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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

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Table of Contents: Volume 9 Number 1, January 2015

ARTICLES

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Full Length Research Paper

Biomonitoring of heavy metals pollution in Lake Burullus, Northern Delta, Egypt

Elsayed M. Ali. Nafea[1]* and Mohamed A. Zyada[2]

[1]Aquatic Environment Department Faculty of Fish Resources, Suez University, Egypt.
[2]Environmental Sciences Department Faculty of Science Dameitta University, Egypt.

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Aquatic macrophytes and benthos are unchangeable biological filters and they carry out purification of the water bodies by accumulating dissolved metals and toxins in their tissues. In view of their potential to entrap several toxic heavy metals, 3 groups of benthos and 6 macrophytes (submerged species: Potamogeton pectinatus, Ceratophyllum demersum and Najas armata); (floating species: Lemna gibba and Eichhornia crassipes root and shoot) and (emergent species: Phragmites australis shoot) were collected from 15 different locations on Lake Burullus and analyzed for determination of 6 heavy metals (Fe, Zn, Ni, Cu, Pb and Cd) contenets. The study was aimed at understanding the importance of these benthos and macrophytes in accumulation of toxic metals and suggesting preservation and restoration of Lake Burullus ecosystem. The distribution of the investigated metals in water, sediments, benthos and aquatic plants of the lake showed that, the eastern and eastern southern parts of the lake have generally higher concentrations of heavy metals than the western and middle one. Potamogeton pectinatus showed high contents of Pb, Cd and Zn respectively. On the other hands Eichhornia crassipes showed high level of copper while in Ceratophyllum demersum high concentration of Iron was detected. The present study reveals that the aquatic macrophytes and benthos play a very significant role in removing of the different metals from the aquatic environments and they probably reduced the effect of high concentrations of these metals on the lake ecosystem. Bioaccumulation factor values showed that the trend of accumulation of most metals in the benthos was as follows: Mullusca > Arthropoda > Annelida > and in aquatic plants as: Lemna gibba> Potamogeton pectinatus > Ceratophyllum demersum > Eichhornia crassipes Root > Najas armata>phragmites australis shoot> Eichhornia crassipes shoot, which make them suitable candidates to be used in biomonitoring surveys as a good tools for heavy metal pollution markers, in the biological treatment of the polluted water and in sustainable development of Lake Burullus.

Key words: Biofilter, bioaccumulation, sustainable developments, biological treatment, macro benthos, aquatic plants, sustainable management.

INTRODUCTION

The term heavy metal refers to any metallic chemical element that has a relatively high density and is highly toxic or poisonous at low concentrations (Harris and Santos, 2000). Macrophytes are aquatic plants, growing in/or near water that are emergent, submerged or floating. Macrophytes are considered as important component of the aquatic ecosystem not only as food source for aquatic invertebrates, but also act as an efficient accumulator of heavy metals (Devlin, 1967; Chung and Jeng, 1974). They are unchangeable biologi-

cal filters that play an important role in the maintenance of aquatic ecosystem.

Some sources of heavy metals are industry, municipal wastewater, atmospheric pollution, urban runoff, river dumping, and shore erosion. High levels of Cd, Cu, Pb, and Fe can act as ecological toxins in aquatic and terrestrial ecosystems. Some of these metals (Cu, Ni, Cr and Zn) are essential trace metals to living organisms, but become toxic at higher concentrations. Others, such as Pb and Cd have no known biological function but are toxic elements (Guilizzoni, 1991; Balsberg-Påhlsson, 1989). Many of the aquatic macrophytes and benthos are found to be the potential scavengers of heavy metals from water and wetlands sediments (Gulati et al., 1979). The present investigation was planned and executed considering the potentials of benthos and macrophytes as biological filters for metals that become bound to living materials.

Biomonitoring of pollutants using accumulator species is based on the capacity which has some plants and animal taxa have to accumulate relatively large amounts of certain pollutants by concentration many times higher than those of the surrounding waters, (Nafea, 2005). In addition, the pollutants concentration in sediments and the organisms are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutant concentrations in the water only indicate the situation at the time or seasons of sampling (Ravera et al., 2003).

Although, Lake Burullus attracts attention of many authors because of its economic and scientifically importance to study its unique ecosystem but, the studies dealing with the accumulation of heavy metals in different ecosystem components are still scarce except few studies (Elsaraf, 1995a; Radwan and Lotfy, 2002; Nafea, 2005). The present study deals with the aquatic plants and macro benthos as biomarkers and bio accumulators for heavy metals, in order to use these aquatic plants and benthos in sustainable development and management of Lake Burullus.

MATERIALS AND METHODS

The study area

Al Burullus Lake is situated along the Mediterranean coast. It occupies more or less, a central position between the two branches of the Nile and extends between 31° 22' - 31° 26' N and 30° 33' - 31° 07' E. It's a shallow brackish lake connected with the sea by a small outlet (Boughaz), about 44 m width and 150 m length. The length of the lake was about 65 km, and its width varies between 6 and 16 km, with an average of about 11 km. The depth of the lake anges between 0.42 and 2.07 m. The eastern sector of the lake is the shallowest, showing an average depth of 0.8 m. The present area of the lake is about 410 km^2 (100,000 Feddan), of which 370 km^2 is open water. The capacity of the lake is about 330 million cubic meters. The eastern and southern parts of the lake receives agricultural sewage drainage water through 8 drains and one brackish water canal, while saline water enters the lake from the sea through El-Boughaz (Figure 1).

Methods

The study focused primarily on metal investigation in water, sediments, benthos and aquatic plants. The sampling program was carried out in the summer and winter of 2013. Aquatic plants and benthos were collected from the 15 sites and five samples were prepared for each species at every sampling site. At the same time water and sediment samples were collected at the corresponding sampling locations. The collected water was filtered through a Whatman glass-fiber filter (0.45 µm). The filtered water was stored in a 0.5-L polypropylene bottle to avoid any adsorption of metals on the wall of the sample bottles; the filtered water was preserved by acidification with 1.0 ml concentrated nitric acid. Water analysis for heavy metals was according to Solvent extraction method (APHA, 1992). The sediment samples were air dried at room temperature (25°C) for 10-15 days, then ground in a mortar and sieved in 0.5 nm sieve, the samples were then finally stored for analysis according to Moore and Chapman (1986).

Five plant samples were mixed with each other's and analyzed for heavy metals where the dry samples of Macrophytes were wet-digested in a mixture of concentrated nitric acid and perchloric acid (4:1 v/v) (Sawicka-Kapusta, 1978). Samples were analyzed with a Perkin Elmer model 2380 atomic adsorption spectrophotometer (A.A.S.). Bottom fauna were classified to three main groups (Mullusca, arthropoda and Annelida), and digested after drying according to Metcalfe-Smith (1994). Method metals concentrations were determined using atomic absorption (Perkin Elemer Model 3700) with flameless graphite furnace (GA-2). The bioaccumulation factor was calculated according to Klavinš et al. (1998) as follow: BAF = M_tissue / M_water or sediments where M_tissue is metal concentration in plant tissue and M_water is the metal concentration in water or sediments.

RESULTS

Water and sediments

Copper content in water of Lake Burullus ranged between19.7 µg/l in the western parts and 35.8 µg/l in the eastern part. Its values in sediment ranged from 19.4 (µg/g) dry wt and 47.9 µg/g dry wt. in the western and eastern sites, respectively. Iron content in water ranged between 25.3 µg/l in station 8 and 60.4 µg/l in station 4. Its Iron values in sediments ranged between 42.4 µg/g dry wt.in site 15 and 97.5 µg/g dry wt in site 4. Cadmium contents ranged between 2.9 µg/l in station10 and 8.5 µg/l in station 4 while in sediments ranged between 3.2 µg/g in station 10 and 8.5 µg/g in station 6. Zinc contents in water ranged between 20.6 µg/l in station15 and 55.3

*Corresponding author. E-mail: drsayednafea2005@yahoo.com.

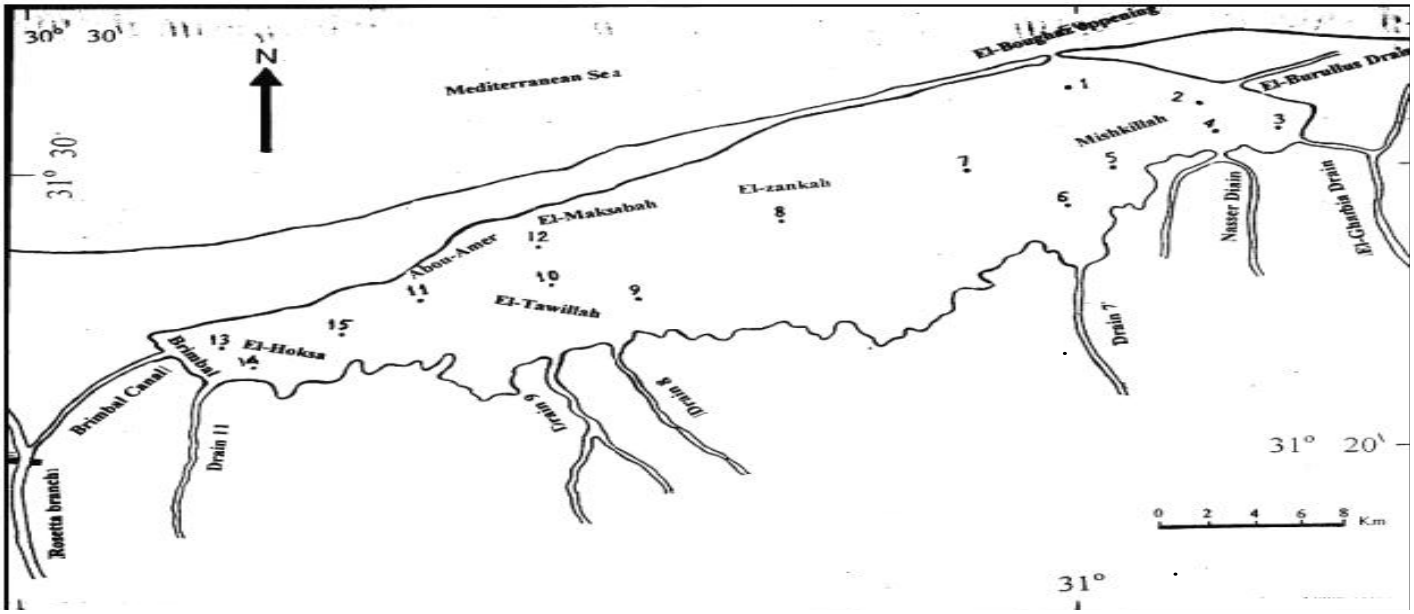

Figure 1. Location map for the study area.

Table 1. The concentration of heavy metals in water (µg/l) at 15 stations at Lake Burullus.

Stations	Metal concentration					
	Cu (µg/l)	Fe (µg/l)	Cd (µg/l)	Zn (µg/l)	Pb (µg/l)	Ni (µg/l)
1	24.5	32.3	4.1	28.2	7.4	6.2
2	33.6	45.2	5.2	35.7	7.2	10.3
3	18.2	52.3	6.1	33.1	8.5	5.3
4	30.1	60.1	8.5	55.3	10.1	5.4
5	20.2	33.2	6.1	50.6	7.1	5.2
Mean eastern	25.32	44.6	6.0	40.58	8.06	5.64
6	22.3	30.2	7.3	42.3	8.6	5.2
7	23.5	34.5	6.5	36.2	4.3	6.5
8	24.6	25.3	5.3	42.3	8.5	4.3
9	18.6	35.2	4.2	26.4	5.1	5.3
10	11.3	55.3	2.9	25.3	6.6	5.9
Mean middle	20.6	44.45	5.24	18.8	6.62	5.38
11	21.6	40.2	5.5	23.5	6.9	5.2
12	26.4	42.3	4.6	22.6	4.5	4.6
13	18.3	59.2	5.1	27.5	5.3	5.3
14	12.9	41.3	4.2	25.7	7.2	6.1
15	16.2	39.2	4.0	20.6	6.3	4.9
Mean western	19.1	44.4	4.6	24	6.1	5.22

µg/l in station 4 while in sediments it ranged between 24.2 µg/g in station15 and 97.2 µg/g in station 4.

Lead content showed its high values in water at site 4 (10.1 µg/l) and low value (4.5 µg/l) in station 15 while in sediments high value was 27.5 µg/g in station 1 and 6.5 µg/g in station15. Nickel showed its high value in water (10.3 µg/l) in station 2 and the low one (4.3 µg/l) in station 6 while in sediments high value recorded 19.7 µg/g in station 2 and 7.1 µg/g in station 15. The metals concentrations are given as shown in Tables 1 and 2.

Table 2. The concentration of heavy metals in sediment (µg/g) dry weight at 15 stations at Lake Burullus.

Stations	Metal concentration					
	Cu (µg/l)	Fe (µg/l)	Cd (µg/l)	Zn (µg/l)	Pb (µg/l)	Ni (µg/l)
1	29.5	71.3	5.2	58.6	27.5	18.4
2	47.6	92.4	6.1	72.4	18.2	19.7
3	29.6	94.5	5.9	65.3	27.1	10.2
4	39.5	97.5	7.8	97.2	19.7	14.2
5	32.2	58.9	7.2	94.7	20.4	11.6
Mean eastern	35.7	83	6.5	77.64	22	15
6	39.1	81.1	8.2	81.2	17.4	12.9
7	35.4	44.2	5.9	57.9	11.4	10.2
8	29.5	61.3	6.1	64.3	18.6	8.7
9	22.7	57.5	5.2	36.1	15.7	9.7
10	20.8	75.7	3.1	25.3	17.4	12.8
Mean middle	29.5	64	5.7	53	16.1	11
11	31.2	52.1	5.3	37.2	12.3	9.2
12	34.1	51.3	5.2	34.4	9.7	8.7
13	27.3	60.2	5.4	31.2	11.2	9.1
14	19.7	52.3	4.1	27.1	10.9	8.2
15	19.4	42.1	5.0	24.1	9.6	7.1
Mean western	26.4	51.6	5	30.1	10.8	8.5

Aquatic plants

Copper contents in the aquatic plants showed high range of variation which ranged between 13.9 µg/g in *Eichhornia* root in eastern site and 5.1 µg/g in *Ceratophyllum* in western site. Iron contents in aquatic plants ranged between 107 µg/g in potamogeton and 50 µg/g in *Najas*, while cadmium content ranged between 1.0 µg/g in Ceratophyllum and 4.7 µg/g in potamogeton. On the other hand nickel ranged between 15.3 µg/g in Lemna and 5.8 µg/g in Najas. High value of Lead observed at *potamogeton* 15.4 µg/g and low value 5.5 µg/g at *Eichhornia* shoot. Zinc contents ranged between 98 µg/g in Lemna and 43 µg/g in *Eichhornia* shoot as shown in Table 3.

Benthos mullusca

Benthos mullusca showed high ranges of metal content in their bodies and tissues more than Arthropoda and Annelida as shown in Table 4.

Bioaccumulation factor

The bioaccumulation values of heavy metal by aquatic plants in relation to water ranged between (260-548, 1256-5370, 200-913,1111-2392,1171-2722 and 850-2220 for Cu, Fe, Cd, Zn, Pb and Ni, respectively (Table 3), while in benthos in relation to sediments ranged between 0.59-0.69, 0.96-1.3, 0.32-0.62, 1.1-1.44, 0.63-0.75 and 0.93-1.2 for Cu, Fe, Cd, Zn, Pb and Ni respectively (Table 4).

DISCUSSION

Generally the high concentrations of heavy metals were measured in the sediments, benthos and macrophytes in the eastern sites of the lake, while the low concentrations were detected in the middle and western sites of the lake. The concentration of lead varied from site to site where the high concentrations were detected in water, sediments, Mullusca and *Potamogeton pectinatus* in the eastern site (8.06 µg/l, 15, 15 and 13 µg/g dry wt) respectively while the low concentrations were measured in the western parts of the lake (6.1 µg/l, 8.5,10 and 5.5 µg/g dry wt) respectively (Tables 1, 2, 3 and 4). The variation of lead content in benthos sediments and macrophytes depends on the inflow of many sources of pollution from sewage, agricultural and industrial wastes into the lake. El-Sarraf (1995a) mentioned that in Lake Manzala *P. pectinatus* had high lead concentration (26 .6 µg/g dry wt) and thus it is a good lead contamination indicator. This agrees with the conclusion of Abo-Rady (1977) that *P. pectinatus* may be considered as an indicator for lead in Lake Manzala. Our results in burullus confirm this conclusion (Radwan and shokier, 2005).

High levels of cadmium contents were found in *L. gibba*

Table 3. The mean concentrations of heavy metals (µg/g) dry weight and the bioaccumulation factor values for the aquatic plants in the (east, middle and west) of Lake Burullus.

Plants	Metal concentration (µ g/g)					
	Cu	Fe	Cd	Ni	Zn	Pb
Ceratophyllum demerssum E	6.6	94	1.2	10.5	98	8.5
M	5.4	84	1.1	9.5	92	7.8
W	5.1	81	1.0	8.2	84	6.4
Bioaccumulation factor	263	3268	368	1853	2234	1102
Potamogeton pectinatus E	10.2	107	4.7	13.4	64	15.4
M	9.1	78	2.7	12.5	61	11.4
W	8.3	83	2.3	10.2	52	9.7
Bioaccumulation factor	426	3469	679	2116	1459	1780
Lemna gibba E	11.8	104	4.2	14.2	92	14.2
M	10.4	101	3.6	15.3	98	14.7
W	9.2	87	4.2	11	87	14.2
Bioaccumulation factor	484	3852	766	1822	2247	1807
Phragmites aus. Shoot E	9.1	72	2.0	8.5	75	10.2
M	8.2	71	1.7	5.8	71	10.1
W	7.2	66	2.0	8.5	64	8.9
Bioaccumulation factor	392	2323	401	1418	1698	1480
Eichhornia crass. Shoot E	8.6	62	1.5	7.6	53	7.5
M	7.3	63	1.6	6.4	52	6.9
W	6.5	54	1.5	7.6	43	5.5
Bioaccumulation factor	436	2879	300	1344	1223	1266
Eichhornia crass. Root E	13.9	95	3.5	8.7	86	9.1
M	8.3	91	2.7	7.4	75	9.3
W	8.7	82	3.5	8.7	56	5.1
Bioaccumulation factor	417	3081	575	1558	1724	980
Najas armata E	11.5	51	1.4	6.2	76	11.6
M	9.5	46	1.5	5.8	78	10.2
W	9.3	50	1.4	6.2	66	10.0
Bioaccumulation factor	469	2371	274	1132	1868	1615

E, M, W means east, middle and west, respectively.

Table 4. The mean concentrations and bioaccumulation of heavy metal in the benthos (µg/g) dry weight in the (east, middle and west) of lake burullus in relation to sediment concentration.

Benthos	Metal concentration					
	Cu (µg/g)	Fe (µg/g)	Cd (µg/g)	Zn (µg/g)	Pb (µg/g)	Ni (µg/g)
Mullusca : east	27	72	4.5	83	13	15
Middle	22	69	3.2	76	12	13.5
West	13	63	2.9	73	11.6	12.7
Bioaccumulation	0.69	1.03	0.62	1.44	0.75	1.2
Arthropoda: east	23	72	2.3	75	11	12
Middle	19	65	1.4	69	10.5	11.7
west	11	57	1.9	71	10.1	11.3
Bioaccumulation	0.59	0.98	0.32	1.34	0.65	1.02
Annelida :east	21	68	3.2	67	11	11
Middle	19	62	1.2	58	10	10.9
west	17	60	1.1	49	9.7	10
bioaccumulation	0.63	0.96	0.32	1.1	0.63	0.93

and Eichhornia root, Mullusca and sediments of the eastern parts (4.5, 6.5 and 4.2 µg/g dry wt.) while the lowest concentrations of cadmium were observed in *C. demersum* (1 µg/g dry wt). El-Sarraf (1995b) mentioned that there was high significant correlation between lead and cadmium concentration in aquatic plants which is probably attributed to their association in the same phase during assimilation (Tables 2, 3 and 4).

The macrophytes and benthos have different levels of zinc concentrations in their organs where the high levels were recorded in *L. gibba*, *P. pectinatus* and Mullusca (83, 77.6, 107 and 104 µg/g dry wt.) respectively, Alloway and Davis, (1971); while the low concentrations were found in *N. armata*, *E. crassipes* shoot and Annelida (50, 46 and 49 µ g/g dry wt.) respectively. Heydt (1977) found that *P. pectinatus* has high zinc content which ranged between 16.5 and 517µ g/g dry. For weight in Elsenz River, Bauda et al. (1981) recorded that in Lake Manzala the mean concentration of Zinc level in the same species is 168 µg/g dry wt. El-Sarraf (1995a) found that the concentration of Zinc in *P. pectinatus* was 117 µg/g dry weights whereas Abo-Rady (1977) found that the zinc content of *P. pectinatus* ranged between 137 and 213 µg/g dry weight in Leine River.

The copper concentrations fluctuated between 5.4 and 35 µg/g dry wt. in plants, benthos and sediments. The copper content in Lake Manzala varied from 5.0 to 37.6 µg/g wt. in potamogeton *pectinatus* (Boudo et al. 1988). On the other hand El-Sarraf (1995a) found that copper content showed a small range of fluctuation with irregular concentration in aquatic plants. In *Ceratophyllum demersum* the highest level was 18.5 µg/g dry wt. The positive correlation between Cu and Zn was attributed to the same biological behaviors during the assimilation in macrophytes (Alloway and Davis, 1971; El-Sarraf, 1995b).

The concentrations of trace metals (Cu, Zn, Pb, Fe, Ni and Cd) in the aquatic macrophytes, benthos and sediments varied according to their locations at the different parts of the lake; this depends on the source of pollution invading the lake from several directions. Seidal (1996) and Ozimek (1978) recorded high contents of trace metals in the macrophytes growing in habitats affected by industrials effluents and effect of sewage and industrial wastes on the chemical composition of aquatic macrophytes is very obvious. The magnitude of aquatic plants and benthos to assimilate heavy metals would be largely dependent upon the levels of these metals in the water and sediment. The removal of certain mineral from water reservoirs by submerged macrophytes and benthos is observed as practical methods for water purification (Hillman and Cully, 1978). The high variations found in the element content of the aquatic macrophytes both between species and within species were related to different location. Crowder and Painter (1991) inferred that the variation of metals content in macrophytes is not necessarily bioaccumulations or biomagnified these metals from the sediment and it may be attributed to site-specific and species specific differences in metals uptake. From this hypothesis it is important to mention that the non-essential trace metals such as lead and cadmium were highly concentrated in Lake Burullus eastern side (Nafea, 2005) and the industrial wastes may also be responsible for the elevation of the Pb and Cd in Lake Burullus. The order of abundance of the trace metals in the macrophytes and benthos of Lake Burullus were:

(1) Lead: *Lemna > Potamogeton > Eichh. Root > Ceratophyllum > phragmites sh. >Najas > Eichh. Sh., Mullusca>Arthropoda> Annelida.*
(2) Cadmium: *Lemna > potamogeton > Najas>phragmites > Eichhornia Root > Eichh. Shoot > Ceratophyllum.*
And in benthos: Mullusca>arthropoda> Annelida
(3) Zinc: *Lemna > Ceratophyllum > Potamogeton > Eichh. Root >phragmites shoot > Eichh. Shoot > Najas*
And in benthos: Mullusca>arthropoda> Annelida
(4) Copper: *Lemna > Eichh. Root > Najas >phrag. shoot >Eichh.Shoot >Ceratophyllum.> Potamogeton*
And in benthos: Mullusca > Annelida> arthropoda.
(5)Nickel: *Lemna > Potamogeton > Ceratophyllum > Eichh. Root > Najas > phrag. Shoot > Eichh. Shoot and in benthos: Mullusca > arthropoda > Annelida.*
(6)Iron: *Lemna > Ceratophyllum >Eichh. Root > Najas > phrag.shoot> Potamogeton > Eichh. Shoot and in benthos: Mullusca>arthropoda> Annelida*.

Lemna gibba, *potamogeton pectinatus* and Mullusca showed the higher capacity of heavy metal accumulation than the other aquatic plants and benthos groups. Aquatic macrophytes and benthos can be used as bio-indicator and biomarkers for water and sediment pollution as they can trap micro- and macro-elements (inorganic pollutions) as investigated by Fayed and Abdel-Shafy (1985). El-Khatib and Sawaf (1998) reported that the concentrations of heavy metals in macrophytes were positively related to the concentration in the environment and the macrophytes have high potential power for pollution monitoring (Yamanowska et al., 1999).

Depending on the heavy metals concentration in the aquatic macrophytes and benthos it can be concluded that the aquatic macrophytes and benthos can accumulate heavy metals and have a restricted role in the treatment and control of pollution of the aquatic ecosystems. Accordingly, the macrophytes and benthos can be considerable as reliable way for Biomonitoring the heavy metals contamination in Lake Burullus. Trace metals concentration in macrophytes and benthos species widely differ. This can confirmed if a species is used for heavy metals monitoring within one or different areas. Ghobrial (2000b) reported that *Ceratophyllum demersum* can accumulate zinc more than Cu, Pb and Cd and acts as a potential biological filter for trace metals removal from domestic effluents and has a capacity to

retain heavy metals in its tissues.

High range of the heavy metals concentration in the studied aquatic plants and benthos indicates different extent of pollution; this high variability is associated with the different absorption rate for the heavy metals by the aquatic plants and benthos (Pajević et al., 2003; Klink, 2004; Maria et al., 2006).

Recently, there has been growing interest in the use of metal-accumulating plants or benthos for the removal of heavy metals from contaminated aqueous streams, in the biological purification of waste water and in Biomonitoring of heavy metals pollution in the Egyptian lakes (Nafea, 2005).

We conclude that there is a uniform pattern of heavy metal variation in the macrophytes, sediments and benthos of Lake Burullus. In general, values of some metals like iron, zinc and copper are higher in almost all the specimens. This shows the universal importance of these macrophytes, sediments and benthos in cleaning up of the aquatic environment. The results presented here could be very useful for environmental monitoring and checking the health of the water body. The aquatic macrophytes and benthos were found to be the potential source for accumulation of heavy metals from water and sediments and act as biofilters for metals. Accordingly they could be used in sustainable development, management and pollution assessment program in the northern deltaic lakes of Egypt especially lake burullus.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Full Length Research Paper

Effects of NPK fertilizer on the shoot growth of *Vitellaria paradoxa* C.F. Gaertn.

Yakubu F. B.*, Asinwa I. O., Shodeke D. K. A., Williams, O. A. and Obekpa N. B.

Forestry Research Institute of Nigeria, P.M.B. 5054, Jericho Hill, Ibadan, Oyo State, Nigeria.

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This study examined the effects of different levels of NPK fertilizer on the growth of *Vitellaria paradoxa* . Shoot height, collar diameter and leaf productions were assessed fortnightly up to the sixteenth week after transplanting. The results showed that there were no significant differences (P < 0.05) among the treatments in shoot height, collar diameter and leaf production. It was observed that shoot height of *Vitellaria paradoxa* exhibited close values ranging from 8.49 to 10.64 cm. The leaf production ranged from 6 to 10 at the end of sixteenth week of study. Different levels of NPK fertilizer applied did not have effect on collar diameter of seedlings of *V. paradoxa* during the period of study. The study has shown that application of NPK fertilizer did not have significant effects on the growth of seedlings of *V. paradoxa.* In conclusion, more effort should be employed in determining optimum quantity of mineral fertilizers required to promote the growth of *V. paradoxa* seedlings in the nurseries.

Key words: *Vitellaria paradoxa,* NPK fertilizer, growth, seedlings.

INTRODUCTION

Vitellaria paradoxa is an indigenous fruit tree of Sudano-Sahelian Africa, it is called shea butter tree. There are two subspecies of *V. paradoxa*, one of which (*V. paradoxa*) extends from Senegal eastwards to the Central African Republic whilst the other (*V. nilotica*) occurs in southern Sudan and Ethiopia, Uganda and northeast Zaire (Boffa, 1999). In natural range, shea butter trees are both economically and ecologically important, they are often the main component of the tree stratum in traditional parkland systems, which are farmlands with scattered trees forming an open permanent over-storey of associated annual crops (Bonkoungou, 1992). As a perennial woody species, that shed its leaves annually, it plays a major role in nutrients recycling (De Bie et al., 1998; Bayala et al., 2006). The litter of shea butter tree was shown to have lower nutrient content when compared with *Parkia biglobosa* (another common parkland non N_2-fixing leguminous tree), and it was found to decompose at a low rate with time (Bayala et al., 2005), suggesting a more sustainable impact on soil fertility (Bayala et al., 2006).

Furthermore, *V. paradoxa* is highly valued by farmers, mostly because of its fat containing kernels which are sold both in local and international markets, thereby considerably contributing to wealth creation. The vegetable fat of shea nut is second in importance only to palm oil in Africa (Hall, 1996). The commercialization of shea products represents an important source of income at different parts of the community chain, from community levels, with rural children and women who gather and process nuts, to town dwellers as well as entire countries (Bonkoungou, 1992; Boffa et al., 1996). For instance,

*Corresponding author. E-mail: fredyakubu@yahoo.com.

Table 1. Analysis of variance for shoot height growth of *V. Paradoxa*.

Source of variation	df	Sum of square	Mean of square	F-cal
Treatment	4	393.71	98.43	1.77ns
Error	43	2386.49	55.50	
Total	47	2780.20		

ns = Not significant at 5% probability.

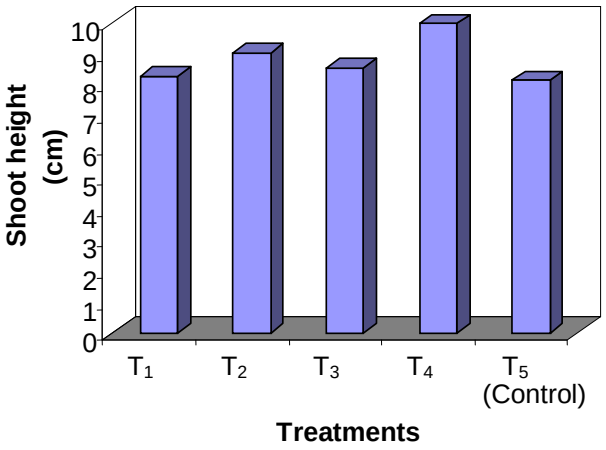

Figure 1. Graph showing variation in shoot height growth in relation to treatments

shea nut was the third export product of Burkina Faso in the 1980's (World Bank, 1989). Shea butter tree also provides fruits, medicine, construction materials, fuel wood and carving wood (Hall, 1996). Despite its great contributions to both local and national economies, *V. paradoxa* remains undomesticated. Shea butter trees parklands result from naturally occurring individual trees that are protected by farmers when clearing their fields, thus creating parkland systems (Boffa et al., 1996). These parklands have been reported to be degrading steadily resulting in decreasing tree density and vegetation cover as well as reduced soil fertility (Gijsbers et al., 1994; De Bie et al., 1998; Ouédraogo, 2006). This trend suggests the need to use artificial regeneration to promote this species in farmer's fields. Thus, very few studies can be found that have varied nutrients availability to assess their full potential in tree management (Sanginga et al., 1990; Karanja et al., 1999). Consequently, basic information on nutrient requirements of important indigenous tree species is not readily available, leading to lack of practical fertilizer prescription especially at the nursery stage. The practice of using NPK fertilizers separately is seen as one factor contributing to low fertilization efficiency because it always overlook the advantageous interaction that often occurs among the elements when fertilizers are incurporated in association into the soil (Teng and Timmer, 1996). Therefore, from a domestication perspective, the evaluation of NPK fertilizer appears to be important as a prerequisite for determining how the fertilizer can be managed to promote rapid growth and development in slow growing tree species.

MATERIALS AND METHODS

Fertilizer trials were conducted to examine the effects of NPK fertilizer on the growth performance of *V. paradoxa* seedlings at the nursery stage. This study was carried out in the green house of Forestry Research Institute of Nigeria (FRIN), Ibadan. The fruits used in this study were freshly procured from Igbeti in Olorunsogo Local Government Area of Oyo State in June, 2008. They were then depulped, washed in tap water and sown in different germination trays containing different sowing medium of river sand, saw dust and topsoil each. The experimental top soil consisted of sand 88.46%, clay 7.6% and silt 3.94%. It had the following characteristics: pH 5.6, organic carbon 1.232%, total Kjeldahl nitrogen 0.106% and organic carbon matter of 2.12%. The soil was sieved with 2 mm mesh and filled into polythene pots sized 30 cm by 27 cm and weighed 6.5 kg.

Uniform seedlings of *V. paradoxa* were then transplanted into polythene pots after eight weeks of germination. The study consisted of four different levels of NPK fertilizer: 100, 200, 300, 400 mg and control. Each level representing a treatment was replicated ten times making total number of fifty seedlings. These were laid out in a completely randomized design (CRD). Watering was done once daily and weeding carried out daily. The following parameters were assessed within 16 weeks of study: shoot height, collar diameter and leaf numbers. Collected data were analysed by means of Analysis of Variance (ANOVA) while the means were separated with least significant difference (LSD).

RESULTS

There is no significant difference in shoot height growth of *V. paradoxa* at 5% level of probability during the period of study (Table 1). This conforms to the findings of Muhammad et al. (2009) that there were no significant differences among the growth parameters of *V. paradoxa* assessed within the period of study. This is evident in Figure 1 with shoot height readings close to each others, ranging from 8.49to 10.64 cm.

Table 2 shows that the difference in leaf production among the treatments and control samples of *V. paradoxa* were not significantly different at 5% level of probability during the period of study (Table 2). Treatment 4 had the highest number of leaves of 10 followed by treatment 1 with 9, control with 8, T_2, 7 and the lowest value of 6 for T_4 (Figure 2). This does not agree with findings of Anokwu (1997) that NPK had significant effect on the leaf production of *Gmelina arborea* seedlings.

The analysis of variance (ANOVA) shows that there is no significant difference in collar diameter of *V. paradoxa* at 5% level of probability during the period of study (Table

Table 2. Analysis of variance for leaf production of *V. Paradoxa*.

Source of variation	df	Sum of square	Mean of square	F-cal
Treatment	4	32.32	8.08	1.20ns
Error	43	288.98	6.72	
Total	47	321.31		

ns = Not significant at 5% probability.

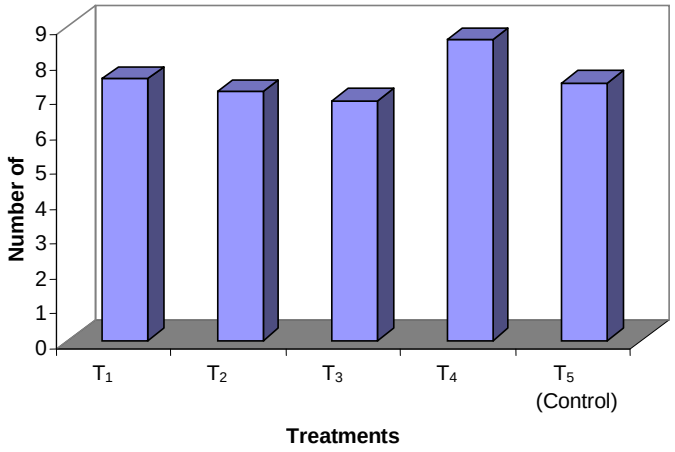

Figure 2. Graph showing variation in leaf production of *V. paradoxa* in relation to treatments.

Table 3. Analysis of variance for collar diameter of *V. Paradoxa*.

Source of variation	df	Sum of square	Mean of square	F-cal
Treatment	4	11.22	2.81	1.66ns
Error	43	72.89	1.70	
Total	47	84.12		

ns = not significant at 5% probability.

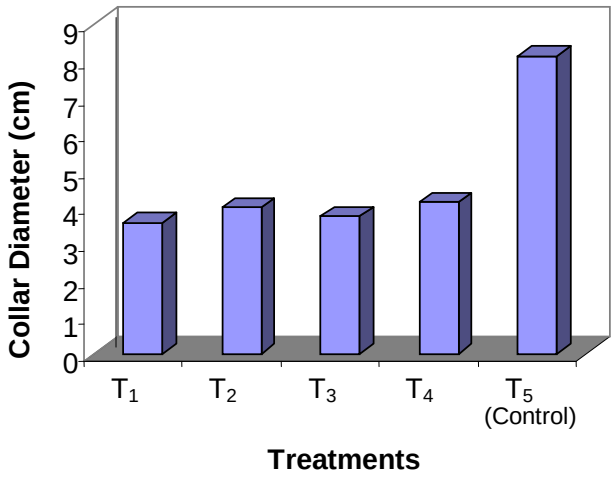

Figure 3. Graph showing variation in collar diameter of *V. paradoxa* in relation to treatments.

3). Figure 3 shows that different levels of NPK fertilizer applied did not have effect on the seedlings of *V. paradoxa* during the period of study as the control (T_0) had the highest mean collar diameter of 9.63 cm followed by T_4 with 4.86 cm, T_2 with 4.65 cm, and T_1 with 4.41 cm and T_3 with 4.34 cm. This disagrees with findings of Abdul-Raheem (2000) that NPK fertilizer vigorously enhances growth performance and development of plants.

DISCUSSION

The results of the study showed that growth of *V. paradoxa* was not responsive to NPK fertilizer irrespective of the levels at the seedlings stage. This is shown from the data collected on shoot height growth, leaf production and collar diameter relative to non-fertilized seedlings (control). The importance of this result is that although shea butter tree is widely recognized as a

slow growing species, its inherent poor growth may be partly due to unfavourable soil nutrient status and that a higher quantity/level and other inorganic nutrients may be combined to improve the growth of *V. paradoxa*. The application of NPK fertilizers also declined collar diameter development, suggesting that NPK fertilizers had inhibiting effects that limit seedling growth at this stage. Although soil NPK were simultaneously increased by fertilizers application, but they have negative effects on the growth of species. This is in line with findings of Elliot (1994) that addition of NPK fertilizer had no effect on growth of temperate red pine at nursery stage.

Similar results have been found in other studies (Elliott and White, 1994; Davidson, 2004). Tree growth in the Amazonian forests was found to be not responsive to NPK fertilization. Baker et al. (2003) also reported the limitation in growth of *Celtis mildbraedii* due to the relative availability of nitrogen, phosphorous and potassium in valley soils in semi-deciduous tropical forest of Ghana. In our study, application of different levels of NPK fertilizer had no significant difference when compared with control treatments possibly because of sufficient soil supplies of these elements.

Conclusion

The results of the investigation showed that application of NPK fertilizer did not have significant effects on the growth of seedlings of *V. paradoxa.* There is no evidence however that NPK had any beneficial effects on this species at seedling stage, probably because of low quantity of NPK fertilizer applied. Thus, further studies are needed to address the required quantity of NPK fertilizer for effective growth of *V. paradoxa* seedlings. The results also showed that application of the fertilizer posed to be limiting factor inhibiting the seedling's collar diameter. Therefore, from the study reported here and the very limited literature on *V. paradoxa*, it can be concluded that more effort should be employed by research scientist in determining optimum quantity of mineral fertilizers required to the promote growth of *V. paradoxa* seedlings in nurseries.

Conflict of Interests

The author(s) have not declared any conflict of interests

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Full Length Research Paper

Correlation and path coefficient analysis of yield characters of bambara (*Vigna subterranea L.Verdc*.)

S. M. Maunde[1]*, B. Tanimu[2] and M. Mahmud[2]

[1]Adamawa State College of Agriculture, Ganye, Nigeria.
[2]Department of Agronomy Ahmadu Bello University, Zaria, Nigeria.

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The study was conducted to determine the inter-relationship between grain yield of Bambara groundnut and its various yield characters at Samaru (11°11'N, 07°38'E, 686 m above sea level) in the Northern Guinea Savanna of Nigeria, using simple correlation and path coefficient analyses. The result reveals strong positive correlation between number of pods/plants (r = 0.74), 100-grain weight (r= 0.35**) and harvest index (r = 0.83**) with seed yield. Harvest index made the highest direct percent contribution to seed yield (39.872%) followed by number of pods/plant which contributed 12.809%. The largest combined percent contribution to seed yield were obtained through number of pods/plant and harvest index (13.677%). Although 100-grain weight had significant positive correlation with grain yield (r = 0.35**), its direct independent contribution to grain yield was found to be very low (0.778%) due to high component compensation and unfavourable weather conditions while the correlation and direct contributions of number of seeds and shelling percentage to grain yield were weak and small, respectively. Therefore, the most important yield determinants of bambara groundnut which should be exploited through a breeding programme for improving its yield potentials, were number of pods/plant, and harvest index.**

Key words: Correlation, path coefficient, yield characters and percent contributions.

INTRODUCTION

Yield characters of crops such as number of flowers per plant, number of seeds/pod, seed size, spikelet number/spike,100-seed weight, fruit weight/plant among others have been found to be associated with the final yield of crops. These relationships tend to give an insight into the importance and possibility of exploiting these characters to improve the yield potentials of crops through the use of certain agronomic practices and breeding programmes. In this regards, several researchers have, therefore identified important yield characters which influence the final yields of many crops. For instance, in legumes, such as green gram, John (1982), reported that number of pods/plant, number of pods/peduncle, and 1000-seed weight significantly influenced yield. In soybean, the main contributing components to yield were number of pods/plant and 100-seed weight (James et al., 1999; Amodu, 2004). In Irish potato, tuber yield/hill, tuber fresh weight and number of tubers/plant influenced the final yield of the crop (Babaji, 2004).

In bambara groundnut, the relationship between characters has not been extensively studied. However Tanimu (1996), reported significant and positive correlation

*Corresponding author. E-mail: sanimaunde@yahoo.com.

Table 1. Correlation coefficients between yield characters and grain yield in bambara groundnut.

Parameter	Grain yield	Number of pods/plant	100-grain weight	Shelling %	Number of seeds/pod	harvest index
Grain yield	-					
No. of pods/plant	0.74**	-				
100-grain weight	0.35**	0.21	-			
Shelling %	0.09	0.02	0.05	-		
No. of seeds/pod	-0.12	-0.08	0.02	0.10	-	
Harvest index	0.83**	0.55**	0.28*.	-0.05	0.11	-

Data is average of two years.* and ** Significant and highly significant, respectively.

of shelling percentage and 100-seed weight with grain yield of the crop. Similarly, a study by Oyiga and Uguru (2011) revealed a strong positive correlation and contributions of number of pods and number of flowers to seed weight per plant of early and late planted bambara groundnut. Misangu et al. (2007), and Itai et al. (2009) have also reported significant positive correlation and large contributions of number of pods/plant to seed yield of bambara groundnut. Although correlation between 100-grain weight and seed yield was not significant, it had large direct contribution to seed yield (Misangu et al., 2007). As a result, information on the relationships between the various yield characters as well as their percentage contribution to grain yield are still needed to determine the extent of contribution of each yield component to the yield. The present study is, therefore, aimed at determining the inter-relationships between grain yield of Bambara groundnut and some of its yield characters in the Northern Guinea savanna of Nigeria using simple correlation and path coefficient analysis.

MATERIALS AND METHODS

Field experiments were conducted during the 2007 and 2008 wet seasons at the Experimental Farm of the Institute for Agricultural Research, Samaru (11011'N; 70 38'E, 686 m above sea level) in the Northern Guinea savanna zone of Nigeria to determine the inter-relationships and contributions of various yield characters to Bambara groundnut seed yield. The experiment was laid out in a randomized complete block design with three replications. The cultivar used for the study was 'Mubi white; a cream white seeded cultivar, bunched, early maturing, high yielding, with medium sized pods and seeds grown widely in Northern Nigeria.

To ensure optimum crop performance, weeds were controlled by pre-emergence application of Galex (metabromuron + metalochlor) at rate of 4.5 L/ha. Sherpa plus (Cypermethrin + Dimethoate) at the rate of 1 L/ha was applied fortnightly along with Benlate (Benomyl) to control insect pests and fungal diseases, respectively. At physiological maturity, the net plot ($9m^2$) of each plot was harvested. The number of pods/plant, 100-grain weight, number of seeds/pod, shelling percentage and harvest index were determined from a sample obtained from the net plot yield.

Simple correlation analysis (Little and Hills, 1978) was done to determine the magnitude and type of association between the characters concerned. Path coefficient analysis which measures the direct and indirect effect of one variable upon another and permits the partitioning of the correlation coefficient into components of direct and indirect effects was employed in line with procedure described by Wright (1921) and modified by Dewey and Lu (1959), Li (1948) and SAS Inst. (1997).

Path coefficients were calculated using the following simultaneous equations which express the basic relationships between correlation and path coefficients:

$$P_1 + r_{12} P_2 + r_{13} P_3 + r_{14}P_4 + r_{15}P_5 = r_{1y}$$
$$r_{12}P_1 + P_2 + r_{23} P_3 + r_{24} P_4 + r_{25}P_5 = r_{2y}$$
$$r_{13} P_1 + r_{23} P_2 + P_3 + r_{34}P_4 + r_{35}P_5 = r_{3y}$$
$$r_{14}P_1 + r_{24} P_2 + r_{34} P_3 + P_4 + r_{45}P_5 = r_{4y}$$
$$r_{15}P_1 + r_{25} P_2 + r_{35} P_3 + r_{45}P_4 + P_5 = r_{5y}$$
$$1 - (r_{1y} P_1 + r_{2y} P_2 + r_{3y} P_3 + r_{4y}P_4 + r_{5y}P_5 = R$$

Where, 1 =number of pods/plant; r = correlation; 2 =100-grain weight; y = grain yield; 3 = shelling percentage; R = residual factors; 4 = number of seeds/plot; P = direct contribution; 5 = harvest index.

RESULTS AND DISCUSSION

The strong and positive correlation between number of pods/plant (r = 0.74**), 100-grain weight (r = 0.35**), and harvest index (r = 0.83**), and grain yield (Table 1) shows that these yield characters are important and have direct bearing on the final yield of Bambara groundnut. The significant positive correlation amongst the yield characters, such as: number of pods per plant and harvest index (r = 0.55**), and between 100-grain weight and harvest index (r = 0.28*) suggest that these characters also make positive indirect contribution to the final grain yield since there is no negative component compensation between them. The relationship between yield and yield characters such as shelling percentage and number of seeds/pod were however not significant (Table 1) which could be attributed to the sacrificial and unfavourable influence through number of pods. These relationships, particularly, the indirect associations could not sufficiently be compared using simple correlation analysis but by using path coefficient analysis (Table 2). This provides effective means of separating the direct and indirect causes of associations; and permits for an in-

Table 2. Path coefficient analysis of yield characters influencing grain yield in bambara groundnut.

Parameter	Value
Number of pods (x_1) vs yield (Y)	r =0 .7400
Direct (P1)	0.3579
Indirect via 100-grain weight (x_2)	0.0185
Indirect shelling % (x_3)	0.0026
Indirect via number of seeds/pod (x_4)	0.8137
Indirect via Harvest index (x_5)	0.3473
Total	**0.7400**
100-grain weight (x_2) vs. yield (Y)	r = 0.3500
Direct (P_2)	0.0883
Indirect via number of pods/plant (x_1)	0.0752
Indirect via Shelling % (x_3)	0.0065
Indirect via number of seeds/pod (x_4)	0.0034
Indirect via Harvest index (x_5)	0.1768
Total	**0.3500**
Shelling % (x_3) vs yield (Y)	r = 0.0900
Direct (P_3)	0.1269
Indirect via number of pods/plant (x_1)	0.0072
Indirect via 100-grain weight (x_2)	0.0044
Indirect via number of seeds/pod (x_4)	-0.0172
Indirect via Harvest index (x_5)	-0.0316
Total	**0.0900**
Number of seeds/pod (x_4) vs yield (Y)	r = -0.1200
Direct (P_4)	-0.1716
Indirect via number of pods/plant (x_1)	-0.0286
Indirect via 100-grain weight (x_2)	-0.0018
Indirect shelling % (x_3)	0.0127
Indirect via harvest index (x_5)	0.0695
Total	**0.1200**
Harvest index (x_5) vs yield (Y)	r = 0.8300
Direct (P_5)	0.6314
Indirect via number of pods/plant (x_1)	0.1969
Indirect via 100-grain weight (x_2)	0.0247
Indirect via shelling % (x_3)	-0.0064
Indirect via number of seeds/pod (x_4)	-0.0184
Total	**0.8300**

depth examination of the factors producing a given correlation and measures the relative importance of each factor. The use of path analysis shows that there was a positive direct association between grain yield and the various yield characters except with number of seeds/pod which was negative (Table 2).

The path coefficient analysis (Table 2) revealed that harvest index made the highest direct positive contribution of 0.6314 to grain yield followed by number of pods/plant (0.3579) while direct contribution by number of seds/pod was negative (-0.1716). Most of the yield characters assessed made their highest indirect contribution to grain yield through number of pods per plant and harvest index (Table 2). The least indirect contribution to the grain yield was via number of seeds per pod which was negative. Number of seeds/pod had negative yield component compensation with number of pods per plant and 100-grain weight. The positive association of shelling percentage with grain yield (Table 2) was compromised by its negative indirect associations with number of seeds/pod and harvest index. The 100-grain weight though significant and positively correlated to grain yield (Table 1), had little direct contribution to grain yield (Table 2).

The significant positive correlation and contributions of number of pods/plant and 100-grain weight to the grain yield are consistent with the findings of Misangu et al. (2007), and Oyiga and Oguru (2011). Although 100-grain weight had significant positive correlation with grain yield, its direct contribution to grain yield was low (0.0883) which contradicts results of previous studies (Karikari and Tabore, 2003; Misangu et al., 2007) due to high component compensation and unfavourable weather conditions. According to Wigglesworth (1996), the negative relationships among plant components could result from competition for ambient resources, such as; nutrients, moisture, light, genetic factors, such as linkage and pleitropy. Investigation by Jonah (2011) also showed that both phenotypic and genotypic associations of number of pods/plant with seed yield per plant were positive and significant. The significant positive correlation and direct positive contributions of number of pods and 100-seed weight conformed with similar results by John (1992) on green gram, Manggoel et al. (2012) on cowpea, James et al., (1999) and Amodu (2004) on soybean.

Result of direct and combined percent contributions of the various yield characters to grain yield is presented in Table 3. The highest direct percent contribution to grain yield was by harvest index (39.872%), followed by number of pods/plant (12.809%). Direct percent contributions of 100-grain weight, shelling percentage and number of seeds per pod were very small. They contributed only 0.778, 1.610 and 2.945%, respectively. Large combined per cent contribution to grain yield were made through number of pods per plant and harvest index (13.677%), combined contributions of number of pods per plant and 100-grain weight to grain yield via number of seeds/pod were -0.079 and -0.001, respectively. Contributions by other factors not accounted for by the various characters considered, as represented by residual factors was 27.236%.

Conclusion

The result revealed strong and positive correlation between number of pods/plant (r = 0.74**), 100-grain weight (r = 0.35**) and harvest index (r = 0.83**) with

Table 3. Direct and combined percent contributions of yield characters to bambara groundnut yield.

Parameter	% contribution
Direct contributions to yield	
Number of pods/plant, $x_1(P_1^2 \times 100)$	12.809
100-grain weight, (x_2) $(P_2^2 \times 100)$	0.778
Shelling %, x_3 $(P_3^2 \times 100)$	1.610
Number of seeds/pod, x_4 $(P_4^2 \times 100)$	2.945
Harvest index, x_5 $(P_5^2 \times 100)$	39.872
Total	58.014
Combined % contributions to the yield	
Number of pods/plant (x_1) and 100-grain weight (x_2)	0.279
Number of pods/plant (x_1) and shelling % (x_3)	0.004
Number of pods/plant (x_1) and Number of seeds/pod	0.079
Number of pods/plant (x1) and Harvest index (x_5)	13.677
100-grain weight (x_2) and shelling % (x_3)	0.006
100-grain weight (x_2) and Number of seeds/pod (x_4)	-0.001
100-grain weight (x_2) and Harvest index (x_5)	0.156
Shelling % (x3) and Number of seeds/pod (x_4)	0.044
Shelling % (x_3) and Harvest index (x_5)	0.401
Number of seeds/pod (x_4) and Harvest index (x_5)	0.263
Total	14.750
Residual ®	
$R = 1- rx_1YP_1 + rx_2YP_2 + rx_3YP_3 = rx_4YP_4 + rx_5YP_5$	27.236
Total	100.00

seed yield of bambara groundnut. Harvest index made the largest percent contribution of 39.872% to seed yield followed by number of pods/plant which contributed 12.809%. The highest indirect percent contribution to seed yield was obtained through number of pods/plant and harvest index (13.677%). We therefore conclude that harvest index and number of pods/plant were the most important yield components of bambara groundnut which should be exploited through a breeding programme for improving its yield potentials.

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Ecological value orientations of prospective secondary school teachers in Addis Ababa University, Ethiopia

Aklilu Dalelo

College of Education and Behavioural Studies, Addis Ababa University, Ethiopia.

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The value orientation of a person is highly likely to have consequences in his/her attitudes and behavior. The study reported in this paper examined the ecological/environmental value orientations of prospective secondary school teachers enrolled at Addis Ababa University for a one year Postgraduate Diploma in Teaching (PGDT) program. An environmental and sustainability literacy questionnaire (ESLQ) was used to measure the awareness and views of participants on key environmental/ecological issues and concerns. The 15 items that make up the New Ecological Paradigm Scale have been included in the ESLQ as they are. This paper reports findings related to participants' entry profile and their views about key environmental/ecological issues. The results show two interesting trends with regard to participants' ecological value orientations. First, both the eight pro-NEP and the seven pro-DSP statements have been endorsed. Second, the level of agreement with the two apparently contradictory groups of statements happened to be almost exactly the same (with an average of 67.1% endorsement for pro-NEP statements and strikingly equal level of endorsement of 67.4% for pro-DSP statements). The findings thus show that the prospective secondary school teachers hold a syncretic (NEP plus HEP) not a dualistic (NEP vs. HEP) worldview. In fact, a closer look into the patterns of responses to the five categories of statements shows that respondents had, on average, a pro-DSP worldview in four of the five categories. The only category where respondents had a pro-NEP view relates to 'possibility of eco-crisis'.

Key words: Dominant social paradigm, ecological value orientations, green development, new ecological paradigm, prospective teachers.

INTRODUCTION

Value orientations and pro-ecological behavior

It has long been argued that traditional philosophical (and theological) views on the human relationship with nature have contributed to environmental destruction and degradation (Jardins, 2001). Achieving the goals of a sustainable future therefore requires reaching peoples deep convictions and their emotions, which partake in ethical values (Szagun and Mesenholl, 1993). This is because an individual's action in favor of or against ecological balance is believed to depend largely on values acquired in the course of his/her life. Putnam

*Corresponding author. E-mail: akliludw@gmail.com or dalelowa@leuphana.de.

(2006) suggests that environmental paradigms influence an individual's frequency of pro-environmental behavior. Job (1996) also underscores that the 'means to adjusting our lives to avoid abuses of the planet appear to entail not merely different ways of doing, but different ways of being'. With regard to people's action for or against ecology, it is specifically noted that what people do about their ecology depends on what they think about themselves in relation to things around them (White, 1967). Values, in general, are considered as criteria not only for guiding action but also developing and maintaining attitudes toward relevant objects and situations (Stern and Dietz, 1994).

With regard to development and/or inculcation of pro-environmental/pro-ecological values, it is essential to understand when a person starts acquiring and developing a value system. Stern and Dietz (1994) suggest that value orientations take shape during the socialization process and are fairly stable in adults.

It is also important to underline here that values and beliefs may not lead in a straightforward way to attitudes because social influence agents, including acquaintances, the mass media, and social movements, may manipulate individuals' attention or focus so as to affect the ways they construct their preferences and thereby influence their opinions and actions (Stern and Dietz, 1994). A point of equal importance is that value orientations may vary across individuals, social-structural groups and cultures.

The major value orientations

From the perspective of environmental/ecological values, Stern and Dietz (1994) make a very helpful distinction between three types of value orientations: egoistic, social-altruistic and biospheric. Egoistic values predispose people to protect aspects of the environment that affect them personally, or to oppose protection of the environment if the personal costs are perceived as high. The egoistic value orientation assumes that the motivation for pro-environmental action is predominantly economic and socio-biological and that the ultimate motivation for pro-environmental action is the benefit to be gained by the individual (Watson and Halse, 2005). The second model, altruistic value orientation, presumes that people act on social-altruistic values that may come with moral imperatives such as the Golden Rule: 'Do unto others as you would have them do unto you'.

People who apply such values judge phenomena on the basis of costs or benefits for a human group (for example, an ethnic group) or all humanity. In the case of the third model, biospheric value orientation, people judge phenomena on the basis of costs or benefits to ecosystems or the biosphere. Watson and Halse (2005) suggest that the biospheric orientation reflects the motivation of the 'deep ecologists' whose primary motivation for proenvironmental action is the welfare of ecological systems. In fact, Szagun and Mesenholl (1993) suggest that ethical concerns may be 'strong motivations for preserving nature, possibly more so than enjoyment of nature'.

In general, people would commit themselves to action when pro-environmental personal norms were activated by beliefs that an environmental condition has adverse consequences for self and close kin (in the egoistic value orientation), for other human beings (in the social-altruistic orientation), or for other species or ecological systems (in the biospheric orientation), and by ascription of responsibility to themselves for preventing those consequences (Stern and Dietz, 1994).

The DSP vis-à-vis NEP

The past two to three decades saw a growing body of research conducted to see the relationship between value orientations and pro-environmental/ecological actions though such researches were mostly conducted in advanced industrial countries. In relation to this, it has been underlined that modern research into environmental values is predominantly western in origin, and the Dominant Social Paradigm (DSP) and the New Environmental Paradigm (NEP) as theoretical concepts have been formulated and developed in the United States (Stern et al., 1995; Ojomo, 2011). The DSP entails, among other things, a belief in limitless resources; continuous progress, and the necessity of growth; faith in the problem solving abilities of science and technology; and strong emotional commitment to a laissez-faire economy and to sanctity of private property rights (Albrecht et al., 1982 cited in Erdogan, 2009). The DSP is also said to be characterized by consumerism, rationalism, utilitarianism and reductionism (Job, 1996). The NEP worldview on the other hand, is based on high valuation of nature; generalized compassion toward other species, other people and other generations; careful planning and acting to avoid risks to humans and nature; recognition that there are limits to growth to which humans must adapt; new society with cooperation, openness and participation; and consultative and participatory new politics emphasizing on foresight and planning (Milbrath, 1984 cited in Erdogan, 2009).

A dualistic vis-à-vis syncretic worldview

Some scholars argue that the NEP is nothing new in nonwestern and non-industrialized societies (Corral-Verdugo and Armendariz, 2000). It is often said that indigenous, non-industrialized societies tend to believe in the profound connection between humanity and nature. In contrast, in western or European societies, dualism permeates peoples' environmental beliefs. It was suggested, for instance, that the pro-Human Exceptionalism

Paradigm - (HEP) would be closely allied with consumerism and the related concept of technocratic modernity (Colwell, 1997 cited in Corral-Verdugo and Armendariz, 2000), whereas pro-NEP view would be allied with the post-materialist values of frugality and conservation. As people in industrially advanced societies tend to base their attitudes on just one of the paradigms, those who follow the NEP would be the ecologically oriented in western communities (Corral-Verdugo and Armendariz, 2000).

Corral-Verdugo and Armendariz (2000) also indicate that the results of their study reflect the dualistic nature of North American culture and the more ecological vision of the Latin American belief systems. Whereas Americans conceive of the world as either pro-NEP or pro-HEP, for Brazilians, there is no conflict in holding both belief systems thereby reflecting a syncretic, ecological vision, by which some societies find compatibility between the natural balance and the needs of humans (using natural resources). A study from Mexico (Corral-Verdugo and Armendariz, 2000) indicates that the agreement with pro-NEP items was higher than the agreement with the pro-HEP items, implying that the community is more committed to preserving the environment than to a utilitarian view of nature. However, the participants of this Mexican community did not see a major conflict between these two apparently opposing views. In Mexico, 'individuals can be concerned with a natural balance- the negative human impact on the environment and, at the same time, believe in humans' control over nature and be interested in possible profits they could obtain from nature'(Corral-Verdugo and Armendariz, 2000).

Another study (Watson and Halse, 2005) was conducted to see if the NEP scale has equal relevance in non-industrial societies by investigating the environmental attitudes held by pre-service teachers in three communities, one each from Australia, Republic of Maldives and Indonesia, and to compare the similarities and differences between the countries. The results indicate that Australian respondents viewed environments from a deep ecological perspective when compared with Maldivian respondents (Watson and Halse, 2005). The Australian and Indonesian respondents also tended to consider environments as a balance between the needs of humans and the needs of environments while the Maldivian sample was considered as less altruistic. The Australian respondents tended to agree that environments should not be dominated by human need. The Maldivian respondents, however, appear to place more importance on human need when their views were compared with Australian respondents, while the views of the Indonesian respondents lay in between and significantly different from the views of both the Australian and Maldivian respondents. The analysis of the Indonesian and Maldivian interviews further suggests that these communities are anthropocentric in their environmental attitudes and indicates that they may hold environmental attitudes developed from a different conceptual framework to that underpinning the NEP (Watson and Halse, 2005).

A similar study conducted in Turkey found out that about one fourth of university students who took part in the study had a pro-DSP orientations though majority (56.0%) held pro-NEP views (Erdogan, 2009). Erdogan (2009) further suggests that there was no widespread adoption of the NEP orientation by students (students approving some statements of the NEP scale while disapproving other parts of it).

The traditional African worldview

The traditional African worldview is believed to be more holistic with a tendency to see the material and spiritual as constituents of a single phenomenon. Tangwa (2004) emphatically argues, for instance, that within the traditional African metaphysical worldview, the dichotomy between plants, animals, and inanimate things; between the sacred and the profane; matter and spirit; the communal and the individual, is a slim and flexible one. It is further suggested that the absence of the dichotomy between the aforementioned constituents in the African metaphysical worldview informed the traditional African disposition and attitude of 'live and let live' (Ojomo, 2011, p.101). Hence an assertion that such metaphysics is 'not one of domination instigated by greed nor is it consumerist in nature'. Latent in that metaphysics are folkloric assertions and certain taboos that are conservational of ecological balance of the environment' (Ojomo, 2011). Nevertheless, an empirical study that assessed Nigerian secondary school teachers' environmental knowledge and attitude showed that the teachers not only demonstrated 'a poor formal knowledge of the environmental issues involved' but also 'manifested attitudes which may well be inimical to a healthy environment' (Mansaray et al., 1998).

In Ethiopia, the environment is believed to have always been the fundamental concern of the rural people (Workineh, 2001). The Oromo people (the largest ethnic group in Ethiopia), for instance, are said to not only possess accumulated practical knowledge of their environment through experience and productive activity but also firmly believe that the natural environment and human beings are linked together in a web of relationships. It is thus suggested that 'the ethics of truly sustainable development may benefit from the wealth of biological and ecological insights and sustainable resource management systems developed by the Oromo people and other cultural groups' in Ethiopia (Workineh, 2001). Workneh's (2001) study also indicates that the kind of ethic embodied in indigenous beliefs and values does not completely contradict the kind of ethic found in modern beliefs and values complement each other. The study reported in this paper tried to investigate the environmental/ecological value orientations of a specific

group of people in Ethiopia: prospective secondary school teachers at Addis Ababa University.

Rationale and objectives of the study

As indicated earlier, studies meant to assess the ecological/environmental value orientations of different segments of a society have been limited mainly to the advanced industrial countries of the West. Some scholars also indicate that there are only a few studies of this kind conducted in developing countries (Corral-Verdugo and Armendariz, 2000). It is thus argued that "if the growing phenomena of environmental degradation are of a global nature and if environmental beliefs truly reflect individuals' concern about the environment, then researchers should investigate such beliefs in societies with low, as well as high, technological development" (Corral-Verdugo and Armendariz, 2000; Ojomo, 2011). With regard to Africa, it was noted that little has been done to investigate "the African perspective to environmental ethics and the people's cultural understanding of the environmental crisis" (Ojomo, 2011). The study reported here was therefore aimed at assessing the ecological value orientations of prospective secondary school teachers being trained at Addis Ababa University, Ethiopia.

The study focuses on students who are being trained to become secondary school teachers because teachers, as a group, "are potentially influential in shaping the environmental attitudes of future 'generations' (Watson and Halse, 2005). University students, in general, are also believed to be "the leading crusaders in the modern environmental movements throughout the world" (Erdogan, 2009). What is more, UNESCO considers teacher education as crucial to re-orientation of education towards sustainability (Gough and Scott, 2007). Teacher education is often presented as the 'priority of priorities', in view of its contributions to capacity-building of a large group of population with relatively low cost. Chambers (2009) thus sees teacher education as a good, non-economic, example of a multiplier effect in action arguing that if a teacher learns something, potentially, all the students in his/her care over the duration of his/her career can be influenced by the learning of that teacher.

The study, part of which is reported in this paper, attempted to assess the environmental/ecological literacy and value orientations of prospective teachers trained in the largest and oldest of the higher education institutions in Ethiopia-Addis Ababa University. The findings are hoped to show, among other things, whether or not prospective teachers' environmental/ecological values support Ethiopia's plan to build a green economy (EPA, 2011). There is another recent development that could make the findings of this study interesting for policy makers at Ministry of Education (MOE). In 2010, the MOE introduced a new secondary school teachers' training modality called the Postgraduate Diploma in Teaching (PGDT). The PGDT is a training modality whereby candidates earn their first degree in different subjects (Biology, Geography, etc.) and then join the Faculties/Colleges of Education to get a one year professional training that equips them to become secondary school teachers (CEBS, 2013). As the study was conducted shortly after graduation of the participants of the study (graduation from their subject area departments), the results are expected to shed some light on the degree to which education in the different departments contributed to students' environmental and sustainability literacy. This is most important in light of the ambitious plan by the MOE to give training on 'Environmental Education and Protection' to half of the teachers in the country, in five years (MOE, 2010). The results of the study could give hints as to the general value orientations of beginning teachers thereby indicating areas that might need interventions.

The more specific objectives of the broader study were to assess the entry profile of prospective secondary school teachers; awareness of prospective teachers about key issues related to environment and sustainability; and ecological/environmental value orienttations of prospective teachers. This paper presents findings related to the first and the last objectives of the study. The paper also tries to compare the findings about value orientations of Ethiopian respondents with those of similar studies conducted in the United States of America and Turkey.

METHODOLOGY

Sampling

As indicated earlier, the Ethiopian Ministry of Education introduced an entirely new modality of teacher education called Postgraduate Diploma in Teaching (PGDT). The programme admits candidates with a bachelor degree (a three year programme) in subject area disciplines. Graduates from these disciplines would be enrolled into the PGDT programme (on the basis of, among other things, their academic performance and expressed wishes to become teachers) and get professional training for one year in College of Education and Behavioral Studies. This would make them eligible to teach in secondary schools throughout the country. This study sought to cover all the prospective teachers enrolled into the PGDT programmes of seven subject areas (Table 1) in the 2012/13 academic year.

A total of 132 prospective teachers had been admitted into the seven areas of specialization of whom 95 (72.0%) took part in the study. The others missed the class that day or failed to return the questionnaire.

Instrument of data gathering

An 'Environmental and Sustainability Literacy Questionnaire' *(ESLQ)* had been developed by the author to assess the level of awareness and views of teachers and prospective teachers in Ethiopia about issues related to environment and sustainability. It has three parts. Part one seeks personal information including area of specialization; and academic performance at the end of education for their first degree (in the case of prospective teachers).

Table 1. Number of study participants by department and discipline.

Department	Discipline	No. of Prospective teachers enrolled in 2013/13 academic year*	No. of study participants	Percentage
Social Science and Language Education	Geography	10	10	100.0
	Civics	13	12	92.3
	History	19	15	78.9
Science and Mathematics Education	Chemistry	17	7	41.2
	Mathematics	28	15	53.6
	Biology	10	9	90.0
	Physics	35	27	77.1
Total		132	95	72.0

*Source: CEBS, 2013, p. 19.

This part was meant to understand the entry profile of the prospective teachers. Part two is meant to assess the awareness of prospective teachers about environmental and sustainability issues. It has 22 statements, and respondents are asked to choose one of the three options provided for each statement: 'correct', 'incorrect' or 'I don't know'. Part three is meant to assess respondents' ecological/environmental value orientations. The last part has 24 statements each offering five options for respondents to choose from, namely, strongly agree, mildly agree, unsure, mildly disagree and strongly disagree.

The *ESLQ* was developed based on extensive review of local and global environmental and sustainability issues and problems. The draft questionnaire was then reviewed by the staff of the Institute of Environmental and Sustainability Communication (INFU), Faculty of Sustainability, Leuphana University of Lüneburg, Germany. The final version of the questionnaire was prepared after fully considering comments from colleagues at INFU, related to both content and structure of the questionnaire. Furthermore, the 15 statements that make-up the New Ecological Paradigm (NEP) Scale, developed by Dunlap et al. (2000), have been used 'as they are' in order to see the ecological/environmental value orientations of prospective teachers in Ethiopia as compared to participants of similar studies elsewhere in the world. The eight odd numbered items in the NEP were worded so that agreement indicates a pro-ecological view, and the seven even-numbered ones worded so that disagreement indicated a pro-ecological worldview (Dunalp et al., 2000). The NEP scale is often said to be one of the "most widely used and scrutinized methods to measure environmental orientation, attitudes and behavior" (Erdogan, 2009).

This paper reports the results of part one and part three of the *ESLQ*. Part three includes all the 15 statements of the NEP along with nine statements addressing ecological/environmental issues specifically related to Ethiopia.

Data gathering and analysis

The heads of the two Departments of the College of Education and Behavioral Studies which run PGDT (namely, Department of Social Science and Language Education; and the Department of Science and Mathematics Education) were contacted to seek help in the administration of the questionnaire. After discussions on the objectives and significance of the study, the Heads of the two departments agreed to take the responsibility of circulating the *ESLQ* among their prospective teachers in their respective departments. The questionnaires were then distributed to the participants of the PGDT in July, 2012. Table 1 shows the number of participants who took part in the study by discipline (subject area). The data gathered was fed into SPSS and then analyzed.

RESULTS

Entry profile

Colleges and faculties of teacher education in Ethiopia used to receive students who scored relatively lower cumulative GPA in their secondary school leaving examinations (Aklilu et al., 2008). Recently, efforts have been made, at policy[1] level, to change this situation thereby enabling the various departments that train secondary school teachers to have students with a reasonably good performance in secondary school leaving certificate examinations. This study tried to look into the entry profile of the prospective secondary school teachers who were enrolled into their professional training in the summer of 2012/13 academic year. Responses as to students' performance in secondary school leaving national examinations were secured in two formats: in cumulative average points (out of the maximum of 4 cumulative average points) and raw scores (out of the maximum of 700 points). Analysis of results indicates that more than half of the participants of the study had a fairly good entry performance. For instance, more than one fourth (27%) had GPA of above 2.76 whereas 14% had scores above 276 (Table 2) when they joined their respective universities. This appears to be a clear departure from the older situation where students with the lowest GPA were placed in teacher education departments. Nevertheless, the results also show that 'high' and 'very high' achievers were still not attracted by the teaching profession (for instance, only 17% the prospective teachers had GPA above 3.0 and only 4% had scores above 350).

As indicated in the introductory section of the paper, the Ethiopian Ministry of Education introduced a new modality of teacher education called Post Graduate Diploma in Teaching (PGDT) whereby prospective

[1]Introduction of the Postgraduate Diploma in Teaching (PGDT) Program could be taken as an example. Students with good performance in their higher education entrance exam are first trained in subject area departments and then compete to get admission into colleges of teacher education.

Table 2. University entry profile of prospective secondary school teachers.

Range of GPA (out of 4)	Frequency	Percentage excluding the missing
Below 2.5	3	3.9
2.51-2.75	7	9.1
2.76-3.0	16	20.8
3.01-3.50	10	12.9
Above 3.50	3	3.9
Range of raw scores (out of 700)	**Frequency**	**Percentage excluding the missing**
Below 200	3	3.9
200-250	14	18.2
251-275	7	9.1
276-300	11	14.3
301-350	3	3.9
Above 350	0	0.0
Total	77	100.0
Missing	18	
Grand total	95	

Table 3. PGDT entry profile of prospective secondary school teachers.

Range of GPA at entrance	Frequency	Percentage excluding the missing
Below 2.5	3	3.4
2.51-2.75	3	3.4
2.76-3.00	12	13.8
3.01-3.50	34	39.1
Above 3.50	35	40.2
Total	87	100.0
Missing	8	
Grand total	95	

graduates receive their first degree in the subject area disciplines (History, Chemistry, etc.) and then join faculties of education in the various universities for one year professional training to become a secondary school teacher in their respective subject areas. It was hoped that PGDT would be a competitive program attracting students with a better performance at the end of their university stay (CEBS, 2013). This study also tried to find out whether this hope is being actualized. Result of the study clearly shows that the PGDT indeed attracted students who scored relatively higher cumulative GPAs in their respective areas of specialization (Table 3).

It is interesting to note that 79.3% of the students who willingly joined the PGDT had a cumulative GPA of 3.00 and above on graduation. This is indeed a good news for secondary teacher education in Ethiopia as it addresses one of the age-old concerns of teacher educators in Ethiopia that the entry profile of would be teachers was too low to help them cope up with the rigorous requirements of university education. Though a high cumulative GPA does not guarantee creation of a committed teacher, it is one of the important input factors which help the education system to generate academically competent teachers.

Ecological/environmental value orientations

This section presents the findings of the study divided into five categories of value orientations: limits to growth; fragility of natural balance; possibility of eco-crisis; anti-anthropocentrism; and rejection of human exceptionalism. Besides, results specifically related to issues concerning Ethiopia have been presented in the last part of the section.

Limits to growth (LTG)

The LTG refers to the results of the study by a group of scientists at the Massachusetts Institute of Technology

Table 4. Views about statements related to 'limits to growth (LTG)'.

S/N	Views		Agree	Strongly agree	Mildly agree	unsure	Mildly disagree	Strongly disagree
1 (1)*	We are approaching the limit of the number of people the earth can support.	ET	68.1	29.8	38.3	10.6	7.4	13.8
		US	52.9	27.7	25.2	21.0	16.0	10.0
		TR	62.0	28.5	33.5	22.0	8.5	7.5
19 (11)	The earth is like spaceship with very limited room and resources.	ET	56.0	32.3	23.7	15.1	12.9	16.1
		US	74.3	38.0	36.3	7.5	13.4	4.8
		TR	53.9	18.2	35.7	23.2	13.7	9.1
6 (6)	The earth has plenty of natural resources if we just learn how to develop them.	ET	85.9	70.7	15.2	5.4	3.3	5.4
		US	59.2	24.4	34.8	11.3	17.5	11.9
		TR	86.9	60.5	26.4	7.8	3.0	2.3
	Average		44.3**					

*The figure in bracket shows the serial number of the item in the NEP scale whereas the other shows the serial number of the same item in the ESLQ prepared by the writer. **Average of pro-NEP endorsement (agreeing to pro-NEP statements and disagreeing to pro-DSP statements) for Ethiopian respondents. ET = Ethiopia; US = United States; TR = Turkey.

who attempted to model the evolution of the worldwide economic system over a time span of more than a century (Bardi, 2011). The study shows among other things, that, in a “business as usual” set of assumptions, economic growth could not be maintained throughout the twenty-first century; and projected a gradual depletion of nonrenewable resources, coupled with increasing pollution and population growth. Three statements in the revised NEP scale are related to 'limits to growth'.

The prospective teachers who took part in this study endorsed all three statements, both pro-NEP views (Item Nos. 1(1) and 19(11) and pro-DSP (item 6(6)). It is thus to be noted that respondents endorsed the two apparently contradictory positions, namely, pro-NEP and pro-DSP at the same time. Though the magnitude of support differs, similar patterns were also reported by studies from US and Turkey (more than half of the participants supported all the three statements albeit to a different degree). In the case of Ethiopian participants, the statement which asserts that the 'earth has plenty of natural resources...' had been endorsed by overwhelming majority (85.9%). It is interesting to see that almost equal percentage of participants from Turkey (86.9%) supported this statement (Table 4). The second part of the statement, '...if we just learn how to develop them', might have led to such a high endorsement by giving the impression that any perceived or actual problem related to use of natural resources is a problem related not to availability but how we use such resources.

The statement which declares that the Earth has 'very limited room and resources' is endorsed by much lesser proportion of the Ethiopian respondents (56%). Once again, a similar proportion of respondents from Turkey (53.9%) supported this statement. On the other hand, close to one-third (30%) of the participants from Ethiopia rejected the view that the Earth has limited room and resources. When we see this in light of the high support to another statement which seems to contradict this one, 'we are approaching the limit of the number of people the earth can support', a degree of confusion seems to be evident. More than two-third of the respondents endorsed one of the typically biospheric views that the limit of the number of people the Earth can support is being approached. A similar trend was reported by the Turkish study on this statement (Table 4).

Erdogan (2009) tries to explain the apparent contradictions in the Turkish university students' views about statements related to 'limits to growth'. For some, the writer argues, the constituent parts seem unrelated; and there are some items that respondents probably cannot relate to without hesitation. The latter refers specifically to item 11 which uses “spaceship with very limited room and resources” metaphor. It is further argued that some people may agree with “limited room” idea, but disagree with “limited resources” (Erdogan, 2009). Based on these observations, Erdogan (2009) concludes that "agreeing or disagreeing with the items 1, 6 and 11 does not necessarily make a person a supporter of the NEP (or DSP) view, at least in Turkish culture".

Fragility of natural balance (FNB)

This view assumes that there is a delicate balance in nature thereby implying a need for keeping that balance while using natural resources for socio-economic development. The prospective teachers in Addis Ababa University seem to hold a pro-NEP view on two of the statements related to 'fragility of the natural balance'. Close to two-thirds of the respondents endorsed the view that human interference often leads to disastrous consequences (Item No. 3(3)). The degree of support to this statement is less than that reported by a Turkish study (1295 participants) and by far less than that

Table 5. Views about statements related to 'fragility of natural balance' (FNB).

S/N	Views		Agree	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
3(3)*	When humans interfere with nature it often produces disastrous consequences.	ET	63.5	35.5	28.0	16.1	11.8	8.6
		US	82.2	44.6	37.6	4.0	11.2	2.5
		TR	71.6	36.2	35.4	13.9	9.3	5.2
22(13)	The balance of nature is very delicate and easily upset.	ET	52.8	18.0	34.8	20.2	13.5	13.5
		US	78.7	45.9	32.8	5.9	14.1	1.4
		TR	70.3	34.6	35.7	14.6	12.0	3.1
8(8)	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	ET	52.7	29.0	23.7	17.2	11.8	18.3
		US	8.5	1.1	7.4	11.3	30.9	49.4
		TR	25.0	8.4	16.6	28.8	27.9	18.3
13	Artificial insemination is a threat to livestock diversity in Ethiopia.		53.9	24.7	29.2	36.0	4.5	5.6
17	Eucalyptus is an ecologically hazardous tree species.		43.5	20.7	22.8	40.2	12.0	4.3
	Average		48.8**					

*The figure in bracket shows the serial number of the item in the NEP scale whereas the other shows the serial number of the same item in the ESLQ prepared by the writer. **Average of pro-NEP endorsement (agreeing to pro-NEP statements and disagreeing to pro-DSP statements) for Ethiopian respondents. ET = Ethiopia; US = United States; TR = Turkey.

reported by the US study (676 participants) (Table 5). An additional statement was included in the scale to see the view of the Ethiopian respondents about impacts of artificial insemination on livestock diversity. More than half (53.8%) of the respondents endorsed the statement which says "artificial insemination is a threat to livestock diversity in Ethiopia" (Item No. 13) whereas a very significant proportion (36%) preferred neither to agree nor disagree.

The statement on the delicacy of the balance of nature has been endorsed by a little more than half of the Ethiopian respondents. Once again, we see a huge difference between the respondents in the three countries with regard to their degree of enthusiasm in supporting this statement (Item No. 22(13)). More than one-fourth of the respondents in Ethiopia rejected the view which asserts that the balance of nature is very delicate and hence easily upset! On the contrary, half of the Ethiopian respondents endorsed the pro-DSP view that the 'balance of nature is strong enough to cope with the impacts of modern industrial nations' (Item No. 8(8)). This is one of the statements where we see a clear difference between the views of Ethiopian respondents on the one hand and those of American and Turkish respondents on the other (Table 5). Here again, Ethiopian respondents tended to support both pro-NEP and pro-DSP views at the same time. In relation to such a pattern of values, Stern and Dietz (1994) noted that value orientations are not mutually exclusive, that is, individuals may hold several orientations to some degree.

Some people in Ethiopia (mainly environmentalists) argue that the ever increasing size of eucalyptus plantation is damaging the ecosystem. Among the concerns are its inability to provide quality wood or services such as watershed or soil conservation; its impact on the environment such as heavy use of soil water, thus affecting streams and underground water; high consumption of soil nutrients, inability to prevent soil erosion, inhibition of growth of other plants in the understory; and failure to provide food supplies or adequate habitat for wildlife (Gessesse and Teklu, 2011). It is thus interesting to see that less than half of the respondents endorsed the statement: "Eucalyptus is an ecologically hazardous tree species" (Item. No.17). A great number of the respondents also seemed to struggle to take a position on the impact of eucalyptus (40.2% indicated that they were unsure). This is one of the statements where respondents had difficulty to take a position.

Possibility of eco-crisis (PEC)

The NEP stresses on human dependence on nature and disastrous outcome of human interference to nature (Erdogan, 2009). Three fourth of the Ethiopian respondents endorsed the biospheric view that humans are severely abusing the environment (Item No. 12(5)). The level of endorsement to this statement is even much higher in the case of US and Turkish respondents (Table 6). With regard to the current status of the natural environment, more than half (54.4%) of the respondents seem to share the common view among Ethiopian scholars in the area of natural resource management that the country's "natural environment has been damaged beyond any chance to recover" (Item No.11). It is also interesting to note here that one-third of the prospective teachers rejected such an alarmist view about the

Table 6. Views about statements related to 'possibility of eco-crisis' (PEC).

S/N	Views		Agree	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
12(5)*	Humans are severely abusing the environment.	ET	74.7	42.5	32.2	14.9	4.6	5.7
		US	86.6	51.3	35.3	2.6	9.3	1.5
		TR	83.7	48.4	35.3	6.5	6.1	3.6
24(15)	If things continue on their present course, we will soon experience a major ecological catastrophe.	ET	64.5	35.6	28.9	18.9	8.9	7.8
		US	65.3	34.3	31.0	16.9	14.1	3.6
		TR	72.4	35.6	36.8	19.9	4.8	2.9
18(10)	The so called “ecological crisis” facing humankind has been greatly exaggerated.	ET	52.2	17.4	34.8	20.7	16.3	10.9
		US	21.8	3.9	17.9	13.8	25.9	38.5
		TR	15.2	4.1	11.1	25.5	30.0	29.3
11	The Ethiopian natural environment has been damaged beyond any chance to recover.		54.4	19.6	34.8	10.9	22.8	12.0
	Average		55.5**					

*The figure in bracket shows the serial number of the item in the NEP scale whereas the other shows the serial number of the same item in the ESLQ prepared by the writer. ** Average of pro-NEP endorsement (agreeing to pro-NEP statements and disagreeing to pro-DSP statements) for Ethiopian respondents. ET = Ethiopia; US = United States; TR = Turkey.

present state of the natural environment in the country (Table 6).

Close to two-third of the Ethiopian respondents (64.5%) endorsed the view which states that 'If things continue on their present course, we will soon experience a major ecological catastrophe' (Item No. 24(15)). Close to three fourth of the Turkish respondents endorsed this view. More than half of the Ethiopian respondents consider that 'the so called “ecological crisis” facing humankind has been greatly exaggerated' (Item 18(10)) thereby showing their support, once more, to a pro-DSP view. Table 6 shows that the proportion of US and Turkish respondents who considered 'ecological crisis' facing humanity as exaggeration is much lower. This is another case where we see a clear difference between the views expressed by the US and Turkish respondents on one hand and that of Ethiopian respondents on the other.

Anti-anthropocentrism (AATC)

The Ethiopian respondents seemed to exhibit contradictory views on the three statements related to 'anti-anthropocentrism' views. On the one hand, more than three-fourth endorsed the view that "plants and animals have as much right as humans to exist" (Item No. 14(7)). On the other, 72.8% endorsed the contradictory view that "humans were meant to rule over the rest of nature" (Item No. 21(12)). The view that promotes human dominion over nature is clearly rejected by more than half of the respondents from US and Turkey (Table 7). A similar statement which proclaims that "humans have the right to modify the natural environment to suit their needs" got support from even greater proportion of Ethiopian respondents (80.9%). More than 60% of the respondents from US and Turkey disagreed. Table 7 shows that Ethiopian respondents held a very strong anthropocentric view though they also supported the bispoheric view that calls for equal right to non-human species. Close to one-third of the respondents also endorsed the additional statement (not included in the NEP scale) meant to crosscheck the consistency of respondents' views about plant and animal right: "One should also preserve species that have no direct economic benefits at present" (Item No.4). With regard to such a tendency to support both pro- and anti-NEP views, Erdogan (2009) makes an interesting note that "one does not have to be an environmentalist in order to acknowledge the right of existence of plants and animals".

Rejection of human exceptionalism (RHE)

Two of the three statements in this category are designed in pro-DSP format and one in pro-NEP. The Ethiopian respondents endorsed all three albeit to a different degree (Table 8). The pro-DSP view that 'human ingenuity will insure that the earth remains livable' (Item No. 5(4)) has been endorsed by more than half (57%) of the Ethiopian respondents (the level of endorsement is much less in the case of Turkish and American respondents). Another pro-DSP statement in this category declares that 'humans will eventually learn enough about how nature works to be able to control it' (Item No. 23(14)). A clearly greater proportion of the Ethiopian respondents (70%) endorsed this statement, slightly more than half of the Turkish respondents also agreed. The only pro-NEP statement in this category which says that '... humans are still subject to the laws of

Table 7. Views about statements related to 'anti-anthropocentrism (AATC).

S/N	Views		Agree	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
10(2)*	Humans have the right to modify the natural environment to suit their needs.	ET	80.9	58.4	22.5	6.7	3.4	9.0
		US	32.6	4.1	28.5	9.2	33.9	24.3
		TR	19.8	6.2	13.6	15.1	26.5	38.6
14(7)	Plants and animals have as much right as humans to exist.	ET	78.2	55.4	22.8	5.4	7.6	8.7
		US	76.9	44.7	32.2	4.7	12.8	5.7
		TR	91.0	74.5	16.5	4.2	2.4	2.4
21(12)	Humans were meant to rule over the rest of nature.	ET	72.8	39.8	33.0	14.8	5.7	6.8
		US	33.9	13.5	20.4	8.2	23.9	34.0
		TR	26.9	8.2	18.7	19.6	22.2	31.3
4	One should also preserve species that have no direct economic benefits at present.		62.4	36.6	25.8	11.8	10.8	15.1
	Average		34.4**					

*The figure in bracket shows the serial number of the item in the NEP scale whereas the other shows the serial number of the same item in the ESLQ prepared by the writer. ** Average of pro-NEP endorsement (agreeing to pro-NEP statements and disagreeing to pro-DSP statements) for Ethiopian respondents. ET = Ethiopia; US = United States; TR = Turkey.

Table 8. Views about statements related to 'rejection of human exceptionalism' (RHE).

S/N	Views		Agree	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
5(4)*	Human ingenuity (capacity to invent) will Insure that the earth remains liveable (RHE).	ET	57.0	22.6	34.4	28.0	7.5	7.5
		US	31.3	7.8	23.5	21.5	24.4	22.7
		TR	40.1	14.9	25.2	35.6	16.8	8.5
16(9)	Despite our special abilities, humans are still subject to the laws of nature (RHE).	ET	79.3	47.8	31.5	13.0	4.3	3.3
		US	90.9	59.6	31.3	5.4	2.9	0.8
		TR	67.1	29.2	37.9	20.6	7.5	4.7
23(14)	Humans will eventually learn enough about how nature works to be able to control it (RHE).	ET	70.0	35.6	34.4	13.3	12.2	4.4
		US	23.3	3.2	20.1	24.2	27.9	24.6
		TR	53.4	21.3	32.1	30.0	10.2	6.4
	Average		37.0**					

*The figure in bracket shows the serial number of the item in the NEP Scale whereas the other shows the serial number of the same item in the ESLQ prepared by the writer. **Average of pro-NEP endorsement (agreeing to pro-NEP statements and disagreeing to pro-DSP statements) for Ethiopian respondents. ET = Ethiopia; US = United States; TR = Turkey.

nature' has been endorsed by 90.1% of the US respondents. This may not be surprising given the assumption that pro-NEP statements normally get huge endorsement by respondents from industrially advanced societies. What is interesting is that 79.3% of the Ethiopian respondents also endorsed this statement which contradicts the view that humans will be able to control nature (the latter view was also endorsed by 70% of the Ethiopian respondents, as indicated above).

Ecological/environmental issues related to Ethiopia

As indicated in the methodology section, the scale used in this study has nine statements in addition to the 15 that form the revised NEP scale. Five of the nine statements are related to two of the issues causing a great deal of controversy and debate both in academic and political circles (Table 9). The first issue relates to the impact of land use policies and practices on the environment while the second relates to the impacts of one of the mega hydroelectric dams being built in southern Ethiopia: Gilgel Ghibe III Dam. Some ecologists and human rights advocates fiercely oppose the construction of the Gilgel Ghibe III on the ground that it would affect the lifestyles and livelihoods of people in the Omo Valley. These groups also argue that the Dam could also lead to significant fall in the amount of water that reaches Lake Turkana. The Ethiopian Government, on the other hand,

Table 9. Views about ecological issues specifically related to Ethiopia.

S/N	Views	Agree	Strongly agree	Mildly agree	Unsure	Mildly disagree	Strongly disagree
15	The GilgelGhibe III Dam could reduce the flow of water into Lake Turkana thereby severely affecting the Lake's ecosystem.	50.6	23.7	26.9	31.2	12.9	5.4
2	Negligent destruction of forests in Ethiopia is due mainly to lack of clearly defined ownership rights.	63.0	32.6	30.4	14.1	12.0	10.9
7	The ineffectiveness of traditional natural resource management systems is the root cause of environmental degradation in Ethiopia.	78.5	50.5	28.0	6.5	8.6	6.5
9	The hydropower projects in Ethiopia have no adverse impacts on their surrounding communities.	51.6	24.7	26.9	8.6	15.1	24.7
20	At present, decisions on use of natural resources in Ethiopia are made taking full account of habitat loss.	64.1	36.0	28.1	15.7	7.9	12.4

rejects both assertions as groundless.

A little more than half of the prospective teachers (51.6%) endorsed the position held by the Ethiopian Government that "hydropower projects in Ethiopia have no adverse impacts on their surrounding communities" (Item No.9). It is also interesting to see that a significant proportion of the students (39.8%) rejected this view which pronounces that dams in Ethiopia are free from adverse impacts. This is a clear departure from the view frequently conveyed on the Ethiopian public media. The more biocentirc view that 'The Gilgel Ghibe III Dam could reduce the flow of water into Lake Turkana thereby severely affecting the Lake's ecosystem' (Item No.15) has been endorsed by half of the respondents. Nearly one third of the respondents found it difficult either to agree or disagree with the statement related to the impact of Gilgel GhibeIII Dam on the ecosystem of Lake Turkana.

The mode of land ownership is believed to have direct impact on protection of natural resources. The mainline argument is that private ownership encourages better management of resources. Close to two-third (63%) of the respondents endorsed the statement that "negligent destruction of forests in Ethiopia is due mainly to lack of clearly defined ownership rights" (Item No.2). A higher proportion (78.5%) of respondents agrees that "The ineffectiveness of traditional natural resource management systems is the root cause of environmental degradation in Ethiopia" (Item No.7). Environmentalists in Ethiopia often argue that the current use of natural resources in Ethiopia does not give due consideration to habitat loss associated therewith. Nevertheless, about two-third of the respondents endorsed the view that "at present, decisions on use of natural resources in Ethiopia are made taking full account of habitat loss" (Item No.20).

DISCUSSION

Values are widely believed to affect people's actions for good or bad. The value orientation of a person is highly likely to affect his/her beliefs about the consequences of attitude objects for the things a person values; and thus has consequences on that person's attitudes and behavior (Stern and Dietz, 1994). Values may act as filters for information, influencing beliefs by leading people to accept information selectively. Someone who values economic development above other social goals may be likely to accept information suggesting that environmental protection will compromise economic goals whereas someone who values the physical beauty of nature above other social objects may accept information that supports a belief that any environmental change is a threat to that value (Stern and Dietz, 1994). Similarly, an individual who holds strong egoistic or materialistic values tends to deny that human activities are harmful to nature. On the other hand, an individual who values the biosphere for its own sake tends to accept the proposition that human activities threaten natural systems (Stern and Dietz, 1994). This is, however, only one side of the matter. The relationship between value and action is often colored by many factors including cultural background and level of technological advancement.

In Ethiopia, the past two decades witnessed remarkable developments in promulgation of policies related to environment and development. A series of proclamations related to environment and sustainable development have been issued; and offices in charge of environmental protection established both at federal and regional levels. Furthermore, Ethiopia showed her unwavering commitment to building what she calls a 'climate-resilient green economy' (EPA, 2011). The country's plan to build a green economy comprises actions to reduce greenhouse gas emissions while safeguarding economic growth ("green economy") as well as adaptation initiatives to reduce vulnerability to the effects of climate change ("climate resilience") (EPA,

2011). Whether these and other policy provisions are used to improve the ways in which environmental- and sustainability issues have been addressed in Ethiopian institutions of higher education is not systematically investigated.

The study reported in this paper tried to see the ecological/environmental value orientations of prospective secondary school teachers enrolled at Addis Ababa University for a one year Postgraduate Diploma in Teaching program. The results show two very interesting trends. First, all the eight pro-NEP and the seven pro-DSP statements have been endorsed by the respondents albeit to a different degree. Second, the level of agreement with the two apparently contradictory groups of statements happened to be almost exactly the same (with an average of 67.1% endorsement for pro-NEP statements and strikingly equal level of endorsement of 67.4% for pro-DSP statements). In the first instance, the writer was bewildered by the results having a difficulty to internalize how the two apparently opposing views could be endorsed at the same time. Careful review of both the theory on value orientation and result of empirical studies conducted elsewhere shows that such a trend has not only a theoretical backing but also an empirical support.

Stern and Dietz (1994) make an important note that the major ecological value orientations, often presented as independent, are not mutually exclusive, that is, individuals may hold several orientations to some degree. They argue that those who believe human actions are having an adverse effect on the biosphere and who assign value to such effects are more, rather than less, likely than others to perceive and be concerned with adverse effects on human beings. Corral-Verdugo and Armendariz (2000), analyzed the covariances between factors to see whether the Mexican population studied held either a dualistic (NEP vs. HEP) or syncretic (NEP plus HEP) worldview. The highest values were obtained for the pro-NEP items “humans must live in harmony with nature” and “the balance of nature is delicate,” whereas the lowest values corresponded to the HEP statements “humans have the right to modify the natural environment” and “plants and animals exist primarily to be used by humans.” In general, the pro-NEP items elicited higher acceptance. Their study also showed a moderate level of agreement with the HEP among the participants" (Corral-Verdugo and Armendariz, 2000).

The study reported here, like the one by Corral-Verdugo and Armendariz (2000), shows that the prospective secondary school teachers hold a syncretic (NEP plus HEP) not a dualistic (NEP vs. HEP) worldview. In fact, a closer look at the patterns of responses to the five categories of value orientations shows that respondents had, on average, a pro-DSP worldview in four of the five categories. The only category where respondents had a pro-NEP view (no matter how marginal- an average of 55.5% endorsed pro-NEP) relates to 'possibility of eco-crisis'. In all other categories, the proportion of respondents who endorsed pro-NEP was less than 50% showing that, on average, the participants of this study were less concerned with 'fragility of natural balance', and 'limits to growth', and, on the other hand, are not willing to reject 'anthropocentrism' and 'human exceptionism'. In fact, the two statements which got more than 80% endorsement are both pro-DSP: "The earth has plenty of natural resources if we just learn how to develop them" (85.9% endorsement); and "humans have the right to modify the natural environment to suit their needs" (80.9% endorsement). At present, the most pressing concern in Ethiopia seems to be poverty eradiation (at any cost). This concern seems to be widely shared both by political leaders and religious fathers. The tendency to endorse anti-NEP worldview can also be seen from this angle. Hence a suggestion that communities characterized by local rather than global perspectives were less likely to reflect a pro-NEP perspective on environmentalism (Gooch, 1995; Watson and Halse, 2005).

Participants' responses to the additional statements, specifically related to Ethiopia, show a similar trend. On the one hand, half of the participants agree that the 'Gilgel Ghibe III Dam could reduce the flow of water into Lake Turkana thereby severely affecting the Lake’s ecosystem'; and, on the other, almost equal proportion endorsed the view that the 'hydropower projects in Ethiopia have no adverse impacts on their surrounding communities'. A similar contradiction is also to be seen in statements related to natural resource management. Close to two-third of the respondents agree that 'decisions on use of natural resources in Ethiopia are made taking full account of habitat loss'. An equal proportion endorsed the statement which suggests that Ethiopia lacks 'clearly defined ownership rights' and this is a cause for the negligent destruction of forests in the country.

Conclusion

Some researchers doubt whether the NEP questionnaire is the best instrument for accurately measuring environmental attitudes across cultures and communities (Corral-Verdugo and Armendarez, 2000; Watson and Halse, 2005). A study conducted in a Mexican city indicated, for instance, that individuals held both pro-NEP and pro-HEP attitudes at the same time, even though the conceptual framework underpinning the instrument would hold that these two paradigms are mutually exclusive. The study reported in this paper also shows that the Ethiopian respondents held both pro-NEP and pro-DSP worldviews, at the same time. One possible explanation for such a trend is believed to be the fact that the conceptual framework underpinning the NEP reflects a developed, western cultural perspective, and may not be adequate for assessing environmental attitudes in non-

western or developing countries (Corral-Verdugo and Armendarez, 2000; Watson and Halse, 2005). The findings of the present study thus seem to support the hypothesis that the NEP scale may not be adequate for assessing environmental attitudes in non-western or developing countries.

It is also appropriate to note here that the present day Ethiopia apparently harbors two contradictory views about environment and development (Aklilu, 2012). The first view seems to be highly concerned with the severe degradation of the natural environment and accuses past government policies on use of natural resources which led to massive destruction of forests and loss of fertile soil. Those who hold such a view seem to categorize the situation as hopeless and tend to believe that the country's natural environment is already degraded beyond recovery. The other view is not that pessimistic. It holds that it is still possible to treat and heal the degraded environment and achieve accelerated and sustained development. This is encapsulated by the 'green development' policy which calls for use of natural resources (e.g. water for irrigation and generation of hydroelectric power) so as to eradicate poverty and elevate the country to a middle income country in the next ten to fifteen years. Some of the potential negative impacts of such an accelerated and sustained growth are either downplayed or utterly denied. The tendency of the prospective teachers to endorse both pro-NEP and pro-DSP views can thus be seen against this backdrop.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Dimensions in rural water coverage and access in Akwa Ibom State, Nigeria

Jacob Atser[1]* and Peter U. Udoh[2]

[1]Department of Urban and Regional Planning Faculty of Environmental Studies, University of Uyo, PMB 1017, Uyo, Nigeria.
[2]Department of Architecture, Faculty of Environmental Studies, University of Uyo, PMB 1017, Uyo, Nigeria.

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This study examined the levels of rural water access and coverage in Akwa Ibom State, Nigeria. In Akwa Ibom State, there are two statutory bodies involved in water supply: Akwa Ibom State Water Company Limited and Akwa Ibom State Rural Water Supply and Sanitation Agency. Apart from these two statutory bodies, the federal government, United Nations Development Programme (UNDP), Exxon Mobil, and other foreign bodies are involved in rural water supply. This study explores the contribution of these bodies towards improved rural water coverage and access using scientific approach. Data on mini water schemes and hand pump boreholes in rural areas in the state were obtained from official records and utilized for analysis. The result indicated inequity in the location of projects. The distribution however does not conform to the clearly spelt out criteria for sitting of water schemes in the rural communities. With this distribution gap created by such chaotic pattern, it was apt to examine the level of access which also revealed that access to safe water in the state is grossly inadequate. At the state level, the coverage and access levels of 37.69 and 33.99% were observed. Four spatial factors were examined to ascertain their influence on rural water supply using correlation analysis and result singled out rural population to be highly significant correlated with the number of safe water points(r=0.678). This implies that about 46% of variance in safe water points in rural areas of the state is explained by rural population factor. It can be inferred that poor coverage and access to safe water facilities provide clear indicators of the state of poverty in rural areas of Akwa Ibom State and thus, call for urgent attention.

Key words: Water coverage, water access, rural areas, trends, dimensions, Nigeria.

INTRODUCTION

Water is one of the essential needs of man. Securing access to potable water supply is a central issue of concern not only in urban areas but much more in rural areas. The importance of water supply for domestic uses cannot be compromised not only because of its social and economic values, but also because water based sources of livelihoods have become critical to the survival and health of most rural households, providing valuable contributions to rural livelihoods (Bain et al., 2014). Water is therefore a very strategic socio-economic asset especially

*Corresponding author. E-mail: jacobatser@yahoo.com , jacobatser@uniuyo.edu.ng.

in poor economies where wealth and survival are measured by the level of an access to water. Water is an important element in the varied and complex social relations of production within which conflict between individuals and communities are bred. Therefore no nation, city or rural area can survive as an entity without access to sustainable water supply. Access to water supply is therefore one of the key factors that enhance the wellbeing of the rural households. Inaccessibility and unequal access to safe water supply can constrain the inclusiveness of growth and thus result in low standard of living among the rural people (Yange et al., 2013). In circumstances where access is denied, communities' as well as individuals standard of living and productivity becomes drastically reduced.

However, despite the critical role of water for social and economic development, only about 89% of the population had access to improved/safe drinking water supply in the year 2012 (WHO/UNICEF, 2014). This implies that that nearly one in every ten people worldwide have access to improved drinking water and as a result, millions of people, mostly children, still die yearly from diseases mainly associated with lack of access to safe water source (Bain et al., 2014). One of the millennium development goals (MDGs) targets is that by 2015 the proportion of people without sustainable access to safe drinking water should have been reduced by 50%. Perhaps the most frightening is the UNWWD Report (2006) which predicted that by 2050, at least one in every four people are likely to live in a country affected by chronic or recurring lack of access to safe water source. This calls for immediate and sustaining action amongst our policy makers and various stakeholders involved especially in rural water supply if we are to avert this menace.

Rural water coverage and access are terms that have been used interchangeably. However, the same term may have different meanings for different practitioners (Ross and Bostoen, 2010). According to WHO/UNICEF (2004), water coverage refers to the proportion of the population using improved sources of drinking water. It is based on the principle that an improved source of water is designed to deliver water to a certain number of people. Rural water coverage is often calculated by multi-plying the number of each safe water points by the number of people who should be served by those water points. However, coverage may not give accurate estimate of access due to functionality and distance to the water source(s). For example, it could be assumed that water point can serve a particular number of people but the number actually having access could be very different (IIDL, 2008).

The Ministry of Local Government and Housing in Zambia; defined access to water in rural areas based on the ability of people to collect at least a minimum of 25 liters of water per person per day for domestic purposes all year round, and also walk less than 500 meters to the water point (Village Water, 2010). This could be a good definition; however, it is important to note the length of time spent queuing at the water point. The Mozambique definition, for example, refers to a 30 min round trip including going to the water point, queuing, fetching the water, and returning home (Ross and Bostoen, 2010). However, WHO/UNICEF (2004) broadly defined rural water access as the availability of at least 20 L per person per day from an improved source within one kilometer of user's dwelling. The standard for Nigeria according to FGN (2000) is that access to rural water supply should guarantee minimum level of service, serving about 250-500 persons per point. WHO/UNICEF (2004) estimated that in Africa, the rural areas enjoy between 25-50% of rural water coverage. WHO/UNICEF (2014) estimates in 2012 indicate that Sub-Saharan Africa achieved 53% of safe water access while the rural water courage for Nigeria in the same year was 49%. It was against the background of poor water coverage that the federal government in the year 2000 came up with the following targets while emphasizing on the provision of sufficient potable water to all Nigerians in an affordable and sustainable way:

i) Improving service initial coverage of 40 to 60% by year 2003;
ii) Extension of service coverage to 80% of population by the year 2007;
iii) Extension of service coverage to 100% of the population in the year 2011; and
iv) Sustain 100% full coverage of water supply and wastewater service for the growing population beyond the year 2011.

Improved water sources are defined in terms of the types of technology and levels of services that are more likely to provide safe water than unimproved technologies. Improved water sources include household connection, public standpipes, boreholes, protected dug wells, protected spring and rainwater harvesting. Unimproved sources are unprotected wells, unprotected springs, vendor provided water, and bottle water (WHOSIS, 2008). It is emphasized here that potable/wholesome water is the same thing as safe water source as long as its availability is enough to guarantee water demand. The more reason bottled water is not considered as safe source unless there are other improved sources to compliment it. This research adopts safe water source instead of potable/wholesome to be in line with the current trend in public water supply.

Equitable and sustainable distribution of water supply facilities in our rural communities is very fundamental for guaranteeing rural water coverage and access. Population of a place is very fundamental when issue of water coverage is to be addressed whereas water access looks beyond population issue, where the water points are actually sited is also of paramount importance. This implies that for equitable distribution of safe water to our rural populace, coverage and access should be seen to

satisfy these tenets (Atser, 2012). Compromise to these tenets could likely result in under utilization, mismanagement and neglect of the facility. Nigeria has a water policy and rural water programs should be implemented in line to guarantee right to both coverage and access of safe water delivery especially in the rural communities of Akwa Ibom State. This research is concerned with investigating the extent to which water coverage and access is guaranteed in Akwa Ibom State.

Improving water coverage and access is not only imperative but more importantly, it is within the tenets of sustainable development, which according to the WCED (1987), is development that meets the needs of the present generation without compromising the ability of future generation to meet their own needs and is widely understood as either intergenerational equity principle or intra-generational equity principle. The overall aim is to eliminate poverty which Millennium Development Goals intend to achieve through equitable distribution of amenities such as right access to safe water. On this basis, sustainability has been added to equity in distribution (Haughton, 1998). Furthermore, Haughton while examining equity did not only based on how environmental "disamenities" such as pollution are distributed but also on environmental assets, in particular, the issue of inequitable access to environmental resources, such as water, remarked that many water developments failed to satisfy the basic distribution equity and environmental justice tenet; and that no groups, particularly the disadvantaged, should be made worse off in absolute or relative terms because of water policies. This issue has been taken care in the water policy of Nigeria and there is no discrimination between the rich and poor in rural and urban areas of the country. This is also linked to the research because the degree of success or failure in guaranteeing safe and sustainable water coverage and access to a large extent depends fully on the understanding of emphasis placed in this concept, which are some of the salient points the Nigeria water policy is anchored on.

The stratification of equity into horizontal and vertical dimensions still relates to two broad issues namely: the universality of needs (horizontal equity) and special or targeted supplies (vertical equity). For horizontal equity, everyone needs a particular basic necessity at some point where as vertical equity relates to targeting a specific supply to the needs of a special group such as the poor. The distinction between these situations still turns on the interpretation of need. In line with the benchmarks in Article 2 and 25 of the Universal Declaration of Human Right of 1992, access to domestic water supply services, of an acceptable level, is vital to human well being and dignity and is widely recognized as a human need and, therefore, a basic human right (Anan, 2003). It is therefore essential that coverage be universal. Contaminated water jeopardizes both the physical and social health of the people. It is an affront to human dignity. Once again, this recent definition of access to water as basic human need and right emphasized the responsibilities of governments and international community in the water sector to come up with a sustainable framework on water coverage and access without negating the tenet of distributional equity.

MATERIALS AND METHODS

Akwa Ibom State is the study area. It is one of the oil rich states in the Niger Delta Region of Nigeria. Located in the southeastern coast of Nigeria, Akwa Ibom State was created on September 23, 1987 from the former Cross River State of Nigeria. The State is wedged in between Rivers, Abia and Cross river States and the Republic of Cameroon to the Southwest, North, East and Southeast respectively while the Bight of Bonny bordered the State to the South. It lies between latitudes 4°32' N and 5°32' N; and longitudes 7°28' E and 8° 25' E. According to NPC (2007), Akwa Ibom State has a total land area of 6,187 km^2, which represents 0.67% of the total land mass of Nigeria. The State has 31 Local Government Areas with Uyo, Eket, Ikot Ekpene, Abak, Etinan, and Oron being the most developed urban centres (Table 1). According to the most recent National Population Census conducted in 2006, Akwa Ibom State had a total population of 3,920,208 persons out of which 87.89% constituted rural population while 12.11% formed the urban population (NPC2007). The most striking characteristic of the population of Akwa Ibom State is its crude density. When compared with other states in the south and southeastern parts of the country, the area is one of most densely settled state. Apart from Imo and Anambra States, Akwa Ibom State is the third most densely populated state with densities as high as 634 persons per square kilometer in Nigeria (NPC 2007).

In Akwa Ibom State, there are two statutory bodies involved in water supply. The first is Akwa Ibom State Water Company Limited which is charged with the responsibility of urban and peri-urban water supply while the second, Akwa Ibom State Rural Water Supply and Sanitation Agency has the mandate of rural water supply. Apart from these two statutory bodies set up by Akwa Ibom State Government, the Federal Ministry of Agriculture also intervenes in rural water supply in the state directly or through Cross River Basin Development Authority. There is also foreign collaboration with UNICEF and UNDP on rural water supply. Multinational oil companies like Exxon Mobil, Elf and Shell Petroleum Development are also involved in rural water supply in the state. Sometimes Local Government Administration extends their statutory function of maintaining the water schemes in their domains to direct execution of water supply projects. The research examined the dimensions in rural water schemes in the state in terms of coverage and access particularly that the level of coverage does not necessarily translates to the same level of access unless it is matched with population. Data on the total length of all the roads in the state and total area of all the 31 Local Government Areas in the state were obtained from the State Ministry of Works and Transport. Data on poverty index were obtained from the Akwa Ibom State Ministry of Economic Planning and Development. The data on rural population was projections from the 2006 census results. To compute water coverage, the following formula was used:

$$Pc = (ps / pp)\ 100\%$$

Where pc =%age water coverage, ps = Population served (500 as maximum number of persons to be served per one safe water point multiplied by the number of safe water points) and pp = projected population to year 2013.

For rural water access, different formulae were applied in computing the percentage rural water access for each LGA. The

Table 1. Population distributions in urban and rural Akwa Ibom State in 2013.

Local Government Area	Urban	Semi-Urban	Rural	Total
Abak	61826	18398	111528	191752
Eastern Obolo			24509	24509
Eket	64790	37962	42797	145549
Esit-Eket		32528	38739	71267
Essien Udim		18557	211865	229423
Etim Ekpo		17948	105642	123590
Etinan	32359	38357	88104	158720
Ibeno		20924	51956	72880
Ibesikpo Asutan		8875	143333	152208
Ibiono-Ibom			182264	182264
Ika			79294	79294
Ikono			162012	162012
Ikot-Abasi		23309	93234	116543
Ikot-Ekpene	100297	58971	12165	171433
Ini			125608	125608
Itu		13589	127327	140916
Mbo			118578	118578
Mkpat-Enin		18240	165219	183459
Nsit-Atai			78965	78965
Nsit-Ibom		32194	79808	112002
Nsit-Ubium		31852	98219	130071
Obot-Akara			114155	114155
Okobo		47091	75241	122332
Onna		108703	90457	199178
Oron	63819	14727	19637	98183
Oruk Anam			223276	223276
Udung Uko			40813	40813
Ukanafun		25699	12923	38622
Uruan		59070	81719	140789
Urue Offong/Oruko			54150	54150
Uyo	151566		71275	222841
State Total (%)	474657 (11.17)	626994 (15.55)	2924812(72.66)	4026463 (100.0)

Source: National Population Census 2006 projected to 2013.

basic assumption is that each safe water point is expected to service a maximum of 500 people within maximum distance of 250 m radius (FGN, 2000).

Ppc - Pp/Nc
Where Ppc = Average community population in a LGA; Pp = LGA population; Nc = Number of communities per LGA.

Wprc = Ppc/Tpwp
Where Wprc = Required water points per community in LGA; Tpwp= Threshold population for water point (500 persons)

Wprl = Wprc x Nc
Where Wprl = Required water points in LGA

Percentage access = (NSWP/WPrl) x 100

Where NSWP =Total number of water points found in LGAs Pearson correlation statistics was employed to investigate the relationships between spatial influences of the number of safe water points among the 31 Local Government Areas in the State using version 17 of Statistical Package for Service Solutions (SPSS) software.

RESULTS AND DISCUSSION

Table 2 shows the rural water coverage in the 11 Local Government Areas (LGAs) with its total population as rural and while Table 3 shows the access status in the same 11 LGAs adjudged as entirely rural. To analyze the rural water coverage in each of the LGAs, water per capita in each of the LGAs was calculated based on Nigeria water demand standard. This is based on the fact that each water point should be able to serve a maximum of 500 persons per day and delivers at least 30 liters of

Table 2. Analysis of rural water coverage for eleven rural LGAs in Akwa Ibom State.

LGA	Population	HPB	MWS	NSWP	Pop. served	% coverage
Eastern Obolo	24509	4	20	24	12000	48.96
Ibiono Ibom	182264	4	63	67	33500	18.38
Ika	79294	3	80	83	41500	52.34
Ikono	162012	5	84	89	44500	27.47
Ini	125608	8	70	78	39000	31.05
Mbo	18578	7	40	47	23500	19.82
Nsit Atai	78965	11	60	71	35500	44.96
Obot Akara	114155	17	70	87	43500	38.12
Oruk Anam	223276	19	70	89	44500	20.00
Udung Uko	40813	5	50	55	27500	67.38
Ureoffiong/Oruko	54150	9	50	59	29500	54.48

HPB= Hand pump borehole, MWS= Mini water schemes, NSWP= Number of safe water points.

Table 3. Percentage rural water access analysis for eleven rural LGAs of Akwa Ibom State.

NAME OF LGA	Pop	NC	Ppc	WPrc	WPrl	NSWP	% access
Eastern Obolo	24509	17	1442	3	51	24	47.06
Ibiono Ibom	182264	161	1132	3	483	67	13.87
Ika	79294	54	1468	3	164	83	50.61
Ikono	162012	79	2051	5	395	89	22.53
Ini	125608	79	1590	4	316	78	24.68
Mbo	118578	78	1520	4	312	47	15.06
Nsit Atai	78965	49	1612	4	196	71	36.22
Obot Akara	114155	61	1871	4	244	87	35.66
Oruk Anam	223276	108	2067	5	540	89	16.48
Udung Uko	40813	25	1633	4	100	55	55.00
Urue Offong Oruko	54150	37	1464	3	111	59	53.15

water per day per person (FGN, 2000). The maximum of 500 persons to be served by one safe water point was then multiplied by the total number of safe water points in each of the LGAs to arrive at estimated water coverage. This implies the expected population that water supply could meet their water demand given the right access. The percentage of this was then found with respect to the entire population of the LGA to give percentage coverage for coverage analysis and the result is in Table 2.

For rural water access analysis, the eleven LGAs adjudged by National Population Census of 2006 to be 100% rural were first considered. The idea of averaging the community approximate population was to enable application of 250 – 500 persons service standard per safe water point so as to arrive at required number of points for the respective communities which is to be used in calculating the number of points required in a particular LGA. With this the percentage access was then calculated by finding the number of water points within a community against the number of community in the LGA. Table 3 shows the analysis of percentage rural water access in the eleven rural LGAs.

There is an indication of inequity in the location of projects. The distribution however does not conform to the FGN (2000) which clearly spelt out criteria for sitting of water schemes in our rural communities. With this distribution gap created by such chaotic pattern, it is apt to say there is urgent need to correct the lopsidedness being observed. Similarly, the study also revealed that safe coverage in the state is grossly inadequate. Based on FGN (2000) which states that Nigeria should attend 100% full coverage of safe water supply for the growing population beyond 2011, many LGAs are still not able to meet the target. Even among the LGAs that are classified as urban, the attainment of 100% full coverage is still not achievable. There are 18 LGAs with coverage range of 18 – 40% with Ibiono Ibom LGA being the least with coverage level of 18.38%. Few LGAs that had coverage levels above 70% are those LGAs having peri-urban and urban centres and these are Eket, Ikot Ekpene and Ukanafun. Probably all the water points could not be said to belong entirely to the rural areas and vice versa. A total of 12 LGAs had coverage levels of between 41 to 69% while only 3 LGAs had coverage levels of 70% and

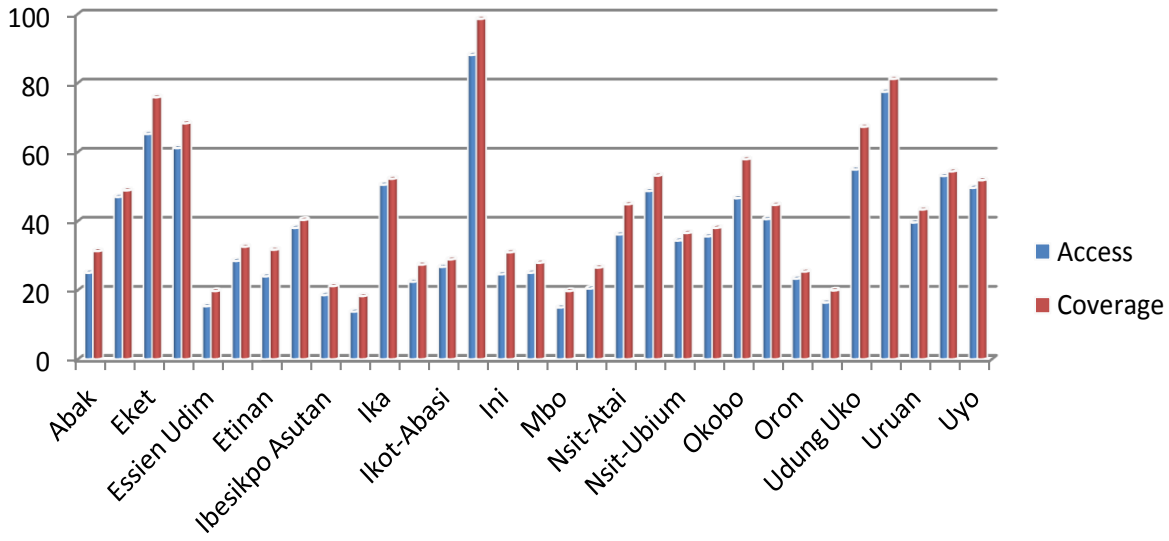

Figure 1. Rural water coverage and access relationship among the LGAs.

above (Figure 1). Table 4 shows the dimensions in rural water coverage and access for the entire state. The data in Table 4 were utilized to examine the relationship between rural water access and coverage as illustrated graphically in Figure 1. The R-square coefficient value of 0.979 indicates that about 98% of access level relate to coverage levels. This implies that improving coverage levels would indirectly impact positively on access to safe water points. Water coverage has spatial connotation and therefore could improve access. The result of poor access revealed in this study is a good pointer to policy makers and various stakeholders to reflect on the design and implementation of mini water schemes in the state with emphasis given to water distribution.

Based on FGN (2000) rural water access benchmark no LGA could rightly be said to have access to safe water. Ikot Ekpene had what could be regarded as the highest precent age water access of 88.20% and closely followed by Ukanafun (77.51%) while Ibiono Ibom had the least access level (13.87%). A comparison of water access with coverage even revealed more water access problem among the LGAs. In ideal situation and given the right framework, water generated should be equal to water access (FGN, 2000). That is to say that the volume of water generated must be distributed proportionately in accordance with the standard stipulated by FGN (2000) before coverage could be equated to access. A situation where many inhabitants and communities have to travel long distances (more than 30 min) as well as queue for water, irrespective of the number of water points within the water headwork does not add any special advantage but rather creates access problem. For a community to have access to water, it therefore means that the households within the community should travel a maximum distance of 250m to fetch water and each water points should not serve more than 500 persons per day (FGN, 2000). Thus, if the number of water points were said to be evenly distributed across the community such that no individual would travel more than 250 m, then such area would have met the required access target.

In Table 5, four spatial factors were examined to investigate their influence on number of safe water points among the LGAs. The choice of these factors was based on their relative importance. Road infrastructure is the artery of major developments, that is, road infrastructure is preceded by other developments. This implies that where a road goes, development follows. Mini water schemes are provide using heavy motorized driller equipment and as such the more motorable the LGA is in terms of road network, the more the potentials for the provision of mini water schemes. All the four independent variables are surrogate to rural development. The poverty index as well as rural population is good indicators of the level of water accessibility. It is expected that poverty incidence is low among households and communities that have improved access to water supply while areas with high rural population should have more safe water points than those with less population. However, the result as presented in Table 6 and Figure 2 shows that only the rural population factor highly significant correlated with the number of safe water points in the state ($r = 0.678$, $p < 0.001$), implying that about 46% of variance in number of safe water points is explained by rural population. The area (0.402) and road (0.280) factors though positively related, had weak influences on water supply going by their R-square values of 16.2 and 8.0% respectively. The poverty index factor however shows negative symptoms (-0.130) of relationships which is expected. The higher the index factor, the lesser the number of safe water points. This relationship is however very weak accounting

Table 4. Water supply coverage and access in rural Akwa Ibom State.

LGAs	Rural pop	HPB	MWS	NSWP	%access	% coverage
Abak	111528	10	60	70	25.11	31.40
Eastern Obolo	24509	4	20	24	47.06	48.96
Eket	42797	10	55	65	65.30	75.94
Esit-Eket	38739	3	50	53	61.22	68.40
Essien Udim	211865	12	72	84	15.44	19.82
Etim Ekpo	105642	9	60	69	28.55	32.66
Etinan	88104	12	44	56	24.07	31.78
Ibeno	51956	3	39	42	38.11	40.42
Ibesikpo Asutan	143333	6	55	61	18.66	21.27
Ibiono-Ibom	182264	4	63	67	13.87	18.38
Ika	79294	3	80	83	50.61	52.34
Ikono	162012	5	84	89	22.53	27.47
Ikot-Abasi	93234	14	40	54	26.82	29.00
Ikot-Ekpene	12165	5	19	24	88.20	98.64
Ini	125608	8	70	78	24.68	31.05
Itu	127327	1	70	71	25.11	28.00
Mbo	118578	7	40	47	15.06	19.82
Mkpat-Enin	165219	10	78	88	20.54	26.63
Nsit-Atai	78965	11	60	71	36.22	44.96
Nsit-Ibom	79808	5	80	85	48.80	53.25
Nsit-Ubium	98219	10	62	72	34.44	36.65
Obot-Akara	114155	17	70	87	35.66	38.12
Okobo	75241	7	80	87	46.71	58.00
Onna	90457	15	66	81	40.66	44.77
Oron	19637	1	10	11	23.41	25.46
Oruk Anam	223276	19	70	89	16.48	20.00
Udung Uko	40813	5	50	55	55.00	67.38
Ukanafun	12923	8	13	21	77.51	81.25
Uruan	81719	1	70	71	39.67	43.44
Urue Offong/Oruko	54150	9	50	59	53.15	54.48
Uyo	71275	4	70	74	49.71	51.91
State Total (%)	2924812(72.66)	238	1750	1988	33.99	37.69

for only 2% of the variance in the number of safe water points across the state.

RECOMMENDATIONS AND CONCLUSION

There is a need for the statutory government organs to interface with stakeholders involved in rural water programs to maintain a robust spatial database which amongst other things should include hydrologic parameters of all their water programs. This will aid in design, costing and execution of rural water projects. The redesign of the mini water schemes should be looked into. Concentration of the water points at the headwork does not help to address the issue of water access. Steps should be taken to reduce the widening gap between water points away from immediate confines of the headwork but within the limit of hydraulic head. By the year 2015, the target year of MDGs to increase access of population by 50% to safe water, Akwa Ibom State rural population will still be left behind. The result of this research has revealed very low access in the rural communities of Akwa Ibom State. There is urgent need for Akwa Ibom State Government, at least for interim measures, to harness other sources of water to complement groundwater. Effort should be made to explore the possibility of rainwater harvesting and utilization. Some parts of China with annual rainfall less than 500mm have utilized rainwater potentials to balance her water needs, so the lesson from other developing countries' experiences and international collaboration are very important (Yang et al., 2013). Water quality in our numerous streams should be looked into and improve upon as the case may be to serve as a stop gap in those

Table 5. Underlying factors for rural water supply in Akwa Ibom State.

L.G.A	Total Length (Km)*	Area (Km^2)*	Poverty index**	Rural population***	NSWP
Abak	152.4	252	83.64	111528	70
Eastern Obolo	141.0	117	50.82	24509	24
Eket	218.5	175	78.31	42797	65
Esit Eket	41.0	164	49.74	38739	53
Essien Udim	364.0	295	56.67	211865	84
Etim Ekpo	189.9	235	59.58	105642	69
Etinan	214.2	182	30.81	88104	56
Ibeno	19.0	248	53.37	51956	42
Ibesikpo	501.0	191	75.13	143333	61
Ibiono Ibom	273	333	26.88	182264	67
Ika	97.2	68	45.93	79294	83
Ikono	150.3	390	43.98	162012	89
Ikot Abasi	318.6	335	45.33	93234	54
Ikot Ekpene	216.9	115	36.59	12165	24
Ini	129.0	320	41.21	125608	78
Itu	193.0	273	39.79	127327	71
Mbo	83.6	335	56.18	118578	47
Mkpat Enin	393.0	332	45.61	165219	88
Nsit Atai	174.0	101	77.04	78965	71
Nsit Ibom	194.1	109	69.35	79808	85
Nsit Ubium	202.5	243	45.23	98219	72
Obot Akara	75.0	227	59.38	114155	87
Okobo	77.5	360	46.48	75241	87
Onna	291.3	174	45.70	90457	81
Oron	59.8	96	66.67	19637	11
Oruk Anam	449.9	512	30.96	223276	89
Udung Uko	113.5	64	90.36	40813	55
Ukanafun	223.4	254	67.20	12923	21
Uruan	356.0	422	71.36	81719	71
Urue Offong	121.6	118	77.89	54150	59
Uyo	253.9	249	68.75	71275	74

Sources: *Atser (2012), **Akwa Ibom State Ministry of Economic Planning and Development (2013); ***National Population Census 2006 projected to 2013.

Table 6. Correlations.

Parameter		Road	Area	Poverty index	Rural Pop
NSWP	Pearson Correlation	0.280	0.402*	-0.130	0.678**
	Sig. (1-tailed)	0.064	0.012	0.244	0.000

*Correlation is significant at the 0.05 level (1-tailed). **. Correlation is significant at the 0.01 level (1-tailed).

communities that are in dying need of safe water source (Bain et al., 2012). In conclusion therefore, sustainable rural water coverage and access for Akwa Ibom State cannot be overemphasized. Thus for rural water coverage and access to be sustainable, creation and maintenance of efficient and up-to-date database containing vital information is essential. Also, rural communities in the state are still far from attaining the

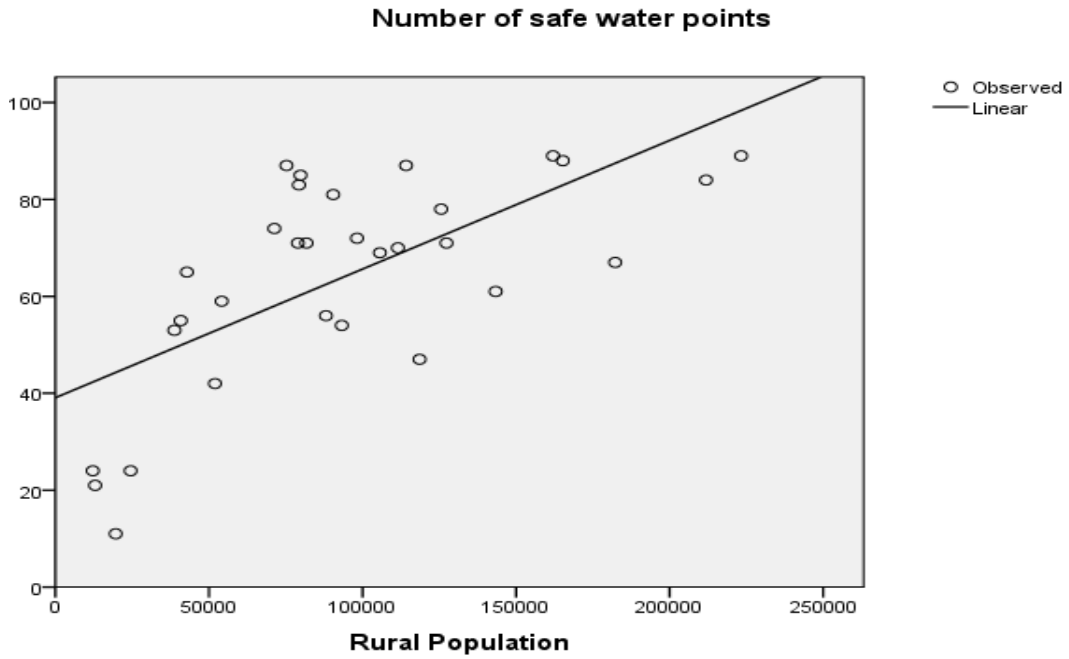

Figure 2. Relationship between rural population and safe water points.

100% coverage target as specified in Nigeria water policy. In some areas, more safe water points are generated or covered but only to be poorly distributed or accessed.

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Full Length Research Paper

An assessment of flood vulnerability on physical development along drainage channels in Minna, Niger State, Nigeria

Musa Dalil[1]*, Nda Hauwa Mohammad[2], Usman Mohammad Yamman[3], Abdul Husaini[4] and Sanni Lekan Mohammed[1]

[1]Department of Urban and Regional Planning, Federal University of Technology, Minna, Niger State, Nigeria.
[2]Government Reserve Area, Minna, Niger State, Nigeria.
[3]Department of Urban and Regional Planning, The Federal Polytechnic, Bida, Niger State, Nigeria.
[4]Niger State Geographic Information Systems, Minna, Nigeria.

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The occurrence of floods and its effects on human existence as well as the general environment has unfortunately been on the increase owing to human-induced climate change. Consequently, the vulnerability of the poor and the downtrodden has also increased; therefore the need to embark on sustainable human settlement development as well as awareness creation on the effects of flooding. As a result of this, this paper set out to analyze the causes of flooding in parts of Minna, with a view to providing solutions to forestall its impacts along the channels of River Suka. In order to achieve this, secondary as well as primary sources of data collection such as questionnaire administration and reconnaissance survey were undertaken. The data obtained from the questionnaires were analysed using the descriptive statistical method while the topographic and land use maps of Minna were digitized using the ArcView GIS package, which enabled the mapping of the Flood Risk Vulnerable Areas in Minna, Niger State. The result shows that human activities like construction on the flood plains, poor drainage network and relief of the area are primarily responsible for the perennial floods along the bank of River Suka. To this end, it was recommended that sensitization campaigns should be embarked upon by the government and stakeholders in order to create public awareness to the likely effects of flooding. The paper also recommended the monitoring by authorities, of water levels during the raining season, thereby allowing for the transmission of warning signals to the residents of the flood plains.

Key words: Drainage channel, flood, risk assessment, vulnerability.

INTRODUCTION

Natural disasters have been a regular occurrence globally right from time immemorial; but its frequency and intensity have, in the recent past, increased due to human activities. It is therefore the developmental choices (actions or

*Corresponding author. E-mail: dalilmusa@gmail.com.

inactions) made by individuals, communities and nations that pave way for disasters, which are unequally distribute (Ladan, 1998). The negative effects of which are debilitating and multifaceted, ranging from the destruction of the ecosystem, agricultural activities, infrastructural facilities and amenities, injury, illness, death, inhibition of access to education, health services, comfortable housing, drinking water and sanitation, aggravation of poverty and hunger, among others. One of such natural disasters is flooding, and it is usually associated with some social, economic, and environmental consequences (Queensland Government, 2014) that critically threaten the ecosystem and human existence. As a result of this, meeting some of the Millennium Development Goals (MDGs) has extremely been challenged in many communities, especially those of the less developed countries.

Flooding, according to *Geoscience Australia* (2013) can simply be described as “water where it is not wanted”. It can also be conceptualised as a situation that results when a part of the earth surface that is usually dry is inundated and covered with water due to high amount of rainfall or the overflowing of a water body. Furthermore, flooding was expounded by *pagasa.dost* (2013) as a “natural hydrological phenomenon and its occurrence is usually the aftermath of metrological events such as seismic activities, astronomically influenced phenomena (high tides coinciding with occurrence of high rainfall), construction of temporary dams, as well as the failure of hydraulic and other control structures.” The effects of floods are always debilitating, though their intensity and scope vary depending on terrain, intensity of human activities, quantum of water and the level of prepared-ness by the stakeholders.

Flooding, especially River flooding are among the most devastating natural disasters in the world, claiming more lives and causing more property damage than any other natural phenomenon (Abubakar, 1993). Though not the leading cause of death in Nigeria, but it affects and displaces more people than any other natural disaster (Usman, 2012). Therefore, there is the need to understand, prevent, prepare for, and mitigate its effects by authorities concerned, especially in developing countries. This has now particularly become rife due to the rapid urbanisation and population growth experienced in developing countries, which often results in increased population concentration in unplanned environment. Consequently, Ishaya et al. (2009) opined that identifying areas that are vulnerable to flooding as well as collecting and analysing information on the “elevation, slope orientation, proximity of built-up areas to drainages, network of drains, presence of buffers, extent of inundation, cultural practices as well as attitudes and perceptions” are the most effective means of ensuring flood preparedness and risk reduction.

Owing to this therefore, there is always the need for the production of maps of flood risk zones with a broad range of functions capable of manipulating both spatial and attribute data (Abah, 2013). Daffi et al. (2014) stated that although “conventional traditional methods can be used for flood hazard assessment, the use of remote sensing and geographic information system techniques have been suggested to provide quick, efficient and effective results as investigated and documented by Balanova and Vassilev (2010), Damayanti (2011), Kafle et al. (2006), Salimi et al. (2008), Ahmed et al. (2010) and others.” In view of the foregoing therefore, this paper sets out, with the aid of Geographic Information System (GIS), to map flood prone areas of Minna, as well as analyze the causes of flooding in parts of Minna.

The aim of this study was to analyze the causes of flooding in parts of Minna with a view to providing solutions to developmental challenges along the channels of River Suka. This has been achieved through the following objectives: i) Analyze the causes of flooding along the River channel;ii) Identify the areas at risk in the study area and; and iii) Map the flood prone areas using the GIS technique.

The study area

Minna is located between latitude 9° 36'22''N and longitude 6° 33'l 5''E; and it is situated on a geographical base of undifferentiated basement complex of much gneiss and magnetic. The town is drained by many drainage channels, with the main course of River Chanchaga taking its source from the north central highlands and thereafter, flowing towards the western lowlands before meeting River Kaduna at a point south west of Minna. Its main tributaries include Rivers Wana, Shaho, Godina, and Dunalape, which are flowing from their respective highlands and isolated compounds such as Gwam, Kpewi, Zuru, and Tsauran Nabi hills.

The study area is located in a tropical climate region which is characterized by two seasons in a year, the wet seasons and dry seasons. The annual rainfall received within the region is less than 1000 mm in the wet season and it lasts between May and October with a maximum downpour between the months of July and September. The dry season lasts between the month of October and March. Temperature varies within the region annually, with the dry season having low temperatures because the sun is at the southern hemisphere. Thus minimum temperatures of below 30°C are recorded during the harmattan period, which is late December and January in the following year, and its maximum temperature often do not exceed 42°C. During the wet season, the sun moves northwards from the equator to the tropics of cancer. This results in high temperatures because the sun overheads at noon.

METHODOLOGY

The data used for the study which included the research design and techniques were obtained through both the primary and secondary sources.

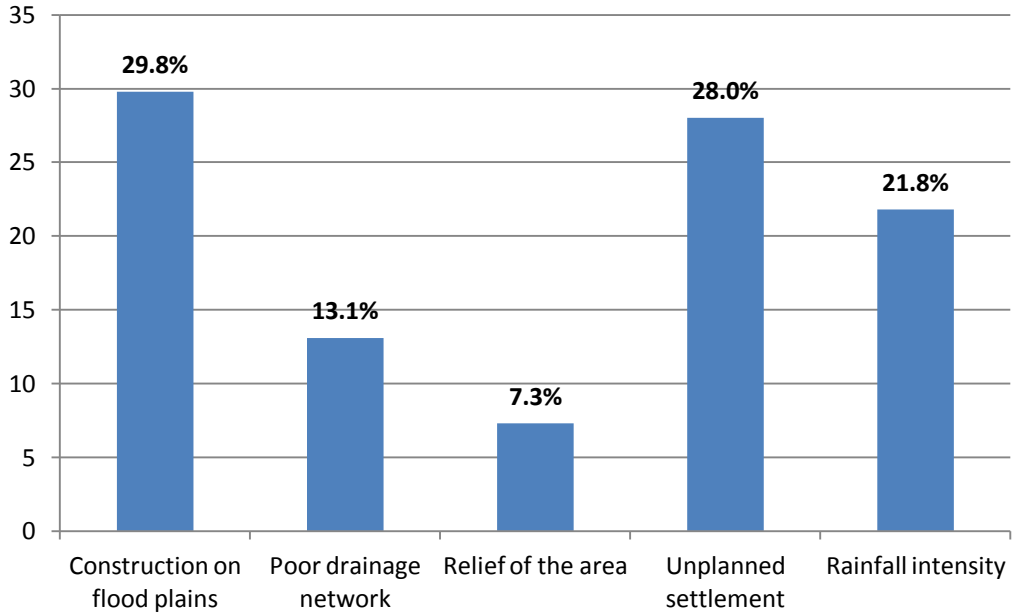

Figure 1. Causes of flooding along River Suka.

Primary and secondary data collection

The primary data used for the study were obtained through questionnaire administration and reconnaissance survey, where the Global Positioning System (GPS) and digital camera were robustly used. The questionnaires sought to feel the pulse of the respondents on the causes of flooding as well as the flood control measures adopted by the residents of the study area, while the reconnaissance survey allowed for the independent assessment of the effects of flooding in the study area, taking snapshots of objects of interest to the study using the digital camera and the delineation of flood plains with the aid of the GPS which aided the production of the flood risk vulnerable areas map of Minna, Niger State whereas the secondary data used were basically obtained from internet materials and journals, as well as the topographic and land use maps of Minna obtained from the Niger State Ministry of Lands and Housing, Minna.

Sampling technique

For the purpose of this study, a total of 350 households were randomly selected (using the random number table) within the areas declared as flood-prone by the Niger State Emergency Management Agency (NSEMA). This meant that all surveyed households were at risk, but due to local topographic effects and construction of drainage channels, not all households had been flooded. Responses from 275 households were filled and returned appropriately, giving an overall response rate of 78.6%.

Data analysis

The data collected from the field was coded and analyzed using the Statistical Package for Social Sciences (SPSS), and presented with the aid of descriptive statistics. Also, in order to create a map of flood risk vulnerable areas of Minna, the ArcView GIS package was used to digitize the topographic and land use maps of Minna. GIS Thereafter, the maps were spatially superimposed with the aid of to create a Flood Risk Vulnerable Areas in Minna, Niger State.

RESULTS AND DISCUSSION

Floods usually occur along the bank of River Suka when Minna records an unprecedented amount of precipitation or when the river is inundated by high amount of water from upstream. But its effects can be mitigated or eliminated through drainage construction, which unfortunately does not cover the entire length of the study area (Figure 2); thus areas without constructed drainages are more prone to flooding and erosion, and they as well, do not have well laid setbacks (Plate 1 and 2) when compared to those with constructed drainages (Plate 3 and 4). Therefore, flooding along parts of the bank of the river is inevitable, and this has been compounded by the reduction in the depth and width of parts of the River course due to sediments deposition resulting from the myriads of human activities taking place along the course of the River. But in order to feel the pulse of the household members residing on the floodable areas of Minna, they were asked to state the single most likely cause of flooding being experienced in their area. As shown in Figure 1, 29.8% of the respondents stated that construction on flood plains are the causes of flooding in Minna, 28.0% adduced it to the problem of unplanned settlements, whereas 7.3% of the respondents stated that relief was responsible for flooding. The usually varying opinions as regards causes of flooding was expounded in Kofo (2012), but the study conversely asked the residents of Lagos metropolis to state as many causes of flooding as possible in their neighbourhoods. The result showed that “torrential rains (94.10%), filled/silted/dirty drainage channels (87.15%), blocked canals (97.55%), inadequate drainage channels (94.30%), non-compliance with Environmental Laws(81.45%), and nature of the physical

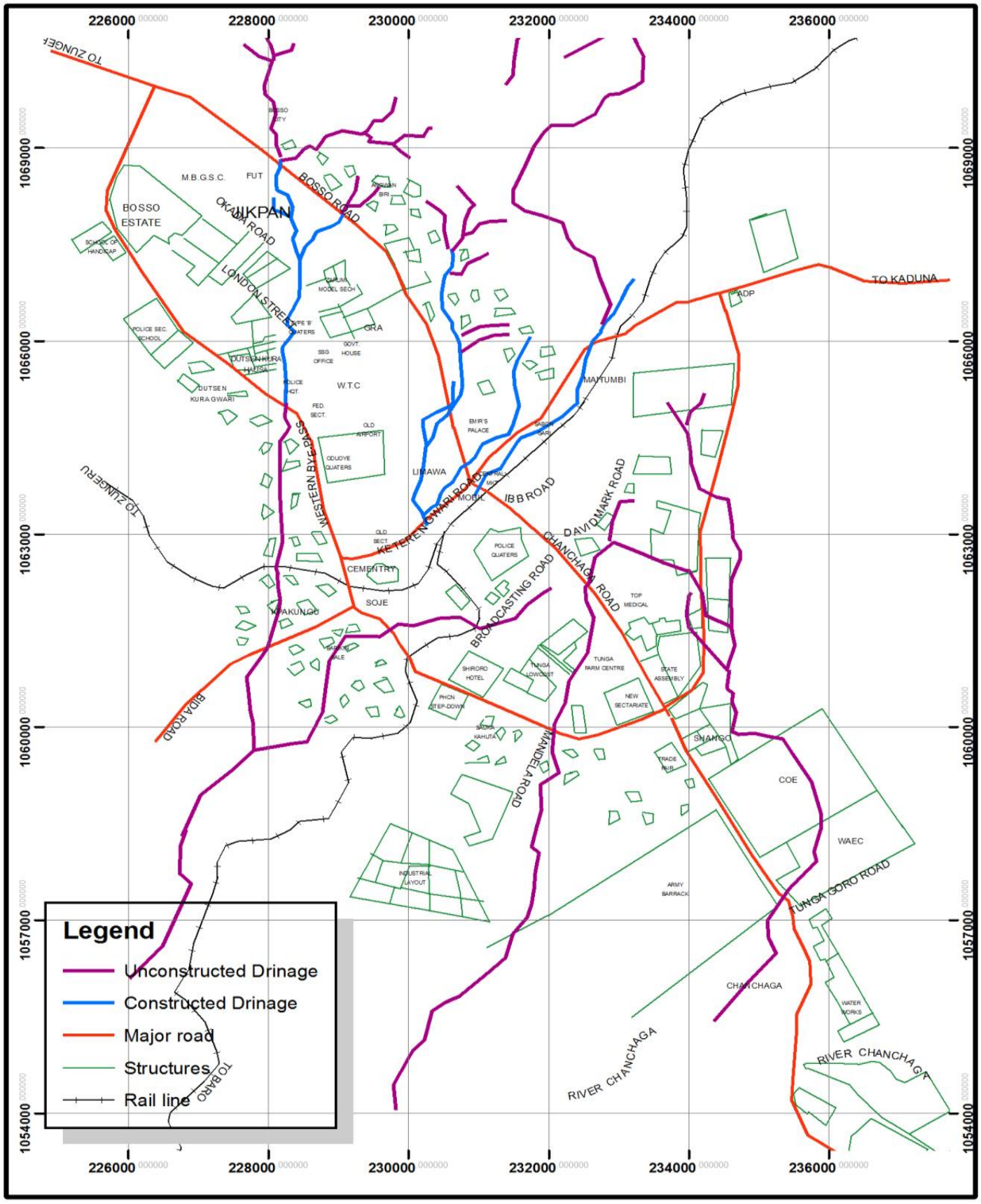

Figure 2. Constructed and unconstructed drainage channels in Minna.

Plate 1. The drainage channel that passes through Kpakungu area of Minna.

Plate 2. Human activities along the drainage channel in Soje area of Minna.

Plate 3. The drainage channel along Sabon Gari area of Minna.

Plate 4. The drainage channel along Kateren Gwari area of Minna.

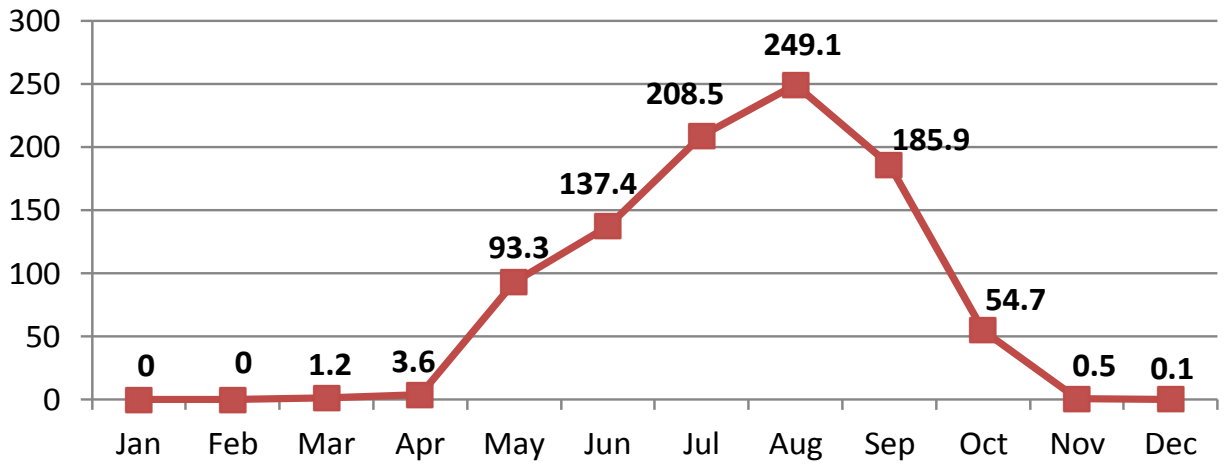

Figure 3. Rainfall pattern in the study area (in mm). Source: Nigerian Metrological Agency.

terrain (90.55%), planlessness (88.95%) and encroachment on drainage channels (90.90%)" were adduced as the causes of flooding in Lagos. Also, the residents of Minna residing along the bank of River Suka also confirmed that there are usually some negative environmental, economic and social problems that results from flooding in the study area. This apprehensive state of affairs was elaborated in Ajayi et al. (2012) which cited different sourcing as stating that over the years, flooding in the watersheds of Ogunpa and Kudeti streams in Ibadan, South West Nigeria has resulted in the loss of hundreds of lives and properties worth millions of Naira.

Rainfall variability of the study area (2002-2011)

The mean monthly discharge of a 10-year period ofMinna was obtained from the Nigerian Metrological Agency in order to analyse the monthly variability of the rainfall pattern. The result of the analysis shows that the study area experiences about 933 mm of rainfall per annum, with about half of that occurring between the months of July and August every year. Consequently, the residents of the flood-prone areas confirmed that the chances of flood occurring are usually higher between the months of July to October, as presented in Figure 3. This is in tandem with that of Makurdi, Benue State, Nigeria as expounded by Ologunorisa and Tersoo (2006); the study pointed that the outcome of seasonal variability of rainfall between 1979 and 2004 shows that the month of August recorded the highest amount of rainfall with 36.43% of the total, June (21.39%), September (20.43%) and July (19.67%).

Identifying flood prone areas using GIS

As earlier mentioned, the GIS technique was adopted in identifying the flood prone areas in Minna. Parts of Soje towards Makera, down to Kpakungu were identified as risk areas, as well as parts of Bosso due to lack of proper drainage channels. Downstream of Keteren Gwari towards River Suka was also identified as risk area due to un-constructed drainage channel and human activities along the River channel. Settlements around new extension of Farm Centre, down to some areas around Mandela road were also identified as risk areas, including parts of Shango and Chanchaga, as presented in Figure 4. Also in a study by Ikusemoran, Anthony and Maryah (2013) which aimed at assessing flood risk and vulnerability of communities in the Benue Floodplains, Adamawa State, Nigeria using the GIS method, the flood vulnerability map was developed through the use of Geo-information techniques which involved the use GPS to capture the studied communities which were consequently linked to a generated digital map of River Benue valley using ArcGIS software to assess each of the communities for flood vulnerability.

Flood control methods adopted by the residents

In the course of the research work, the following were discovered to be the local flood control methods adopted by the residents of the flood-prone areas of Minna: Opening up of new water channels and the construction of drainages; Evacuation of debris from existing drainages and; the use of sand bags to block excess water from reaching residential areas.

Conclusion

The challenges of reducing the risk of floods in the rapidly increasing global urban population in the face of vagaries of the weather due to climate change and dwindling economic fortunes has attracted enormous attention from

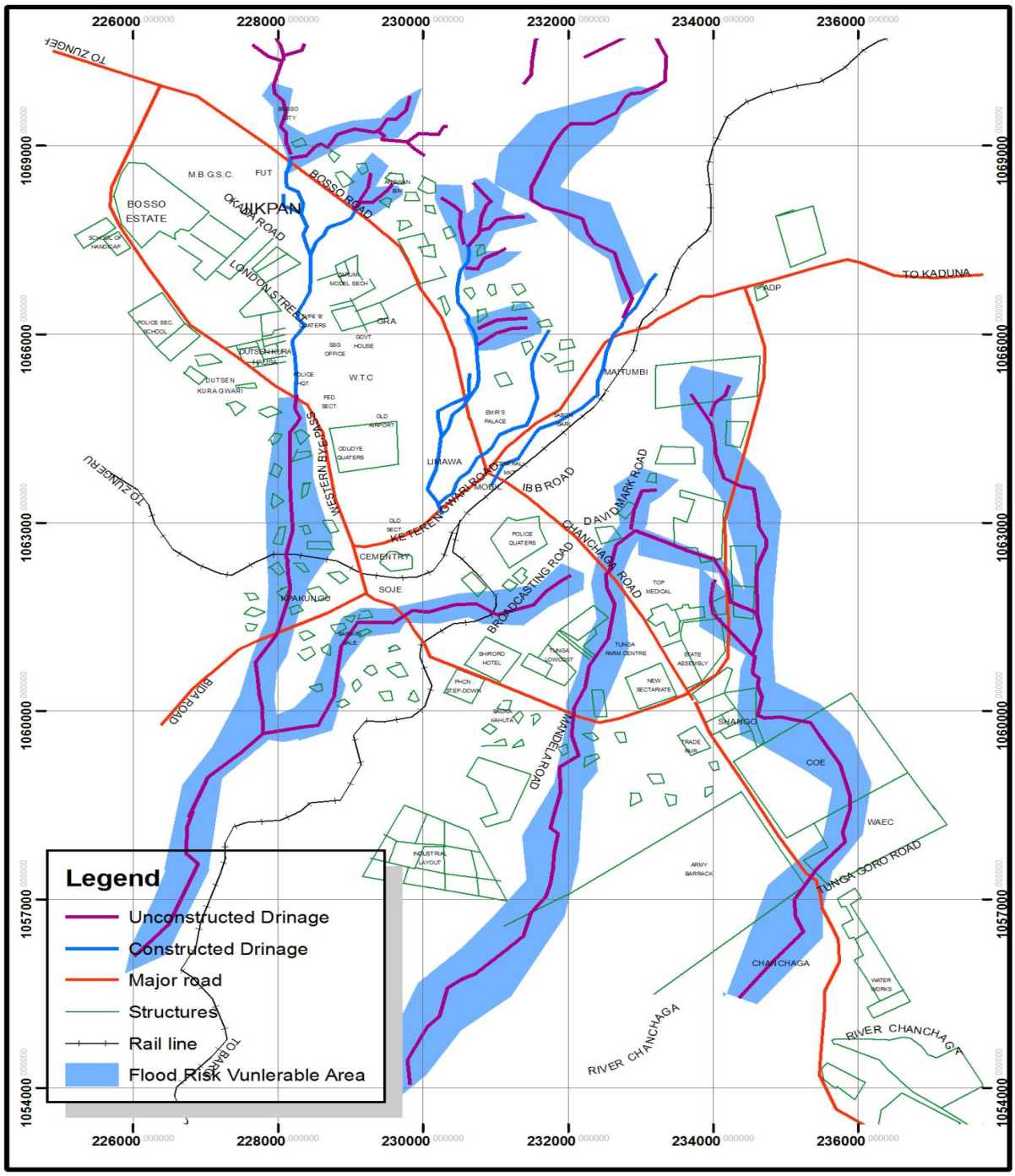

Figure 4. Flood Risk Vulnerable Areas in Minna, Niger State.

the international community, especially as regards achieving the sustainable human settlement development and the MDGs. Therefore, the need to assiduously tackle the problem of flooding through systematic physical planning approach and enlightenment campaigns, as well as the convocation of regular stakeholders' meeting for the purpose of stock taking. This, is believed, would enhance the capacity of communities in preparing for and tackling the likely occurrences of flooding.

Recommendations

In order to effectively ensure that the effects of flooding are less felt in the flood-prone parts of Minna, the following recommendations have been advanced:

1) Embarkment on sensitization campaigns in order to create public awareness on the need to understand, prevent, prepare for, and mitigate the likely effects of flooding;
2) The monitoring by authorities, of water levels during the raining season, thereby allowing for the transmission of flood signals to the residents of the flood plains and;
3) The restriction of human activities along the floodable areas of Minna by the Physical Planning Agency.

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Species composition and biomass of annelids of Wular Lake, a Ramsar site in Kashmir, India

Rafia Rashid*, Ashok Kumar Pandit and Sami Ullah Bhat

Department of Environmental Science/Centre of Research for Development, University of Kashmir, Srinagar-190 006, Kashmir India.

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During the present investigation of Wular lake in terms of species composition and biomass of annelids, 10 taxa were recorded which belonged to two major classes namely Oligochaeta (7) and Hirudineae (3). The class Oligochaeta included *Limnodrilus hoffmeisteri*, *Tubifex tubifex*, *Branchiura sowerbyii, Nais* sp., *Aelosoma* sp., *Pristina* sp. and an unidentified taxion. Similarly, the class Hirudinaea was comprised by *Erpobdella* sp., *Placobdella* sp. and *Glossiphonia* sp. The seasonal mean value for biomass of annelids fluctuated between 0.31 g/m^2 at site I in winter to 14.92 g/m^2 at site III in summer. The annual mean biomass was highest at site IV (10.82±2.02 g/m^2), followed by site III (10.47±2.07 g/m^2), site II (8.94±1.90 g/m^2), site I (1.85±0.94 g/m^2) and site V (1.71±0.50 g/m^2).

Key words: Biomass, species composition, annelid, Lake and Ramsar site.

INTRODUCTION

In an aquatic ecosystem the life of aquatic biota is closely dependent on the physical, chemical and biological characteristics of water that directly acts as a controlling factor (Yaqoob and Pandit, 2009). Macrozoobenthos is an important constituent of aquatic ecosystem and has functional importance in assessing the trophic status. Thus as the abundance of benthic fauna mainly depends on physical and chemical properties of the substratum, the benthic communities are known to respond to changes in the quality of water or habitat. The benthic macroinvertebrates are associated with bottom or any solid liquid interface, which includes a heterogeneous assemblage of organisms belonging to various phyla like Arthropoda, Annelida, Mollusca and others. The benthos occupies an important position in the lake ecosystem, serving as a link between primary producers, decomposers and higher trophic levels (Pandit, 1980). They also play an important role in the detrital food web which in turn affects the cycling of minerals (Gardner et al., 1981). Macroinvertebrates are used as indicators of pollution as their communities change in response to changes in physicochemical factors and available habitats (Sharma and Chowdhary, 2011). According to Jumppanen (1976) the first signs of eutrophication and pollution in a lake are reflected in the benthic flora and fauna as the suspended waste immediately sink to the bottom to decompose and thus cause a change in the benthic composition and abundance. The lakes and wetlands having soft bottom sediments are characterized by annelids either as the dominant or one of the most abundant group. Of the fresh water annelids,

*Corresponding author. E-mail: rafiarashid11@gmail.com.

Table 1. Geographical coordinates of the five study sites

Sites	Latitude	Longitude	Altitude (m) (a.m.s.l)
Vintage	34° 21' 56.9" N	74° 39' 42.0" E	1583
Ashtung	34° 24' 3.8" N	74° 32' 41.7" E	1580
Watlab	34° 21’ 29.4” N	74° 31’ 48.2” E	1581
Makdomyari	34° 20’ 39. 2” N	74° 34’ 52.2” E	1579
Ningle	34° 17’ 74.31”N	74° 31’ 29.8” E	1578

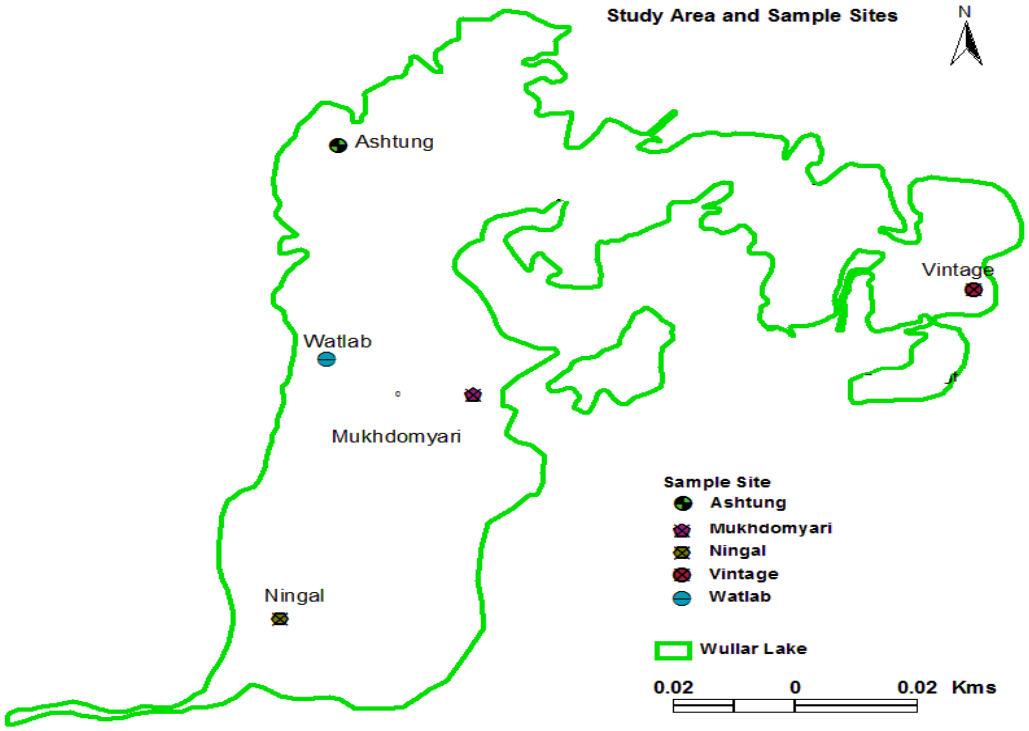

Figure 1. Map showing the study sites of Wular lake.

the oligochaetes display the greatest diversity and have the greatest indicator value. Oligochaetes worms are diverse and occur in a wide spectrum of freshwaters from unproductive to extremely eutrophic lakes and rivers. Leeches are found in warm water of shallow standing sites (Peckarsky et al., 1990) and are generally pollution tolerant. Oligochaeta, especially the Tubificidae family, have been universally applied on bioassessment assays, as bioindicators to reflect the organic pollution (Lin and Yo, 2008). This is because their capacity to increase in number with increasing organic matter, replacing other benthic macroinvertebrates, less tolerant for this condition (Schenkova and Helesic, 2006). It is in the backdrop of paucity of researches on Wular Lake, the largest freshwater body of Indian subcontinent, being recognised as a Ramsar Site, that the present study on community structure and biomass of annelids has been undertaken during 2012.

MATERIALS AND METHODS

Study area and study sites

Wular lake is the largest freshwater lake of Indian subcontinent, located in the flood plains of Jhelum river with an open water area of 24 km^2 (Pandit, 2002). The rural valley lake in the north-west of Kashmir extends from Bandipore to Sopore and is at a distance of about 54 km from Srinagar city and is situated at an altitude of 1,580 m (amsl), lying between 34°16´-34°20´N latitudes and 74°33´-74°44´E longitudes. The lake is mono-basined, elliptical in shape and is of fluviatile origin, formed by the meandering of Jhelum River. Its depth on an average is 3.6 m throughout length, reaching 5.8 m at its deepest point. The major inflows to Wular Lake are Jhelum, Madumati and Erin. The lake plays a significant role in the hydrographic system of Kashmir valley by acting as a large reservoir and by absorbing high annual flood of the Jhelum River. In 1990, this shallow lake was designated as a Ramsar Site, a Wetland of International Importance. For the present investigation, five sampling sites were selected which are described in Table 1 and Figure 1.

Table 2. Species composition of annelids at five sites in Wular lake (+ indicate taxa presence and – indicates taxa absence).

Annelids	Sites				
	Site I	Site II	Site III	Site IV	Site V
Oligochaetea					
Limnodrilus hoffmeisteri	+	+	+	+	+
Tubifex tubifex	+	+	+	+	+
Branchiuria sowerbyii	-	+	+	+	-
Aelosoma sp.	-	+	+	+	-
Nais sp.	-	+	+	+	+
Pristina sp.	-	+	-	+	-
Unidentified taxion	+	-	-	-	-
Total	3	6	5	6	3
Hirudinea					
Erpobdella sp.	+	+	+	+	+
Placobdella sp.	+	+	+	+	+
Glossiphonia sp.	-	+	+	-	-
Total	2	3	3	2	2
Annelids total	5	9	8	8	5

Collection and preservation

The benthic fauna encompassing annelids was collected from all five sites of the lake, with an Ekman Dredge (15 x 15 cm). The sites differered in water depth, vegetation and bottom sediments. The samples were taken in triplicate. The sediment samples collected were sieved carefully in order to remove fine sediments and other extraneous material without damaging the fragile organisms, using sieves of 1mm and 0.5 mm mesh size for checking annelids. The macroscopic organisms were collected with the help of forceps and brushes. The organisms collected were preserved in 70% alcohol for detailed examination.

Identification

Preserved annelids were identified by observing them under a microscope and identification was done with the help of standard taxanomical works of Edmondson (1992), APHA (1998), Pennak (1978), Adoni (1985), Brinkhurst (1971) and Kiemm (1995).

Biomass

Biomass of annelids was determined as fresh weight. The organisms were kept on filter paper for some time until the samples dry and weight became constant. Then organisms were weighed by using electronic balance with the accuracy of 1 mg. The biomass was calculated by using the formula:

$$\text{Biomass (g m}^{-2}) = \frac{n}{a \times s} \times 10,000$$

Where, n = weight of organisms counted; a = extraction area of dredge; s = number of samples

RESULTS

Species composition

During the present investigation of Wular lake, 10 taxa of annelids were recorded which belonged to two major classes namely Oligochaeta (7) and Hirudinaea (3). The class Oligochaeta included *Limnodrilus hoffmeisteri*, *Tubifex tubifex*, *Branchiura sowerbyii, Nais* sp., *Aelosoma* sp., *Pristina* sp. and an unidentified taxion. Similarly, the class Hirudinea was comprised by *Erpobdella* sp., *Placobdella* sp. and *Glossiphonia* sp. Amongst the 10 species listed, the highest taxa richness was obtained at site II (9), followed by site III (8), site IV (8), and decreasing to the minimum of 3 species each at sites I and V (Table 2). The most common taxa encountered across all the sites were *L. hoffmeisteri*, *T. tubifex*, *Erpobdella* sp. and *Placobdella* sp. The unidentified annelid taxion was found only at site I. Among the two classes, Oligochaeta dominated both qualitatively and quantitatively at each site and was represented by a maximum number of 6 species each at sites II and IV, followed by site III (5), till it reached a minimum number of 3 species each at sites I and V. The class Hirudinea was represented by 3 taxa each at sites II and III and 2 taxa each at sites I, IV and V.

Biomass

The annelid biomass showed a considerable variation between the study sites. Depending upon the species composition biomass of annelids varied seasonally. The seasonal mean value for biomass of annelids fluctuated between a lowest of 0.31 g/m^2 at site I in winter to a highest of 14.92 g/m^2 at site III in summer. However, the annual mean biomass was revealed to be maximum at site IV (10.82±2.02 g/m^2), followed by site III (10.47±2.07 g/m^2), site II (8.94±1.90 g/m^2), site I (1.85±0.94 g/m^2) and decreasing to the lowest ebb (1.71±0.50 g/m^2) at site V.

At site I, the annual mean biomass of Hirudineae was highest (1.18±0.61 g/m^2) as compared to class Oligochaeta

Table 3. Seasonal variation in biomass of annelids (g/m^2) at five different sites of Wular lake.

S/N	Class/ Taxa	Sites	Spring	Summer	Autumn	Winter	Mean
	Oligochaeta						
		Vintage	0.57	0.73	0.28	0.04	0.41
		Ashtung	4.04	4.81	3.51	1.74	3.53
1	*Limnodrilus hoffmeisteri*	Watlab	5.05	6.1	4.02	2.48	4.41
		Makdomyari	4.99	6.18	4.4	2.66	4.56
		Ningle	0.82	0.96	0.55	0.19	0.63
		Vintage	0.03	0.53	0.08	0.03	0.17
		Ashtung	3.99	4.5	3.37	1.72	3.39
2	*Tubifex tubifex*	Watlab	4.89	5.7	4.02	2.39	4.25
		Makdomyari	4.56	5.43	3.99	2.52	4.13
		Ningle	0.67	0.88	0.39	0.09	0.51
		Vintage	0	0	0	0	0
		Ashtung	0.12	0.19	0.11	0	0.11
3	*Branchiuria sowerbyii*	Watlab	0.12	0.19	0.11	0	0.11
		Makdomyari	0.17	0.19	0.11	0	0.12
		Ningle	0	0	0	0	0
		Vintage	0	0	0	0	0
		Ashtung	0.44	0.56	0.35	0.13	0.37
4	*Aelosoma* sp.	Watlab	0.49	0.59	0.37	0.07	0.38
		Makdomyari	0.58	0.61	0.41	0.11	0.43
		Ningle	0	0	0	0	0
		Vintage	0	0	0	0	0
		Ashtung	0.47	0.66	0.34	0.13	0.40
5	*Nais* sp.	Watlab	0.55	0.71	0.35	0.09	0.43
		Makdomyari	0.56	0.71	0.45	0.11	0.46
		Ningle	0.25	0.07	0.06	0	0.09
		Vintage	0	0	0	0	0
		Ashtung	0.05	0.12	0.04	0	0.05
6	*Pristina* sp.	Watlab	0	0	0	0	0
		Makdomyari	0.18	0.23	0.07	0	0.12
		Ningle	0	0	0	0	0
		Vintage	0.26	0	0.08	0	0.09
		Ashtung	0	0	0	0	0
7	Unidentified taxion	Watlab	0	0	0	0	0
		Makdomyari	0	0	0	0	0
		Ningle	0	0	0	0	0
	Total		33.85	40.65	27.46	14.5	29.15
	Hirudinea						
		Vintage	0.77	0.59	0.36	0.18	0.48
		Ashtung	0.58	0.82	0.47	0.11	0.49
8	*Erpobdella* sp.	Watlab	0.51	0.88	0.41	0.12	0.48
		Makdomyari	1.06	0.77	0.53	0.12	0.62
		Ningle	0.35	0.28	0.29	0.06	0.25
9	*Placobdella* sp.	Vintage	2.13	0.47	0.17	0.06	0.71

Table 3. Condt.

S/N	Class/ Taxa	Sites	Spring	Summer	Autumn	Winter	Mean
	Placobdella sp.	Ashtung	0.48	0.53	0.24	0.06	0.33
		Watlab	0.35	0.53	0.29	0.06	0.31
		Makdomyari	0.71	0.54	0.22	0.05	0.38
		Ningle	0.29	0.3	0.17	0.11	0.22
		Vintage	0	0	0	0	0
10	*Glossiphonia* sp.	Ashtung	0.11	0.29	0.59	0	0.25
		Watlab	0.11	0.22	0.05	0	0.10
		Makdomyari	0	0	0	0	0
		Ningle	0	0	0	0	0
Total			7.45	6.22	3.79	0.93	4.62
Grand total			41.3	46.87	31.25	15.43	33.77

(0.67±0.33 g/m^2). Among Oligochaetes, the *L. hoffmeisteri* acquired maximum mean biomass (0.41±0.15 g/m^2) while the unidentified taxion made a minimum mean biomass (0.09±0.06 g/m^2). Among Hirudineae, only *Placobdella* sp. maintained the greatest biomass (0.71±0.48 g/m^2). On a seasonal basis, the oligochaetes registered the maximum biomass during summer (1.26 g/m^2) and the minimum in winter (0.07 g/m^2) whereas the Hirudineae registered the highest biomass in spring (2.90 g/m^2) and the lowest in winter (0.24 g/m^2) (Table 3).

At site II, the annual mean biomass of Oligochaeta was highest (7.86±1.51 g/m^2) as compared to class Hirudinea (1.08±0.39 g/m^2). Further, among Oligochaeta, *L. hoffmeisteri* attained the maximum mean biomass (3.53± 0.65 g/m^2) whereas *Pristina* sp. had the minimum mean biomass (0.05±0.02 g/m^2). On a seasonal basis, the annelids showed maximum biomass in summer (12.48 g/m^2) and lowest in winter (3.89 g/m^2). *Erpobdella* sp. had the highest mean biomass (0.50±0.15 g/m^2) whereas *Glossophonia* sp. had the lowest mean biomass (0.25± 0.13g/m^2) in class Hirudinae (Table 3).

At site III, the annual mean biomass of annelids varied between 9.58±1.76 g/m^2 (Oligochaeta) and 0.89±0.31 g/m^2 (Hirudinea). *L. hoffmeisteri* obtained maximum mean biomass (4.41± 0.77g/m^2) and *B. soewerbyii* registered the minimum mean biomass (0.11±0.04 g/m^2). *Erpobdella* sp. obtained the highest mean biomass (0.48±0.16 g/m^2) and *Glossophonia* sp. the lowest mean biomass (0.10± 0.05g/m^2). On a seasonal basis, the annelids showed a maximum biomass during summer (14.92 g/m^2) and the lowest in winter (5.21 g/m^2) as depicted in Table 3.

At site IV, the mean biomass of *L. hoffmeisteri* was maximum (4.56±0.73 g/m^2), followed by *T. tubifex* (4.13±0.61 g/m^2) while *B. soewerbyii* and *Pristina* sp. registered lower mean biomass (0.12±0.05 g/m^2 for each). *Erpobdella* sp. recorded its greatest biomass (0.62±0.20 g/m^2) while *Placobdella* sp. had its lowest biomass (0.38± 0.15g/m^2). The annual mean biomass of annelids varied between 9.82±1.67 g/m^2 for Oligochaeta and 1.0±0.35 g/m^2 for Hirudinea. In general, on a seasonal basis, the annelids showed maximum biomass (14.66 g/m^2) in summer and minimum (5.57 g/m^2) in winter (Table 3).

At site V, the annelids registered their maximum biomass (2.49 g/m^2) in summer and their minimum (0.45 g/m^2) in winter. The biomass of Oligochaeta was highest (1.24±0.39 g/m^2) than the biomass of Hirudinea (0.47±0.11 g/m^2). Among Oligochaetes, the *L. hoffmeisteri* attained greatest mean biomass (0.63±0.17 g/m^2) while the lowest mean biomass (0.10±0.05 g/m^2) was found for *Nais* sp. *Erpobdella* sp. was the dominant maintained leeches (0.25±0.06 g/m^2) and *Placobdella* sp. was the less abundant one (0.22± 0.05 g/m^2) (Table 3).

DISCUSSION

Assessment of species composition, distribution and biomass of macroinvertebrate community often gives an important clue to the functional status of a water body. Benthic macroinvertebrates are tools that enable rapid bioassessment which is cost effective and quick assessment strategy to determine the health of an ecosystem (Loeb and Spacie, 1994). According to Jumppanen (1996) the first sign of eutrophication and pollution is reflected by the benthic biota, because the pollutants are rapidly deposited into the sediments where they evolve an impact on the benthic organisms. Therefore, it is essential to study the benthic composition to help in the evaluation of the trophic status of the water bodies.

During the present study, 10 taxa of annelids belonging to two major classes namely Oligochaeta (7) and Hirudinea (3) were recorded. Amongst the 10 species listed, the maximum number of species was obtained at site II (9), followed by site III (8), site IV (8), and decreasing to the minimum of 3 species each at sites I and site V. The lowest species richness at site V may be due to the physical heterogeneity of substrate, being reflected in the number of taxa (Marshall and Winterbourn,

1979) as site V is chracterized by sandy sediment with small boulders and diminished macrophytic growth. Conversely the highest richness at sites II, III and IV may be due to the dense macrophytic cover and soft bottom sediments as macrophytes provide suitable habitat for macroinvertebrates. The above finding corroborates the fact that oligochaete community thrives well in soft depositing substrates rather than stony beds (Bhat and Pandit, 2010).

Biomass is a potential renewable source of energy, which is related to the ecological conditions of the habitat. Estimation of biomass is necessary for understanding the trophic dynamics and productivity of an ecosystem (Mir and Yousuf, 2003). During the course of the present study, biomass of annelids fluctuated between 0.31 g/m^2 at site I and 14.92 g/m^2 at site III. This reflected the higher productivity and trophic status of site III and inversely, the relatively lower productivity at site I. Biomass showed a seasonal trend with maximum in spring and summer and minimum in winter. Thus, biomass fluctuated in close relation with density of annelids, which also showed higher value during summer and lower in winter, indicating a positive correlation between the two parameters. Sunder and Subla (1986) and Mortensen and Simonson (1983) also noticed a positive relationship between density and biomass of zoobenthos.

Conclusion

During the present investigation 10 taxa of annelids belonging to two major classes namely Oligochaeta (7) and Hirudinea (3) were recorded. The most common taxa encountered across all the sites included *L. hoffmeisteri*, *T. tubifex*, *Erpobdella* sp. and *Placobdella* sp. However, the unidentified annelid taxion was found only at site I. Among the two classes, Oligochaeta dominated both qualitatively and quantitatively at each site and was represented by a maximum number of taxa at each site. The presence of *L. hoffmeisteri* and *T. tubifex* on an average in great numbers is indicative of organically rich sediments. The class Hirudinea was represented by three taxa each at sites II and III and two taxa each at sites I, IV and V. In general, Oligochaeta comprised 95% of the total annelid community and remaining 5% was made by Hirudinea. During the course of the present study, biomass of annelids fluctuated from the lowest of 0.31g/m^2 at site I to the highest of 14.92 g/m^2 at site III. However, the biomass of oligochaetes fluctuated from 0.67 to 9.82 g/m^2 and the biomass of Hirudinea varied from 0.47 to 1.18 g/m^2, indicating that overall biomass was dominated by oligochaetes and hence reflecting the moderate eutrophication of lake.

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Climate change, environmental security and displacement in Nigeria: Experience from the Niger Delta Flood Disaster, 2012

Luke Amadi* and C. U. Mac Ogonor

Department of Political Science and Administrative Studies, University of Port Harcourt, Nigeria.

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The coastal regions of Africa are prone to series of environmental disasters arising from vulnerability of climate change. The October 7th and November 3rd, 2012 coastal floods in the Niger Delta region Nigeria, provides an evidence of the persistence and inevitability of climate change vulnerability which has been an issue of global concern with potential for havoc on human existence including environmental security, displacement and their far reaching consequences. Using primary and secondary data sources, the paper foreshadows the imminent dangers of climate change vulnerability. It deployed a participatory methodology through focused group discussions (FGDs), questionnaires and oral interview guide as primary data sources. While secondary data sources included relevant authoritative reports from National Emergency Management Agency (NEMA), UNDP, UNEP, newspapers, magazines and documents published by governmental and Non-Governmental Organizations (NGOs). The sampling technique was largely purposive due in part to the sensitivity of the issues investigated. Two open-ended questionnaires were used to elicit two types of information on coastal flood, environmental security and displacement within the purposively selected areas of study namely; Bayelsa, Delta and Rivers States. The findings suggest that the 2012 flooding negatively affected the region with evidence of displacement, out migration, impoverishment, food production decline, etc. The paper made some policy recommendations on mitigation of climate change vulnerability.

Key words: Climate change, environmental security, development, Niger Delta, Nigeria.

INTRODUCTION

The African coastal zone consists of a narrow, low-lying coastal belt. It also includes the continental shelf and coasts of 32 mainland countries. It is composed of a variety of ecosystems, including barrier/lagoons, deltas, mountains, wetlands, mangroves, coral reefs and shelf zones. These ecosystems vary in width from a few hundred meters (in the Red Sea area) to more than 100 km, especially in the Niger and Nile deltas. In west Africa (Mauritania to Namibia), the coastal zone spans a broad range of habitats and biota and includes the pristine islands of

*Corresponding author. E-mail: madils007@yahoo.com.

Bijagos Archipelago; the offshore island nations of Cape Verde and São Tomé and Principe; and the remote central Atlantic islands of San Helena and Ascension (IPCC, 2007).

A large percentage of West Africa's urban population lives in coastal cities. In Nigeria, for example, about 20 million people (22.6% of the national population) live along the coastal zone; about 4.5 million Senegalese (66.6% of the national population) live in the Dakar coastal area. About 90% of the industries in Senegal are located within the Dakar coastal zone. In Ghana, Benin, Togo, Sierra Leone and Nigeria, most of the economic activities that form the backbone of the national economies are located within the coastal zone. Coastal areas also form the food basket of the region. Offshore and inshore areas, as well as estuaries and lagoons, support artisanal and industrial fisheries accounting for more than 75% of fishery landings in the region (IPCC, 2007).

Similarly, the coastal zone of East Africa, including coastal wetlands, extends from Sudan to South Africa and includes the near-shore islands off the coast of Tanzania and Mozambique and the oceanic islands of Madagascar, the Seychelles, Comoros, Mauritius and Reunion. The desert margins of the Red Sea feature some of the richest coral reefs in the world. Coral reefs further south, extending from Kenya to the Tropic of Capricorn, are well distributed around most of the oceanic islands. They buffer the coastline against the impact of wave breakers and the full force of storms and cyclones. Many principal east African cities are located inland. Despite their low densities, however, coastal cities like Dar es Salaam and Mombasa are experiencing annual population growth of 6.75 and 5%, respectively (World Bank, 1995a). Coastal tourism and fisheries represent large inputs into the GNP of east African states (IPCC, 2007).

In recent times, environment and security discourse have emerged as a central policy concern for countries across the world. This has been under consideration since the 1980s mainly by two groups: (1) the environmental policy community, addressing the security implications of environmental change and security, and (2) the security community, looking at new definitions of national security, particularly in the post-Cold War era. With the surge in environment and security challenges, the General Assembly officially introduced the concept of security and environment at its 42nd session.

The 90s and 2000s revealed increasing vulnerability of climate change such as recent environmental disasters namely; the Japanese Okushiri, Hokkaidō tsunami which struck Okushiri Island of Hokkaidō on July 12, 1993, the 2004 Indian Ocean tsunami with over 230,000 people killed in 14 countries bordering the Indian Ocean, the US Atlantic hurricanes (Andrew, 1992; Katrina, 2005; Irene, 2011) Sandy flood, 2012 and the Haiti earthquake; In West Africa, the most recent severe floods in the coastal regions of Nigeria on 2nd November 2012, etc (Amadi, 2012).

There are several perspectives in recent literature on environmental security discourse (Mathews, 1989; Homer Dixon, 1992; Awosika et al., 1992). The 1990s witnessed a paradigm shift to human security (UNDP, 1994; Klare, 1996).

Adibe (1994) had examined the change, security had assumed in recent literature encompassing “security expansionism”. Suhrke (1995) argued on “environment change, migration and conflict”. Her treatise is premised on terminological shifts in line with social changes and transformations in environment and conflict discourse.

Homer-Dixon (1991) identified “gaps” among the poor countries to meet environmental demands which could result conflicts unlike rich countries. He observed that the rich countries have the potential for a widening gap between demands on the state and its financial ability to meet these demands- a gap which he argued could lead to internal conflict between competing ethnic groups or significant out-migration to countries better able to cope with environmental stresses.

Choucri (1994) argued that environmental degradation forces people to move, sometimes across borders and more assuredly to impinge on and ultimately challenge those (host) populations, thus becoming a key element of conflict.

Suhrke (1995) identified four principal ways pressure on the environment has affected security of the state. They are: (1) environmental degradation can cause health hazards or jeopardize the economic livelihood of a significant part of the population; (2) intensified competition for declining or degraded resources can create conflicts within or among States: these in turn can generate regional instabilities that affect nations further afield; (3) environmental degradation may force people to migrate, thereby creating conflict over scarce resources in the receiving areas; and (4) the existentialist argument advanced by a school of environmentalists and “ecological economists” to the effect that an environmental resource has an intrinsic value regardless of its being consumed (even in the form of being seen), and hence its loss is a matter of security (Suhrke, 1996).

Kaplan (1994) re-echoed the persistent environmental degradation and deforestation in West Africa. He writes that in Sierra Leone, Guinea, Ivory Coast and Ghana, most of the primary rain forest and the secondary bush is being destroyed at an alarming rate. He reports that he “saw convoys of trucks bearing majestic hardwood trunks to coastal ports”. (p.48)

In 1987, the World Commission on Environment and Development linked security with environment as foreshadowed in the Brundtland Report:

> Humankind faces two great threats. The first is that of a nuclear exchange. Let us hope that it remains a diminishing prospect for the future. The second is

> that of environmental ruin world-wide and far from being a prospect for the future, it is a fact right now (Bruntland, 1987).

These terms are marginalized in policy discourse or at the best superficially addressed in the poor countries. Thus, environmental security and climate change issues seem not to have been prioritized in development discourse especially in the coastal regions of Africa such as the Niger Delta region in Nigeria.

Issues of displacement in the region now take various forms such as in and out migration, flood induced displacement, acid rain and oil spill, to crisis induced displacement, etc.

Ibeanu (1998) observed the continued marginalization of displaced persons in Nigeria; "the proclivity among the displaced is rarely to contest their predicament. Only in a few celebrated cases, like that of the Bakolori peasants who were displaced by a dam in the 1980s and the Ogoni whose livelihoods are threatened by oil exploration, have internally displaced people organised and effectively put their condition on the political agenda. The lack of organization among displaced people generally serves to keep their plight concealed".

In 1999 was the adoption of the United Nations Framework Convention on Climate Change (UNFCC) which was aimed to develop a global framework on climate change. The coastal areas in Africa are fraught with environmental challenges and flood related disasters. The East African floods of 1998 and the Mozambique floods in early 2000 and 2001 caused considerable damage to property and infrastructure. The major infrastructure damage was road and rail network damage. Communications among human settlements in Kenya, Uganda, Rwanda and Tanzania were seriously disrupted, impeding movement of goods and persons in the region (AEO, 2002).

Aspects of coastal erosion have been examined in recent literature (Ibe and Quelennac, 1989; Awosika et al., 1992; Dennis et al., 1995; French et al., 1995). For instance, the occurrence of coastal erosion has been reported in the Niger Delta by Okon and Egbon (1999). The report of Udofa and Fajemirokun (1978) showed a rise in sea level along Nigerian coastal water. They conducted a mechanical analysis of tide data from 1960 - 1970 and reported mean sea level rise to be 0.462m above zero level of the tide gauge which have been of increasing concern in the region.

In 2007, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) predicted that rising global temperatures will contribute to an upsurge in severe storms, floods, droughts, glacier melt and sea level rise. In vulnerable areas of the developing world, extreme weather is expected to intensify pressures on land and water resources, disrupt agricultural production, and threaten food security. In the wake of the IPCC report, a number of policy studies concluded that there is a strong likelihood that the natural hazards and environmental stresses associated with climate change will trigger or amplify conflict, especially in vulnerable or unstable areas of the developing world (CNA Corporation, 2007; Campbell et al., 2007; Smith and Vivekananda, 2007; Fingar, 2008; UN, 2009).

Among the projected scenarios were severe resource scarcity, dramatic increases in internal and external migration, disease outbreaks and a host of destabilizing social and political effects (Campbell and Weitz, 2008). The CNA Corporation envisioned a confluence of factors that might overwhelm weak or flawed systems of governance and public institutions, setting the stage for "internal conflicts, extremism and movement toward increased authoritarianism and radical ideologies" (CNA Corporation, 2007.)

The Nigerian Environmental Study/Action Team (NEST), reported that sea-level rise and repeated ocean surges will not only worsen the problems of coastal erosion that are already a menace in the Niger Delta, the associated inundation will increase problems of floods, intrusion of sea-water into fresh water sources and ecosystems destroying such stabilizing system as mangrove, and affecting agriculture, fisheries and general livelihoods (NEST, 2004).

The Niger Delta is the product of both fluvial and marine sediment build-up since the upper Cretaceous period, some 50 million years ago. Over time, up to 12,000 m of shallow marine sediments and deltaic sediments have accumulated, contributed mainly by the Niger River and its tributaries (UNEP, 2011).

The coastal area comprises three vegetation zones: (i) beach ridge zone, (ii) saltwater zone and (iii) freshwater zone. The beach ridge zone is vegetated by mangroves on the tidal flats and by swamptrees, palms and shrubs on the sandy ridges. The saltwater zone is mainly vegetated by red mangrove (*Rhizophora mangle*). The coastal plain and freshwater zone is vegetated by forest tree species and oil palm. The Niger River floodplains are covered by rainforest trees, oil palm, raffia palms, shrubs, lianas, ferns, floating grasses and reeds (UNEP, 2011).

The coastal regions are at the most prone to these threats as they repeatedly experience intense environmental stress with minimal response from the government and the international community. There are several causes of environmental insecurity such as the depletion of the ozone layer, pollution, deforestation, acid rain, erosion, flood, sea level rise, gas flaring, etc.

This study focuses on the recent Niger Delta coastal flood, where no fewer than three million persons were displaced and a few others died. The study and its case scenario are linked to a broader elucidation of Nigeria's commitment to global environmental conventions. This is significant in an era of post Rio +20 world environmental summit of 2012. We argue that climate change vulnerability remains an issue of urgent policy attention among the poor coastal regions.

In this context, we seek to examine the recent environmentally induced travail of the Niger Delta people namely; the October and November 2012 coastal floods. This is important in view of the reoccurring incidence of coastal erosion, acid rains, oil minority politics, ozone layer depletion, oil spill, environmental pollution, sea level rise and ocean surge within the volatile region. The region is a minority area in Nigeria which implies that they are numerically less as compared to the major ethnic groups. This study significantly examines how the federal government is responding to the problems of these groups. This is linked to a brief elucidation of Nigeria's commitment to some global environmental protocols and how these have impacted awareness on climate change vulnerability. The essay argues that policy discourse to improve the lots of the poor coastal regions is important.

MATERIALS AND METHODS

This study provides a case analysis of displacement arising from coastal erosion, the victims and implications for policy discourse. It adopted a participatory methodology through Focused Group Discussions (FGD), Questionnaires and Oral interviews as primary data sources to evaluate the level of environmental damage and security threats arising from the October and November 2012 flood disaster.

Participatory methodology is suitable, being a direct and all inclusive approach, the victims were reached for interviews and on the ground analysis of the problems of the study. According to Chambers (2010), current development thinking and practice have diverged into two clusters, with procedures associated with the paradigm of things imposed by powerful actors and organizations in tension and contradiction with participatory methodologies (PMs) associated with the paradigm of people. PMs that combine methods have proved increasingly versatile and adaptable to contexts and purposes. For our purpose we explore the "paradigm of people".

Secondary data sources included authoritative reports from National Emergency Management Agency (NEMA), UNEP reports, newspapers, magazines, reports and documents published by government and non-governmental organizations. The sampling technique was largely purposive due in part to the sensitivity of the issues investigated.

Two open-ended questionnaires were used to elicit two types of information on climate change vulnerability, displacement and insecurity. The first, the general sample (GS) questionnaire elicited general information about climate change in the Niger Delta and was directed at community members, youths, women and elders. A total of 255 questionnaires were received from those distributed, (80 in Bayelsa, 100 in Delta and 75 in Rivers). The second questionnaire (key informant sample) sought in-depth, broad and sensitive information from more informed citizens of the region such as teachers, civil servants, environmental engineers, literate farmers, etc.

A total of 55 questionnaires were received: 20 in Bayelsa, 20 in Delta and 15 in Rivers State). The overall return rate of distributed instruments for data collection revealed 88% response. Oral interviews were also conducted. The objective was to elicit detailed and informed information from rural women, heads of households, fishermen and farmers who could not write. Beyond the interviews were FGDs, three each were conducted in Bayelsa (Yenagoa), Delta (Asaba) and Rivers (Port Harcourt) with sample sizes of 12, 8 and 8, respectively. The aim was to further retest the earlier data for validity.

Nigeria and commitment to some global environmental summits and protocols

Nigeria is committed to several multilateral environmental agreements (MEAS), summits and protocols. The Stockholm conference of 1972 became a spring board on which subsequent global environmental summits were organized. This include the 1992 Rio earth summit, the UN –Rio +5 by group of experts in 2007, in 2002 the Johannesburg Plan of Implementation and the Rio +20 in 2012.

The international community has negotiated and brought into effect various Multilateral Environmental Agreements (MEAs), including the Rio Conventions: the UNFCCC, UNCCD, CBD developed at the Rio Earth Summit in 1992. These conventions are also related to other MEAs that have been agreed over the years including the CITES and Ramsar Convention on Wetlands. Nigeria is party to all these MEAs listed above. However, like most of the developing world, progress in implementing the obligations of these agreements has been limited, as has been identified in the reports that the country has been submitting to the conferences that these conventions hold regularly.

Ramsar, Convention on Wetlands 1971

The Convention on Wetlands, commonly referred to as the Ramsar Convention was signed in the city of Ramsar, Iran in 1971. The purpose of this convention is to conserve and promote wise use of the wetlands. Furthermore, the convention aims to raise awareness among the nations about the ecosystem services that wetlands provide including biodiversity aspects of habitats to a wide variety of plants and animals (Final Act, 1971).

Kyoto Protocol to the United Nations Framework Convention on Climate Change

The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. The detailed rules for the implementation of the protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords." Its first commitment period started in 2008 and ended in 2012. The objective of the protocol is that each party included in Annex I, in achieving its quantified emission limitation and reduction commitments under Article 3, in order to promote sustainable development, shall:

(a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as:
(i) Enhancement of energy efficiency in relevant sectors of the national economy;
(ii) Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation;
(iii) Promotion of sustainable forms of agriculture in light of climate change considerations;
(iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies;
(v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the convention and application of market instruments;
(vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal

Protocol;
vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;
(viii) Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (Kyoto Protocol, 1998).
(b) Cooperate with other such parties to enhance the individual and combined effectiveness of their policies and measures adopted under this Article, pursuant to Article 4, paragraph 2 (e) (i), of the Convention. To this end, these parties shall take steps to share their experience and exchange information on such policies and measures, including developing ways of improving their comparability, transparency and effectiveness. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, consider ways to facilitate such cooperation, taking into account all relevant information (Kyoto Protocol, 1998).

In Doha, Qatar, on 8 December 2012, the "Doha Amendment to the Kyoto Protocol" was adopted. The amendment includes:
1. New commitments for Annex I Parties to the Kyoto Protocol who agreed to take on commitments in a second commitment period from 1 January 2013 to 31 December 2020;
2. A revised list of greenhouse gases (GHG) to be reported on by Parties in the second commitment period; and
3. Amendments to several articles of the Kyoto Protocol which specifically referenced issues pertaining to the first commitment period and which needed to be updated for the second commitment period.

On 21 December 2012, the amendment was circulated by the Secretary-General of the United Nations, acting in his capacity as Depositary, to all Parties to the Kyoto Protocol in accordance with Articles 20 and 21 of the Protocol.

During the first commitment period, 37 industrialized countries and the European Community was committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18% below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first (Doha Amendment Report, 2012).

United Nations Convention on Biological Diversity 1992

The main objectives of this convention as indicated in Article 1, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding (UN, 1992).

United Nations Framework Convention on Climate Change 1999

The objective of the Convention on Climate Change is to achieve, in accordance with the relevant provisions of the convention, stabilization of greenhouse gas concentrations in the atmosphere at the level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC, 1999).

Within African sub region, there are regional environmental summits. The first ever regional comprehensive report on the state of Africa's environment-*Africa Environment Outlook* (AEO),which was specifically requested by African Ministerial Conference on Environment (AMCEN), in collaboration with United Nations Environmental Programme (UNEP), reinforces environmental breakdown as it traces environment and development trends since the 1972 United Nations Conference on the Human Environment and provided a comprehensive analysis of status and trends of the environment in Africa which has been abysmal.

Also, the First Africa Drylands Week and World Day to Combat Desertification which recently held in Dakar, Senegal, from June 10-17, 2011 was aimed to Combat desertification. Overall deforestation has declined globally, but persists in Africa and South America, according to the FAO's 2010 Global Forests Resource Assessment. The pressure on arid zone forests and the rangelands that protect them may increase, especially in the tropical and subtropical regions, from two opposing forces, according to the assessment (Wolf, 2011).

RESULTS AND DISCUSSION

Dynamics of the October and November 2012 flooding

The data collated from the study including Focused Group Discussions (FGD) questionnaires and oral interviews provided objective significant relationship between flooding, environmental security and displacement.

Similarly, a recent empirical study in this direction equally corroborates this result (Amadi, 2013). On October 7, 2012 a flood disaster affected communities lying on the path of the River Niger and River Benue, this included the people of the Niger Delta area as the River Niger overflew and had disruptive effects on lives and properties (Figure 1). Data collated from the study revealed 95% damage on farms lands and animals, while several houses submerged and many people were rendered homeless especially in the Delta and Edo states axis. This phenomenal occurrence was historic and significant to the growing discourse on vulnerability of climate change as corroborated in a similar study (Amadi, 2013; NEMA, 2012).

In Rivers State, a subsequent occurrence was witnessed the Orashi river a tributary of river Niger overflew on November 3, 2012. Our data confirmed that “about three persons: an infant and two women died”, several others displaced, as “no fewer than 24 communities and several houses were submerged” (Agbu, 2012). Most affected included Udoda, Igovia, Kunsha, Ikodi Town, Mbiama, Akinima, Okolobiama, Okparaki, Okarki town, Akiogbologbo, Agbo, Ishiaye, Akioiso, Isusu, Isua, Odqwa, Edagberi and Betterland as well as Oshiebele, Oshi, Odiereke-Ubie, Enito, Akara-mini, all in Ahoada-West local government area of the state.

One of the displaced flood victims in Omoku, the headquarters of Ogba/Egbema Local Government Area of Rivers State, Mr. Ikediukwu Adiele, lamented that people in his village lost many property and many of them are now homeless. “For three days now, we have been wading through the water to pick some valuable items from our flooded homes. As you can see, we are now using canoe to move around (Agbu, 2012). Several

Figure 1. Map of Niger Delta showing the major cities in the region. Source: National Bureau on Statistics.

dimensions of hazards and challenges were experienced by the affected communities.

"Also, areas badly hit by the disaster included, Okwuzi, Ase-Azaga, Isukwa, Odugiri, Agwe, Onikwu, Ugbaja, Isala, Ogbe-Ogene, Utu, Adiawai, Obiofu, Kreigani, Obrikom, Idu and Ebocha as well as Umu-Onyema quarters in Ndoni, all in Ogba/Egbema/Ndoni local government area of the state. Unfortunately, the Rivers State government, the authorities of two affected local government councils as well as the National Emergency Management Agency (NEMA) was not in the know of the flooding in the communities until the Senate Committee on Environment and Ecology raised the alarm" (Daily News, 2012).

While families parked out of the affected communities in the area, farmers in the area began early harvesting of their root crops, especially cassava and yam so as to avoid losing them to the flood. (Amdi, 2013). An indigene of Edageberi community, Bonny Otatie Ulolo, said although, people of the area usually experience minor flooding every November as a result of over-flow of the Orashi River, the present situation was unprecedented in the history of the communities (Leadership Newspaper, 2012).

According to some victims, "the intensity of the disaster has never been experienced in recent times in the area as floods usually come and go but this persisted magnificiently" (Leadership Newspaper, 2012).

The Rivers State Commissioner for Special Duties, Chief Emeka Nwogu, in company of the chairman of the council, Hon. Raymond Nwokeocha has visited the affected communities to ascertain the level of damage. Nwogu, who was deeply touched by the plight of the victims, expressed sympathy over the incident, describing it as a great loss to the state and appealed to those that are yet to evacuate to do so to avoid more loss of lives (Leadership Newspaper, 2012).

Indigenes of the affected communities blamed the cause of flood on the over flow of the River Niger, explaining that the last time they experienced such flooding was in 1994 and 1998 respectively and described this year's disaster as exceptional (Leadership Newspaper ,2012).

To Emenike Umesi, the South-South co-ordinator of NEMA, the agency had been aware of the flood situation in the affected communities in Ahoada-West and Ogba/Egbema/Ndoni Local Government Area of the state and had been working on the affected areas. He said they had concluded assessment of the affected communities to determine the level of assistance that could be given to the victims, adding that the agency identified a camp for victims but it was swept off by flood (Leadership Newspaper, 2012).

In Delta State, communities have been sacked, farmland destroyed from Asaba, the Delta State capital to Oko, down to Utchi to Aboh, Abari and Bomadi, residents were displaced even as over 1,000 houses are believed to have collapsed. "We thought it will not come to some of us who were some distances away from the river. "We kept vigil all night and it was when the tide increased that we decided to move our things upland in the open.

"It is amazing to us that the water is increasing this time

of the year", Mr. Ifeanyi Okafor, a tenant at OgbeOfu/Jarret area of Asaba, said (Leadership Newspaper, 2012). "Areas that were spared at the initial time, have now been submerged. For instance, the former secretary to the then Bendel State government and Iyase of Asaba, Chief Patrick Onyeobi was hit severely as his palace compound and others were submerged. Before now, the shoreline around his house by the River Niger was very secured and no one ever thought the vexatious Niger could have been so offended to rise to such a level as to sack the former SSG and many others in Delta Capital" (The Tribune, 2012).

One of the earlier sufferers of the flood in Asaba was the Nigeria Immigration service office and the tourist Ganda hotel by the bridge head. The riverine people braved the odds, paddling canoes to their homes, retrieved their property and ferrying them to the highways which have become home for them (The Tribune, 2012). The Asaba experience speaks for several communities now devastated by the ravaging flood especially in Aniocha North, Ndokwa land, Isoko, Patani, Bomadi and Burutu communities amongst others. The case of Ewulu community in Aniocha South Council is Pathetic in the sense that over 100 houses, were pulled down, and both elderly and the sick ones trapped as water from River Umuoni, a tributary of the Niger overflowed its bank, The Ase River, which traversed the Ndokwa nation was also a channel through which the rising Niger flood unleashed more troubles on inhabitants (The Tribune, 2012).

Scores of displaced farmers in Ndokwa East of Delta are now seeking refuge on the upland of Ashaka and Utagba-Ogbe, Kwale towns following the washing away of their communities, farmland and crops by flood from the River Niger and its tributary, Ase Creek (The Tribune, 2012).

A visit to the area revealed that the water rose in fury and submerged farmlands and crops on the alluvial rich islands and adjoining farms on both sides of the River Niger thereby sacking the farmers and destroying their fish ponds, homes and markets. "We have never had it this bad in a life time, government and its agencies should come to our rescue" (The Tribune, 2012). Communities most affected along the River Niger are, Aballa-Oshimili, Utchi Communities of Okwumedo, Umuochi, Owelle, Obalu and Obeche, Okpai, Abalagada, Aboh, Abuato, Ugbene, Agwe-Iyom, Ise-Onokpo, Onuobiuku, Umu-Ugbome, Umu-Uti, Afiankwo, Umuolu, Adiai, Utuoku, Oworubia, Wari-Irri, and Onyah. Other communities affected included Aballa-Obodo, Aballa-Uno, Inyi communities of (Umu-Inyagbo, Obeche, Umu-Agwuyam, Isiolu, Umuoga, Ezinyi, Utuke, Ude, Ogigogwe, Ezeagba), Umu-Eche, Ogwasi, Umugwo, Umuazu, Ozala, all in Onuaboh. The flood also ravaged Akarai, Azagba, Ekpe, Ibedeni, Osafu, Ase, Asaba-Ase, Onogbokor, Iyede-Ame and Anyama (Kiagbodo, 2012). "Chief Nnamdi Olise-Atuoku and Mr. Raphael Nwammana who are now seeking refuge at Ashaka and Kwale respectively said that yam, cassava, plantain, vegetables, garden eggs and pepper among others were completely destroyed in their farms" (The Tribune, 2012).

Camps were opended in Asaba, Tuomo in Burutu Bomadi, Okwagbe in Ughelli South, Patani and Aboh among other places to take in the displaced persons. On a daily basis, the camps received more victims, even in Asaba, another camp was opened at I.C.E to take in people from Utchi and Oko communities to compliment the St Patrick College camps for hundreds of displaced persons in Asaba (The Tribune, 2012).

According to the Delta State Governor, Emmanuel Uduaghan, "After the aerial overview, I started the ground assessment by vehicle and boat. The situation is pathetic. My first encounter with the victims was at Oko communities in Oshimili South Local Government Area of the state. The three communities of Oko Amakom, Oko Ogbele and Oko Anala were flooded and the villagers gathered as refugees by the roadside. I had to talk to them that we will open camps to offer them temporary accommodation from the rage of nature, but some of them were reluctant to come to the camp, one of which was already opened at Saint Patrick's College, Asaba" (The Tribune, 2012).

"The displaced persons occupied half of the Benin-Asaba-Onitsha expressway and it was obvious that there would not be movement from either Asaba to Onitsha or vice versa if the situation was not taken care of" (The Tribune, 2012).

According to a rural farmer, "our farms are badly damaged we are faced with dual challenges of hunger and housing" (Ifejika, 2012).

The situation in Oguta was no less distressing several victims of the flood in Oguta and Ohaji/Egbema Local Government Areas of Imo State were equally lamenting. About eight communities were affected in Egbema. According to the director of administration of the Ohaji/Egbema LGA, Barrister Alloy Obinna, "eight communities were affected in the Egbema area alone. Our fish ponds, farm lands, plantain, cassava, economic trees and crops are now under water. Over 123 farm settlements and satellite towns are under water and about 8,000 persons have no homes now", he said (The Vanguard, 2012).

In Edo State, the Edo State Deputy Governor, Dr. Pius Odubure counted the intensity of the disaster in the communities in the area (Daily News, 2012).

In Cross-River State, Mr Fabian Okpa, the Special Adviser to Gov. Liyel Imoke on Special Duties, recounted that, " nine of the 18 local government areas of the state were affected" (Daily News, 2012).

'In an interview, Obi Emmanuel Obiechina, a leader of the Aika community in Ndokwa East local government area, said his residence was submerged by the flood. In addition, he stated that the lives of members of his community were shattered, with most of them refugees in various communities in Delta and Anambra States. Mr. Obiechina had taken refuge in a hotel in Asaba' (Daily

News, 2012). 'The traditional ruler said that he refused to send his people to camps for displaced people set up by the state government because those in the camps were being dehumanized. He blamed the excessive flooding on dereliction of duty by the government'. "We have lived in that community for more than 500 years and we have not had this kind of disaster before. It's the opening of the dams that have now brought this flooding on us. We are so devastated and everything that the Aika people have– land, crops, houses have been washed away" (Daily News, 2012).

Till date, rehabilitating the impacted areas have been a challenge. Awosika et al. (1992) study foreshadowed this concern as they observed that, "In Nigeria, a potentially massive "environmental refugee" migration will occur. For a 1-m rise, more than 3 million people are at risk, based on the present population. The estimated number of people that would be displaced ranges from 740,000 for a 0.2m rise to 3.7 million for a 1m rise and 10 million for a 2m rise".

Also, the presence of crude oil and its exploitation means further environmental degradation and hazards for the region. These are threats to environmental sustainability.

Experts have noted that, riverine flooding, is often a function of precipitation and water runoff volumes within the watershed of the stream or river; also there is the Coastal flooding, which is typically a result of storm surge, wind-drive waves, and heavy rainfall (Awosika et al., 1992). They contend that storm surges may overrun barrier islands and push seawater up coastal rivers and inlets, blocking the downstream flow of inland runoff. Also, there is the Urban flooding, which occurs where there has been development within stream flood plains, these are indicators that the Niger Delta region like most African coastal areas are volatile and prone to environmental hazards.

The growing discussion is that several coastal communities are prone to dangers of climate change vulnerabilities in several disruptive manners.

Challenges and effects of the flooding

There are divergent challenges of the effects including peasant food production decline in the region (Amadi, 2013), hunger, displacement and migration.

The United Nations says Nigeria will need $38 million (about N5.7 billion) in emergency aid to help 2.1 million people uprooted from their homes by flooding (Channels Report, 2012). According to Jens Laerke the spokesperson for the UN's Office for the Coordination of Humanitarian Affairs, explaining the aid plan said, "the plan includes help with food, water, shelter and schools mainly in farming and fishing communities along the Niger River" (Channels Report, 2012).

There are several dimensions to the effects of the flood disaster. A close observer on the Delta State incident recounts: At least five people, including two children and a traditional ruler, have died as a result of continued massive flooding that has ravaged parts of Delta State in Nigeria's oil-rich Niger Delta. In addition, the floods have submerged a multi-billion naira Okpai Independent Power Plant (IPP). Large parts of Ndokwa East local government area are also under water". The still rising flood has affected parts of Asaba, the state capital, as well as such communities as Ovrode, Ofagbe, Okpe-Isoko, Lagos Iyede, Igeh, IkpideIrri, Ivrogno, Onogboko, Itebioge, Iyede-Ame and Azagba. Other flooded areas include Otoka-Ekegbresi, Egbeme, Okrama-Oyede, Warri, Iwrie Ogbokor, Ekpe, Asafo, Umeh, Aviara, Uzere, Asaba-Ase, Aboh, Kwale and Ashaka. Isoko South and North and Ndokwa East local government areas are the most devastated. In Aboh community, the flooding led to the death of a local monarch and two children. Three other persons reportedly lost their lives at the relief camp in Ivrogbo, Isoko South council area. Survivors of the flood were then relocated to St. Michael's College in Oleh, the headquarters of the local government area. The flood wreaked havoc on farms, schools, courts, health centers, markets and electricity installations. People now use canoes as the only means of getting about in the flooded communities (Sahara Reporters, 2012).

According to the National Secretary of the Ijaw National Congress, Mr. Robinson Esite, "some of the residents of Patani who struggled to get some valuables from the flooded community were just standing by the road side not knowing what to do. He said, "I can tell you that there is a serious humanitarian crisis in this part of the Niger Delta now. The town of Patani, Adagbabiri and Bomadi have been sacked by flood. "In Patani, the flood is such that no building is spared and the people of Patani are in a terrible state. Many of them are just standing by the road side with the few properties they were able to rescue from the flood (Sahara Reporters, 2012).

Also, a Niger Delta activist from the town Mr. Presidor Ghomorai, said, "Patani is gone, it is a hopeless situation, only the youths are left there. And as it is, the flood is threatening Bomadi seriously" (Sahara Reporters, 2012).

"In Bayelsa, for instance, much of government business has been limited to managing the flood fall-outs. Even the Creek Haven, Yenagoa, the seat of the state government is not on safe grounds. The state has been marooned by flowing water for close to a month now into an island" (Sahara Reporters, 2012).

In Yenogoa (capital of Bayelsa State) where the ex-militants were undergoing a rehabilitation training, the spokesperson for the presidential aid on amnesty, expressed concern over the magnitude of destruction inflicted on Niger Delta by the recent flood, saying; "the greatest challenge facing the region would be how to manage the disaster caused by the deluge". Coordinator of the Presidential Amnesty Programme and Special Adviser to the President on Niger Delta Affairs, Mr. Kingsley Kuku, in Yenagoa while presenting three truckloads of

relief materials to the state government for victims of the flood, said the aftermath of the disaster would be more challenging than the disaster itself. Represented by Mr. Tawari Dortimi, Kuku called on all the affected states to map out strategies to contend with the challenges ahead (In NEWS, 2012). The ex-militants undergoing rehabilitation donated some money from their allowances to alleviate the sufferings in the affected areas.

In his remarks, the Deputy Governor, Rear Admiral John Jonah (rtd), said the government had held series of meetings to develop post disaster management, saying that government was also worried about transporting relief materials to displaced persons in remote areas. "Our post flood management strategies will include policies in agriculture. We are thinking of how to get our food back to avoid food shortage. We are brainstorming to know how to reduce the pains", he said (In NEWS, 2012).

Other areas affected included the Niger Delta University at the Wilberforce Island in Amassoma. The flood destroyed several offices, lecture halls, hostels, students properties-including credentials, textbooks/materials, vehicles, farmlands, etc .In a statement by the Registrar of the institution Mr. Tonbra Morris-Odubo a notice of indefinite suspension of resumption date for the 2012/2013 academic session' supposedly fixed for 8th October 2012 was made (In NEWS, 2012). There was fear of outbreak of epidemic in the flood-ravaged Obuwari settlement, equally referred to as Mile I, in Sagbama, headquarters of Sagbama Local Government Area in Bayelsa. About 300 buildings, including public and private schools in the area, were submerged.

Equally affected are those living along the Rivers Niger and Benue and with the volume of water from the two biggest rivers confluencing in Lokoja, Kogi State, if the water rose above sea level toward the south down to the creek mostly of Delta and Bayelsa State. Communities on both sides of the river Niger as well as those along the distributional became victims (In NEWS, 2012).

In Rivers State, the impact is mainly in the areas traversed by the Orashi and Sombreiro Rivers in the west senatorial district. Specifically, Ahoada West and East, Ogba/Egbema/Ndoni and Abua/Odua councils were in the bull's eye. From Akabuka and westward through Oboburu, Obagi, Edu, Obigbo and Etu, down to Ohali, the road had become part of the Orashi River. Eastward to Erema, Ibewa and Ituli, there is respite, thereby forcing a drift in that direct from the western end. Both sides, demographically, constitute Egi clan, which is part of Ogba Kingdom, where about 90% of the upstream operations of French oil giant, Total, is concentrated (The Guardian, 2012).

Chibuzor Ugwoha, the immediate past managing director of the Niger Delta Development Commission (NDDC), whose father's house in Erema has since been taken over by distant relations and even unknown persons sacked by the flood in the west end of the Egi kingdom, said: "I have never seen a thing like this since I was born. In situations like this, you do not ask questions or even probe the clans and identities of persons flooding in. The first and most logical thing to do is to let them in and then do whatever is possible to offer them immediate hope" (The Guardian, 2012).

Several heart-ripping stories came from the impacted communities several animals including pythons,antelopes and grasscutters were seen floating" (Wokocha, 2012). Ojumite, who claimed he had remained separated from his children and wife since the flood began, explained: "Our people are not conversant with canoes; we cannot swim, we conduct all our businesses on land and so what we are currently witnessing is like asking us to adopt new ways of life after centuries of existence" (The Guardian, 2012). That helplessness was most tragically expressed in the event involving one Odoka Benson from Obagi a rural community in Rivers State. He had returned to Obagi from Omoku, where he was taking refuge. At sunset, he was ready to go. As if actually bent on departing finally, he turned down entreaties to stay the night anyhow in the flooded town, because it had become late and the boat operators had closed business for the day (The Guardian, 2012). He reportedly got to the anchorage, forced out a boat and boarded, in company of his pregnant wife and daughter of one Pastor Blessing Dikogwo, their two children, a lady and himself (The Guardian, 2012). Apparently, Benson might have reasoned that the business of moving canoes on water was all mechanical without any form of mental calculations. But midway or midstream, because the Akabuka-Obagi road had also become a stream, 'the captain' got what he did not bargain for. He was up against the forceful tide of the water flowing across the road (Sahara Reporters, 2012).

It became an ill-fated voyage, as everyone on board, except himself, was swept away by the tide. The lady on board was the elder sister of Wisdom Nwoko-Omere, who is among persons awarded scholarship by the NDDC to pursue post-graduate studies in universities abroad (Sahara Reporters, 2012).

'One Azubike Nwaoga returned from Babcock University in Ogun State, where he is studying hard to become a better priest of the Seventh Day Adventist Church, to begin from the scratch'. 'The flood overwhelmed his home while away in school and the folks he left behind reported that all his belongings went with the water, except his motor-bike. He took solace in the Bible: "In all things, we give thanks to God" (Sahara Reporters, 2012). OjumIte could not also do much when his house was overrun in Ahoada. "The only thing I could take out of my house is my certificate," he bemoaned. His ponds were flooded and the fishes in them spilled into the wild.' The collective loss is equally enormous (Sahara Reporters, 2012).

'Many of the social facilities provided by Total as part of its Corporate Social Responsibility (CSR) to its host

communities are endangered. For instance, the health centre in Ogborgu stood submerged as at last week. The water scheme at Akabuka was itself under water and it was not likely it was still giving good water to the community' (Sahara Reporters, 2012).

'The grand benefactor itself, Total, is battling for a lifeline. It has been forced to temporarily closed shop in Ogba Kingdom. Its External Communications manager, Charles Ebereonwu, neither confirmed nor denied outrightly the claim that the oil company had shut down operations. He only said: "We are talking about lives here and I think life is more important than production" (Sahara Reporters, 2012).

'In real terms, this means that about 40,000 barrels of crude, representing Total's contribution, have been cut back from the 2.6 million barrels per day (bpd) national output. One environmentalist in Port Harcourt added a frightening dimension'. He said: "Total's waste pits and other disposal sites have been flooded. Chemicals and other harmful substances that the company uses in its operations have all been washed into flooded homes and farmlands. "We cannot measure the extent of impact until a proper assessment is conducted" (Sahara Reporters, 2012).

'Reacting, Ebereonwu sounded more like a lawyer in court, saying whoever that was asserting should offer proofs'. He said: "This is a nationwide tragedy, not restricted to Total, and so whoever that is alleging pollution should provide the evidence" (Sahara Reporters, 2012).

'All the same, the company has been part of the coordinated efforts by the Rivers State government at rehabilitating the victims, donating materials to the various relief camps in the area. Unlike fire, water can hardly be contained. It dissipates on its own and it is not different in the current situation' (Sahara Reporters, 2012).

With several persons displaced and living in temporary camps, their daily subsistence has been a challenge. An observer on the allocation of the relief materials provided by the Niger Delta Development Commission (NDDC) said, "We are not satisfied based on what the masses are facing in the hands of those feeding us. They are mismanaging the relief materials that are given to them; even though government supply those things in quantity; they economise them," one of the victims complained. The representative of the Agency, Prof. Aminigo advised the people to always cooperate with those managing affairs in the camps, noting that the materials donated by the agency would go a long way to ameliorate their plight. The materials were provided in most affected communities in the various Niger Delta states' (Sahara Reporters, 2012).

"Flooding in the oil rich Niger Delta, has disrupted oil production to the tune of around 500,000 barrels per day (bpd)– more than a fifth of nation's oil output according to the Department of Petroleum Resources" (Sahara Reporters, 2012).

Managing the issue has been a complicated affair for both the victims and the governments of the region. Most of the camps established for the Internally Displaced Persons (IDPs), could hardly contain them, others are not in good habitable conditions. The temporary camp has been described as worse and could lead to outbreak of diseases as most of them are over-stretched.

Recommendations: Mitigation strategies

Climate change has been an issue of global concern. Flood control in the region needs collaborative efforts including the cooperation of government, policy makers, international and local communities, enlightenment programmes and capacity building through environmental education involving NGOs, CBOs and the mass media, could reassert the level of awareness of the poor inhabitants of the coastal regions to understand the enormity of the challenges posed by climate change.

Gender and environmental security should be given novel policy priority especially among the volatile and poor coastal regions. According to the Rio 2012 report, "the implementation of sustainable development will depend on the active engagement of both the public and the private sectors. We recognize that the active participation of the private sector can contribute to the achievement of sustainable development, including through the important tool of public-private partnerships. We support national regulatory and policy frameworks that enable business and industry to advance sustainable development initiatives, taking into account the importance of corporate social responsibility. We call on the private sector to engage in responsible business practices, such as those promoted by the United Nations Global Compact" (Rio, 2012).

Importantly, key mitigation strategies could involve mainstreaming climate change adaptation into development planning at all levels of government including local, state and federal. Novel environmental policies should as a matter of expediency evolve participatory strategies to interface with the rural populace on climate change issues such as Rural Climate Change Monitoring Forum (RCCMF). This could be linked directly to State Emergency Management Agency as focal points to relate climate change issues in the rural areas.

Adaptation to climate change and concomitant adverse effects will involve an understanding of climate change parameters and dynamics, including monitoring and data analysis of climate change parameters. This strategy should lead to an African Climate Change Scenario (ACCS), upon which countries can base their adaptation options. Existing scenarios and adaptation measures for climate change and sea-level rise are built around Western experiences (IPCC, 2007).

Within an integrated approach, there is a great opportunity to anticipate problems associated with sea-

level rise rather than simply reaction to change as, or after, it occurs (Nicholls and Leatherman, 1994).

Furthermore, a well-planned response that seeks to anticipate the physical impacts of sea-level rise in a timely fashion will minimize unwise decisions and result in lower costs for reactive responses such as protection (Nicholls and Leatherman, 1995). Anticipatory responses include urban growth planning, building setbacks, wetland preservation and mitigation, public awareness, and integrated coastal zone management (IPCC, 2007).

Policies and regulations concerning the use of the coastal zone for any form of human activity should include consideration of sea-level rise. Physical planning and building-control measures and regulations should be instituted and implemented. Allocation of land for any economically useful purpose in areas likely to be flooded or inundated should be avoided. The public should be informed of the risk of living in coastal and lowland areas that are threatened by sea-level rise. Timely public education on erosion, sea-level rise, and flooding risks could be a cost-effective means of reducing future expenditures. Where coastal infrastructures such as roads, fish land, and curing plants are approved and must be constructed, the authorities and owners of these infrastructures should make sure that marginal increases in the height of the structures are included to offset sea-level rise (Smith and Lenhart, 1996) and other related phenomena. People located in high-risk areas should be offered incentives to relocate out of these areas. Setbacks could be used as buffer zones to allow sea level to rise without threatening coastal development. French et al. (1995) recommended incorporating buffer zones between the shore and new coastal development in Nigeria (IPCC, 2007).

There is urgent need of bringing all actors in the coastal areas together to address coastal-zone problems. The program should consist of a set of principles and plans to guide the use of coastal land and resources for conservation, recreation and sustainable.

Environmental activism and awareness will ameliorate unsustainable environmental consumption by all stakeholders including the MNCs operating in the region.

Conclusion

Climate change and global warming are now scientifically established facts. Climate change is a massive threat to human development and in some places it is already undermining the achievement of the Millennium Development Goals (MDGs) and the international community's efforts to reduce extreme poverty. The issue of climate change is global. Nigeria and indeed Africa is not excluded from its threats.

Our study had the aim of understanding environmental security in the coastal regions of Nigeria; how disasters such as flooding and its effects have impacted the region, the level of response by the state and the international community. The results derived from this study show that majority of the people in the area have little knowledge of climate change vulnerability, frequency in occurrence of the incident and the causes. Again, most flood victims do not get compensation or relief during flood disaster, majority of those we interviewed who are artisans and peasants, with occupation such as fishing, subsistence agriculture, expressed dissatisfaction with the level of response by the government and policy makers to their plights.

Climate change will exacerbate existing physical, ecological/biological and socioeconomic stresses on the African coastal zone. Most existing studies focus on the extent to which rising sea level could inundate and erode low-lying areas or increase flooding caused by storm surges and intense rainstorms. The coastal nations of west and central Africa (Senegal, The Gambia, Sierra Leone, Nigeria, Cameroon, Gabon, Angola) have low-lying lagoonal coasts that are susceptible to erosion and hence are threatened by sea-level rise, particularly because most of the countries in this area have major and rapidly expanding cities on the coast (IPCC, 2007).

Africa's west coast often is buffeted by storm surges and currently is at risk of erosion, inundation, and extreme storm events. Inundation could be a significant concern (Awosika et al., 1992; Dennis et al., 1995; French et al., 1995; ICST, 1996; Jallow et al., 1996; IPCC, 2007). Major cities such as Banjul (Jallow et al., 1996), Abidjan, Tabaou, Grand Bassam, Sassandra, San Pedro (ICST, 1996), Lagos and Port Harcourt (Awosika et al., 1992)- all situated at sea level would be very vulnerable. Finally, tidal waves, storm surges, and hazards also may increase and may modify littoral transport (Allersman and Tilsmans, 1993 cited in IPCC, 2007).

Carbon dioxide emissions in the area are among the highest in the world. Some 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger Delta from flaring 1.8 billion cubic feet of gas every day. It has been reported that gas flaring has raised temperatures of the region and rendered many areas uninhabitable.

This study attempted to examine the scenarios of the climate change in the Niger Delta region, its vulnerability and impacts and provided possible mitigations to stem the tide of global warming and environmental degradation in the region.

Finally, the study concludes that climate change is largely though not exclusive attribute of anthropogenic activities of man and could be checked only if these activities are reduced.

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