to the following year's fill. The carryover water was used to assess the water security in the river basin (Simpson et al., 2011; Alexander, 1995). Allocations of water by the model satisfy the demand of upstream users ahead of downstream users.

Conceptual Model of the Safari-Igava Water Resources and Uses

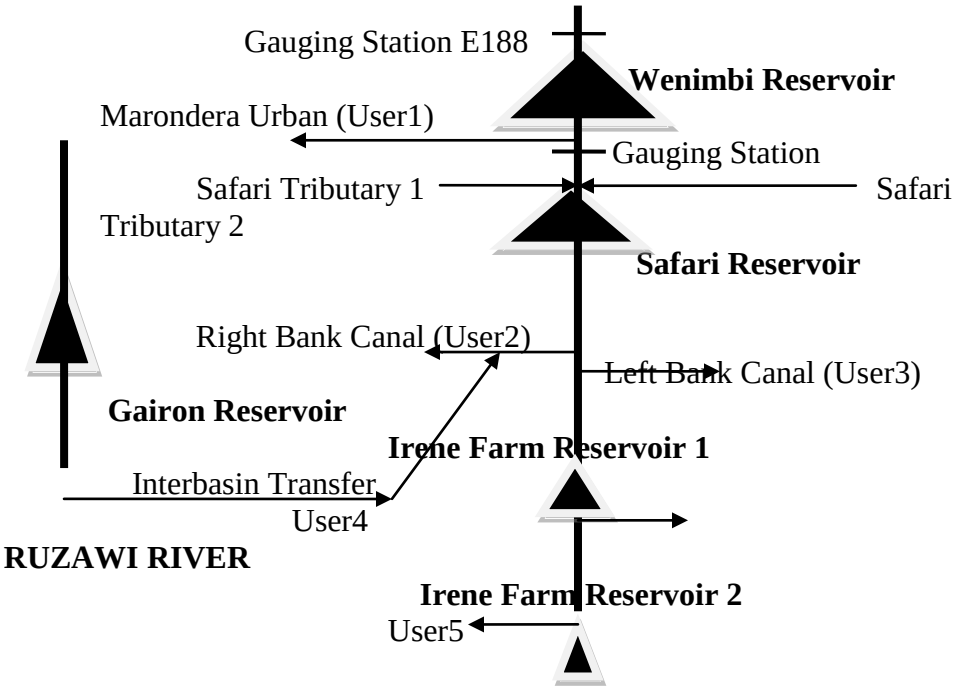

Figure 3: Conceptual Model of the Safari-Igava Water Resources and Uses

Calibration and validation of the simulation model was done using ZINWA's records of storage levels of Wenimbi Reservoir for the respective

periods 2006 to 2009 and 2009 to 2012. Simulated and actual storage levels were compared using Pearson's correlation coefficient (Gurung et al., 2013) and the mean absolute error which gave indication of relative difference between simulated and actual data (Almasri and Kaluarachchi, 2007). Information on times when Safari and Irene Reservoirs were at full supply capacities and dead storage/dry was obtained from interview of farmers and the operator of Safari Reservoir, because there were no written records for water abstracted from the Safari and Irene reservoirs. Also there were no records and measurements for irrigation water used, therefore weekly irrigation water demands were calculated using a CROPWAT 8.0 model (Ncube et al., 2011), which use the Penman-Monteith equation (Balkhair eta al, 2013). The area under irrigation, from each point of abstraction was used in the CROPWAT 8.0 model to calculate the weekly irrigation water demands.

The WAFLEX model was used to analyse impact of water management practices by running simulations under high and low water demand scenarios. Due to the difficulty of projecting water politics for the study area, recorded historical average water transfers between dams, water and agronomic data collected from government departments, water allocations by the sub-catchment council and data on agricultural management practices obtained from farmer interviews were used in the simulation model (Tapia et al., 2014).

Safari Reservoir's annual time series capacity was developed from response to an questionnaire administered to operators. The unknown intermediate capacity was assumed to be the average of the full capacity and dead storage capacity (1.04 Mm^3). There were no records on Safari Reservoir water levels, and water releases, hence simulations were run at different irrigation efficiencies (different water demand scenarios), in order to find the best fitting Safari Reservoir storage curves, and the curves were used to estimate the irrigation water releases from the Safari Reservoir. Hence, average irrigation efficiencies were obtained for the periods of conflict, when some farmers experienced shortages (2005-2008) and periods without shortages/conflicts (2009-2012). For each time step, the average irrigation efficiency was equal to the irrigation water demand determined using CROPWAT 8.0 model divided by water released from Safari Reservoir.

Estimation of Flow in Ungauged Streams

For ungauged streams that flow into Safari Reservoir, the similar catchments method was used, on the basis of inflow at gauging station E188, located upstream of Wenimbi Reservoir. The runoff per unit catchment area was multiplied by the catchment area of the streams.

Scenarios

Records of irrigated area and urban water consumption were used to draw graphs and trendlines. Several scenarios were drawn after an analysis of the trendlines, annual variation of urban water demand, wastewater release and area under irrigation. The stability or robustness of the simulation model was checked by analyses and comparisons of results produced by the simulation model after running it under different scenarios against observed data. The sensitivity of the simulation model was tested by running it after changing input data (e.g. climatic and water demand) and analysis of the results on shortages and reservoir capacity. The different scenarios provided the variations in input data. In the different scenarios the simulation model was subjected to the following conditions;

1. Historical and recorded water abstraction in the years 2005 to 2008 (period of shortages and conflicts) and from 2009 to 2012, a period without water supply shortages.
2. Low abstraction/ water demand; when area under irrigation was reduced e.g. the 2009 agricultural year shown in Figure 6.
3. Low inflow into reservoirs e.g. hydrological drought year 2008/09 with a 15% non-exceedance probability. Global climate model HadCM2 predicted that climate change could cause annual average summer rainfall to decrease by 10 to 15% in Southern Africa (Ragad and Prudhomme, 2002).
4. Increased water availability through interbasin transfer from Ruzawi River into the right bank canal (RBC).
5. No rationing, hence no restriction to water released from farmer operated reservoirs. (During the study period farmers had no operation rules for rationing water releases from the Safari Reservoirs and the two farm reservoirs).
6. High demand scenario, whereby demand would be equal total allocations by ZINWA.

Assumptions Made

The following assumptions were made in the development of the simulation model;

- Soils and hydrographical conditions were relatively homogenous in the Wenimbi basin. Climatic data recorded at Marondera Town weather station 15 km from the Safari-Igava area was used in the modeling. The impact of climate change was negligible.
- Wheat and tobacco were the irrigated crops, but other crops which took less than 7% or irrigated area had negligible water demand. Average irrigation efficiency was used for all irrigators.

- In the absence of design data and reservoir capacity measurements, dead storage capacity of Eirene Farm Reservoirs was estimated at 10% of full capacity. Effect of siltation was negligible. Net seepage from all reservoirs was not considered as a loss from the system and evaporation from Eirene Farm Reservoirs were considered negligible because they had relatively small capacities.
- River normal flow was fixed at 10% of mean annual runoff (MAR) and was considered adequate for environmental and primary purposes for users downstream of the Safari-Igava area. The supply from reservoirs with a combined storage 5.4 Mm^3 located upstream of Wenimbi reservoir was considered too small to help in alleviating shortages in the Safari-Igava Area. The water use and operation of the reservoirs by upstream irrigators was steady in all scenarios.

Results analysis and discussions

Questionnaire

The unstructured questionnaire administered to farmers, water authorities and government departments revealed the following information about water use in the Safari-Igava area;

- Farmers managing Safari Reservoir said that in average rain seasons the Safari Reservoir is at full capacity at the end of the rainy season, i.e. at the end of March. It would be at dead storage capacity by end of August, unless water has been released by ZINWA from the upstream Wenimbi Reservoir, after a request and a payment by the farmers. Operators were not keeping records of water releases from Safari and Eirene Farm reservoirs.
- Competition for water might increase since most of the farmers wished to expand their area under irrigation; therefore reallocation of water and/or controls of expansion were required as conflict prevention measures.
- There was no evidence that farmers were employing well calculated irrigation scheduling methods as a water management tool. Scheduling irrigation could be one of the solutions to water shortages in the canal system.

Analysis of the results of the questionnaire, helped to understand the management of the water resources in the study, and the following inferences were made;

a. Monitoring, measurement and recording of irrigation water abstraction (especially on the canals) was not done which made water allocation and demand management in the system to be

ineffective and inefficient. Over abstractions by upstream farmers and shortages for canal tail end farmers was possible under such situations and conflicts were inevitable.

b. Accurate measurement and recording at Safari Reservoir, each demand (point of abstraction) on the two canals and the Wenimbi River could help to locate points where there were water wastages, either in conveyance or in use.
c. It was difficult to use pricing of water as a water demand management tool in the Safari-Igava system because billing was not based on measured quantities of water used but on allocated amounts.
d. ZINWA and the Macheke Sub-catchment Council were not involved on the release of water from Safari and Eirene farm reservoirs, but the new farmers (with little training), were responsible for the releases which weakened management of the water resources.

Water Availability

There was little security of water supply in the Safari-Igava area because the carryover was 1.35 years, and 1.37 years with interbasin transfer, as shown in Table 2. Recommendations by Alexander (1995) are that the safe reservoir carryover for Southern Africa, where river flow is seasonal is 2 to 5 years. For the Safari-Igava area, in the event that there were two consecutive dry years, most of water supplied would be from reservoir releases. Hence the reservoirs in the Wenimbi River system may not be able to meet peak demand.

Canal Conveyance Efficiency

The canal conveyance efficiencies were found to be above 95%. Field measurements were done during the rainy season when the canals' water levels were less than half full and the surrounding soil was relatively moist. Determining the conveyance efficiencies of the two canals during the dry season at maximum canal water levels would give the best information on water losses from the canals.

Reservoirs Operational Rules

ZINWA was responsible for operation of the Wenimbi Reservoir, hence ZINWA kept a record of the reservoir water levels; inflow, natural out flow, and the releases to farmers. Releases to farmers were done after the farmers had formerly applied and paid for the water. Also, as a minimum, 10% of mean annual runoff was released from Wenimbi Reservoir for downstream environmental requirements, and hence the downstream reservoirs also released the same amount for downstream environmental

requirements. Safari Reservoir, Eirene Farm Reservoirs on Wenimbi River and Gairon Reservoir on Ruzawi River were operated by resettled farmers on behalf of the Macheke Sub-catchment and ZINWA. The operators were not keeping records on reservoir water levels, water inflows and releases.

Model Calibration: Simulation of Wenimbi Reservoir Capacity between March 2006 and September 2009

The model underestimated the dynamic storage in the Wenimbi Reservoir. A mean absolute error of 4% was attributed to the estimation of ungauged runoff contributed by groundwater sources and ungauged streams. The graphs in Figure 4 show the simulated and recorded time series capacities of the Wenimbi Reservoir between the years 2006 to 2008.

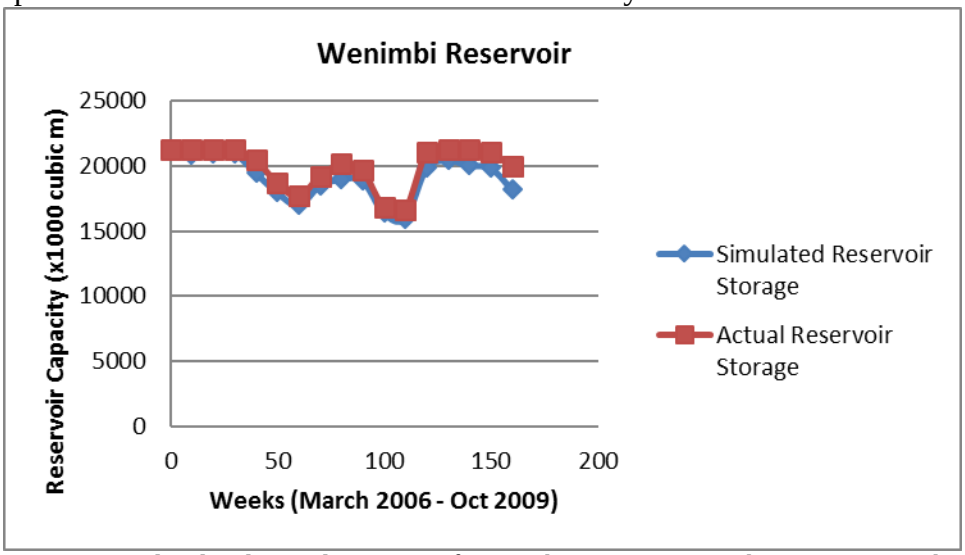

Figure 4: Simulated and Actual Capacity of Wenimbi Reservoir, March 2006 to September 2009.

The simulation mean absolute error of 4% was considered acceptable (Almasri and Kaluarachchi, 2007); therefore the model was validated using Wenimbi reservoir storage data obtained between 2009 and 2012 as shown in Figure 5. The Pearson correlation coefficients were 0.98, 0.994 and 0.986 for the hydrologic years 2006/07, 2007/8 and 2008/9 respectively, which showed that the model could simulate the water storage levels satisfactorily (Gurung et al., 2013).

Model Validation: Simulation of Wenimbi Reservoir Capacity between October 2009 and September 20012

Simulated reservoir levels and ZINWA records for Wenimbi Reservoir were compared The Pearson correlation coefficients were 0.856, 0.013 and 0.971 for the hydrologic years 2009/10, 20010/11 and 2011/12

respectively, which showed that the model simulated the water storage levels satisfactorily for the first and third hydrologic years. The Pearson correlation coefficient for the three hydrologic years (combined) was 0.647, which was a satisfactorily simulation, hence the model was used for simulation of the Wenimbi River basin (Gurung et al., 2013). The simulation mean absolute error of 5.6% was considered acceptable (Almasri and Kaluarachchi, 2007); therefore the validated model was used for analysis of operation of the reservoirs and estimation of agricultural water use efficiency. All the water released for the farmers from the Wenimbi reservoir into Safari reservoir was ultimately used for irrigation. The two reservoirs are situated in similar topography and hydrological conditions, therefore it was assumed that the same model could simulate Safari reservoir's response to water release with a similar degree of accuracy, and hence analyse irrigation water management in the Safari-Igava area.

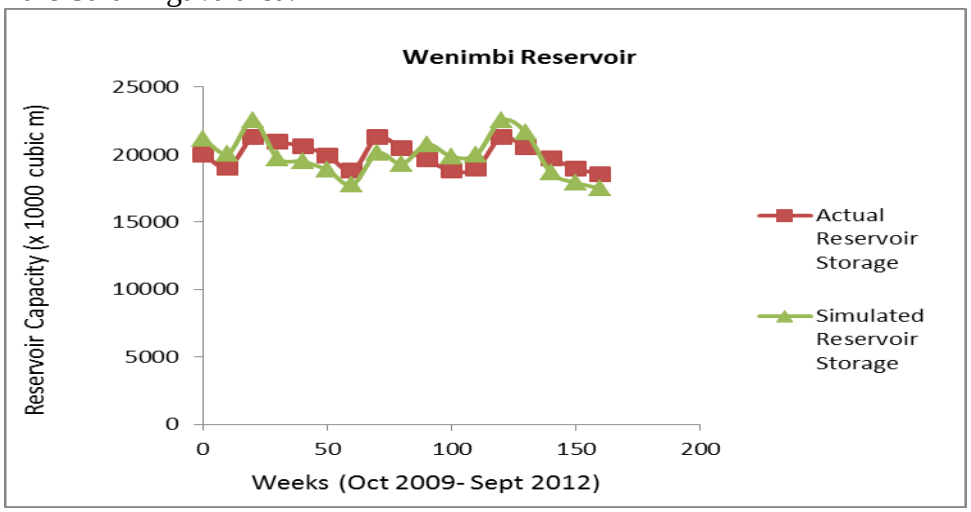

Figure 5: Simulated and Actual Capacity of Wenimbi Reservoir, October 2009 to September 20012.

Irrigation Water Demand

There were no records on irrigators' water abstractions; therefore the size of land under wheat was used as the optimum area that was under irrigation. Records available at government departments and farmers' organization were from the years 2006 to 2012. Figure 6 show that there was a general increase in area under irrigation between 2006 and 2008 which corresponds to a period of water shortages and conflicts, and a second phase of reduced area under wheat from 2009 to 2012. The increase in area under irrigated wheat between 2006 and 2008 was attributed to government subsidies on inputs (fertilizer, seed and fuel for tillage) for wheat production, as well as marketing of the crop. The decrease in irrigated area under wheat may have been caused by a change in government policy, after a new

government of national unity formed in 2009, reduced subsidies for wheat production. From 2010 to 2012 area under wheat was on a decreasing trend, because of marketing problems (AGRITEX, 2012). The farmers reduced the area under wheat, but increased area under irrigated tobacco in the same period. Farmers had a new cropping program, hence irrigation water demand characteristics effectively changed in the year 2009. No complaints of water shortages were reported since 2009 (AGRITEX, 2012). There were no water shortages and complaints because tobacco is mainly a summer crop and hence supplementary irrigation is practiced and therefore irrigation water demand from the reservoirs is lower compared to wheat, a dry season and winter crop. Also, the total area under irrigation was reduced since 2009 hence irrigation water demanded by the farmers was lower.

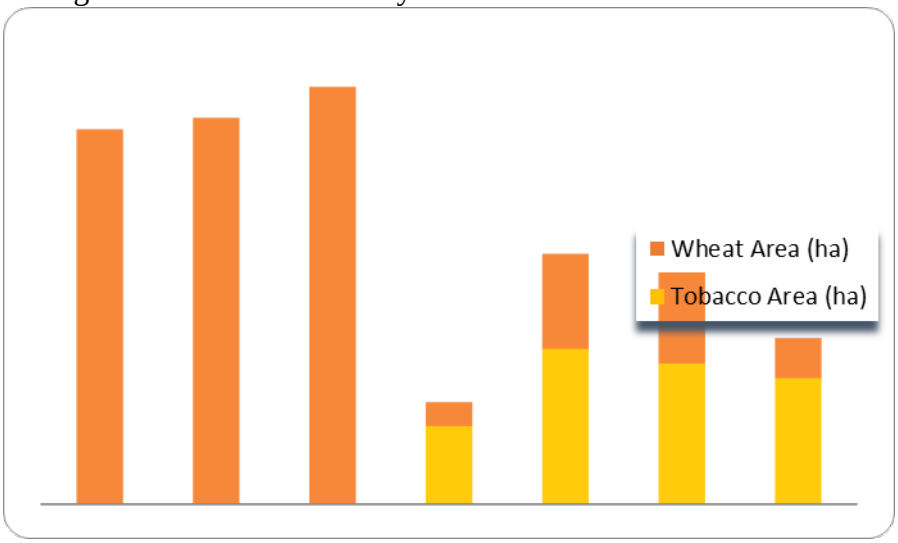

Figure 6: Estimated Area under Irrigation in Safari-Igava, Years 2006-2012 **(**Department of Agricultural Research and Extension, 2009 & 2012)

Model Simulation for Analysis of Safari Reservoir's Capacity and Agricultural Water Demand

Irrigation efficiency was estimated at 75%, that is, the average for portable sprinkler systems (Savva and Frenken, 2002). The computer model produced simulation results for the temporal variation of the capacity of the Safari Reservoir (due to irrigation water demand/releases), between the years 2006 and 2009, as shown in Figure 7.

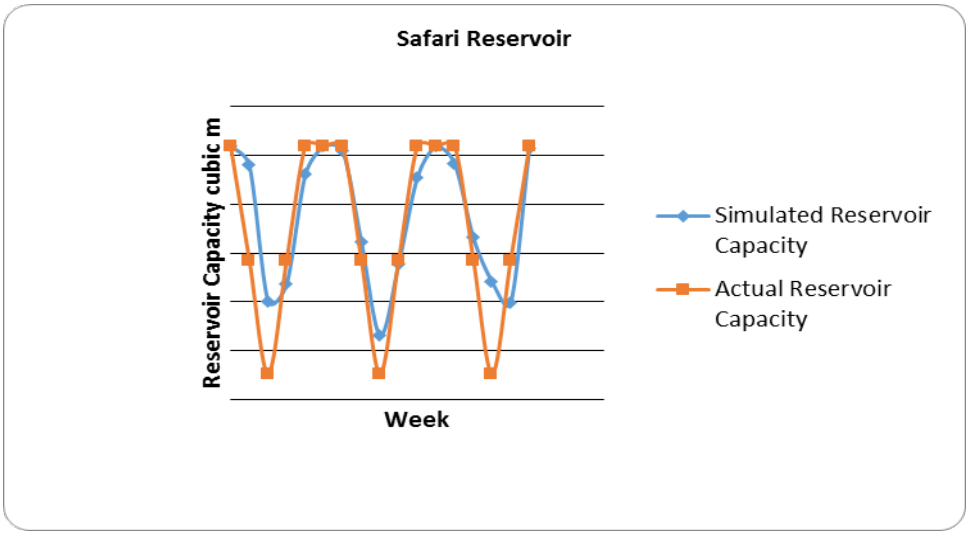

Figure 7: Safari reservoir simulated and actual capacity curves, irrigation efficiency at 75% from October 2006 to September 2009.

Simulation mean absolute error was 17% and the reservoir was never at dead storage capacity. This showed that actual water abstracted from the dam was higher than the estimated water demand for the portable sprinkler irrigation systems. High irrigation inefficiency could be one cause of the high error in simulation. Therefore the actual irrigation efficiency was lower than 75%.

The model was run when irrigation efficiency had been reduced to 40%, which was a relatively high water demand scenario. The computer model produced simulation results as shown in Figure 8.

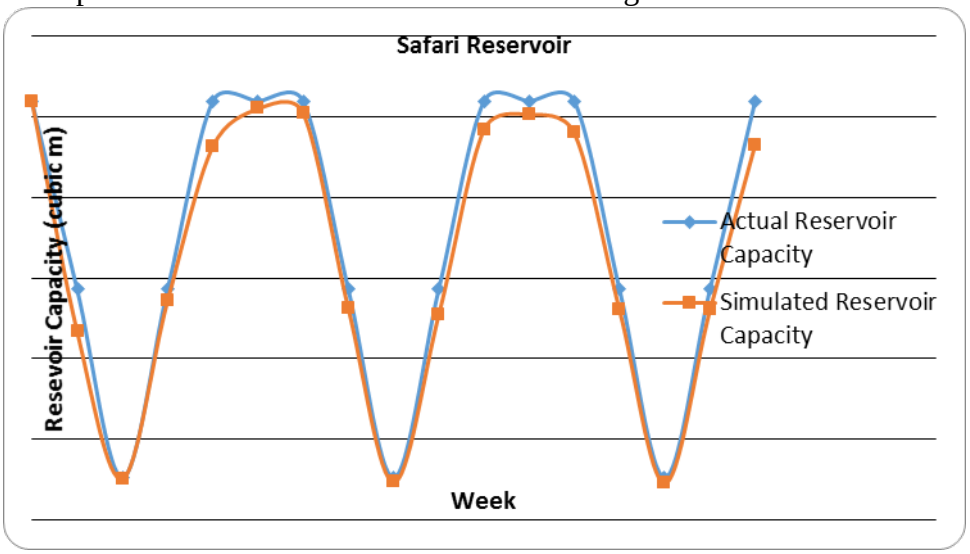

Figure 8: Safari reservoir actual and simulated capacity curves; irrigation efficiency is 40% from October 2006 to September 2009.

Mean absolute error was 7% which meant that the average irrigation efficiency in the Safari-Igava area could have been less than 40%. Decreasing the efficiency below 40% did not produce perfectly fitting curves of simulated and actual reservoir capacity and mean absolute error increased above 7%. The minimum mean absolute error was 7 % and the range was 7 to 9.4 % between irrigation efficiencies of 40% and 50 % respectively. Therefore other factors could have a significant influence to the mean absolute error. Some of the factors were;

(i) Errors in estimation of irrigated area.
(ii) Errors in derivation of the actual time series Safari Reservoir capacity curve.
(iii) Variations in water demand due to farmers that used other methods of irrigation, like surface irrigation instead of portable sprinkler in order to cope with lack of adequate equipment and different topological conditions.
(iv) Variations in water demand due to production of other crops like horticultural crops which were planted at the same growing period with the wheat crop.

For the period 2009 to 2012, the simulation result for Safari Reservoir had a mean absolute error of 6% at an irrigation efficiency of 65%. There were no water shortages and hence no conflict in this period (AGRITEX, 2012). Also the simulation model had no shortages. Probably inefficient farmers stopped producing wheat possibly preferring a summer crop like tobacco, especially after the new government had stopped subsidizing wheat production and stopped support in the marketing of the crop. Hence it was inferred that government policy or water governance and external factors like markets had strongly influenced water use and access, hence reduced conflict in the Safari-Igava farming community.

Simulation under Various Scenarios of Available Water, Demand and Allocations

In the years 2006 to 2009 urban water supply system was not yet connected and agricultural production was rising but had not yet reached its peak. Downstream famers using the canals were experiencing water shortages. The model simulation, with an irrigation efficiency of 75%, showed that there was enough water for all irrigators in the Safari-Igava area. The model showed that the shortages (for six months of each year) could only begin if water use efficiency was less than 40%. Therefore the shortages experienced were caused by inefficient use of water by upstream farmers using the canal.

For the peak demand scenario; Marondera Town water supply would be connected and the irrigation water demand would be at peak, hence water

demand would be equal to allocations as in records at ZINWA (2009). The simulation model showed that irrigators would not get water shortages for three years. Figure 9 and Figure 10 show the respective storage changes for Wenimbi and Safari Reservoirs.

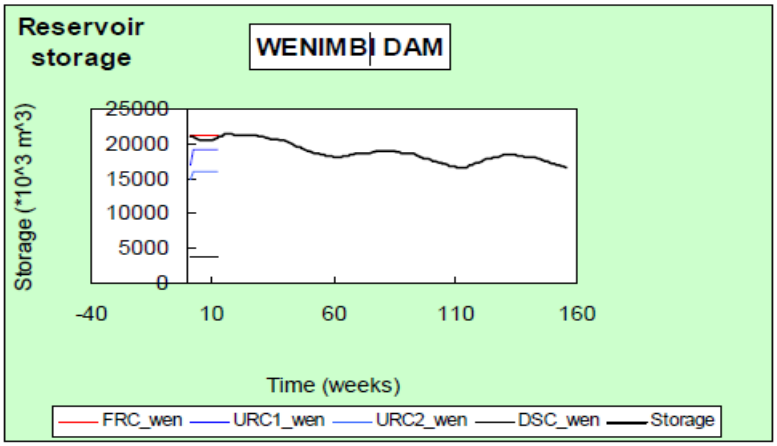

Figure 9. Wenimbi Reservoir storage at peak demand (Marondera Town water supply connected and 75% irrigation efficiency)

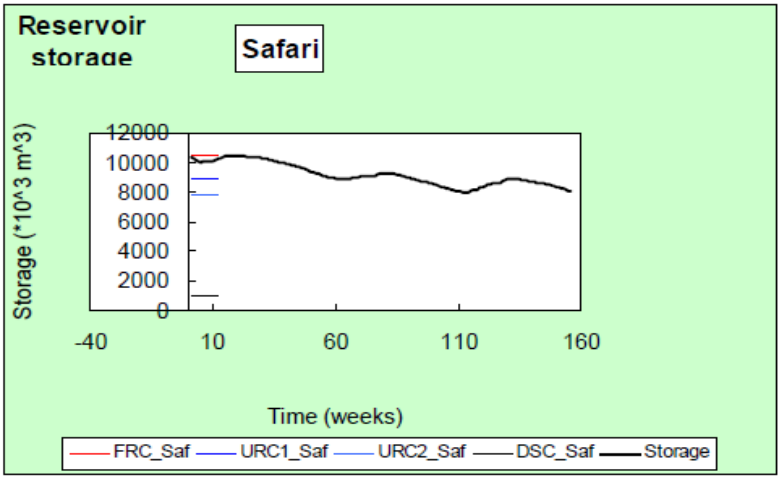

Figure 10. Safari Reservoir storage at peak demand (Marondera Town water supply connected and 75% irrigation efficiency)

The model showed a continuous depletion of storage on Wenimbi and Safari Reservoirs whereby rainy seasons between 2006 and 2009 could not fill up the reservoirs. The rainy seasons had a combined average annual rainfall above 800 mm, and the 2008/9 rainy season was drought year with non-exceedance probability of 15% (Santos et al., 2000). The continuous reduction in storages indicated low water security which was also indicated by a carryover of 1.35 years in Table 2. Therefore water management under a maximum allocation or a peak demand scenario may require; either review

of allocations, use of alternative supplies, enforcement of strict rationing combined with/ or strict water demand management measures that ensure farmers utilize irrigation methods with efficiencies above 75%. Figure 11 and Figure 12 respectively showed insignificant storage changes in Eirene Farm Reservoir 1 and Eirene Farm Reservoir 2. Therefore farmers pumping directly from the river downstream of Eirene Farm Reservoirs 1 and 2 should get water releases from these two reservoirs until they are depleted to minimum/dead storage capacity before getting water from Safari and Wenimbi Reservoirs, thereby reducing direct demand on the Safari and Wenimbi Reservoirs.

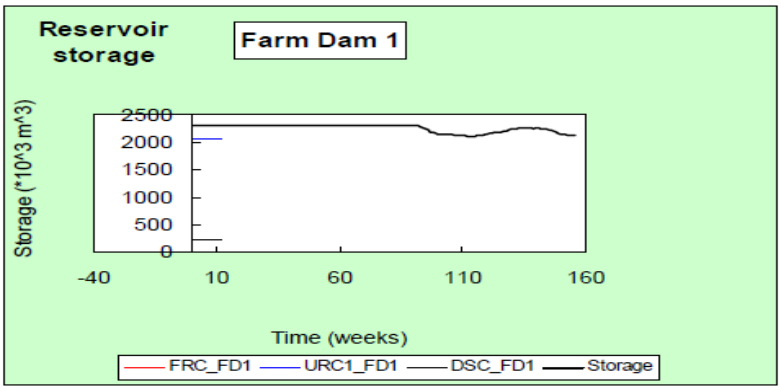

Figure 11. Eirene Farm Reservoir 1 storage at peak demand (Marondera Town water supply connected and 75% irrigation efficiency)

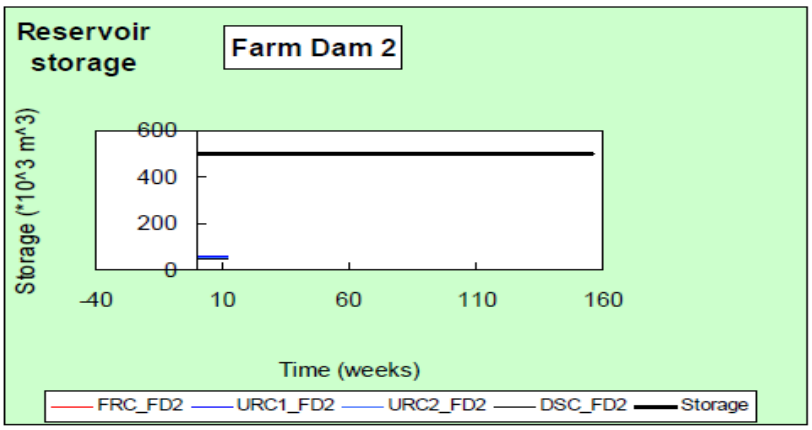

Figure 12. Eirene Farm Reservoir 2 storage at peak demand (Marondera Town water supply connected and 75% irrigation efficiency)

Two consecutive dry years (15% non-exceedance like the 2008/2009 hydrologic year), at the 2006-2009 water demand (where urban water supply was not yet operational) have an impact on water availability, hence demand could not be met 43% of the time, which indicated low water security. This was in agreement with the results in Table 2 which gave a respective

carryovers of 1.35 and 1.37 years without and with interbasin transfer (Finnerty and Hecht, 1992; Alexander (1995).

To alleviate shortages strict monitoring of water consumption and adherence to allocations could be required. Therefore supporting external organisations like government departments or national water authorities must help in enforcing the installation of flow meters at all pump stations, and making sure that water measurement devices on the canals are functioning, and water bills are derived from quantity of water used. Area under irrigation and method of irrigation could be used to determine the quantity of water consumed. The supporting organisations must review and fractionally allocate water in times of shortages for equity at peak demand (Derbile, 2012). Investigating transmission losses of the canals at peak flow rates and farmers' water use efficiencies for maintenance combined with a review of operations of Safari Reservoir are required for formulating effective strategies for water release.

Sensitivity Analysis of the Computer Model

A sensitivity analysis was carried out to test the overall responsiveness of the model to some input parameters (Zheng and Bennett, 1995 and Oyarzun et al., 2007). The model was run when there was no rationing (control of water released), both Wenimbi and Safari Reservoirs were depleted to dead storage, but the Eirene Farm Reservoirs were spilling. The algorithm made the water released equal to the demand when there was no rationing as long as storage was above dead storage. With a water release control instruction, the model started to regulated water release proportionally as long as there was enough water above the dead storage capacity (DSC). Therefore the model was responsive and hence it was an appropriate decision support tool for reservoir operation.

The simulation model was run when storage in reservoirs was at dead storage capacity and irrigation water demand was for 540 ha, and negative releases equivalent to the net evaporation and 100% shortages were obtained. This was accurate result since the there were no water supply at DSC, but evaporation was the only net loss from the system.

Interbasin transfer whereby 80% of water supplied to Marondera Town was released into the Ruzawi River as treated wastewater, then transferred into the downstream end of the right bank canal (RBC) had insignificant impact on water security for the Safari Igava Area. The model showed that interbasin transfer reduced water shortages by 3% for 3 months which indicated the sensitivity of the model.

Conclusion

The quantity of water available for the Safari-Igava area was enough for irrigating over 540 hectares of wheat, provided irrigation efficiency was at least 75%. In the 2006-2008 period there was over abstraction of water from the reservoirs due to low efficiency of the irrigation methods.

The increase in area under irrigated wheat was driven by subsidies on wheat production.

Policies and marketing factors that led to increased area under wheat resulted in increased irrigation water demand causing water shortages and conflicts among irrigators. Replacing wheat with tobacco which only required supplementary irrigation reduced shortages and conflicts.

In case of consecutive two years of drought, the water available in the reservoirs cannot satisfy total allocations especially in the second year, which means there was little water security in the Safari-Igava Area. The computer model simulated well, the multiple reservoir system in the Safari-Igava area. Therefore the model could be used as a decision support tool for regulation, water distribution, allocations and analysis of reservoir operational strategies. The model could be used to analyse the long term impact of weekly inflows and abstractions on reservoir storage and hence assess the impact of management strategies for conflict resolution. Also, the model can be used in impact assessment before developments of new area for irrigation or new water demand scenarios.

Acknowledgements

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FLOODING AND TRAFFIC MANAGEMENT IN AKURE (NIGERIA) METROPOLITAN ENVIRONMENT

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Abstract

In order to extend areas usable in cities, migrants to cities, often reshape the natural landscapes in various forms. In some cases, they reduce hills, reclaim beach regions, fill valleys and wetlands, and sometimes encroach on river valleys not minding the consequences on the environment. These cultural ways of increasing usable lands have some negative impact on the urban physical environment. The major negative impact is change in the micro-climate of urban environment which manifest in various forms including flooding. Based on the above impact, the paper identified the consequences of flooding in Akure and determines ways by which its menace on traffic congestion could be reduced. Structured questionnaire was administered to residents of Akure living within 200 meter radius to areas where flash flood had been witnessed. Result shows positive correlation between flash flood and traffic congestions in the city. Similarly, accident rates were found to increase during heavy downpour in many of the flood hot spots as many vehicles struggle for right of way. Flash flood on traffic corridor was noted to influence numbers of stranded vehicles in the pool of water. The paper recommends regular clearance of drainages at the on-set of rainy seasons especially in areas prone to flooding. Property developers should ensure that gutters are provided in newly developed areas of cities. The paper also advocated the creation of environmental awareness through both formal and Informal forms of education on how to dispose solid as the hallmark of managing traffic in flooded environment in the study area.

Keywords: Landscape, traffic corridor, flash flood, drainage system, urban managers

Introduction

Natural disasters are unexpected sudden events which impacts with such severity that it is usually disastrous and uncontrollable whenever they occur. They could cause widespread destruction of properties, lives, displacement of people, animals and aquatic life wherever they occur. A natural disaster might be caused by one or more of the following: earthquake, flooding, tsunamis, land submergence, tornadoes, typhoons/hurricanes/willy-willies, smog and the likes. However, in order to be classified as a disaster, it must have profound environmental effect and human lost.

A flood is an overflow of an expanse of water that submerges lands. In a simple language, flood means a temporary covering by water of land not normally covered by water. Flood occurs when excess waterfails to flow in any definite channel but spreads over land that is normally dry. Flooding may also result from the volume of water within a body of water, such as a river or lake which overflows or break levees, with the result that some of the water escapes its usual boundaries (Ayoade, 1983).

When rain falls, there are three (3) ways by which the water is disposed off. The first one is through percolation; the second is through surface runoff while the third one is through evaporation/evapo-transpiration. When the intensity of rainfall is very high, there is little or no time for the rainfall to percolate. Thus, the surface run-off water becomes greater than the water that percolates. It is this, in most cases that lead to flooding in some urban environment. If the duration of rainfall is elongated than usual, the flood becomes devastating and hazardous to people who live very close to river course or channels.

According to SITE some of the most notable flood disasters include:

- The Great Flood of 1931 in Huang-He, China claimed over 800,000 people.
- The 1998 Yangtze River Floods in China left 14 million people homeless.
- The 2000 Mozambique Flood covered much of the country for three weeks, resulting in thousands of death and leaving the country devastated for years afterwards.
- The 2010 Pakistan Floods, damaged crops and infrastructures and claimed many lives.

In Nigeria, there has been several reported cases of flood problems in cities such as Lagos, Port Harcourt, Uyo, Warri, Benin, Aba and so on but the chronological view of flood events in Nigeria include the following, Asa flood at Ilorin in 1976, Lisaluwa and Arogo flood in Ondo in 1988 and 1995. The serious and repeated flood disasters of Ogunpa River in Ibadan in 1978, 1980, 1981, 1985 , 1987 and 1988; Osun River flood in Oshogbo in

1992, 1996 and 2002. The Yobe River flood in 2000; River Ala flood in Akure in 1996, 2000, 2002 and 2004; Lagos flood in 1984, 1988 and 1995, Kano and Dekina floods in 1988, Lafia , Patigi, Kpada and Gbogbondogi floods in Kwara State in 1997, Indiegore flood of 1981 and 2012 in Aba as well as Jos, Gombe, Kaduna and Bauchi floods in 2013.

Apart from Yobe's flood (2012) which was caused by breakdown of a dam, three other dam bursts have occurred in Nigeria, resulting in disastrous floods and these are;

(a) Ojirami Dam in Edo State (1981)
(b) Bagauda Lake Dam in Kano State (1988)
(c) Goronyo Dam in Sokoto State

The dam burst flooded the roads, settlements and farms, thus causing a lot of hardship to the immediate neigbours of such dam sites.

Traffic management is a technique designed and used to promote efficient vehicular and non-vehicular movement in any geographical space. Unfortunately, traffic management has been noted to constitute most daunting problems faced by highly urbanized cities of developed world, whereas some cities of developing world had to contend with urbanization problems in relation to traffic congestion (Ogunbodede and Aribigbola, 2003 and Ogunsanya, 1994). According to Ogunbodede and Aribigbola (2003), a number of factors have been responsible for the precarious traffic problems on roads. Such traffic problems range from inadequate transport facilities, gross inadequacies of public transport services, accidents, poor road infrastructure to environmental pollution and absence of integrated traffic management measures to combat congestion. Today, the rapid development of cities coupled with the fact that drainage facilities are not often developed almost immediately as new areas are developed has introduced another dimension into traffic problems in urban environment. Flash floods often take over the traffic corridors in the new areas of cities thereby unleashing hardship to motorists as well as dwellers in such environment.

In the analysis of vehicular concentrations on roads, Omiunu (1988) applied the index of percentage of vehicular concentration on some selected roads (25rods) in Benin –City (Nigeria) using the formula: IVC = TVM/TVY *100/1. Where IVC = Index of Vehicular concentration, TVM = Total Vehicle of Traffic per Month and TVY = Total Vehicle of Traffic per Year. Both TVM and TVY were based on peak hours from 7.30 – 8.0 a.m., 12.30 – 2.30 p.m., and 5.30 – 7.30 p.m. The formula according to Omiunu (1988) was adapted from Winifred Ashton’s work on theory of traffic flow. This model has no serious application to travel demand modeling but was very relevant in determining vehicular concentration on roads of which floods played significant roles.

Dam failure can also lead to flooding especially in some agricultural regions or in regions that are very close to banks of river valley. This occurred in Nigeria when a dam was opened in Cameroun and the banks of River Benue were flooded up to Lokoja in year 2012. Vehicles going to Abuja from the southern part of the country had to be ferried on roads after about three days of inaccessibility through the major trunk connecting the southern part of the country to the northern part.

Statement of problems

In contemporary time, flooding has become a common feature and part of life in Nigeria not only in the low-lying coastal areas but also in the wetland regions as well as the hinterland. The growing population and rapid urbanization processes, for example, has exerted pressure on available lands to the extent that a larger proportion of river basins have been encroached upon by people.

The poor drainage system and the attitude of people using such drainage as dump sites have led to blockage of drains. The consequences of this attitude are that the run-off water finds its ways on the major roads there by resulting in flooding. These floods not only constitute an obstacle to free flow of traffic but many vehicles get stranded once such water enters into their engines.

Flooded roads and broken down vehicles make journeys to be delayed. Commuters therefore get stranded and in most cases their journey time from home to place of work or other places in the urban environment are unnecessarily prolonged. Similarly, the aftermath of flooding is also felt in terms of loose soils and other debris that are deposited on the roads after flood. Apart from making affected roads to be dirty, they sometimes harbour sharp objects that may deflate tyres thereby causing untold hardship to motorists.

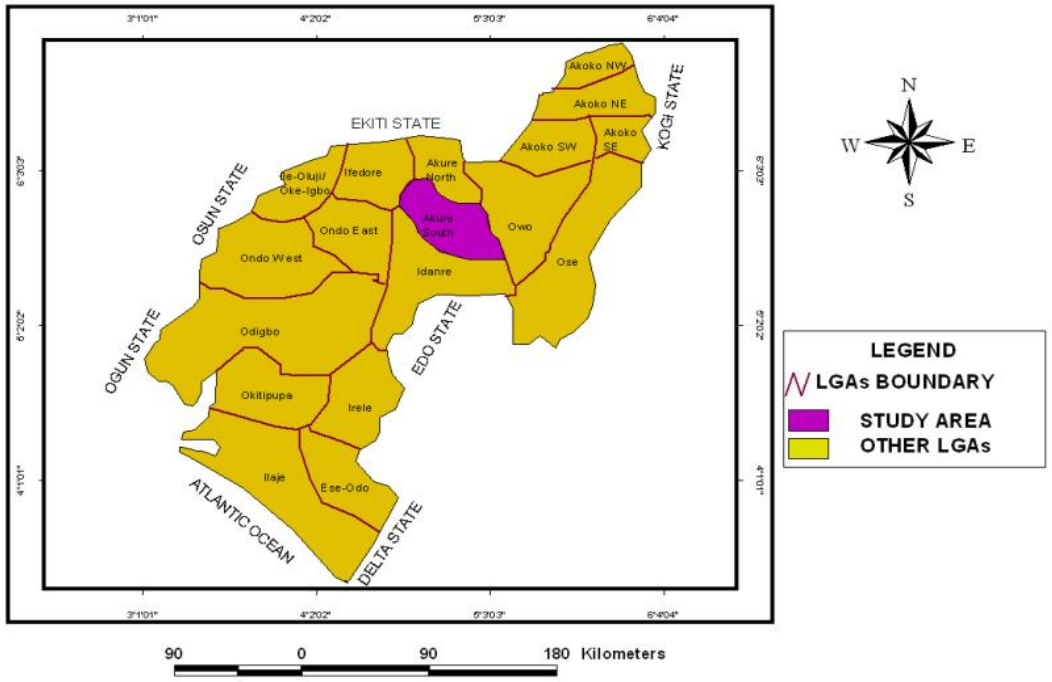
Most, if not all, environmental problems that we currently face can be directly or indirectly traced back to the legacy of lifestyles that we inherited and leading as human beings. Nowhere is this more correct than in the concentrations of human beings in urban environment. Cities and towns in most countries around the world have gained considerable attention due to the large number of migration to such cities and as a result, such high populations have always placed high pressure on their sites and their immediate hinterlands. In order to extend urban usable territories, urbanites often reshaped both natural and cultural landscapes involving the leveling of hilly areas, filling valleys, reclaiming beaches and putting wetlands into usable and profitable ventures, thus, creating huge areas of manmade land in urban areas. Structures of different magnitude occupy this new land irrespective of whether such lands have the capacity to sustain such

structures or not. This is why Oriola (2000) and Sewel (1969) also confirmed that, though floods are purely environmental hazard of meteorological phenomena, very often they are induced by man's improper utilization of or abuse of the physical environment.

In view of the foregoing, this paper **aims** at identifying the consequences of flash floods on roads and traffic management in Akure Metropolis.

The Study Area (Akure)

The study area is Akure, a rapidly developing metropolitan city. The city lies in the South-western part of Nigeria (Figure 1). Geographically, Akure lies approximately on 7^0 15^1North of the Equator and



Longitude 5^0 12^1 East of the Greenwich Meridian. Akure is currently the Capital city of Ondo State as well as Local Government Headquarter. The city has had rapid population increase and space use over time because of its numerous roles in the sub-region. Such roles include being the central of economic activities, religion and cultures, commerce and industries, educational centres, Government seat, central of hospitality and headquarters of corporate organizations. With all these attributes, the city's morphology has changed over time to assume its present status with lots of transport problems.

River Ala and its tributaries are the major rivers that drain the city. The rivers have their annual floods which are very conspicuous in the wetland regions of the city. However, the flash flood which is a common phenomenon of the river has unleashed untold hardship on motorists and commuters during rainy seasons. In some cases, roads are made impassable while in other cases it elongates travelling hours.

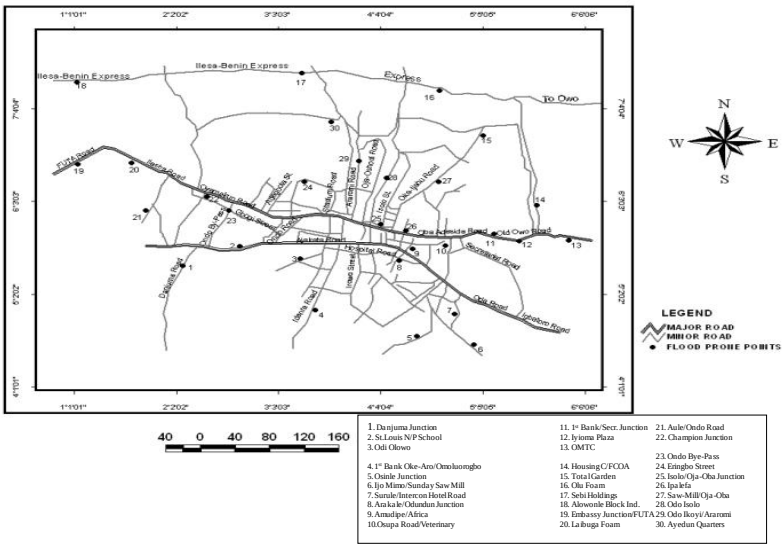
Methodology

The areas prone to flooding as well as wetland regions were identified through a reconnaissance survey in the city of Akure within a radius of about 10kms from the city centre. The streets were identified and mapped. About thirty (30) prominent flooded portions of these roads were identified and mapped (see Figure 2). Structured questionnaire to elicit information from respondents living within a 200metres radius to areas liable to flood were developed.

Data needed for the study and which were collected from the respondents include street names, nature of environment, nature of gutters, width of gutters, depth of gutters, nature of drainage during rainy seasons, waste disposal methods in the environment, causes of flood in the environment, consequences of flood in the environment with particular reference to road traffic and solutions to floods in the environment.

Data needed as specified above were collected using both primary and secondary methods of data collection. Purposive sampling method was used to sample ten hot spots where flash flood is said to be very prominent in Akure and these areas are Ipalefa, Odo Ijomu, Odo Isolo, Odo Ikoyi, Odo Araromi, Champion Junction, Oja Isikan, Ijala Kekere, Oja Adedeji and Ala close (figure 2). Fifteen copies of the designed questionnaire for this study were randomly administered in the ten (10) identified hot spots of the flooded zones in the environment. The target respondents are people living within 200metres radius within the vicinity of flood conflicts points. In all, a total of 150 copies of the questionnaire were administered in the study area.

Figure 2: Flood Prone Points along Major Roads in Akure



The second aspect of primary source was carried out by measuring areas occupied by flash floods as well as the depths and width of gutters in the flooded zone. Similarly, photographs of the affected areas were taken at different times and points. The topographical map of Akure was also used to identify the low and wetland areas.

Descriptive statistical method was used in summarizing responses on flooding and traffic congestion characteristics in Akure. Respondents perception on causes of flood, flood problems and surface run-off in the study area were identified. Respondents were given options ranging from "Strongly Agree" " (SA), "Agree" (A), "Disagree" (D) and "Strongly Disagree" (SD) from which to choose. The 4 point scale response was used to calculate the weight attached to SA, A, D and SD. The Mean Weight Value (MWV) were calculated from these order and compared with Group Arithmetic Mean (GAM) to determine acceptance or rejection of a problem items for taking decision (see Ogunbodede, 2009). Correlation analysis was then used to determine the relationship between width and depth of gutters and its implication on flood.

Results and discussions.

- **Drainage characteristics in the study area**

It was observed in the study area that about 36.57% of the built up areas have no gutters while the width of gutters between 31 and 90 cm

carries a percentage of about 55.97% as shown in Table 1. A substantial part of the areas without gutters are found in the newly developed regions of the city. Thus, flash floods occur frequently in the city areas where there are no drainage system as well as areas with narrow gutter as soon as there is little downpour of rain in cities.

Table 1: Width of gutters in the study area

Width of gutters (cm)	Frequency	percentage
1 – 30	3	2.24
31 – 60	40	29.85
61 – 90	35	26.12
91 -120	01	0.75
121 – 150	06	4.48
No gutter	49	36.57
Total	134	100

Similarly the depth of the gutters in the study area shows that 36.57% of the areas had no gutter hence majority of the surface run-off has no channels to direct floods (see Figure 2). The implication is that all waters in the new areas are channeled on the traffic corridors thereby creating problems for road traffic management.

Table 2 : Depth of gutters in the study area

Depth of gutters (cm)	Frequency	Percentage
1 – 30	02	1.49
31 - 60	29	21.64
61 – 90	11	8.21
91 – 120	38	28.36
121 – 150	01	0.75
151 – 180	04	2.99
No gutters	49	36.57
Total	134	100

- **Causes of Flood in Akure**

Table 3 reveals that, the intensity of rainfall with a MWV of 3.769 ranked first among the cause of flood especially when it is high with little or no time for percolation, this is followed by dumping of refuse with a MWV of 3.291 into the gutters as perceived by respondents. However, the respondents did not accept anger of God with a MWV of 1.813, inadequate storm with a MWV of 2.694 and impervious urban surfaces with a MWV of 2.619 as important causes of flood in Akure. Although these factors were not significant as major factors causing floods but they have been very contributory as noted by respondents in the study area.

Blockage of drainage by sands is also noted to be one of the ways by which traffic corridor get flooded**.** The granitic rock which is the parent rock we have in this country is very loose and easily movable. With time, these loose soils accumulate in the drainage (gutters, culverts etc) and after

sometimes too, start to block the drains. Blocked drainage system hampers smooth movement of water during rainy season. Since water must take its course, the surface run-off finds alternate routes thereby flooding the roads as well as houses (Odermerho, 1988).

Table 3 : Causes of flood as perceived by respondents

S/no	Statement items	Strongly agreed	agreed	disagreed	Strongly disagree	total	Mean Weight Value	Decision	Rank
1	Rainfall	456	42	02	05	505	3.769	accepted	1st
2	Anger of God	76	39	52	76	243	1.813	rejected	7th
3	Building along water flow path	144	153	20	37	354	2.642	rejected	4th
4	Impervious urban surfaces	116	177	24	34	351	2.619	rejected	5th
5	Inadequate storm drains	160	138	30	33	361	2.694	rejected	3rd
6	Dumping of refuse in drains and drainage paths	312	90	26	13	441	3.291	accepted	2nd
7	Concretization of urban surfaces (roads and buildings)	124	81	48	52	305	2.276	rejected	6th
	GMWV = 2.729								

Blockage of drainage by household wastes is one of the ways by which Nigerians have contributed to flood occurrence in our environment. Each time rain falls, you find children and adults emptying their household waste into the drainage. These wastes block the drainage and the surface run-off increases thereby flooding the roads and houses. It becomes difficult sometimes during this period to drive because sharp objects which sometimes accompany such wastes could deflate tyres. Houses that are constructed on low terrain are worst hit by flood because they easily get flooded. Table 3 reveals that dumping of refuse into gutters is an accepted cause of flood in the study area and ranked second as perceived by respondents with a MWV of 3.291.

Building close to river valley makes such structure highly susceptible to flooding. Thus**,** any street or buildings that are very close to river banks stand the risk of experiencing annual flood. This is because water must definitely take their normal course. In the same way a flooded valley allows water to encroach to its adjoining environment and any structure on its way becomes the first casualty. This factor ranked 4th among the causes of floods even though it was rejected by respondents as an important factor using GAMV.

PLATE 1: Flood has taken over this street and evidences of no vehicular movements are obvious

Another major factor influencing flood occurrence in cities is drainage failure. It is very common to find drainage system that are no longer functioning or had failed without attention being paid to it. In such circumstances, the flooded water makes use of the traffic corridor instead of the drainage and this affect free flow of traffic in urban environment as shown in Plate 2.

Another reason for flood occurrence is the absence of drainage system. As much as possible landlords must make provision for proper drainage system that will take care of not only the waste water in the house but also the surface run-off emanating from torrential rainfall.

PLATE 2: Pictures of Flooded road and traffic built-up

Consequences of flood on traffic management

Table 4 shows the major consequences of flood in traffic management and the environment. Damage to landed property ranked 1st with MWV of 3.701 and this was followed by the following: clogging of drains (3.649), sediments build-up on the road (3.642), traffic congestion (3.612) and damage to household properties (3.604) which were all accepted with MWV greater than GMWV of 3.582. Others factors as far as this study is concerned fell below GMWV and so were rejected as not too important consequences of flood in the environment.

Table 4: Flood problems in various Land use zones in Akure as perceived by Respondents

S/no	Statement Items	Stongly agreed	Agreed	Disagree	Strongly disagree	Total	Mean Weight Value	Decision	Rank
1	Damage to landed property	404	84	06	02	496	3.701	accepted	1st
2	Damage to household property	344	132	06	01	483	3.604	accepted	5th
3	Business slow down	332	120	18	02	472	3.522	rejected	6th
4	Traffic congestion	364	102	18	0	484	3.612	accepted	4th
5	Clogging of drains	356	129	4	0	489	3.649	accepted	2nd
6	Accidents on the roads	296	117	28	07	448	3.343	rejected	7th
7	Sediments build up on the road	380	99	6	3	488	3.642	accepted	3rd
	GMWV = 3.582								

- **Surface water run-off and road traffic management**

It has been noted in another study that surface run-off on traffic corridor inhibits smooth traffic flow in cities (Ogunbodede, 2004 and Ogunsanya, 2002) and sometimes lead to road accident. Table 5 shows respondents' perception on the implications of surface run-off on traffic corridors. The most prominent of these factors was that, urban surface run-off in most streets was through open gutters and this accounted for a MWV of 3.276. Next to this, is that, road surfaces in the study area serve as disposal channel for floods in some streets with a MWV of 3.276. The implication of this is that such flash floods on traffic corridors impede smooth movement of vehicles on the road thereby leading to congestion. In some cases it may lead to accident especially when vehicles rush to escape flooded zones. Others factors in descending orders are as shown in table 5.

Table 5: Respondents' Perception of surface run-off in the study area (Akure)

S/no	Statement items	Strongly Agreed	agreed	disagree	Stongly disagree	total	Mean Weight value	decision	Rank
1	The road surface serves as a disposal channel for floods in my street.	300	63	76	0	439	3.276	accepted	2nd
2	Urban surface run-off disposal channel in my street is mainly open gutters	212	228	10	0	450	3.358	accepted	1st
3	Urban surface run-off disposal channel is barely open	192	213	24	3	432	224	accepted	3rd
4	Urban surface run-off disposal channel in my street is mainly through road surface	228	102	80	3	413	3.082	accepted	4th
5	Urban surface run-off disposal channel in my street is mainly covered gutters/drains	240	81	46	24	391	2.918	rejected	5th
6	Concretized surfaces increase surface run-off	112	102	28	58	300	2.239	rejected	6th
	Grand Mean weight value (GMWV) = 3.016								

Other factors which were not significant as important factor since they did not meet the cut-off point of the GMWV are items 6 and 7. This shows that urban surface run-off disposal channels are not covered in most areas covered by the study. The study also shows that respondents do not believe that concretized surface increase surface run-off. Even though this factor was rejected as important factor in flood formation, it was however noted to be a contributory factor.

A correlation analysis was carried out between width of gutter and depth of gutter to determine their influence on flood formation in the study area. It was discovered that correlation (r) between width of gutter and depth of gutter is 0.679 (see Table 6). This is a positive correlation which was significant at 0.01 level. The coefficient of variation (r^2) is 0.46, thus

percentage of variation is 46%. This therefore shows that the depth of gutter in all the zones has 46% influnce on the width of the gutter in the smooth flow of surface run-off in the study area.

Table 6: summary of Pearson correlation between width of gutter and depth of gutter

	Width of gutter	depth of gutter	length of street
width of gutter pearson correlation	1	0.679**	0.263*
significant (2 - tailed)		0	0.015
N	85	85	85
Depth of gutter pearson correlation	0.679**	1	.334**
significant (2 - tailed)	0		0.002
N	85	85	85
Length of street pearson correlation	0.263*	0.334**	1
significant (2 - tailed)	0.015	0.002	
N	85	85	121
**Correlation is sig. at the 0.01 level (2-tailed)			
*correlation is sig at the 0.05 level (2-tailed)			

Measures to reduce flood menace on traffic corridor in urban environment

One thing we should note is that absolute control of floods is impossible rather partial control in form of protection is achievable Two feasible measures for combating flood menace in man's environment according to Oriola, (2000) *is flood prevention/abatement and flood protection.* Flood abatements/preventions are efforts geared towards the management of the water shed or river catchments zones, river bank stabilization and adherence to land use practices.

- **Flood Prevention:** Flood protection is carried out to control flood and minimize the damage it causes by regulating its flow or diverting it away from where it could damage properties. This measure, according to Oriola (2000) includes construction of flood walls, dykes, dams and reservoirs, channel improvement and dredging.
- **Discourage dumping of refuse into gutters:** This study shows that a very high proportion of people living in the study area still dispose off their refuse into the gutters especially when it is raining. This method aggravates flooding that often leads to flooding of streets. This attitude should be changed and the people educated on how to properly dispose their wastes.
- ***Channelization:*** Channelization is one of the major ways by which flood could be controlled in the study area. The river valley as well as gutters channeling water should be properly monitored during rainy seasons to ensure that they are not blocked in any way. Free movement of water in these channels will reduce flood occurrence during the peak of rainy season

- ***Town planning laws*:** Set-back laws must be enforced for all structures close to the banks of river valley in urban areas as much as possible. A set back to streams for any structure is about 20 meters in low-density residential areas and not less than 30 meters in high-density areas.
- ***Reduction in concretization of urban surface:*** Majority of houses in urban environment have concretized surfaces leaving no room for greening environment. This situation reduces rainfall percolation irrespective of whether the rain is heavy or not. These types of water are added to surface run-off and invariably add to water that result in flood. A reduction in concretized surface of urban environment will definitely reduce flood in cities as more of the surface run off will percolate to join underground water.

Recommendations

- **Environmental education:** There is the need to create awareness through both formal and Informal forms of education on how to dispose solid waste in order to reduce its blockage on river channels. Most people are ignorant of the consequences of their uncontrolled use and abuse of the environment. To this extent, we need holistic approach through environmental Education that will capture both the young and the old. Environmental awareness can be created through: drama, radio jingles & TV, community meetings, bill-boards, posters, as well as through other indigenous means to inform people on how to manage their waste.
- **Minimum depth and width of gutters:** property developers should ensure that gutters are provided in newly developed areas of cities simultaneously as the structures are developed. This will reduce the rate at which such areas get flooded and create problems for smooth traffic movement.
- **Reduction in pot holes:** Attention should be paid to road maintenance in cities. Pot holes should be constantly attended to in urban environment and maintenance culture should be made part of the urban policy by urban managers.

Conclusion

Flood is a disaster that has become one of the environmental problems in Nigeria. This is because man's activities on daily basis continuously encourage flooding. The menace of flooding on traffic congestion has increased the problems confronting commuters as well as motorists in cities. Many people are becoming skeptical about travelling to

urban environment as well as working there because of traffic congestion which has become daily menace.

It is therefore important for man to understand the limit of his activities within his environment (environmental determinism) otherwise there will always be conflict. Man should therefore understand that forces of nature can only be held at bay for a short time whenever there are conflicts. The consequences could be very disastrous, if necessary measures are not put in place to address such conflicts. Thus, there is need for man to understand his limit in his interaction with the environment. Man therefore needs to harmonize his actions as much as possibl e with the environment so as to reduce flood and its effects on traffic flow in cities.

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ASSESSING THE LIVELIHOODS ACTIVITIES AT KORARI (DAR FUR STATE, SUDAN)

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Abstract

This Study was conducted on 23-28 Nov. 2011, in Omdiat Korrary in west part of Abata sub-unit of Zalingei locality, West Darfur State, Sudan, which located north Azoum Valley. The study aimed at creating community profiling. PAR Technique is applied in data collection in the study through group discussion mechanism. The area was divided into four group discussions points to facilitate data collection on urgent issues, concentrating on three pressing problems. Descriptive method was applied in revealing results and findings. Study findings showed that the whole area suffers more from the lack of agriculture services either in winter or rainy season.
The study recommends that: agricultural & veterinary services and sanitary water should be provided to support the livelihood in the area.

Keywords: Assessing Livelihoods Activities

Introduction

Oumdiat Korrary is located at north part of Azoum Valley, it is stretch in area estimated about 250 hectares, see figure. Administratively the area considered as a west part of Abata sub-unit of Zalingei locality, West Darfur State, Sudan. In the past before Darfur crisis all area controlled by one local native administration called Oumodia which divided into three Kolyats (Grash, Korgo, and Korrary). Oumdiat Korray is leaded by one Shartaya as first level of local native administration and two Oumdas as second levels of local native administration. The population now is estimated about 10,000 persons, in the past they considered as nomads but now they settle in semi villages in (Damras). Before Darfur conflict there were more than 20 villages existed in these areas, but all of them were displaced due to conflict except one village still existed (Barno village), table (1.1). The

people who displaced from those villages, majority of them are settling in Al-Hassahisa and Hamidia IDPs Camps.

Objectives

Objectives of this study are**:**

1. To assess livelihood of community in the area.
2. To evaluate natural resources.
3. To identify problem facing available natural resources

Methodology

Field survey is conducted for assessment by the team work. Two leaders of the community (Oumda and Sheikh) were participated in community mobilization which took three days for explaining the objectives of survey and encouraging people to participate in group discussions. Checklist for community mobilization was formulated to guide survey process. In addition to that PAR technique (Participatory Rural Appraisal) is applied for data collection and problems analysis, through divided target groups into four meeting points according to their locations (Barno village, Korrary, Korgo for seasonal returnees and qualitative group discussion). However observation and notes were considered. Descriptive approach and estimation are used to show the results.

Live lihood Activities

The results revealed that agriculture and animal breeding are considered as main livelihood activities of people in the area. The survey showed that some Nomads owned lands; they used to raise their animals and grow their land in rainy season, but some of them have no animals, while Barno village people and seasonal returnee depend only on agricultural activities in rainy and winter seasons. After conflicts some Nomads occupied IDPs land, and started to grow the lands without lands owners' permission. Findings showed that Handicraft activities such as tailoring, Blacksmith, etc., are not existed in the whole area, even women handicraft activities. Training is highly needed in the field of handcrafting especially for women. Field survey revealed that women participate in all livelihood activities such as bringing water, working in farms, firewood, grass collection and commerce, besides housekeeping, so empowerment for women is urgently needed to help them to become effective economic agents. Team work has interviewed women representative at Barno village, Damras, and seasonal returnees, their real demands depend on adult education class and provision of agricultural tools (Hand Hoe, Shovels, diggers, rakes etc.), besides other inputs. Study declared that seasonal returnee (women) used to go back to the area, to cultivate their own farms or working as casual labor. Livelihood in the area

is highly vulnerable to income and climatic shocks, so capability building programs are highly needed for helping people to overcome bad situation. As far as coping strategies for famine and bad situation is concern, people in the area used to sell their assets, firewood, grasses, etc. in order to balance income deficiency beside remittances from their children and relative who work out of the area. , Table (1) and table (2) show sources of income, production, productivity and prices.

Table (1) Sources of income

No.	Name of village /Damra	Main Sources of income	Secondary sources of income	Agricultural seasons	T. Crop grown	T. Animal raising
1	Barno Village	Agriculture	None	rain fed and winter season	Onion, Potato, Tomato, and vegetables in winter season. Millet, Dura, Groundnuts, Hibiscus, and sweet Potato in rainy season	None
2	KanKolei (Eest & West)	Agriculture and Animal raising	Firewood and grass collection (women), poles, wooden holders, Driving cattle to main markets, animals trading	rainy season	Millet, Dura, Groundnuts, Sesame, Hibiscus, Tomato in some places in rainy season,	Cow, sheep, Goat, a few Camels
3	Hager-Obeid					
4	Sag Elnaam					
5	Gouz Elnabag					
6	Baldah					
7	UmElgoura					
8	Zougo (North, South&Middle)					
9	Tango					
10	Silo East					
11	Amar-Gadeed					
12	Kirkir					
13	Kurarei					
14	Nougu-Talgei					
15	Golba					
16	Korgu					
17	Douba (South &Middle)					
18	ElGebisha					
19	Zoullei					
20	Seasonal Returnee	Agriculture		Winter and rainy season	Onion, Patato, Tameto, and vegatables in winter season. Millet, Dura, Groundnuts, Hibiscus, and sweet Patato in rainy season	None

Source: Field Survey, Nov. 2011

Table (2) Crops, productivity, and prices

No	Crops	average cultivated land per person in winter season	average prodctivity in feddan per sacks	cost per feddan/SDG	average prices per sack	Seeds Quantity feddan	Seeds cost per feddan/SDG
1	Onion	1 to 2	120	5,000	80	2.8 Kg	770
2	Potatoes	1 to 2	90	4,000	150	7 sacks (50 Kg)	1,225
3	Millet	1 to 2	10	400	160	7 Kg	20
4	Dura	1 to 2	12	400	140	7 Kg	20

Source: Field Survey, Nov. 2011

Environment and natural resources

All the area is well vegetated with trees, shrub, bushes, grasses, and weeds. But the vegetation exposed to some bad conditions and misusing, such as conflagration, cutting trees for firewood, charcoal, and timber. Considering planted forest, there is one planted forest at Grash which controlled by government. There are some wild animals lives in the area such as foxes, wolves, monkeys, chimpanzee, arrdvark, rabbits, wild chicken, ect. Regarding water resources, there are some seasonal valleys and stream.in addition to that ground water is abundant, which can be found about 1.5 to 30 meters deep.

Problem Identification

The three main problems

Illiteracy, lack of sanitary water, lack of agricultural and veterinary Services are the main problems facing community in the area. During group discussion each village/Damra representatives have gotten their enough chance to speak and discuss their pressing problems and prioritize them, table (3). In addition to that community representative were asked about their contribution toward the solution, so they have driven out the areas of effective contribution, for example they can participate in collection of local materials (sand, gravels, mud, .. etc.), keeping others materials, formulating committees and societies, providing security services to others.

Table (3) Problems Analysis

No.	Name of village /Damra	First problem (P1)	Second problem (P2)	Third problem (3)
1	Barno Village	Lack/poor of Education (Young and adults)	Lack of Health services (Preventive and medicative)	Lack of Agricultural services (wells, machineries, Seeds,Pump machines
2	KanKolei (Eest & West)	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
3	Hager-Obeid	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
4	Sag Elnaam	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
5	Gouz Elnabag	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
6	Baldah	Lack of water	Lack of Agricultural services (wells, machineries, Seeds,Pump machines	Lack of Education (Young and adults)
7	UmElgoura	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
8	Zougo (North, South&Middle)	Lack of Education (Young and adults)	Lack of water & Agric. Services	Lack of Health human and animals services (Preventive and medicative)
9	Tango	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
10	Silo East	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
11	Amar-Gadeed	Lack of water	Lack of Education (Young and adults)	Lack of Health human and animals services (Preventive and medicative)
12	Kirkir	Lack of education	Lack of Health human and animals services (Preventive and medicative)	Lack of agricultural services
13	Korray			
14	Nougu-Talgei			
15	Golba			
16	Korgu			
17	Douba (South &Middle)	Lack of agricultural services	Lack of education	Lack of water
18	ElGebisha	Lack of agricultural services	Lack of education	Lack of water
19	Zoullei	Lack of agricultural services	Lack of education	Lack of water
20	Seasonal Returnee	Lack of wells	Lack of engines	Lack of agricultural services

Source: Field Survey, Nov. 2011

Problems Trees

The main two core problems (Illiteracy and low production) are well considered and analyzed according to their root causes, effects, and impacts, figure (1) and (2) show problems trees.

Figure (1) Illiteracy problems

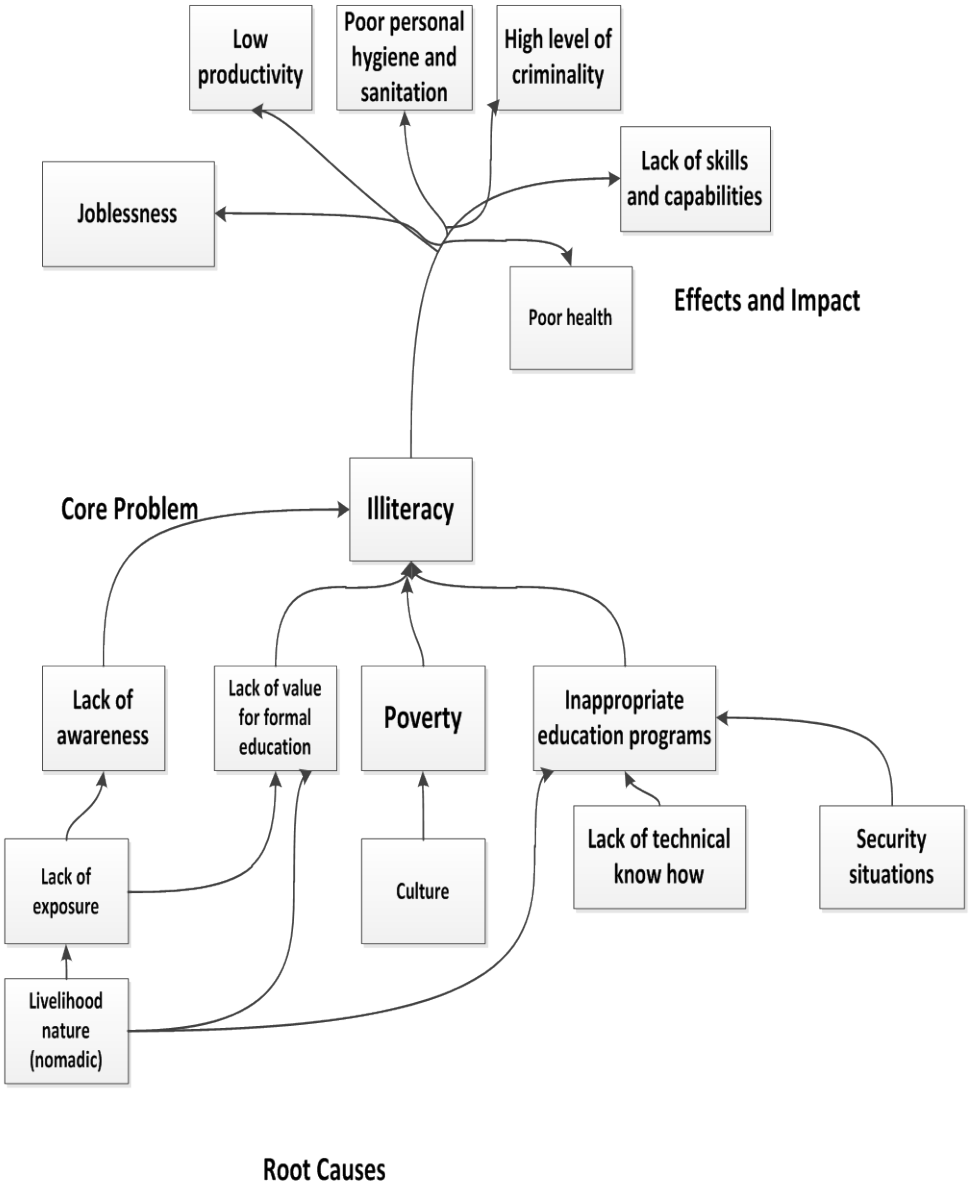
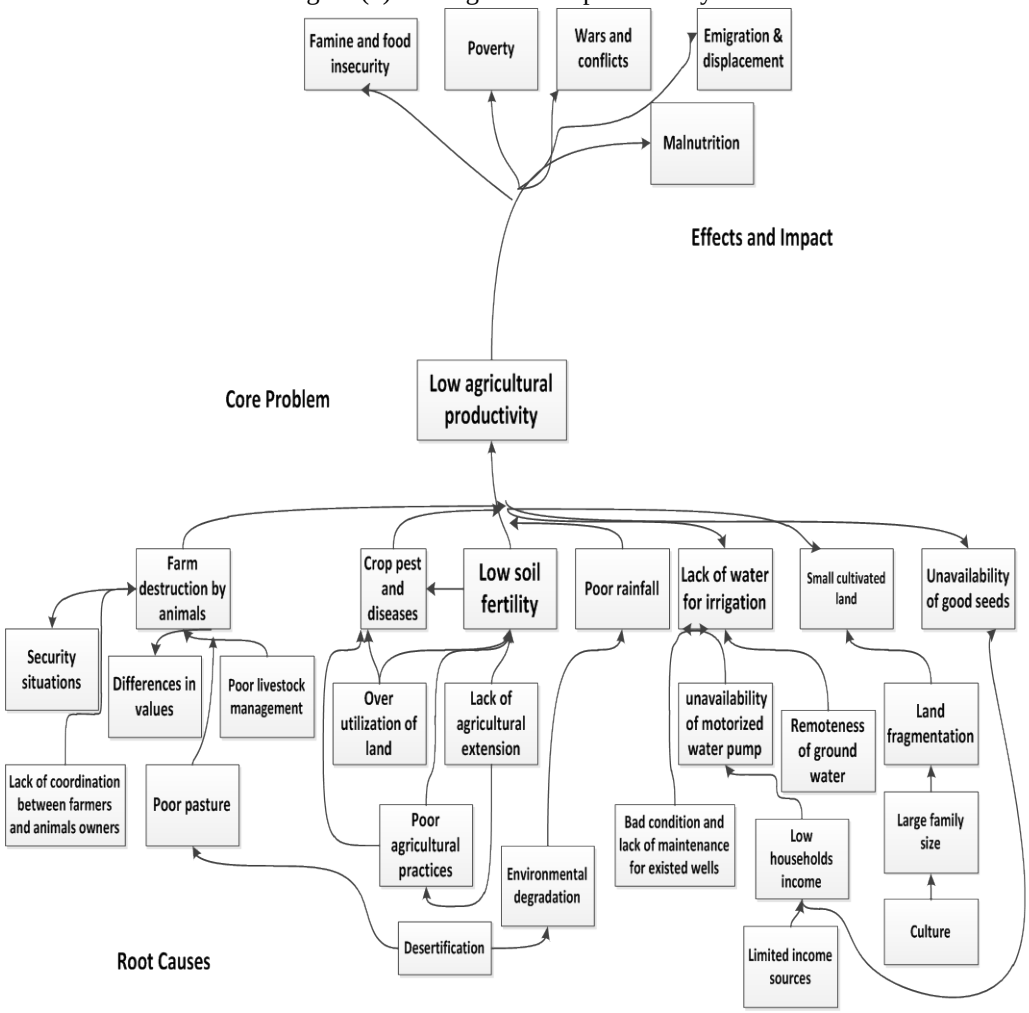


Figure (2) Low agricultural productivity



DESALINATION: AN AMBITIOUS APPROACH TO SOLVING OVERPOPULATION IN EGYPT

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Abstract

The lack of fresh water and energy pose the largest risk to any nation's development and prosperity. This paper shows that locally designed and manufactured mega desalination plants will prove useful to sustainable development in Egypt.

A number of international Egyptian experts, with both the knowhow in designing and building advanced membrane desalination plants, and hands-on experience, are available. In addition, there are a few national organizations that possess the capabilities of manufacturing plants locally. By combining these two elements, Egypt can build cost effective locally manufactured mega size desalination plants outside the Nile valley.

The region's renewable energy resources will help in building and running those plants.

Setting up a strategic plan to build the necessary plants will help create new societies in the desert, which in turn, will lead to a viable solution to the over-population epidemic around the Nile valley.

Keywords: Desalination, Renewable Energy, Nile, Membrane, Egypt, Water Poverty

Introduction:

Overpopulation in the Nile valley is a leading factor behind Egypt's crisis. For years, governments failed to find practical solutions for this ongoing dilemma.

Experts suggest that invading the desert that constitutes approximately 95% of the country's land is the solution, but this approach would prove costly because of the infrastructure necessary to extend pipe lines, electrical energy transfer lines, and roads from the valley.

Fresh water and energy are the main resources that nations need to develop.

Despite Egypt's dependence on the Nile, the future of its existence depends on decisions made by other countries. Egypt is an estuary country, and a number of source countries of the Nile have started building a series of dams that will undoubtedly reduce Egypt's yearly water quota.

Today, Egypt's water quota of 55.5 billion m3 per year is not enough to cover the multiplying population and 21st century living standards.

Consequently, water desalination is a vital solution to water scarcity in Egypt like many countries around the globe.

Goal:

The goal of this study is to highlight the possibility of the economical fabrication of mega size membrane desalination plants locally in Egypt.

Approach:

Egypt is gifted with endless beaches along the Mediterranean Sea and the Red Sea.

The salinity of the unlimited sources of underground water in the Eastern desert, Western desert, and Sinai is a limiting factor for its use.

Foreign companies charge a lot for desalination plants because they keep the xperience, and the know-how secrets.

Egypt lies in the region that has the most intensive renewable solar energy in the world.

This clean energy is not utilized.

A mega size sea water desalination plant with a capacity of 300,000 m3/day is sufficient for 1.5 Million inhabitants. International companies sell plants of this size for about $300 Million. The power required for such plant is about 40 MW, which can be produced by renewable solar energy. The regional solar power plant will help save the cost of long lines needed to transfer power from the valley, besides it saves transmitted power losses that would be in the order of 20%.

The only economical way for Egypt to develop desalination plants is to become self-dependent in building mega plants, using Egyptians minds and manpower.

If such size of plants is locally built, costs would be reduced by about 50%.

Gradually, building twenty such plants in carefully-chosen areas will be sufficient to move 30 Million inhabitants out of the valley for a budgeted cost of $3 Billion.

The cost of the proposed solar power plants is not included in the above estimate.

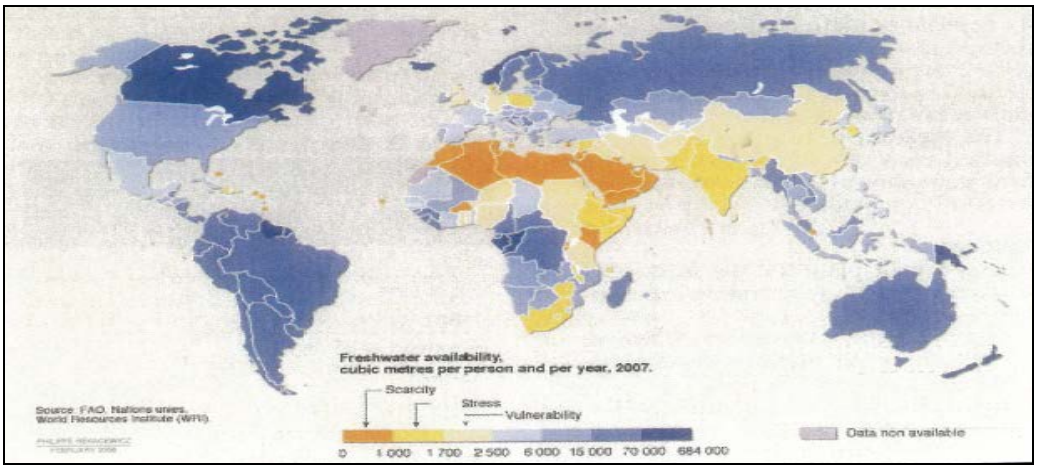

Fig. (1) All Arab countries, including Egypt, are below the international fresh water poverty limit of 1,000 m3/person/year, despite possessing unlimited water resources from surrounding seas

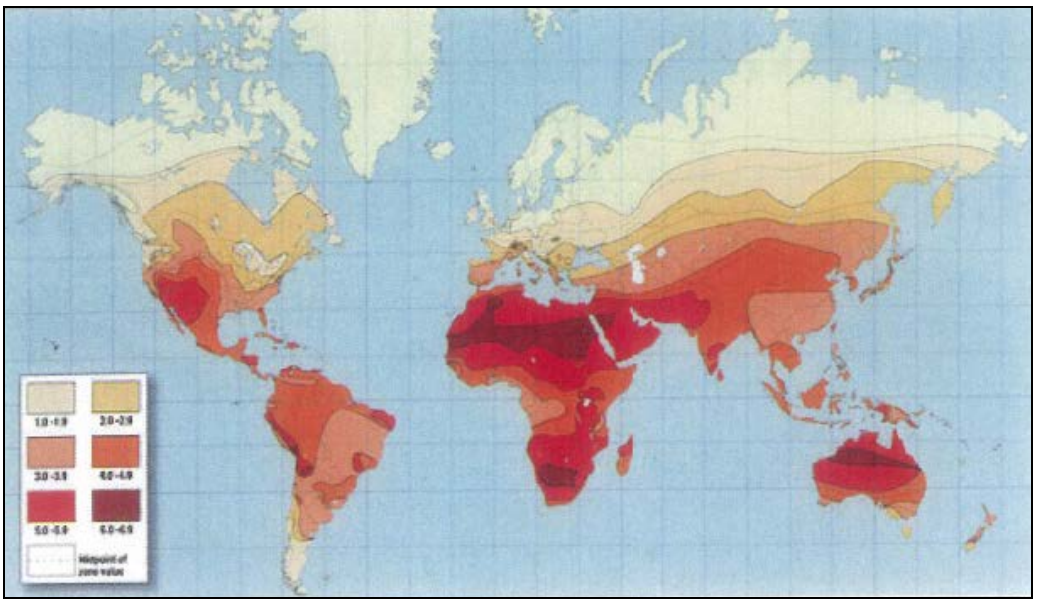

Fig. (2) Egypt lies in the great desert region that has the most intensive solar energy source in the world year-round

Fig.(3) The international trend is using solar power plant to provide power for desalination plants for remote areas and deserts

Methodology:

Fluid Machinery and Pacific Aqua Technologies are two American corporations that have Egyptian engineers living abroad as main share holders in the companies.

The two organizations have gained extensive hands-on experience in designing and building membrane desalination plants.

On February 2012, a protocol was signed by Fluid Machinery Engineering and the Arab Organization for Industrialization (AOI) to provide the knowhow and the design of the high pressure pumps, and the energy recovery systems to build the above-mentioned components locally. Two sets of prototypes are now under manufacture of such components at AOI factories.

The cost of these components constitutes about 30% of the cost of desalination plants.

On April 2014, the Italian company Oltremare Liquid Separation has provided AOI with a proposal to build desalination membrane factory in Egypt.

The membrane's cost constitutes about 25% of the total cost of the plant.

All of the above will facilitate the local building of desalination plants.

Pacific Aqua Technologies (PAT) has built desalination projects all over the world with a total capacity of 3.5 Million Cubic Meter per day of fresh water. More than one third of this capacity is in the Middle East/Africa

region. PAT is ready to transfer its technology to train young Egyptians engineers from AOI on the design, build, and operate desalination plants based on BOOT projects system. PAT will provide the fund from abroad such that AOI as a semi-governmental organization will secure the award of the projects.

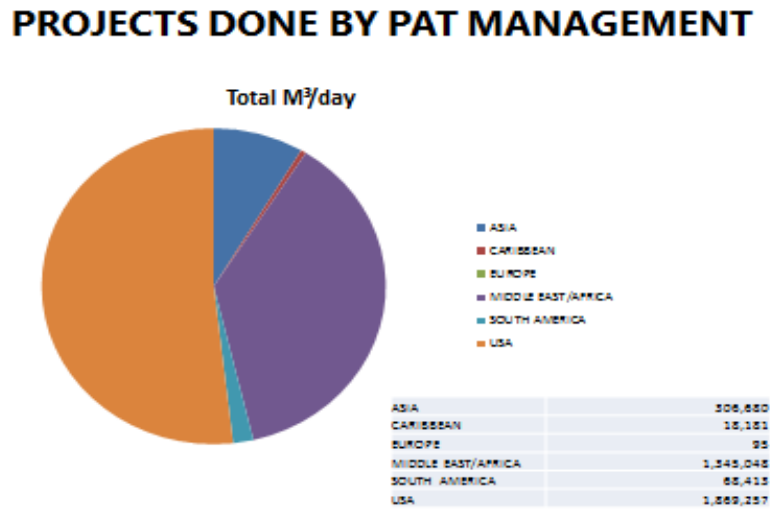

Fig 4. Pacific Aqua Technologies (PAT) management has built desalination plants producing more than 3.5 Million cubic meters of fresh water per day all over the world, more than one third of them in the Middle East and Africa

Conclusion:

Building desalination plants in the Egyptian deserts will help solve over-population around the Nile.

Building desalination plants locally yields numerous advantages, including faster delivery of equipment and spare parts, developing national experts in the field, lower costs due to partial local manufacturing of the components, and the most important factor is being self-dependent in providing local fresh water sources and not relying on foreign plants manufacturers nor on international political decision makers.

DIVERSITY OF ARTHROPODS IN HAFIER DOKA RESERVE FOREST, SUDAN

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Abstract

Sudan has suffered natural drought cycles during the last decades. These cycles coupled with human interventions resulted in desertification. The major impacts of desertification on natural resources can be assumed up in the following: Socio-economic livelihoods, decline of land productivity, food production shortage, and resource based Conflict, decline in environmental quality decline of rangelands and loss of biodiversity.

Arthropods are considered as main components of desert eco-system. They gain this importance via their close association with desert flora .They depend on flora for feeding and shelter. Despite the vital role of arthropods in desert eco-system, they receive little attention by many ecologists in Sudan. Diversity of arthropods was studied in Hafeir Doka forest reserve Southern Khartoum. The study was conducted to evaluate the diversity of arthropods in the reserve forest as well as to through some light on the impact of reserve areas on biodiversity of encountered arthropod. The area of the study was divided into 4 sites according to their topography, these sites were: Hilly, Sandy dune, valley and flat land sites. The study included identification and quantification of arthropods from the four sites. Beating sheet, butter fly net and hand sorting methods were used to collect arthropods. A total of 5639 arthropods identified into 2 classes (Insecta and Arachnida), 18 orders, and 31 families. Statistical analysis showed that members of class Insecta were dominated the class Arachnida in all sites. Within the class Insecta, members of the order Hymenoptera were prevailed members of the other orders followed by members of the orders Coleopteran and Diptera, while members the orders Pseudoscorpionida and Acari were found to be the least represented taxa of the total collected arthropods. Simpson's Diversity Index (SDI) calculated for the total arthropods catch was high (= 0.2). These results could be ascribed to the ability of members of the class Insecta to colonize, proliferate and withstand different environmental conditions. Whereas, the

high (SDI) value could reflects the importance of reserve areas to conserve arthropods diversity.

Keywords: Desertification, arthropods diversity, reserve forest, Insecta, Arachnida

Introduction

Biodiversity as a term is defined as "the variability among living organisms from all sources including terrestrial (above and below ground), marine and other aquatic ecosystems and the ecological complexes of which they are part. This concept covers the diversity of genes, species and ecosystems. The values of biodiversity include: contribution to environmental protection, such as protection of water sources, keeping food sources through cycles of elements in addition to keeping a balance and addressing climate events such as fires, natural cycles of drought and floods. Also, biodiversity provide scientific and social benefits such as providing areas of education, training and research and areas for tourism and recreation, Food and Agriculture Organization of the United Nations, FAO, 2003).

Sudan is characterized by ample natural resources such as water, farmland, forestry, livestock, fisheries and minerals. The natural resources represented in animal and plant species are considered a natural wealth of high economic value. These resources can be reinvested back on the individual and community well- being upon wise use, taking into account their development and sustainable use. The conflict over natural resources is one of the most important recent challenges facing the world generally, and the developing countries, particularly in African; taking into consideration the population growth coupled with declining resources and growing demand. This situation has resulted in the depletion of these resources. Sudan is characterized by multiple natural environments, including: desert, semi - desert, savannah, flood areas and mountain environments, which produce a unique biodiversity, Zinta and MacDonald (2012).

According to Nour El Dayem (2008), biodiversity monitoring began in Sudan before independence, where 3132 of flowering plant species , 106 species of the Nile fish, 265 species of mammals , 938 species of birds and two species of amphibians and many insects and other arthropods were identified. Several combined factors accelerating the rate of loss of these species including: the lack of environmental awareness on the importance of biodiversity, the human using the living organisms as unlimited sources, in addition to the absence of institutional and legislative authority that regulate the exploitation of natural resources and protection. Also disasters such as

floods, fires and drought cycles accelerate the loss of many species. As a result of deterioration of biodiversity; ecological belts shifted to the south. The repeated cycles of drought and desertification have forced the living forms organisms to migrate to the moist south .The same conditions forced farmers to farm in the bottom of the valleys to sustain their livelihoods.

Arthropods are important components of ecosystems occupying vital positions in food as decomposers, parasitoids and pollinators. Arthropods are highly diverse and live in nearly every habitat on Earth. Trillions of them are alive at any one time. Class Insecta alone may have 5-30 million species (Erwin, 1982; Novotny *et al*., 2002). Their high diversity, small body size, high reproductive capacity, makes them suitable for monitoring environmental changes. (Weaver, 1995, Desert arthropods are affected by environmental factors such as habitat conditions, and plant cover (Gitler, *et al* 1997).

Soil arthropods are usually affected directly and/or in directly by changes in their local environment including biotic and abiotic factors. The direct effects of abiotic factors include biological and physiological disturbances, while indirect ones include changes in habitat properties, Mopper *et al*.2004).

Studies on arthropods diversity have gained attention in recent years, due to rapid of species with increasing environmental degradation. Awareness of the dangers of species loss has been translated into environmental convention aiming at conservation and sustain of biodiversity (IUBS, 1992) as well as national ones (Baldwin, *et al* 1992).

In Sudan information of arthropods diversity is limited; few groups have been identified in addition to the frequent loss of diversity. Desert arthropods are affected by environmental factors such as habitat conditions, and plant cover (Seely,1989).

Despite the vital role of arthropods in desert ecosystem they receive little attention by many ecologists in Sudan .Information regarding the diversity of arthropods are limited; few groups have been identified in addition to the frequent loss of diversity. The null hypothesis of this study is that there is no difference in arthropods diversity between the study sites selected at Hafier Doka reserve forest, Sudan. The objectives of the study include evaluating diversity of arthropods in relation to habitat characteristics in a desert reserve forest. It also meant to throw some light on the ecological relation between arthropods taxa as well as their ecological roles in maintain desert ecosystem future.

Material and Method

Study area:

Hafeir Doka forest is located Southern Western Khartoum State, About 40 km, near Khartoum International New Air Port, Sudan. The area occupies about 1.2 hectares ,between longitudes ″32º 24" 23' " and ″32º 13" 23'" E and latitudes″15º 31" 06 "and ″15 º 11" 09' N'", Fig.(1) .

.It thus lies within the tropical semi arid region of the Sudan. Its climate is characterized by short rainy season that extends between (July – October) with high evaporation potential and low relative humidity values indicating the general aridity of the area. Air temperature values fluctuated and show marked rise in May and drop in July and October due to the incidence of rains. The soil is generally sandy clay loam textured, ELHag *et al* (1994).

Plant cover in the reserve

The natural plant cover is mainly composed of *Acacia seyal* species since it lies within the *Maerua crassifolia* - *Acacia tortlis* belt, Harrison and Jackson (1958).

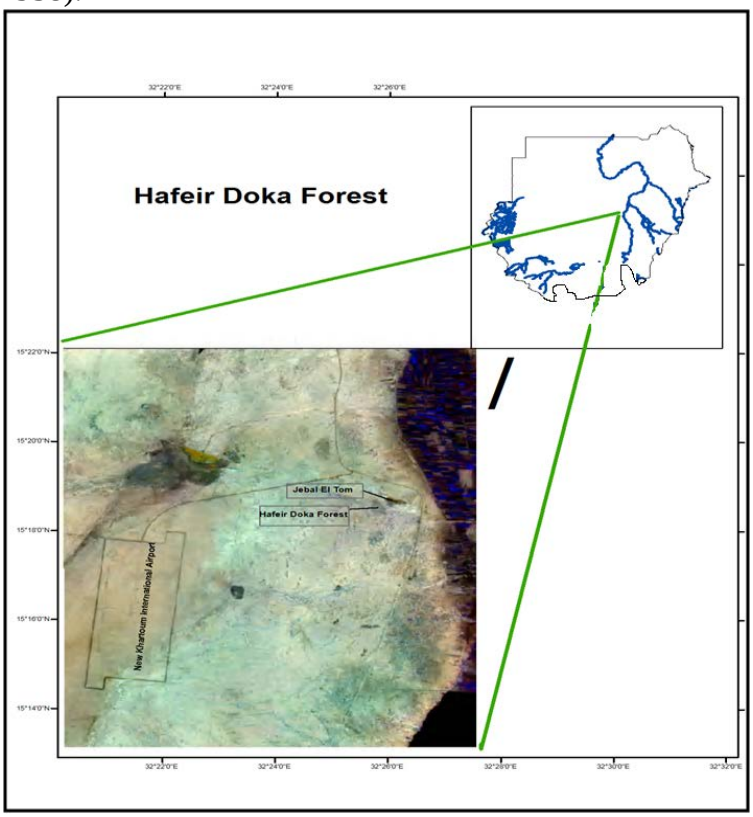


Fig. (1): Location map of Hafeir Doka reserve forest (source, Remote Sensing Authority,2013).

Methods

Experimental sites

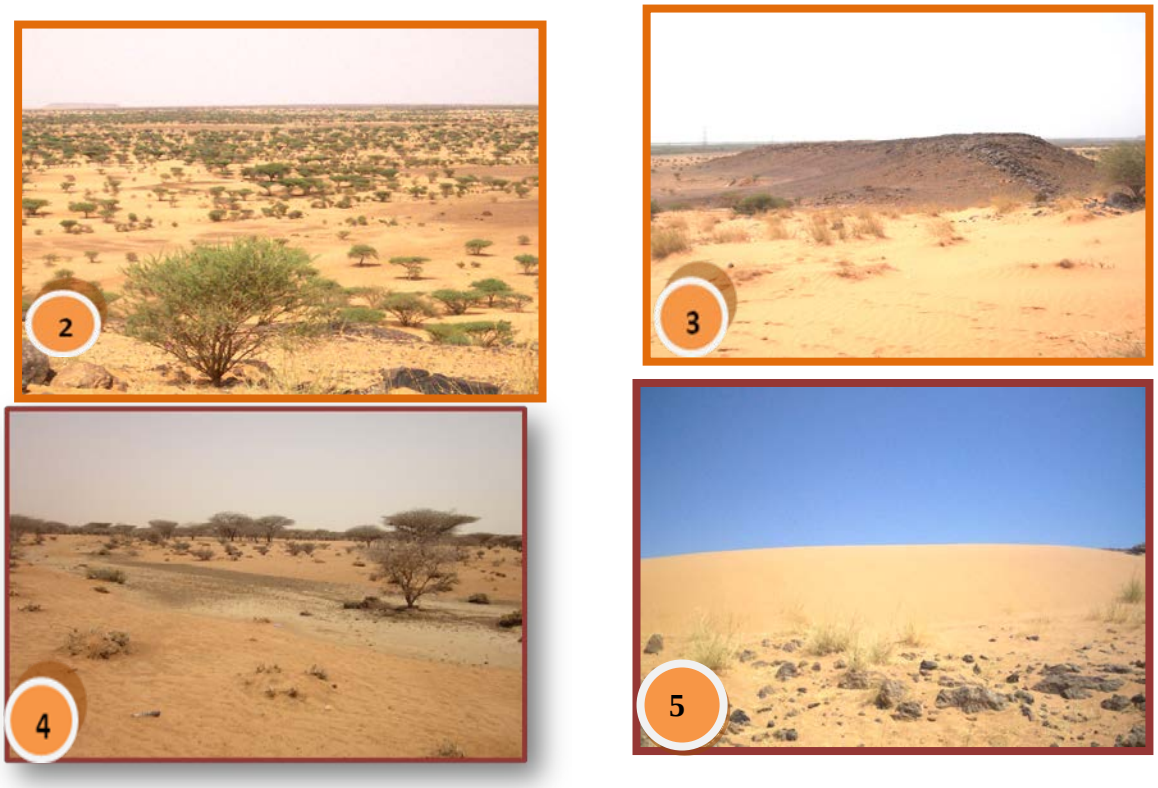
The area of the study was sub divided into four experimental sites according to their topography. The elevation of each site was measured using the Global Positioning (GPS), these sites were:

Control site: elevated 411 m above the sea level and covered with Acacia sp. trees of moderate distribution and considered as control site, (Fig.2).

Hill site: elevated 429 m above sea level and covered by stones and gravels, (Fig.3).

Wadi site: elevated 406 m below sea level and characterized by clay soil and vegetated with Acacia sp. trees of high density, (Fig.4).

Sand dune site: elevated 422 m above the sea level and completely formed of sand with low vegetation cover, (Fig.5)**.**



Figures 2-5. Study sites at Hafeir Doka reserve forest. 2. Control site 3. Hilly site. 4. Wadi site 5. Sand dune site.

Methods

Characterization of the study sites

The four study sites were analyzed for some of their physico-chemical properties using Atomic Absorption Buck scientific VGP 210 made in USA 200. Additionally, topography of all study sites was measured using the Geographical Position System (GPS) Garmin 12.

Arthropods collection

Arthropods were periodically collected using three standard methods as described by Gibb and Oseto,(2010). These methods include:

1-Beating sheet method

This method was used to collect arthropods by beating the *Acacia sp.* plants with a stick while holding a beating a 2x1 feet square sheet under the area being beaten, (Fig. 6). The faunal taxa on the plant fallen onto the sheet were then picked up by hand or with forceps and preserved into 70% ethanol.

Fig. (6): Beating sheet method applied to collect arthropods mat Hafeir Doka Reserve Forest, Sudan.

2-Butterfly netting

A collecting aerial butterfly net composed of net bag made of fine meshed white cloth attached to a wire hoop and affixed to a wooden pole was used to catch flying arthropods fauna associated with the trees, (Fig. 7). Encountered fauna were preserved in 70% ethanol for further identification.

Fig. (7): Butterfly net method applied to collect arthropods at Hafeir Doka Reserve Forest, Sudan**.**

3-Hand collecting method

It is a basic method done by simply collecting arthropods fauna with collectors' hands and putting them into glass jars, (Fig.8). Forceps were used to assist in collecting arthropods. Encountered specimens were then preserved in 70% ethanol for further identification.

Fig. (8): Hand collecting method applied to collect arthropods at Hafeir Doka Reserve Forest, Sudan.

Calculation of Diversity Index

Simpson's diversity index was calculated using the following formula:

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

D= Diversity index

n = the total number of organisms of a particular species

N = the total number of organisms of all species

Statistical analysis

Data obtained was statistically analyzed and compared using Analysis Of Variance (ANOVA).

Results and Discussion

Characteristics of the study sites

Topography: A topographic feature at the four study sites in term of elevation was measured. Result given in Fig. 9 indicated that the hilly site is the highest site followed by sand dune one as compared to the control. The lowest elevated site among all study sites is shown to be the Wadi site. Such elevation variability may induce changes in habitat characteristics and consequently affect arthropods diversity. Brown (1988) illustrated that

many scientists have linked biodiversity to topographical and temporal patterns of habitat diversity. Coblentz and Riitter , (2005), concluded that spatial distribution of topography plays an important role in the distribution of biodiversity. They added that the large elevation gradient have resulted in stacked biotic communities in which species with broadly similar climatic preferences sort themselves along the elevation gradient where the blend of temperature and aridity best supports them.

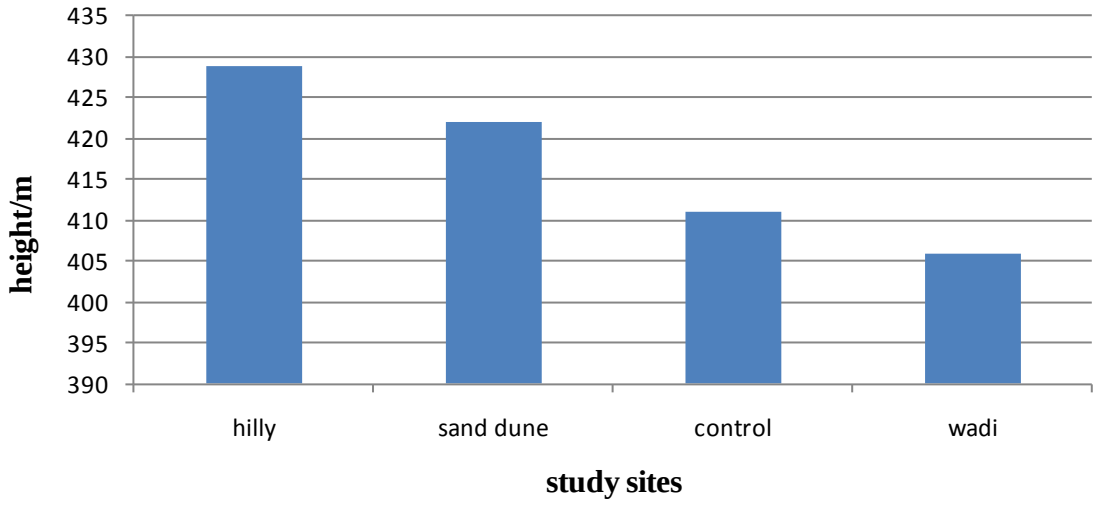


Fig.9: Topograhpy of study sites at Hafeir Doka reserve forest

Soil properties: Study sites were analyzed for some of their physico-chemical properties. Results shown in Table (1) indicated that the control site is classified as: Sandy loam non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. The Hilly site is described as: Loamy sand, non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. Moreover, the Wadi is found to be Sand clay loam, non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. The sandy dune site is shown to be Sandy loam non-saline, non – sodic, neutral and of low Ca, Mg and Na contents. Table (1). It is evident that the Hilly, Wadi and Sand dune sites are different in soil texture and almost similar in chemical properties. This result indicated that variation in habitat characteristics might affect their arthropods community. Chacoff and Aizen, (2005) claimed that arthropods communities at the landscape or local scale may be affected by landscape structure. Soil

physicochemical properties, habitat structure dictate the abiotic environmental conditions at a location that in turn affect arthropods communities, (Byrne, 2007)

Table (1): Physic-chemical properties of the study sites at Hafeir Doka Reserve Forest

Soil properties	**Study sites**			
	Hilly	Wadi	**Sand dune**	**Control**
Soil physics				
Sand	54.733 C	66.067 B	78.733 A	74.733 A
Silt	27.773 A	10.107 B	4.773 C	7.440 BC
Clay	17.493 B	23.827 A	16.493 B	17.827 B
Soil chemistry				
SAT	23.333 B	25.000 B	29.833 A	25.000 B
EC	0.5533 AB	0.3013 B	0.6343 A	0.6570 A
SAR	0.7000 A	0.5667 A	0.3967 A	0.4133 A
pH	6.7367 A	6.8933 A	6.9933 A	7.1567 A
Ca	0.2033 A	0.2533 A	0.1067 A	0.1300 A
Mg	0.7867 A	1.3533 A	0.4500 A	0.5733 A
Na	0.5000 A	0.3600 AB	0.1867 B	0.2233 B

- Means with same letter do not significantly differ; otherwise they do according to Duncan's multiple range tests.

Identification of Arthropods

Arthropods collections revealed 5639 taxa identified into 2 classes (Insecta and Arachnida), 18 orders, and 31 families as shown in Table (2) and Appendix 1. Members of class Insecta dominated the other class Arachnid (92% and 8% respectively) of the total arthropods' collection, Fig. (10).This mode of dominance might be due to the ability of insects to proliferate under varied habitat conditions. Insects' morphology; including small boy size enables them to have permitted exploitation of habitat and food resources at a microscopic scale. Insects can take shelter from adverse conditions in microsites too small for larger organisms, Crawford (1979). Moreover, having an exoskeleton provides protection against predation and desiccation or water-logging and innumerable points of muscle attachment for flexibility. Also, insects' metamorphosis permits partitioning of habitats and resources among life stages. Immature and adult insects can differ dramatically in form and function and thereby live in different habitats and feed on different resources; reducing intraspecific competition, Schowalter, (2006).

Table (2): Systematic list of arthropods collected from different habitats at Hafeir Doka reserve forest, Sudan.

Class	Order (s)	Family (ies)
Arachnida	Pseudoscorpionida	Un identified
	Scorpionida	Un identified
	Acari	Ixodidae
	Araneae	Eresidae
		Salticidae
		Philodromidae
		Lycosidae
Insecta	Embioptera	Un identified
	Thysanura	Lepismidae
	Odonata	Un identified
	Phasmida	Phasmatidae
	Isoptera	Rhinotermitidae
	Orthoptera	Acrididae
		Crycantherdium
	Dictyoptera	Mantidae
	Hemiptera	Lygaedae
		Largidae
		Pentatomidae
	Neuroptera	Myrmeleontidae
	Coleoptera	Tenebrionidae
		Curculionidae
		Buprestidae
		Elatridae
		Scarabidae
	Diptera	Muscidae
		Chaliphoridae
		Tabanidae
	Lepidoptera	Paplionidae
	Hymenoptera	Formicidae
		Apidae
		Pompilidae
		Chrysididae

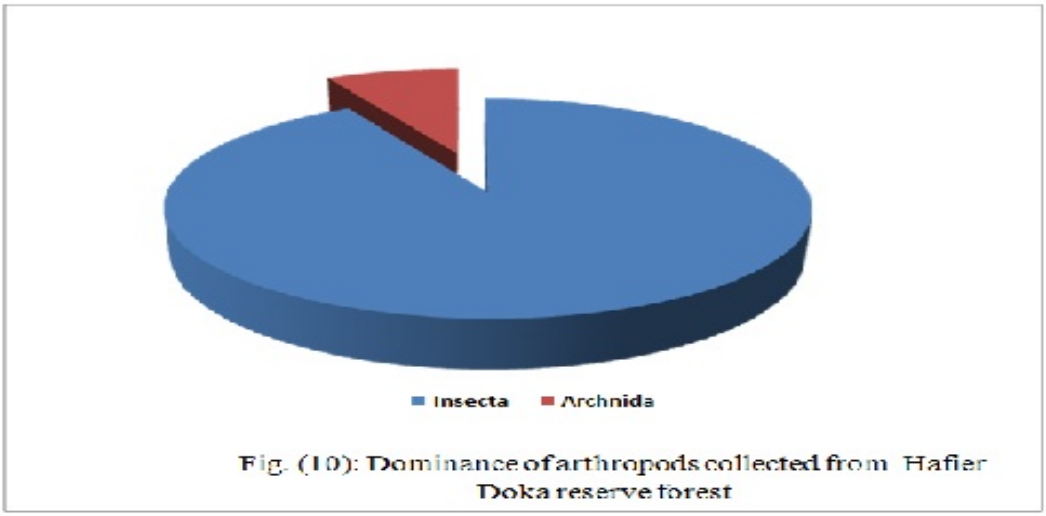


Fig. (10): Dominance of arthropods collected from Hafier Doka reserve forest

Comparison of arthropods' abundance between study sites

Figure (10) showed arthropods fauna encountered in each study site. It illustrated that higher arthropods' abundance was noticed within the Wadi site (38.4%), followed by Hilly and Sand dune sites (16.7%, 14.8%) respectively as compared to the control site (30.1%). Variations in arthropods abundance between the study sites could be attributed to the impact of habitat characterizations in terms of vegetation cover's density and diversity, climatic and other edaphic factors. Abdallah *et al***,** (2010), who studied the ecology of Hafeir Doka reserve forest; claimed that the forest shows significant variations in floral diversity as well as topographic variations. Impact of habitat characterization on arthropods abundance was formerly recognized by **Romoser** and Stoffolano (1998). Mclntyre *et al* (2001) indicated that arthropod community structure is affected by habitat structure and land use, and because they play key roles in nutrient cycling, organic matter decomposition, pollination, and soil aeration; the spatial heterogeneity of ecosystems therefore may affect their role in ecosystem functioning.

Topography also added to the effect of habitat characteristics on arthropods abundance, Ettema and Wardle, (2002). Moreover, their distribution is often very restricted, with many species responding in a very fine spatial and temporal scale to habitat Cardoso *et al*., (2010).

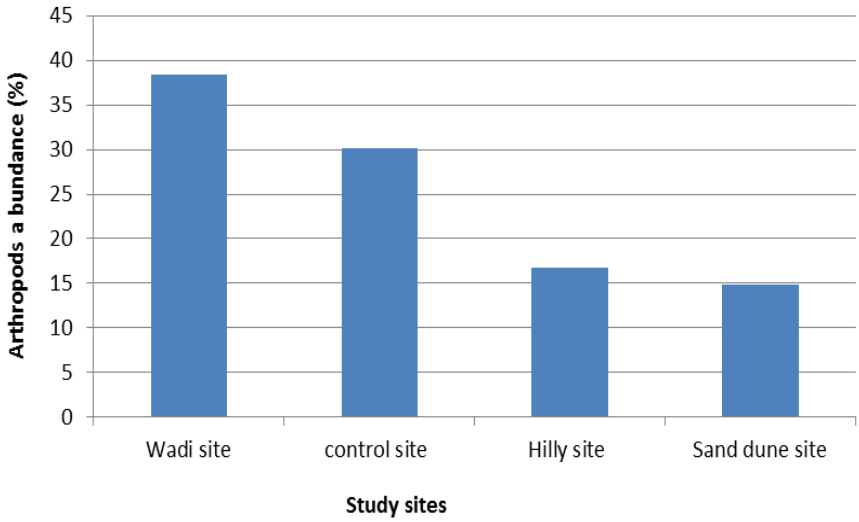


Fig.11: Abundance of arthropods collected from Hafeir Doka Reserve Forest

Diversity of arthropods at order level

Arthropods fauna collected during the study period were classified and compared at order levels. Results indicated that members of order of Hymenoptera were highly represented followed by members of orders Coleoptera and Diptera of all orders, Fig.(12) . These results could be ascribed to the feeding habit of Hymenoptera as phyto-phagous insects. Most of Coleoptera insects are stem borers and some are ground beetles which have modification to avoid heat stress and this agree with findings of Ghabbour (1999).Also most of the Diptera insects are highly adapted and have a great variety of life styles where some are agricultural pests and most depend on plants as shelter. Uys *et a*l (2009) were in conformity with these findings.

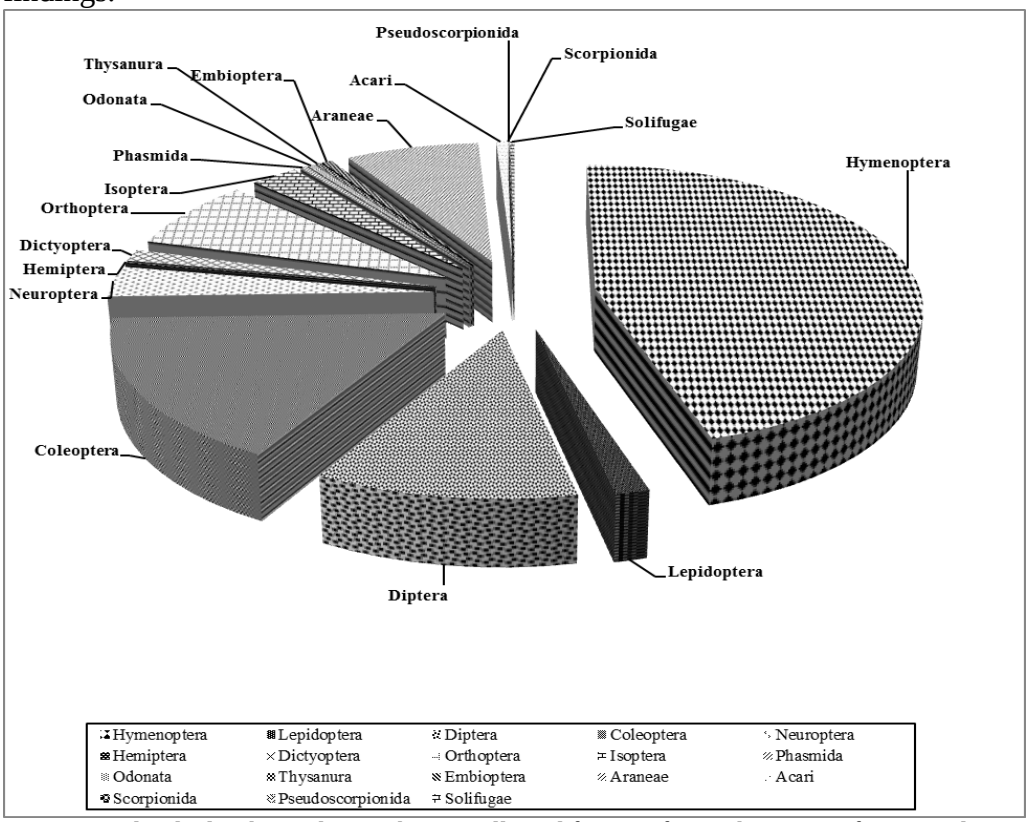


Fig 12: Individual arthropods' number as collected from Hafier Doka reserve forest, Sudan.

Diversity of arthropods within the study sites

Arthropods collected from the four sites showed variation in terms of number of orders, individual and diversity (D) as shown in Table (3). The Table indicated that numbers of orders, individuals and Simpson's index of diversity of the Wadi site exceeded those collected from the other three sites

Table (3) : Number of orders, individuals, and Sampson´s diversity index as compared for

Location	No. of Orders	No. of individual	Diversity
Control	16	1700	0.2
Wadi site	16	2163	0.1
Hilly site	13	944	0.4
Sand dune	12	832	0.4

Arthropods collected from the four sites

Acknowledgement

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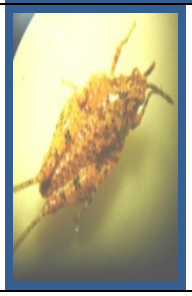
Appendix 1: Some photos of arthropods collected from Hafeir Doka reserve forest, Sudan.

Order	Specimen
Pseudoscorpionida	
Acari	
Araneae	
Thysanura	
Phasmida	
Orthoptera	

Dictyoptera	
Hemiptera	
Coleoptera	
Hymenoptera	

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ENVIRONMENTAL DEGRADATIONAND SUSTAINABLE MITIGATION STRATEGIES INNIGERIA

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Abstract

Our environment is naturally blessed with dynamic resources to includevegetation, waters, soils and animals etc. Naturally, vegetation change, rivers are polluted, soil erodes and species are depletedallcourtesy of human activities.While this is on the increase,some potentially more potent and dynamic activities on top of these already dynamic natural processes are surging up. Man who is at the centre has dramatically altered much of nature and its natural environment through a process which is not new because it has been on for very long. One significant dilemma in that transformation is that nature has been destroyed sharply over the last two centuries, and especially in the last several decades. Today,the natural environment is being progressively destroyedwith bulldozers and forests species felled by machine or handheld saws and reduced to small remnants of its original extent. To substantiate this, by mid-1970s (after the drought that caused serious degradation in Africa), humans had drastically increased the rate at which world's forest cover is destroyed and over the last century development has claimed almost all fringes of major towns. If we have observed one thing common between the human interaction andthe nature, it is that our inability to sustainably and effectively manage natural settings is often quite clear. Efforts tostop further deterioration are never late because as Myers pointed out, "we still have half of all tropical forests that ever existed" (Myers, 1992). Although this paper is theoretically sounded, its aim is to review salient limitations to the development of sustainable mitigationstrategies to Nigeria's rising environmental degradation and proffer some strategic solutions to the phenomena. Success in fighting environmental degradation requires an improved understanding of its causes, impact, degree, methods

and acquaintance with climate, soil, water, land cover and socio-economic factors. Considering this all, it is recommendedthat hybridoptions combining indigenous andcurrent externally developed approaches (which are mostly incompatible with the environment and cultures of Nigeria) should be produced and utilised to combat degradation in the country.

Keywords: Edegradation, mitigation strategies, resources, Nigeria

Introduction

Environmental degradation according to Yiran et al. (2012) would remain an important global issue for the 21st century because of its adverse impact on agronomic productivity, food security and quality of life. Getachew and Demele (2000) holds the most pressing environmental problems in the least developed countries are prevalent in rural areas, where the bulk of the populations live and whose livelihood depends on agriculture and related activities. Izibili (2005) stated that no doubt, damage to the environment is no respecter of frontiers, and damage done to one generation has the consequence of affecting the future generation. Based on this and many salient issues within the context of environmental degradation, Reynolds Stafford-Smith and Lambin (2007) stated that a major environmental challenge of the 21st century is environmental degradation; it adversely affects the sustainable relationship between ecosystems and the livelihoods of people worldwide. These are no doubt pointer to the escalating debates on environmental degradation/combat measures dilemma and which serious work has to be done before degradation is laid to rest.

The United Nations, UN (1997) refers to environmental degradation as the deterioration of the natural environment through human activities and natural disasters.The term environmental degradation implies that environmental resources such as land, soils and vegetation are reduced to a lower rank taking into account the fulfilment of given demands (Blaikie and Brookfield, 1987). Environmental degradation is not a new thing, it has been happening all over the world for centuries. The problem is that it is now occurring at a much faster rate, therefore not leaving enough time for the environment to recover and regenerate (Nicholson, 1990). Environmental degradation is composite phenomenon that has no single, readily identifiable attribute. Perhaps this is why there are so many conflicting and confusing definitions (Reynolds, 2001), as well as terminologies. It is far worst in Africa than in other continents because as noted McCann (1999) that African landscapes are anthropogenic and are subject to constant changes as a result of human interferences. The greatest strengths of African landscapes are their ability to support diverse vegetation resources (woody and herbaceous layers) and their resilience to natural calamities and climate change. It

ishowever widely reported that this ecological zone because of certain natural, socio-economic and political constraints is the one of the most degraded parts of the World (Solbrig and Young, 1992). Dregne et al. (1991) and Solbrig and Young (1992) mentioned that regions worldwide face unprecedented environmental degradation particularly in savannah environments of the developing countries where the natural environment is perceived to be under greatest threat. Reed (2007) noted that environmental degradation is the reduction in value of the environment to meet its ecological and socio-economic needs. It includes issues such as land degradation, deforestation, desertification, loss of biodiversity, land, water and air pollution, climate change, sea level rise and ozone depletion.

Environmental degradation is leading to more severe natural disasters which have already cost the world over $608 billion in the last decade, killed and displaced over 8 million people, mainly poor people in most developing countries in 1998-1999 alone (Worldwatch, 2001). Statistical evidence of the state of the environment by the United Nations have estimated that, of the 8.7 billion hectares of arable land, pastures and forests worldwide, nearly 2 billion of them have been degraded over the past 50 years, of which 18% are of forest land, 21% are of pasture land and 37% are of arable land (Haaften et al., 2004). Nearly 216 million hectares of rain-fed croplands or about 47% of their total area in the world's dry lands (457 million hectares) are affected by various processes of environmental degradation and about 3.3 million hectares of rangeland or nearly 73% of its total area in the world's dry lands (4.5 million hectares) are affected by degradation of vegetation. Each year a total of 6 million hectares of productive dry lands is turned into worthless desert (The World Commission on Environment and Development, WCED, 1987).

With the dangers of further deterioration before us, assessment of environmental degradation has therefore become a global issue for the long-term management of the earth bountiful natural resources and the sustenance of livelihood that depend on them (William, 1998).The problem which warranted the study is that many environmental degradation mitigation approaches and programmes have been organised and implemented in isolation in Nigeria, yet negligible progress in fights against degradation and desertificationis recorded other than hike in deterioration of the environment. The argument is perhaps the approaches are not suitable for the cases (site specific degradation in Nigeria) or that they are not properly articulated for the purpose of mitigation. Hence there is need for understanding some environmental issues properly for a shift in the Nigeria's efforts to combat degradation. To ensure this, review of the concept and approaches of environmental degradation assessment are very vital and therefore elaborated in this work. The hope is that with discussions such as this, better mitigation

measures canbe produced and tailored workableoptions that reflect the environment and people of Nigeria.

Concept of Degradation

Degradation is simply the deterioration of land, soils and loss of bio-productivity of vegetation due to varying causes. The concept has been discussed to refer to all forms of reduction in quality and quantity of ecosystem resources such as lands and forests. Degradation plagues almost all areas of the world but more severe in arid, semi-arid and sub-humid areas and presents a global challenge that requires urgent attention (ReynoldsStamford-Smith and Lambin, 2007; UNCCD, 2008).

The concept of degradation/desertification was discussed earlier than Aubreville (1949) by European and American scientists in terms of increased sand movements, desiccation, desert and Sahara encroachment and man-made deserts (Stebbing 1935), (Lowdermilk 1935 and Jones 1938 in Helldén, 2003). The two terms are interchangeably used by researchers to refer to deterioration in environmental quality and services. However, the word "desertification" was introduced by the French forester Aubreville when he suggests that desertification meant the spreading of deserts or desert-like conditions. Aubreville (1949) also stated that there are real deserts being born today, under our very eyes, in the 700-1500 mm annual rainfall areas. Since then, different concepts of desertification have developed and been discussed over and over again by scientists, politicians and the international community.

The term desertification (advance degradation) evokes an image of the "advancing desert," a living environment becoming sterile and barren. But this is not an accurate picture (Nicholson, 1994). As summarised by Johnson et al. (1997), degradation is "a term whose meaning reflects our perceptions, viewpoints, timeframes, and value attachments". **The words degradation and desertification are used interchangeably in this work. When degradation is used it is ours while desertification remains as obtained from the literature.**

Causes of Environmental Degradation

The causes of degradation also referred to as desertification, remain controversial (Helldén 1991, Geist and Lambin, 2001).It's now thirty seven (37) years after the United Nations Conference on Desertification (UNCOD) in 1977 which has gone and prompted an on-going and still unresolved debate about the causes and effects of degradation and desertification (Gray, 1999). Recent analysis by Geist and Lambin (2004) suggests that claims that desertification is either a human-made or a purely natural (i.e. climate-driven) process should be more nuanced. They carried out a worldwide

review of the causes of desertification, and from 132 case studies identified four major categories of proximal causal agents: (1) increased aridity; (2) agricultural impacts, including livestock production and crop production; (3) wood extraction, and other economic plant removal; and (4) infrastructure extension, which could be separated into irrigation, roads, settlements, and extractive industry (e.g. mining, oil, gas). They concluded that only about 10% of the case studies were driven by a single cause (with about 5% due to increased aridity and 5% to agricultural impacts). About 30% of the case studies were attributable to a combination of two causes (primarily increased aridity and agricultural impacts), while the remaining cases were combinations of three or all four proximal causal factors.

The Study Area

Location, Position and Population of Nigeria

Nigeria is located in West Africa. It lies between 0416^0 and $13\ 53^0$ North of Latitude and $02\ \ 40^0$ and $14\ \ 41^0$ East of longitude. Nigeria is bordered in the West, North, East and South by the Republic of Benin, Niger, Chad and Cameroon and Atlantic Ocean respectively (Figure 1). It has a land area of 923, 850 km^2 (Idowu et al 2011). It has 36 administrative states, a Federal Capital Territory (FCT). It has 774 Local Government Authorities (LGAs). It stretches for about 1,200 km in the N-S and E-W directions and has a coastline of about 853 km long. It is bordered to the north by the Niger Republic; to the north-east, by the Chad Republic, to the east by the Cameroun Republic, to the South, by the Atlantic Ocean and to the west, by the Republics of Benin and Togo.

Nigeria accounts for about one in every five Africans, 60% of West Africa population and 14% of the regional landmass. The 2006 Population and Housing Census puts the population of Nigeria at 140,431,790 consisting of 71,345,488 Males and 69,086,302 Females(NPC, 2006). The estimated average growth rate of the population is put at 2.8%, implying an estimated population for Nigeria of 168 million in 2010.Nigerian Economy is dominated by Agriculture. Over 70% of Nigeria's population is engaged in agriculture as their primary occupation and means of livelihood with an average of 41% contribution to the GDP.

Nigeria is rich in biodiversity as the country is well endowed with a variety of plant and animal species. There are about 7,895 plant species identified in 338 families and 2,215 genera (Federal Government of Nigeria, FGN, 2010). The vegetation ranges from the mangrove and thick forests in the South, followed by Savannah and the Sahel in the middle belt and the North respectively. The country is punctuated by the Obudu and Udi Hills in the East, the Jos plateau in the North Central and the Adamawa highlands in the North East. Nigeria is drained by two main rivers – Niger and Benue**.**

In Nigeria erosion constitutes a major form of environmental degradation. NEST (1991), identified five principal types of soil erosion in Nigeria, namely, sheet erosion, rill erosion, gully erosion, coastal erosion and wind erosion.

Consequences of Environmental Degradation in Nigeria

Environmental degradation is an increasing problem in many parts of the world. The phenomenon is most pronounced in the drylands, which cover more than 40% of the earth's surface (Dobie, 2001). Environmental degradation ofvarying types and degree are generally un-evenly distributed in Nigeria. Ranging from the less devastating such as sheet erosion and mild gullies, to highly dangerous types such as loss of biodiversity, drought and loss of soil bio-physical characteristics, a typical environment in Nigeria may be occupied with one or overlapping sets of degradation consequences. While it is vivid, though arguably, that coastal erosion and water pollution and marine biodiversity loss are typicalin the southern coastal areas of Nigeria, the central states suffers from salinization and acidification of soilsand sediment discharge on lower Niger-Benue catchments.Loss of biodiversity of plants and pockets of reserved areas and well as reduction in soil fertility are quite alarming in Nigeria (David, 2008) and this is moving at alarming rate in Northern Nigeria because of deforestation and fuel wood consumption (Naibbi, 2013).

On regional basis, the southern areas of the country, in the lowland rain forest and derived Savanna ecological zones, where population pressures have resulted in degradation of the forests, severe gullies(in the Enugu and Edo States) continue to develop and erode massive areas of farmlands and settlements. Many of these areas have erosion prone, shallow or sandy soils but yet continue to remove surface cover to plant one or two seasonal crops thus exposing the soils for the rest of the off-farm period of the year to splash and heavy downpours of the tropical continental climate of southern Nigeria. Along the coastline, issues of saltwater inundation are evident. Specifically, new areas of saltmarshes/tidal flats were identified over extensive areas that were not affected before. The coastal area has also witnessed a reduction in the area of freshwater swamp. These areas are being converted to intensive agriculture (Titilola and Jeje, 2008).

The north is prominent with aridity and drought, wind erosion and change in vegetation. In the north, a process of desertification is evident as sand dunes that were stable in the past are now exposed. Large areas of gully erosion are clearly visible, and denuded areas can be identified in many agricultural regions (FORMECU, 1998). Generally deforestation, salinization and loss of plant diversity are most widespread in all parts of Northern Nigeria. The increasing intensity of agricultural activity due to

population growth may be the most important factor influencing this process. Other influential factors may beclimate change or the establishment of major water works projects (i.e. construction of dams).

Methodological Frameworks for Assessing Environmental Degradation

Because of the complex nature of environmental degradation it was argue that global assessments of degradation lack the appropriate methodologies to deal with the complexity of the issue (Convention to Combat Desertification, CCD, 1997), however, these frameworks provide basic methodological underpinnings for the assessment of degradation and therefore valuable tools for its mitigation.They are discussed in consonance with the concept of degradation as it is discussed earlier on.

Stress-Response Framework

The United Nations Statistical Office in the mid-1970s developed a general framework of environmental statistics through a joint initiative with Canada that led to the development of the Stress-Response. The framework considers the stress on the natural environment beyond its carrying capacity and its effects on human beings. The focus of the stress-response framework is on the effects of human activities on the natural environment. The stress-response approach has had a major impact on environmental reporting around the world (Hodge, 1991). The exclusion of the major causes of the stress on the natural environment is, but, one of several serious limitations to current expressions of the stress-response concept, one that reduces significantly its usefulness for assessing environmental degradation holistically (Hodge, 1991).

Pressure-State-Response Framework

The Pressure-State-Response (PSR) assessment framework of Organisation for Economic Cooperation and Development (OECD) (1994) was a step further of the stress-response framework. The PSR framework is based on a concept of causality: human activities exert pressures on the environment and change its quality and the quantity of natural resources. Society responds to these changes through environmental, general economic and sectoral policies (‘sectoral response’) (OECD, 1993). The assessment framework takes into consideration, the ‘pressures’ which describe the intensity and extent of human activities acting directly on the environment beyond its carrying capacity. The ‘state’ refers to the baseline state of the environment as judged from areas relatively unaffected by direct human activities (Pinter et al., 1999). The ‘responses’ deal with the impacts of stresses on the environment and assess human actions, such as legislation, new technology, economic instrument, economic expenditures, changing

consumer preferences and international conventions, undertaken to protect the environment (Gallopin, 1997).

The PSR framework is the most widely accepted of the many frameworks advocated, having been adopted by the OECD for its analysis of the degradation and pollution of the natural environment. The European Environmental Agency of the European Commission also used the PSR approach in assessing various environmental problems within member states (Jesinghaus, 1998). The PSR is also used in the methodology of the World Bank's Land Quality Indicator programmes (World Bank, 2001). In most developing countries, one cannot examine critically environmental degradation without considering the indirect causes of degradation, hence the limitation of PSR in this study.

Driving Force-State-Response Framework

The Driving force-State-Response (DSR) framework was first initiated by United Nations Commission for Sustainable Development, UNCSD (1997) to consider the shortcomings of both the stress-response and the PSR framework. The framework, instead, considered the driving forces of environmental problems that did not feature in both the stress-response and PSR frameworks. The replacement of the term 'pressure' in the PSR framework by the term 'driving force' was motivated by the desire to include economic, social and institutional aspects of environmental problems (European Environmental Agency (EEA), 1999). The World Bank adopted the DSR framework in its work on indicators of environmentally sustainable development (World Bank, 1995), even though in 1997 it published World Development Indicators (World Bank, 1997) which used the PSR framework.

A major advantage of the DSR framework is that it organizes information on sustainable development systematically in a way that guides the user of the framework through all aspects of sustainability. In distinguishing between the social, economic and environmental aspects of sustainable development, the framework ensures that no aspects of sustainability indicators are automatically excluded. The inclusion of the economic and social aspects is particularly important for developing countries with economies in transition, for which an equal balance between the developmental and environmental aspects of sustainability is important in order to ensure future sustainable growth patterns (United Nations Commission for Sustainable Development, UNCSD, 1997). The DSR works perfectly when an environmental stress has been identified and linked to a causative set of human activities as perceived in most developing countries.

Driving Force-Pressure-State-Impact-Response Framework

The European Environmental Agency (EEA), within the legal basis of the European Union Environmental Policy Acts 95, 174, 175 and 176 of the consolidated version of the Treaty on European Union and under the auspices of the European Commission, in their effort to introduce environmental issues in their developmental agenda, further improved the existing assessment frameworks into a five indicator framework (which includes PSR and DSR as special cases) dubbed as the 'DPSIR assessment framework' (EEA, 1999). Each indicator conveys its own distinctive meaning and application. The framework is seen as giving a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future (Kristensen, 2004).

According to the DPSIR framework there is a chain of causal links starting with '*drivingforces*' (economic sectors, human activities) through '*pressures*' (emissions, waste) to '*states*' (physical, chemical and biological) and '*impacts*' on ecosystems, human health and functions, eventually leading to political '*responses*' (prioritisation, target setting, indicators).A 'driving force' is a need. Examples of primary driving forces for an individual are the need for shelter, food and water, while examples of secondary driving forces are the need for mobility, entertainment and culture.Pressures on the environment, according to Geist and Lambin (2002) are human activities or actions, usually at the spatial level, that originate from intended land-use and directly impact negatively on the natural environment. As the driving forces, the 'pressures' of degradation are usually multivariate. Driving forces lead to human activities such as transportation or food production, i.e. result in meeting a need.As a result of pressures, the 'state' of the environment is affected; that is, the quality of the various environmental compartments (air, water, soil, etc.) in relation to the functions that these compartments fulfil. The 'state of the environment' is thus the combination of the physical (air, soil and water quality), chemical and biological conditions (ecosystems-biodiversity, vegetation, soil organisms, water organisms etc.). Environmental 'impacts'are the changes in environmental parameters, over a specific period of time and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initialised. In other words changes in the state may have environmental or economic 'impacts' on the functioning of ecosystems, their life supporting abilities, and ultimately on human health and society.A 'response' by society or policy makers is the result of an undesired impact and can affect any part of the chain between driving forces and impacts.

The components of the DPSIR framework are explained in the following way by (**see Kristensen, 2004 for the framework**).

Environmental Degradation Issues in Nigeria

National Environmental Policies of Nigeria

As part of the Federal Government of Nigeria's overall framework of protecting the environment, policy issues have given prominence to the twin environmental problems of drought and desertification (Federal Government of Nigeria, FGN, 2006). This part evaluates the past and present efforts of governments with a view tohighlight on current efforts which require review of approach and identifying new initiatives that are considered needful. Emphasis of thisreview is on constituent elements to combat desertification within the framework of the National Policy on Environment to include the following:

1. Development of a National Action Programme to Combat Desertification and mitigate the effects of drought towards the implementation of the Convention to Combat Desertification (CCD) in Nigeria,
2. Integrating public awareness and education on causes and dangers associated with drought and desertification, as well as the constraints of the CCD,
3. Strengthening of national and state institutions involved in drought and desertification control programme,
4. Promoting sustainable agricultural practices and management of water resources including water harvesting and inter-basin transfers,
5. Encouraging individual and community participation in viable afforestation and reforestation programmes using tested pest and drought-resistant and/or economic tree species,
6. Encouraging the development and adoption of efficient wood stoves and alternative sources of energy,
7. Establishing drought early warning systems,
8. Involvement of the local people in the designing, implementation and management of natural resources conservation programmes for combating desertification and ameliorating the effects of drought,
9. Intensifying international cooperation and partnership arrangements in the areas of training, research, development and transfer of affordable and acceptable environmentally sound technology and provision of new and additional technical and financial resources,
10. Inventorying degraded lands, and implementing preventive measures for lands that are not yet degraded or which are slightly degraded,
11. Adopting an integrated approach to address physical, biological and socio-economic aspects of desertification and drought,
12. Intensifying cooperation with relevant inter and non-governmental organizations incombating desertification and mitigating the effects of drought,

13. Strengthening the nation's food security system,

14. Establishing, reviewing and enforcing cattle routes and grazing reserves,

National Programmes to Combat Degradation in Nigeria

Nigeria signed the Desertification Convention on the 31st October, 1994 and ratified same on the 8th July, 1997 thereby qualifying the country as a Party to the convention with effect from 6th October, 1997. Part of the fulfilment of the convention's objectives is setting up a number of National programmes to combat degradation (FGN, 2006). These are broadlyreviewed into the following headings;

Forestry Programmes

The country has made several attempts at putting in place programmes that would ensure the efficient management of her Forest resources. These include:

The establishment of Industrial Plantations from 1978, Land Use and Vegetation survey between 1975 and 1978, Production of perspective plan for the period 1990 - 2005 and formulation of a Nigerian Forest Action Program in 1997. However, most of these initiatives have had limited impact in turning around the precarious state of the Forest estates.

An Arid Zone Afforestation Project (AZAP) was instituted by the Federal Government in 1976 to tackle the problems of desertification through the establishment of woodlots, shelterbelts and windbreaks. Over 10 million seedlings were raised annually between 1978 and 1984. About 150 kilometers of shelterbelts, 3,680 hectares of woodlots, 24 boreholes, 70 tree nurseries, and Forestry Vocational Schools were established (FGN, 2012).

The EEC supported a pilot project in Katsina State covering a total area of 1.6 million hectares involving the establishment of shelterbelts, windbreaks, woodlots and trees on farmlands. In addition, the World Bank also financed a similar project in the five arid zone states (World Bank, 1989). Areas of focus of the Forestry Programme include the following:Land Use Policy, Fuel Energy, Mass Tree Planting Campaign, Prevention of Bush Fire, Silvo-Pastoral System and Sand Dune Fixation.

Energy Resources

Draft National Energy Policy was formulated in 2001 (FGN, 2001). In it was stated that Nigeria consumes well over 50 million metric tonnes of fuelwood annually; a rate that far exceeds the replenishment rate through various afforestation programmes. Sourcing of fuel wood for domestic and commercial uses is a major cause of desertification in the arid zone states of Nigeria. In other to reduce deforestation associated with fuelwood sourcing,

the Federal Government, through the Energy Commission of Nigeria (ECN), has put in place the following programmes for the purpose of promoting optimal utilization of renewable energy resources by Nigerians: 1. training programmes on renewable energy technology, 2. biogas and biomass utilization projects, 3. solar photovoltaic electrification projects for remote rural areas.

Integrated Programmes Targeted at Poverty Alleviation

The Federal Government of Nigeria realises that poverty alleviation is a major weapon for combating desertification. Consequently, a number of poverty alleviation programmes have been put in place and notable amongst these are; the Northeast Arid Zone Development Programme (NEAZDP), the FMENV/UNIMAID Linkage model village project, the Katsina State Agricultural and Community Development Project (KSACDP), the Sokoto Environmental Protection Programme (SEPP) (FGN, 2012) and these are reviewed as follows;

The North East Arid Zone Development Programme (NEAZDP), funded by the Federal Government of Nigeria with European Union assistance, commenced in February 1990 with the main objective of motivating and assisting the rural population to improve their standard of living through proper resource use and management. The major components of this programme include water resources development and management (including irrigated agriculture), provision of micro-credit for off season economic activities, cottage industries, livestock fattening, rural banking and popularisation of animal traction for land preparation for agricultural activities.

The Federal Ministry of Environment/University of Maiduguri Linkage Centre on Drought and Desertification Control, based at the University of Maiduguri, initiated a model village project at SabongarinNangere, Yobe State in 1995. Activities carried out at the model village include establishment of community woodlots and roadside tree planting, provision of energy efficient wood stoves, provision of biogas for domestic cooking, provision of Ventilated Improved Pit (VIP) latrines and provision of solar powered water pump for the community boreholes (Gadzama, 1995). The model village project, though presently constrained by lack of funds, is no doubt a major success that deserves replication in other parts of the drylands of Nigeria.

The Katsina State Agricultural and Community Development Project (KSACDP) was conceived as the first stage of an IFAD strategy to speed up and intensify rural development in the drylands of Nigeria. The rationale was to improve resource management through community participatory processes, principally in group mobilisation for credit supply and joint action

against the serious degradation threatening the agricultural productive capacity of the land. Achievements recorded include improvement in farming practices (in both uplands and fadamas) to make their more sustainable, investments in community and amenity development in the villages and in off-farm income generating activities for groups of poor and landless households with emphasis on those headed by women.

The Sokoto Environmental Protection Programme covers an area of about 17,500 km2 in the north-eastern part of Sokoto State. The objective of Programme was to improve the utilisation of resources to achieve long-term sustainable growth and environmental protection. The Programme is jointly financed by the Federal Government of Nigeria, Sokoto State Government and the European Union under the Sixth European Development Fund (Lome III). The programme components include Afforestation, Livestock and Rangeland management, and development of rural infrastructures, Irrigation, Women development and Adult literacy.

Building Partnerships

Government has recognised that the hydra-headed problem of desertification cannot be tackled by itself alone so it facilitated the involvement of other actors including the Private Sector, Non- Governmental Organizations (NGOs) Community based Organizations (CBOs) and Donors. At present, a number of NGOs are actively involved in the implementation of CCD in Nigeria. Some of them participated very actively in the negotiation process as follows: 1. Action Programmes, Co-ordination Mechanisms and Partnerships, 2. Capacity Building, Education and Public Awareness, 3. Financial Resources and Mechanisms, (FGN, 2006).

Some of the NGOs in Nigeria are actively participating in the activities of the Global NGO network on Desertification. As a matter of fact, the Nigerian Environmental Study/Action Team (NEST) is the sub-regional focal point of this network for Anglophone West Africa. Other prominent national and international NGOs that are actively involved in the implementation of CCD include the Nigerian Conservation Foundation (NCF), Forestry Association of Nigeria (FAN), and International Union for Conservation of Nature (IUCN) (Nigerian Environmental Study/Action Team, NEST, 1991).

Challenges of Combating Environmental Degradation in Nigeria

Despite the various national efforts and achievements recorded, desertification and general environmental degradation remain a major challenge to Nigeria's sustainable development. The problem continues to reduce the natural resource base and complicate efforts to reduce the pervasive poverty of the affected regions (FGN, 2006). Of the major

challenges is the inability to domesticate the Nigeria's UNCCD framework to state levels and redress the escalating poverty which mostly cited as the leading driverof environmental degradation in Nigeria.

Other major challenges faced in attempts to combat environmental degradation and desertification in Nigeria include (1) the poor maintenance of irrigation and drainage networks, and over abstraction of groundwater; (2) conversion of land from forestry and agriculture to other land uses (e.g. energy, transportation development, etc.) without compensatory conservation measures on the new non-forest land; (3) excessive grazing in forest lands in the absence of adequate pastureland and a viable policy of fodder development; (4) incessant bush burning during land clearing for agriculture, hunting for games, and the cattle herdsmen desirous of stimulating re- growth of dormant grass buds and (5) sand mining (FGN, 2012).

SalientLimitations to Environmental Degradation Mitigation Initiatives in Nigeria

The capacity of the Nigerian Government to mitigate environmental degradation is limping because certain noticeable issues are left in the development and implementation of programmes. These are presented and discussed with respect to obvious reports obtained from evaluation of the programmes over the years.

Adoption of Externally Developed Approaches toCombat Degradation

Unlike the new shift, in the past natural resource management in the world over has reflected a belief that the top-down application of science to predict and control the natural world is the best practice of management. This has led to the widely accepted approaches even though some are not evaluated to have any advantage over the indigenous practices such as natural regeneration in the Maradi area. Many authors have contended that conventional approaches has not accomplished what it promised; it has not been able to sustain both the healthy functioning of natural systems and humans' use of their resources (Bart, 2006). Instead, ecosystem health is steadily declining: biodiversity continues to decrease and landscapes are degraded, while conflict and litigation frequently overwhelm combat decisions

Nigeria has been a country thatunarguably utilises approaches that are externally driven to manage its environment to the detriment of others that are indigenous without necessarily proving their capabilities. These and practical evidences have led (over the past last two decades) to growing number of critics, including many scientists, who challenged the technocratic optimism of this 'conventional approaches' (Chamber, 1993; Mortimore,

2006; Shepherd, 2008) as substitute to the local intuitive practices that spans generation. This process has been a bad one even though the technocrats would want it that way; it has been yielding limited achievement.

Non-decentralisation of Nigeria's UNCCDD Objectives to States

Nigeria is a Federal entity, it's the system of governance of natural resources has been centralised mostly andmanaged by the federal government from the centre. Although the states and local governments are vital organs of the governments, centralised initiatives form a bed rock upon which all other measures lies on because even the desertification charter that was ratified and domesticated by Nigeria till now is owned and utilised by the federal government agencies. This development has resulted to failure in most programmes aimed at combating degradation and desertification in Nigeria. Decentralisation will help spread development to the rural stakeholder easily and implementation will then reach all without heavy work.

Not to the hands of the poor (programmes, subsidies and incentives)

The global scope of sustainable development issues leads to calls for initiatives that are transferable, inclusive and scientifically valid, to provide good governance of resources together with local actors. However, suchinitiatives, generally defined by experts at high levels, can be lacking legitimacy in the eyes of rural poor always respond to the specific circumstancesat local site. This has always led to the top-bottom dichotomy and resulted to more destruction than cohesion in a matter that requires bonding such as natural resource management and environmental degradation mitigation. As has been argued by Chambers (1997) and Anderson et al. (2006) and many others that a main source of management problems is the centralised means of resources sharing that unfairly allocate environment management funds to the central agencies and in consonance with the reality of continued economic alienation of the rural poor,Chambers, Saxena, and Shah (1991) 'to the hands of the poor'and what Leach and Mearns (1996) and Mortimore et al. (2006) have advocated that, environmental degradation and mitigation should be done with local people inclusive, rural poor are always successful. In their arguments they cited various examples from Machakosand Makueni Districts of Kenya, Maradi in Niger Republic as well as Kano region in Nigeria were local natural management was done by people and was found to be resilient more than in other areas that operate the conventional approaches.

Of the impediments to mitigation of environmental degradation in Nigeria, withdrawal of incentives due to short fallof foreign funds (owing to donor fatigue), privatisation policies which shatter subsidies and bureaucratic

involve in accessing loans are posing serious challengesthat often lead to the failure of most mitigationinitiatives of the rural people. Rural people have intuitive practices of managing their environment which are more resilient, cost effective and friendly but because they lack certain take up capital cannot fully realise most dreams.Today growing numbers of private sector operatives are willing to invest in natural resources management and these offers can be utilised so that their invest can help augment national programmes that cannot continue as a result of economic crunch.

Failure of Mega Projects

The Nigerian government in its bid to create sustainable solutions to certain natural shocks engage into rapid often untested development projects which tend to fail because of over dependence of expertise advises and reports. Among several,few can be listed which are successful while plenty fail due to disregards to ethics of contracting huge projects. Mega projects such as dam have been considered as vital sources for power, irrigation and domestic water provision and so are considered options because of its potentials. However, responses of the environment to such complex structures are of concern to stakeholders because these dams often pose great consequences such as direct impact to biological, chemical and physical properties of rivers and sediments discharge downstream. In Nigeria the consequences of dam construction are witnessed in Bakalori dam site in Sokoto State as well as Ngadda River project (South Chad basin) in Borno States. Serious environmental calamities were recorded owing largely to the failure of the projects. The valley of the KomaduguYobe was green throughout the year until the Tiga Dam was constructed. Before the dam, the valley was a major focus of transhumant herds, but now it is only a seasonal grazing resource (FORMECU, 1998).

How can we Shift to Sustainable Mitigation?

A sustainable measure can be said to be sustainable, if it is resilient in the face of external shocks and stresses, if it is independent from external support, if it is able to maintain the natural environment and its resources without necessarily degrading any of its parts. In other to sustainably mitigate environment degradation in Nigeria, the study suggested some measures to be taken as they are cost effective and practical.

Utilise People Centred Approaches

A people centred approach mitigate environmental degradation should try to increase options and reduce vulnerability. There are several frameworks around which indicators can be developed and organised. There is no unique framework that generates sets of indicators for every purpose.

Based on these and many other facts, two frameworks are found to be effectively better in assessing environmental degradation in Nigeria. These frameworks are very vital because unlike others that are reviewed, they have incorporated local stakeholders in their implementation which is the new paradigm in environmental degradation assessment and combat projects. The frameworks are; the Ecosystem Services and Sustainable Livelihoods Frameworks.

Ecosystem Services (ES) Framework

An ecosystem is a self-regulating functional unit in which both non-living and living organisms interact and which has a boundary that distinguishes it from other ecosystems (Leemans 2011). The term ecosystem is often used to describe both a biome and a habitat. The origin of ecosystem as a concept can be traced to 1864 while coining of the terminology has been traced to 1935 (O'Neill, 2001). The concept of ecosystem has emerged with a renewed force when it was mainstreamed in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, MA, 2005b).This recognition that environmental degradation is scale sensitive and can only be mitigated when people trapped in its impact are involved forced the international community to change thinking on issues relating to degradation and as well re-focus dimension of management to people centred approach such as the Ecosystem services.

The Ecosystem Services (ES) Framework focuses on the benefits people obtain from ecosystems: ecosystem services. This framework encourages the assessment team to think broadly about the range and scale of impacts of Environmental Degradation/Sustainable Livelihood Management ED/SLM (Millennium Ecosystem Assessment, 2005a). Some impacts are easy to quantify, others not; some are felt locally and very differently according to the socio-economic status of the land-user, others are felt nationally or globally.The importance of ecosystems services for human well-being is articulated by many authors (Boyd and Banzhaf, 2006). Humans depend on ecosystem services and on their benefits for their livelihood needs (Fisher et al. 2009). Whereas people and ecosystems are two independent entities, the human interventions always affect the functions of the ecosystems and consequently the services and benefits derived.

Sustainable Livelihood (SL) Approach and Framework

Out of worrying need of approach that will be best applied that will sustain the environment and together with livelihoods of the people, the sustainable livelihood framework was developed as tool that combines both natural and socio-economic aspects of household livelihood and the environment. The framework is centred on people. Its aim is to help

stakeholders with different perspectives to engage in structured and coherent debate about the many factors that affect livelihoods, their relative importance and the way in which they interact (Kollmair and Gamper, 2002). The sustainable livelihoods framework presents the main factors that affect people's livelihoods, and typical relationships between these. The concept of 'sustainable livelihoods' constitute the basis of different Sustainable Livelihood (SL) Framework and has been adapted by different development agencies such as the British Department for International Development (DFID), (DFID, 2000). The livelihoods framework is a tool to improve our understanding of livelihoods particularly the livelihoods of the poor. The Sustainable Livelihoods framework is used for understanding how household livelihood systems interact with the natural, socio-economic and policy environment. Impacts can be in both directions i.e. many pressures leading to land degradation arise from the activities of land-users and ED/SLM causes impacts on land-users' livelihoods. In this assessment the SL approach is used to help understand both: the drivers and pressures leading to ED/SLM and the impacts of ED/SLM on people. Five concepts are crucial for understanding the linkages within the framework (**see MA, 2005a for the figure**). These are;1) The vulnerability context, 2) Livelihood assets, 3) Institutions, 4) Livelihood strategies, 5) Livelihood outcomes

However, the SL Approach is not without some limitations. Among which are a differentiated livelihood analysis needs time, financial and human resources (DFID, 2000).

Ecosystem Approach (EA)

The dry environments are facing daunting collection of challengesand faced with the realities of dry environments constraints, the aims of developing an integrated Ecosystem Approach to research for development must include: sharing access to ecosystem goods and services; securing equitable benefits for livelihoods; conserving biodiversity and ecosystem integrity; maintaining or improving biological productivity; and building institutional sustainability (Mortimore, 2006).

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is the primary framework for action under the Convention on Biological Diversity (CBD) and comprises 12 Principles (for details see Shepherd, 2004). The Approach was developed by the Convention on Biodiversity and recognised that as human beings are ecosystem components, their active roles in achieving sustainable ecosystem management are valued (Shepherd, 2008). In considering how to best implement the Ecosystem Approach, several attempts have been made to rank the principles, either by order of importance or according to theme. The

Ecosystem Approach puts people and their natural resource use practices squarely at the centre of decision-making. Because of this, the Ecosystem Approach can be used to seek an appropriate balance between the conservation and use of biological diversity in areas where there are both multiple resource users and important natural values. It is therefore of relevance to professionals and practitioners active in farming, forestry, fisheries, protected areas, urban planning and many other fields (Shepherd, 2004).

The primary methods used in the application of the approach are structured group or individual discussions, supplemented by inventories of biodiversity (as defined by user groups), livelihood and technical options, and some participatory mapping of ecosystem resources or ecosystem areas (Mortimore et al., 2006).

Prioritise stakeholder ship in Environmental Resources Management

Throughout the last decades after the UN summit on sustainable development in 1977, environmental activists now argue that the public should be more deeply engaged in environmental management decision-making and part of the rationale for this argument is based on the growing recognition that Western, scientific approach has discounted the value of local expertise—often to the detriment of the unique social and ecological system being managed (Fischer 2000).Tiffen, Mortimore and Gichuki, (1994) and Mortimore et al. (2006) argued that growing indigenous capabilities to sustain the environment and agro-management of farmlands using local managers' own initiatives is not harmful to sustainability of the environmental and its resources but only capable of maintaining the base for the future. Site cases such as that of the Machakos(Tiffen, 1993) and Makueni Districts in Kenya showed that between 1932 and 1987, the Akamba people increased the average production per hectare by a factor of>10 while their population grew six-fold. During the latter half of the period, they reserved a crisis in soil erosion, planted trees, extended the cultivated area, and created a landscape of meticulously terraced fields and private pastures. These achievements were sustained during the 1990s even in the dry areas of Makueni District (Tiffen, Mortimore and Gichuki, 1994). Mortimore and Turner (2005) maintained that farmers' capacity to have an impact on the effects of deforestation through conservation of trees on farms should not be under-valued. The surveys in five villages of the Maradi-Kano region have shown that indigenous communities have a capacity to assess their ecosystem resources on the basis of an extensive and detailed knowledge of species, typologies and indicators (Mortimore et al., 2006).

These findings suggest a scenario characterised by strongly held conservation values, and visible in an increasingly wooded landscape, good

use of local knowledge in planning and an active search for more sustainable pathways in ecosystem management (Mortimore et al., 2006).

Aforementioned findings correlates with the ethos of the study that prioritising local stake holders will ensure the sustainability of resources and redress the effects of most consequences of degradation in Nigeria. This is because about 70% of the population of Nigeria are farmers and more than that are natural resource users, utilising their potentials will only restore the deterioration done to the Nigeria's rich resources as done in Machakos District in Kenya, Yatenga District in Burkina Faso and other areas of Niger Republic.

Promote Indigenous Environmental Management Practices

The challenges of finding environmentally sound and culturally acceptable natural resources management practices thus lead researchers to consider community-based-knowledge (Berkes et al., 1998). Provided with many thoughts, Grice and Hodgkinson (2002) further stated that an measures that involves the participation of the local community, has proven to be effective in devising proper management system for the sustainable use of landscapes.

A common argument is that local people, in their groups or communities lack the capacity, skills, and expertise to sustainably manage forests and other resources. Often external expertise refer to the big problem of sustainable management is rural illiteracy. These unreasonable arguments produce growing number of outcomes which do not favour the environment and its management. Local organisations can be building block of rural development (USAID, 2002) and key to empowering and amplifying the voices of the rural poor (Anderson et al., 2006). This is because literacy is no guarantee of good management and illiteracy is no guarantee of poor management (Anderson et al., 2006). Some useful techniques worthy of promoting are;

The Farmer Managed Natural Regeneration

Farmer managed natural regeneration is a systematic regeneration and management of desired tree stumps in fields. The FMNR has become a catalyst for large scale people-led environmental restoration and communities and individuals are benefitting through its impact on poverty alleviation and food security. In its three decades since being in practice in Niger, Republic, FMNR has spread to 50% (5 million hectares) of the nation's farmlands with little NGO or government intervention (Rinaudo, 1994). Practices such Farmer Managed Natural Regeneration (FMNR) should be promoted among local resource managers as they are cost effective and still resilient in management of the natural environment and its

resources.FMNR helps in meeting the commitments to UN conventions such as the convention on desertification (Rinaudo, 1994). Details of benefits of this practice can be found inRinaudo (1999, 2005, and 2008), Reijet al. (2009) as well as Mortimore et al. (2006).

When adopted in Nigeria, the technique can recover degraded lands through improved natural resources management and social status of people who can especially women and vulnerable group as seen in Maradi and Zinder of Niger Republic (Reij, 2006).

Agroforestry

Agroforestry is a natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (ICRAF,2004). Agroforestrywould be the integration of trees, plants, and animalsin conservative, long-term, productive systems.Every part of the land is considered suitable for useful plants. Emphasis is placed on perennial, multiple purpose crops that are planted once and yield benefits over a long period of time (Boffa, 1999).Nair (1989) has explained that the agroforestry approach to land management offers a viable option to make use of the indigenous knowledge about such underexploited species and integrate them with other preferred species for the production of multiple outputs and services from the same unit of land in a sustainable and socially acceptable manner. Agroforestry practices as suggested Boffa (1999) are indigenous techniques that utilises both crops and trees in association on the same piece of land for a better yield.

Some major advantages of this system are that trees enhance soil fertility in terms of plant-available nitrogen and phosphorus (Rao, Nair and Ong, 1997), there is improved water use efficiency as a result of reduced run-off, soil evaporation and drainage (Onget al., 2002) and valuable tree products, including fruit, fodder and wood, can be produced. Agroforestry systems make maximum use of the land. This practice has been in place in farming parklands of Northern Nigeria for decades (Pullan, 1974) and if harnessed it has the propensity of turning around deterioration in degraded farmlands in the area.

Planting Pits Technique (Zai)

Zaï is a traditional soil conservation technique that originated in Mali in the Dogon area. Zaï was adopted and improved by farmers in Burkina Faso after the drought of 1980's. To reclaim severely degraded farmland that water could not penetrate, farmers would dig a grid of planting pits known (also known as Zai) across the rock-hard plots. Zai is an agricultural technique of the Yatenga province of Northern Burkina Faso were gridded

pits are made on soils so that it can survive erosion due to run-off (Reij, 1991). The application of the Zaï technique can increase production by about 500 % if well executed (World Bank, 2005). Sawadogo et al. (2001) explained that pits has been used to diversify plants biomass in Burkina Faso and the practice has help improve soil fertility and crop yield in the area.

If Zai is to be promoted farmers in Southern Nigeria would have better possibility of reclaiming their washed away soils and put it into productive use as the technique is perfect in controlling soil erosion by surface run-off.

Promoting Local Energy Alternatives

Woodfuel supports lucrative local trade. Trade in charcoal is a major source of income for many households. For example, in Zambia, the charcoal industry generated about US$30 million in 1998 alone, and in the same year about 60 000 Zambians directly depended on charcoal production for the bulk of their income (Kalumiana, 2000). Globally, energy demand is surging up and with increase in population; the amount needed to sustain households' demands will never reach some. Essentially because four out of five people without electricity live in rural areas in developing countries, mainly South Asia and Sub-Saharan Africa. About 81% of households burn solid fuels, far more than any other region in the world, with about 70% depending on wood-based biomass as their primary cooking fuel. Nearly 60% of urban dwellers also use biomass for cooking (IEA, 2010). While it is predicted that by 2030 energy derived from wood in Africa will still account for an estimated three quarters of total residential energy consumption serving about 1 billion people, it currently only accounts for about 10% of the global energy supply (IEA, 2008). The 2011 UNDP assessment of the MDGs has included Nigeria among those countries requiring further effort to improve their energy situation. Anozie et al. (2007) highlighted some of the efforts of the Nigerian government through its Energy Commission and the numerous other research efforts in addressing the energy situation. They concluded that the majority of the energy targets set by the government remained unmet, due to lack of policy implementation, general lack of awareness from consumers of the compelling need to conserve energy and lack of logistics and proper funding (Naibbi, 2013). All the four impediments to the improvement of the energy situation in Nigeria described by Anozie et al. (2007) focused on the laxity of the policy makers in either not funding the sectors efficiently or not policing the laws that would regulate the proper use of energy in the country.

Nigeria is moving back to the use of traditional cooking energy, which is why the volume of fuelwood collection rose from about 59,095,000 m^3 in 1990 to about 70, 427, 000 m^3 in 2005 (FAO, 2010) thus pro-poor

options such promotion and adoption of improved cookstoves (ICS) (Zein-Elabdin, 1997; WorldBank, 2011), biomass briquetting technology (see Karekezi, 1994; Freguson, 2012; Danjuma, Maiwada and Tukur, 2013)using local raw materials such as bagasse and municipal wasteas well as biogas technology are a must so as to ease stress on biomass and wood.

Energy issues require integrated and interdisciplinary approaches with a sustainable development focus. For example, interventions designed to improve the production of fuelwoodsuch as wood lots and FMNR should be closely coordinated with Environment and Agriculture and Rural Development departments of Ministries and involve community participation. Further, investments in energy sector (to utilise liquefied natural gas presently booming because of discovery crude oil in Niger Republic) should be promoted especially among users of biomass and charcoal so as to move up the twisting energy ladder.

Improve Rural livelihood Portfolios via localStrategies

Globally, two billion people live on less than US$1/day, about the same number as those lacking access to commercial energy (FAO COFO, 2005). Globally concerns on poverty are glooming in that about 75% of the poor live in rural areas, apparently more in Africa where poverty is predominant (CIFOR, 2005). Africa has the highest percentage of people living on less than a dollar a day (UNDP, 2008). Therefore in order to harness the full potentials of rural areas of Africa and South Asia (next to Africa in terms of poverty) specifically, frameworks and solutions should ensure that future developments options must be geared towards servicing the poor rural resources users. Anderson et al. (2004) maintained that rural natural resource dependant regions should not be treated as mere welfare sinks or ‘problem areas’. In reality they present a repository of hopes and recovery when only their livelihood as producers is secured.Although Nigeria is a wealthy country in terms of human and natural resources, its social and economic development is quite slow. This fact can be illustrated by the country’s high level of poverty, lack of basic social infrastructure and above all, the indisputable high level of corruption (Kar and Freitas, 2012). About 65 percent of the country’s approximate 160 million people are living below the poverty line (live on less than US$1.25 a day) (United Nations Development Programme UNDP, 2009and 2010). The UNDP report further confirmed that the poverty figure in Nigeria (over 90 million people), is higher than the combined population of 10 other West African nations excluding Ghana and Cote D’Ivoire.

Aims to provide incentives to local cottage industries; boost people’s knowledge of vocations through literacy classes, development of assets (**types** Sustainable Livelihood Framework section) and provision of

infrastructures such as markets and roads should be corner stone of economic projects not technically grounded tools that normally dim peoples' interests to modernity. Local household assets such plough and cart traction, farming implements and local level credit facilities can be organised for the people for loanspayable within the limited resources of the community. Typical example is the on-going project in some states of Nigeria through a social development initiative tagged 'Community and Social Development Program (CSDP)' of the Federal Government and Global Environmental Facility (GEF) as well as the IFAD projects in seven north-western States. The projects which have been empowering local technologies to manage the environment is quite a good one in Nigeria.

Conclusion

Natural-resource exploitation is related to crucial sustainability issues. Thus the causes and consequences of unsustainable use of environmental resources cannot be underrated or treated on continental, regional, national even local levels. As collective actions to mitigate environmental degradation are mandatory, every site and case needs its own diagnosis and no isolatedmeasure will suffice unless it is done commensurate to theprior understanding of the phenomena and complete integration of all stake holders.

Significantly, approaches or methods need to be critically selected, taking into account their suitability, applicability and adaptability to local conditions. Fortunately, scientists around the world started long ago to look at the problem of environmental degradation and have developed assessment and monitoring methods. Various assessment methods have been developed at local and scientific scales to determine the status of the land, extent and impact of environmental degradation and to help designing possible conservation activities. It is therefore left to implementers to engage other stakeholder with clear mind and discuss sustainability or otherwise of the approaches and utilise the knowledge for common goal. This has become imperative when we consider Nigeria as the top 4^{th} on list of deforestation countries as reported (FAO, 2010) and other indicators such as soil erosion.

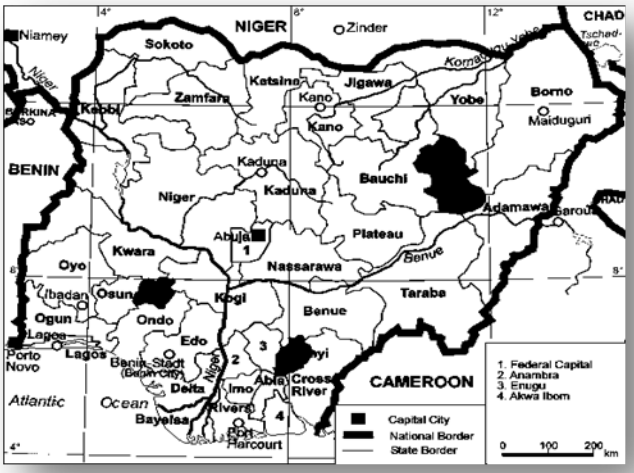

Figure 1: Map of Nigeria

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A SUSTAINABLE ENVIRONMENT FOR THE BASIN OF THE RECONQUISTA RIVER - INCLUDE EDUCATING

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Abstract

Environmental training for citizens of the basin of the Reconquista River. It is necessary to address the issue of caring for the environment with the seriousness required to be able to reverse the habits that caused damage, so far, to our planet. In particular in the basin of the reconquest, considered the second most polluted basin of the Argentina Republic, putting at risk human health and the sustainability of the ecosystem. It is necessary to incorporate the idea that with the passage of time and by keeping harmful behaviours towards the environment we will lose the opportunity to have a better quality of life, we are going to deteriorate our planet and the beings that inhabit it.

Educate about the importance of caring for the environment. To perform this task, it is essential to train the population and teachers so that they have the necessary tools to educate young people about who we are one more element of nature and that we as a society depends on the future of our planet.

Take advantage of these themes, which are contents of school but with a purpose, which is not only the information, but the formation of a conscious citizen involvement in this problem and makes possible then revert the habits that caused damage, so far, to our planet.

So I propose to carry out environmental education workshops citizenship to the inhabitants of the basin of the Reconquista. Teaching and non-teaching. Everyone must participate.

Keywords: Environment, climate change, education, including

Introduction

It is necessary to address the issue of caring for the environment with the seriousness required to be able to reverse the habits that caused damage, so far, to our planet. In particular in the basin of the Reconquista, considered

the second most polluted basin of the República Argentina., putting at risk human health and the sustainability of the ecosystem.

Incorporate the idea that with the passage of time and by keeping harmful behaviours towards the environment we will lose the opportunity to have a better quality of life, we are going to deteriorate our planet and the beings that inhabit it.

Educate about the importance of caring for the environment.

I.

It is essential to train the population and teachers so that they have the necessary tools to educate young people about who we are... one more element of nature, and that we as a society depends on the future of our planet

This work arises from the commitment assumed by the National University of Tres de Febrero with citizens who inhabit the area of the basin of the Reconquista river.

Bring these issues to the community, but with a purpose, which is not only the information, but the formation of a conscious citizen participation to be able to reverse the habits that caused damage to our planet.

The National University of Tres de Febrero is approaching citizenship workshops environmental education to the inhabitants of the Reconquista river basin. Students, teachers and non-teaching. Everyone must participate

The basin of the Reconquista consist of an area of one hundred and sixty seven thousand hectares through eightenn counties of Buenos Aires province.

On the high plain of the basin seventy two thousand hectares are used for agricultural activities. In the medium and low plain ninety five thousand hectares are strongly urbanized.

The Reconquista river basin has much of its territory in the area Metropolitana of Buenos Aires (AMBA) and is consist of eighteen counties.

The population of this area is not homogeneous, on the contrary it present strong discontinuities that can be understood in the light of the relationship established with economic activity prevailing in each sub-area: those areas in which there is strong presence of agricultural activities with very low population densities and more urbanized areas show very high population densities

Most densely populated matches are Tres de Febrero, General San Martín, Vicente López and Hurlingham. It is necessary to emphasize that all of these parties are affected by frequent floods.

The basin has a strong percentage of population in conditions of extreme structural poverty, measured by the indicator of unsatisfied basic needs (NBI)

The poor state of the infrastructure of urban health services, such as the supply of drinking water, collection and treatment of sewage collection and disposal of solid waste, environmental quality strongly affects and is closely linked to the health and well-being of the population.

Historically, the treatment of such waste and fluids was insufficiently covered by the process of provision of health services.

This situation affects the population, deteriorating current resources and the future of young people.

The National University of Tres de Febrero is linked to educational institutions and social organizations establishing records of commitment to improve education.

Generates a network among teachers at all educational levels to improve the learning of students in the engineering sciences that guarantee, starting from basic knowledge, awareness citizen by the care of the environment.

The demographic growth of the basin is related to the rise of subdivisions in the 50's and 60 who were accompanying the process of urban and industrial development. The lack of control and urban planning, gave rise to the lots in areas lacking basic sanitation infrastructure or in areas of low elevation corresponding to the Valley of the river flood, by which these populations were seriously affected by the floods having to suffer in many cases evacuations.

In this area are located three hundred settlements where they live approximately Ninety thousand families in conditions of extreme poverty. Of which 20,000 are located on the banks of the River, being most affected by this problem matches: San Miguel, San Martín, San Fernando, Moreno, 3 in February and San Isidro.

Both industrial activities as residential grew in disorderly way sharing the same spaces

Approximately, there are about Thirteen thousand industrial establishments (of synthetics, ferrous metals, food - preparation and preservation of meat-, slaughterhouses, tanneries, electric storage batteries, rubber, iron and steel, among other items). Of which about three hundred thirty are considered of 3rd category, involving greater environmental risk.

Another problem that generates a strong environmental impact in the basin is the management of municipal solid waste

The problem of waste is not only an environmental issue but also a social problem, around of which excluded poorer of the system develop survival strategies of sectors.

Land affected by sanitary landfills cannot be used for human settlements over a 50 year period, however vast sectors of the population living on garbage and waste. Another problem is lack of collection services in areas where settlements and villages, where trucks can not enter is lie.

Neighbors accumulate garbage, or throw it in ditches, streams or on the same bank of the river.

As a result of the above-mentioned problems prevailing pollution levels are now a serious danger that puts at risk the viability of the ecosystem.

From the entry of the waters of the Brook Moron is produced a significant change in the quality of the water, detected an alarming deterioration. Studies indicate that from this point pollution should be categorized as very high.

Stands a high load of organic matter which responds to household waste, given that according to data from the 2010 census, 52% of the population in the Reconquista area lacks sewer service, in some municipalities as Ituzaingo, José C. Paz, Malvinas, Hurlingham the population without sewer reaches values higher than 95%. 90% Of the sewage are flushed in crude oil, more than 3000 atmospheric trucks daily flow directly into the river. While recently inaugurated in Hurlingham a plant of treatment of the four originally planned, operation provides only a partial response widely surpassed by demand.

The problem of the availability of drinking water is of high gravity as the water supplies are contaminated. The coverage of water in the basin is 60%, however arise strong asymmetries, while Vicente López mains water coverage, is total in Malvinas Argentinas 90% of the population lacks this service.

The problems of the Delta is a special case, given the complex dynamics of the River, aggravated by the construction of the relief channel to prevent flooding.

It is important to highlight the lack of epidemiological studies and the lack of systematic recording of such diseases, which makes difficult the assessment of the damage to the health of the affected people.

Teachers of the basin report the large number of absences for health reasons, mostly respiratory problems caused by high air pollution

It should be noted that efforts to integrate the various problems affecting the basin from a more global approach, were reflected in the report of the Ombudsman of the people of the nation and the papers presented at the seminar "Poverty and environment in the basin of the reconquista". Various governmental actors, national universities, of Civil society organizations and the dioceses of San Isidro and Merlo-Moreno participated in this seminar.

Different works coincided in pointing out the complexity of the problem and the need for further studies on the characteristics of the people seated around the basin and its relations with the environment as a necessary condition to guide the design of policies for tackling the problem. All these agencies agree that are necessary tools to educate the population on the problem of the environment for the inclusion of children, women and teenagers to a society healthier through agreements between universities and civil agencies.

Conclusion

Those who inhabit the basin live with poverty, social inequality and environmental pollution that cause health problems and a great despair.

Since 1970 live in Loma Hermosa, tres de February county , one of the county of the middle basin of the Reconquista. It is my duty to work on their problems and that is what leads me to file this report.

The National University of Tres de Febrero, as institution situated in the area of the basin, is involved with social projects for the inclusion of children and gives me the opportunity to work on this very important issue, not only for the inhabitants of the basin, we are... everyone affected by environmental pollution.

It is said that what is not spoken about, it is not seen, and what is not seen, does not exist.

The basin of the Reconquista affects many people, women, men and children who deserve better and sustainable healthier life to ensure them a harmonious and dignified future.

Our duty is to give them the tool that we have, is to educate children and adults, teachers and non-teachers. Our duty is to include educating everyone

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Cuenca Reconquista
A Sustainable Environment
It is necessary to approach the subject matter of the environment
We must educate the population, women and children,
teachers and students about caring for the environment.
Include Educating