ISRJ ONLINE

INTERNATIONAL SCIENCE RESEARCH JOURNAL
ISSN: 2006 – 1730

IMPACT OF LAND USE CHANGES AND THEIR POTENTIAL DANGERS TO THE BREEDING OF MOSQUITOES OF PUBLIC HEALTH IMPORTANCE IN OWERRI, NIGERIA.

***Amaechi, A.A.[a], Amaka, C.J.[a] and Nwachukwu, O.M.[b]**

[a.] Medical Entomology Research Unit, Department of Animal and Environmental Biology, Imo State University PMB 2000 Owerri, Nigeria.

[b.] Department of Biological Sciences, Federal University Technology, Owerri, Nigeria

ABSTRACT

To assess the impact of land use changes and its rising temperature on the dynamics of mosquito larval densities, we conducted a study in 3 selected sites in 3 different areas of Owerri Imo State, Nigeria, between May and November 2012. The sites represented urban, semi urban and rural areas of the State. Mosquito eggs were reared in 6 artificial containers and their daily temperatures recorded. Overall, 2 species of mosquito genera were found; *Anopheles* and *Aedes*. The rate of development from larvae to adult was fastest at site 1 (which represented urban areas) with peak metamorphosis completion at 7th day. The peak for rural area (site 3) was 11th day. There was significant differences between daily temperature and mosquito larval densities changing to adults ($p<0.05$). The inference from the study is that some factors associated urban areas and other agents of global warming might have influenced the breeding rate of mosquitoes. The study recommended that town planners and capital development authorities should enforce the building of residential houses away from commercial areas to prevent exposure to mosquito bites with health implications.

Keywords: Land Use, breeding of mosquitoes, global warming, metamorphosis.

INTRODUCTION

Although, there are many studies on medical importance of mosquitoes, very few have been tailored on the effect of human activities on their populations (Dorville⁻, 1996). Public health importance of mosquitoes in Africa evidenced by the burden of mortality and morbidity lend urgency to the investigation of the influence of land use changes on the population dynamics of the immature stages. Land use changes including deforestation for agricultural development and urbanization are thought to be the greatest drivers of terrestrial environment (Sala *et al*., 2000) and have often coincided with increase in the range of mosquito-borne diseases around the world (Gratz, 1999; Norris, 2004). This consideration is because they modify the basic physical properties of the ecosystem (Patz *et al*., 2004) which in turn alter the complex biotic and abiotic processes that typified the original ecosystem and the context with in which vector species breed, develop and transmit diseases (Patz *et al*., 2000).

As in most parts of west Africa, diseases transmitted by mosquitoes such as malaria and bancroftian filariasis in rural areas of Nigeria is generally intense, perennial and well documented (Awolola *et al*., 2002, 2006; Eigege *et al*., 2002; Nwoke *et al*., 2007). This situation often is not the same in urban or semi urban areas where exploitation of natural resources, use of

*Corresponding Author: E-mail: amaechiaustine@ymail.com

heavy equipment and development activities are common phenomena. The consequences of unplanned urbanization, deforestation and demographic growth suggest that rapid population growth is liable to alter the ecosystem and habit of vectors affecting their transmission indices. Land use changes increases encroachment over surrounding Greenland meant for agriculture. Today, most of the natural breeding sites of mosquitoes reported before have either disappeared (Service, 1970) or modified and increased due to human activities (Itah, 1998; Nwoke and Oguariri, 1993; Nwoke, 2004), though mosquito-borne diseases still persists endemically in Nigeria.

The differences in the water temperature of larval mosquito habitats in different landscapes and its relationship to the density of immature stages have been reported (William *et al*., 1994). Other surveys do so with the same landscape. In these studies water temperature data was collected as either point measures (Sunish and Reuben, 2000; Harret *et al*., 2001) or from ambient air temperature (Lindblade *et al*., 2000). However, none of the previous studies considered collection of daily temperature in larval habitats. Larval breeding habitats due to human activities abound in the study area and their potentials for mosquito breeding are yet to be assessed. The objective of this study was to examine the influence of land use changes due to human activities and its rising temperature on the dynamics of larval mosquito densities in artificial habitats.

METHODOLOGY

The study was carried out in Owerri the capital of Imo State, Nigeria (Lat. $5^{0}34^{1}$-$5^{0}15^{1}$N and Long. $7^{0}30^{1}$E). Three Local Government Areas namely; Owerri municipal, Owerri North and Owerri West, make up Owerri. After a preliminary survey, three sites situated in 3 different local government areas were purposively chosen. One of the sites was situated in Umuororonjo in Owerri municipal Council representing the urban area. The second site was in Umuguma in Owerri West, representing the Semi urban (pasture land). The third site was in Ngwoma in Owerri North representing the rural area. Each site was placed with 2 similar 6-litre black plastic pails which was also roughened inside with coarse sand paper to provide textured surface for egg attachment. Each pail was then filled with rain water up to 4-litre mark. Twenty grams (20gm) of dried pelletized sheep manure was added to supply Nitrogen (N_2), Phosphorus (P) and Potassium (K). Thereafter, the containers were positioned at their stands. In the first site, the pails were placed in front of a residential building, the second site in the open field while the third site under shade (canopy cover). They were kept still and left uncovered for 3 days. Temperature of the water was also taken using mercury thermometer. After 3 days, some eggs were laid inside it. The stands were re-examined and some eggs were removed with magnifying glass and spatula. This method afforded researchers working in the field on mosquito eggs to estimate the number of eggs when precision is not required for their works (Anosike, in preparation). Water temperatures were also taken.

Then the containers were covered with mosquito netting material (designed like emergent trap) and secured with rope to prevent contamination of the water by other animals and also prevent further oviposition by mosquitoes. The daily temperatures were taken at 9:00am, 12:00pm and 3:00pm from the start till the end of the experiment. The proportions of larvae that develop in to pupae each day were recorded while identification of larvae was done by Nwoke (2009).The emerged adults were also identified using the key of Emukah *et al* (2007).

RESULTS

The results of the different daily temperatures for artificial containers were shown on Tables 1-3. In all the readings, 3:00pm and 9:00am had the highest and least measurements. The comparisons of the daily water temperatures for the sites showed that site 1 (urban areas) had the highest recorded water temperature (490.5^{0}C) followed by semi urban (site 11) and the least was rural areas (site 111), 351.2^{0}C and 278.9^{0}C respectively, Table 4. The differences between daily water temperatures at different sites was significant ($p<0.005$).

Table 5 showed that artificial containers/ pails at sites1, 11 and 111 over the study period contained only 32 mosquito larvae. Peak of complete metamorphosis for the larvae at site 1 occurred on the 7th day of incubation period with a percentage of 44.4%. Also peak day of complete development for the mosquito larvae for site 11 and site 111 was 10th and 11th days with 37.5% and 60.0% respectively. The proportions of larvae becoming adult at the different sites was statistically significant ($p<0.05$)

Table 1: Daily water temperature of artificial containers in site 1

Time of the day/ water temperature

Days	9:00am/^{0}C	12:00pm/^{0}C	3:00pm/^{0}C	Mean water temperature
1	30.0	33.2	36.3	33.2
2	29.0	32.0	35.0	32.0
3	28.0	32.7	33.0	31.2
4	30.0	33.0	36.2	33.1
5	32.2	33.6	36.1	34.0
6	29.2	32.3	35.1	32.2
7	30.1	33.5	36.4	33.3
8	30.0	33.2	36.3	33.2
9	29.0	32.0	35.0	32.0
10	28.0	32.7	33.0	31.2
11	30.0	33.0	36.2	33.1
12	30.2	33.6	36.1	33.3
13	29.2	32.3	35.1	32.2
14	30.1	33.5	36.4	33.3
15	30.0	33.2	36.3	33.2
Total	**445**	**493.8**	**532.3**	**490.5**

***Corresponding Author: E-mail: amaechiaustine@ymail.com**

Table 2: Daily water temperature of artificial containers in site 11

Time of the day/ water temperature

Days	9:00am/^{0}C	12:00pm/^{0}C	3:00pm/^{0}C	Mean water temperature
1	25.0	33.2	36.3	33.2
2	25.5	32.0	35.0	32.0
3	26.0	32.7	33.0	31.2
4	25.5	33.0	36.2	33.1
5	25.0	33.6	36.1	34.0
6	25.7	32.3	35.1	32.2
7	24.0	33.5	36.4	33.3
8	25.0	33.2	36.3	33.2
9	25.5	32.0	35.0	32.0
10	26.0	32.7	33.0	31.2
11	25.5	33.0	36.2	33.1
12	25.0	33.6	36.1	33.3
13	25.7	32.3	35.1	32.2
Total	**329.4**	**349.2**	**375.0**	**351.2**

Table 3: Daily water temperature of the artificial containers in site 111

Time of the day/ water temperature

Days	9:00am/^{0}C	12:00pm/^{0}C	3:00pm/^{0}C	Mean water temperature
1	17.0	19.5	21.8	19.4
2	18.5	20.0	22.5	20.3
3	17.9	18.8	21.5	19.4
4	18.6	20.5	22.5	20.6
5	17.5	19.8	22.6	20.0
6	18.9	20.0	22.0	20.3
7	17.5	19.0	22.0	19.5
8	17.0	19.5	21.8	19.4
9	18.5	20.0	22.5	20.3
10	17.9	18.8	21.5	19.4
11	18.6	20.5	22.5	20.5
12	17.5	19.8	22.6	20.0
13	18.9	20.0	22.0	20.3
14	17.5	19.0	22.0	19.5
Total	**251.8**	**275.2**	**309.8**	**278.9**

Table 4: Comparative Analysis of the temperature at the three study sites

Time of the day/ water temperature

Days	Site 1	Site 11	Site 111
1	33.1	26.6	19.4
2	32.0	36.9	20.3
3	31.1	27.8	19.4
4	33.0	27.5	20.5
5	33.0	26.7	20.5
6	32.3	27.2	20.3
7	33.3	26.3	19.4
8	33.1	26.3	19.4
9	32.0	36.9	20.3
10	31.1	27.8	19.4
11	33.0	27.5	20.5
12	33.0	26.7	20.5
13	32.3	27.2	20.3
14	33.3	-	19.5
15	33.1	-	-
Total	**490.5**	**351.2**	**278.9**

Table 5: Number of Mosquito larvae becoming adult and their percentages in the study sites

Number of mosquito larvae becoming adult

% of adult mosquitoes

Days	Site1	Site11	Site111	Site1	Site11	Site111
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	3	-	-	33.3	-	-
7	4	-	-	44.4	-	-
8	2	2	-	22.2	25.0	-
9	-	1	-	-	12.5	-
10	-	3	-	-	37.5	-
11	-	2	9	-	25.0	60.0
12	-	-	-	-	-	-
13	-	-	3	-	-	20.0
14	-	-	2	-	-	13.3
15	-	-	1	-	-	6.7
Total	9	8	15	100	100	100

***Corresponding Author: E-mail: amaechiaustine@ymail.com**

DISCUSSION

The present study has shown the influence of land use changes and its temperature on immature stages of *Anopheles* and *Aedes* mosquitoes understudy. These changes will likely regulate these stages through changes in local temperatures due to manifest changes to the environment. Elsewhere studies have shown direct association between water temperature and mosquito presence or abundance (Williams *et al*., 1994). The infestation levels of these mosquitoes have been reported to increase due to climate changes, uncontrolled urbanization, and expansion of international travel and trade (Lounibos, 2002). *Aede*s larvae develop in domestic and peri-domestic water holding containers, such as water storage jars, rain filled tires, flower vases(Christopher, 1960) and are commonly found indoors (Lee *et al.*, 1987), while *Anopheles* larvae mainly occur in small temporary, sunlit pools such as borrow pits, cow hoof prints, tire tracks, drainage, ditches and small puddles (Gimnig *et al.*, 2001). However, the absence of other medically important mosquitoes may be due to lack of preferable larval habitat. For instance, *Culex* species are known to breed in wide range of polluted waters while *Mansonia* species in mangrove swamp.

The study revealed further that site 1 (urban areas) haboured larvae with the shortest interval of life cycle when compared with other sites. This fact accounted for fear that increase temperature of an area enhances the chances of a rather high number of mosquitoes. Thus, a confirmation that increases in urban population has major implications for mosquito-borne disease epidemiology both in terms of vector density (Okogun *et al*., 2005) and host-vector contact. In Nigeria, United National reported that the urban population has been growing over the decades; from 1960 at an average annual rate of 2.1-2.2 from the rural areas (World Bank, 1984). This population increase and rapid urban growth lead to overcrowding with accompanied deterioration of the quality of the environment. Therefore, the observation herein should be a source of concern as this could translate to the risk of dynamics of disease transmission which is sensitive to climate changes (Suthers, 2004). Land use change which is a major constituent of global environmental changes could have significant consequences for human health in relation to mosquito-borne diseases. It can influence mosquito habitat and the distribution and abundance as well as mediates human-vector interactions (including biting rate). For instance, using seasonal Autoregressive Integrated Moving Average (SARIMA) model to quantify the relationship between the meteorological variable and malaria cases, the effect of temperature on the epidemiology of malaria was reported (Mennon, 2003; Thomas *et al*., 2006). Urban areas are usually inhabited by people of varied occupational groupings and socio-economic status and urbanization have been found to increase local temperature of the environment by 3-4^0C (Hamitton, 1989). This area (urban) is also characterized by houses that radiate heat (Loevinsohn, 1994), heavy vehicles that combust fuel, human activities (including deforestation and pollution) which releases carbon 1V oxide (CO_2), Carbon 11 oxide (C0) and oxides of Sulphure into the atmosphere (Woodruff *et al*., 2006). These are known agents of greenhouse effects and global warming which leads to increase in the climate-related parameters; ambient temperature (Lindblade *et al*., 2001) and precipitation changes that influence the distribution of vectors (Patz *et al*., 1996). Human activities viz burning of fossil fuels have been noted to increase the atmospheric concentration of important greenhouse gases with resultant warming effects (IPCC, 1996). These factors which urban areas often shared with semi urban areas

***Corresponding Author: E-mail: amaechiaustine@ymail.com**

are known to contribute to the abundance and distribution of mosquitoes (Githeko *et al*., 2000). Furthermore, increase global temperature allows mosquitoes to survive where they would otherwise have died (Hales *et al*., 2002). With the growing trend of gradual modified ecology from rural to ‘rural-urban’, the need to encourage aforestation to check global warming rather than deforestation need not be over emphasized. Although water temperatures recorded in the containers allowed for comparisons between land uses, they are likely to be higher than could have been found in most habitats because of their heat absorbent properties.

Conversely, the containers with the longest interval in the developmental stages; from eggs to adults was site 3 (typical rural areas). They are usually characterized by thick vegetations, with tall trees, little or no vehicles and cool environment which could hardly enhance increase in temperature of the area (Lindblade *et al*., 2001). It is therefore expected that low temperature would have reduction effect on the development of both aquatic stages (larval and pupae) and adult stages but the reverse is the case with increasing temperature.

There was significant difference between the daily temperatures at the different study sites and proportion of mosquitoes becoming adults. It was reported elsewhere that one of the most fundamental mechanism by which land use is thought to alter the prevalence of mosquito vectors is by changing the water temperature of the larval habitats (Walse *et al*., 1993; Lindblade *et al*., 2000). This explains the differences in water temperatures of these sites and support previous findings which reported that elevated water temperatures can influence immature mosquito population directly by driving larval survival and development (Wetzel *et al*., 1995; Clement, 2000). However, we speculate that the association between land use and water temperature of larval habitats may be complex and specific land type dependent.

The overall impact of these land use changes on vector-borne diseases can be direct or indirect. For instance, rise in temperature will accelerate vectoral capacity due to a reduction in the extrinsic incubation period. This increase in temperature will also shorten the time required by the larvae to mature; hence more off springs will be produced during transmission period. This condition is favourable to blood sucking vectors (including mosquitoes). Increase in feeding due to fast rate of blood digestion results in increased egg production which in turn increases transmission intensities (Gillies, 1953). Indirectly, other factors; decrease hygiene, deforestation etc could increase proliferation and vector survival.

The observation of this study together with the habit of indiscriminate dumping of refuge including broken plastics and their likes and water storage for domestic uses in different containers in and around dwellings poses a great health hazard. This would increase the number of mosquito breeding sites and its operational implications could increase severity of disease and parasite burden. The information revealed by the study is essential and may serve as a guide to control mosquitoes with urban areas as starting point. This control can target larval stages because of their immobile, less vulnerable and less active nature with different larvicides. In view of these results, we recommend that the capital city developers and urban planners must design and insist that residential houses should be completely away from industrial and commercial areas. This is because of elevated temperature of these areas which in turn hasten the metamorphosis of the vector and enhance disease transmissions.

REFERENCES

Anosike JC (in prep). Field Estimation of mosquito eggs for laboratory analysis (unpubl. doc).

Awolola TS, Okwa O, Hunt RH, Ogunrinade AF, and Coetzee M (2002). Dynamics of the malaria vector population in coastal Lagos, Southwestern, Nigeria. *Ann. Trop. Med. Parasitol*. 6(1):75-82.

Awolola TS, Idowu ET, Adeneye AK, Mafe MA, Oduola AO, Ogurinade AF, and Appett B (2006). Entomological survey and infection rates of *Plasmodium falciparum* and *W. bancrofti* in mosquito populations in the Kainji Lake Area, Nigeria. *Nig. J. Parasitol*. 27:58-61

Clement AN (2000). *The biology of mosquito development, nutrition and reproduction* CABI . Publishing, OXON.

Christopher SK (1960). *Aedes agypti* (L) the yellow fever mosquito. Cambridge University Press, London, United Kingdom.

Dorville- LFM (1996). Mosquitoes as bioindicators of degradation in Southeastern Brazil. A statistical evaluation of published data in the literature. *Studies in Neotropical fauna and Environ.* 31:68-78.

Eigege A, Richards FO, Blaney DO, Miri ES, Gontor I, Ogah G, Jinadu MY, Mathias W, Amadiegwu S, and Hopkins DR (2002). Rapid Assessment of Lymphatic Filariasis in Central Nigeria: comparism of the ICT and Hydrocoele rates in an area of high endemicity. *Am. J. Trop Med. Hyg*. 68(6):643-646.

Emukah EC, Pam DD, and Nwoke BEB (2007). Manual on mosquito dissection and species. identification (unpubl. docu).

Gillies MT (1953). The duration of the gonotrophic cycle in *Anopheles gambiae* and *An. funestus* with a note on the efficiency of hand catching. *East African Med. J.* 30: 129-135.

Githerko AK, Lindsay SW, Confalonieri UE *et al* (2000). Climate Change and Vector-borne. Diseases: A regional analysis. *Bull. WHO* 78: 1136-1147.

Gimnig JE, Ombok M, Kamau L, and Hawley W (2001). Characteristics of anophelinae (Diptera: Culicidae) habitats in Western Kenya. *J. Med. Entomol*. 38:283-288.

Gratz DT (1999). Emerging and Re-emerging vector-borne Diseases. *Annual Rev. of Entomol*. 44:51-75.

Hamitton AC (1989). The Climate of East Usambaras. In: Hamitton AC, Bensted-Smith R, eds. Forest Conservation in the East Usambara. Gland, Switzerland. International Union for Conservation of Nature Pp 79-102.

Hales S, de Wet N, Maindonald J, *et al* (2002). Potential effect of population and climate changes on global distribution of dengue fever: an empirical model. *Lanc*. 360:830-834

Harrel N, Amerasinghe FP, Ensink J, Mukhtar M, Vander Hook W, and Konradsen F (2001). Breeding of *Anopheles* mosquitoes in Irrigated areas of South Punjab, Pakistan. *Med. and Veter. Entomol.* 15:236-248

***Corresponding Author: E-mail: amaechiaustine@ymail.com**

IPPC (1996). Climate change 1995. The science of climate change. Contribution of Working Group to the Second Assessment Report of IPPC.(Houghton JT *et al*) Eds. Cambridge University Press.

Itah A (1998). Creating Public Awareness in Environmental and Public health Education. The Nigerian Situation. *J of the Scien. Teach*. 9:372-335

Lee DJ, Hicks MM, Griffiths M, Debenham ML, Bryan JH, Russell RC, Geary M, and Marks EN (1987). The Culicidae of the Australasian region. Volume 4. Canberra, Australian Government Publishing Service.

Lindblade KA, Walker ED, and Wilson MI (2000). Early warning of malaria epidemic in African highland using Anopheles (Diptera: Culicidae). *J. Med. Entomol*. 37: 664-674

Lindblade KA, Walker ED, Onapa AW, and Katunga J (2001). Land use changes alter malaria transmission parameter by modifying temperature in high land area of Uganda. *Trop. Med. Inter. Health.* 5:263-274.

Loevinsohn ME (1994). Climate warming and increase in malaria incidence in Rwanda. *Lanc.* 343: 714-718.

Lounibos IP (2002). Invasion by insect vectors of human disease. Annu. Rev. Entomol. 47: 233-266.

Norris DC (2004). Mosquito-borne diseases a consequence of land use change. *Ecohealth* 1: 19-24

Menno (2003). Methodological problems and amendments to demonstrate effects of temperature on the epidemiology of malaria. A new perspective on the highland epidemics in Madagascar 1972-1989. *Trans. Roy. Soc. Trop. Med. Hyg*. 97:113-139

Nwoke BEB, and Oguariri RM (1993). Tropical Diseases: A major obstacle to socio-economic development in rural Nigeria. In: Development Strategies for Nigeria. Pp195-202.

Nwoke BEB (2004). Our environment and emerging and re-emerging parasitic and infectious diseases. Supreme Publishers Owerri, Nigeria.

Nwoke BEB, Nwoke EA, Ukaga CN, Anosike JC, Dozie INS, and Ajero CMU (2007). The Impact of changing human environment and climate changes on emerging and re-emerging parasitic diseses. *Nig. J. Parasitol*. 28(2):135-145.

Nwoke BEB (2009). Atlas of Medical Entomology (unpubl. docum).

Okogun GRA, Anosike JC, Okere AN, and Nwoke BEB (2005). Ecology of mosquitoes of Midwestern Nigeria. *J. Vec. Borne Dis.* 42:1-8.

Patz JA, Epstein PR, Thomas A, Burke A, and Balbus JM (1996). Global climate change and emerging infectious diseases. *J. Am. Med . Assoc.* 275: 217-233

Patz JA, Graczyk TK, Gelleer N, and Vittor AY (2000). Effects of environmental changes on emerging parasitic diseases. *Inter. J. Parasitol*. 30:1395-1405.

Patz JA, Daszak P, Tabor GR, Aguirre AA, Pear M, Epstein J, Wolfe ND, Kilpatrick AM, Foufopoulos J, Molyneux DH, and Bradly DJ (2004). Members of working group on land use and diseases emergence. Unhealthy landscapes: policy recommendations on land use change and infectous disease emergence. *Envt. Health. Perspec*. 112: 1092-1098

Sala OE, Chapin FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Huber-Sanwald E, Huenreke LF, Jackson RB, Kinzig A, Liemans R, Lodge DM, Mooney HA, Desterheld M, Poff NL, Sykes MT, Walker BH, Walker M, and Wall DH (2000). Biodiversity : global scenarios for the year 2000. *Sci.* 287: 1770-1774.

Service MW (1970). Identification of the Anopheles gambiae in Nigeria by larval and adult chromosomes. *Ann. Trop. Med. Parasitol*. 64: 131-136.

Suthers RW (2004). Global changes and vulnerability to vector-borne diseases. *Clin. Microbiol. Rev.* 17: 136-173

Sunish IP and Reuben R (2000). Factors influencing the abundance of Japanese encephalitis vectors in rice fields in India-1. Abiotic. *Med. Veter. Entomol*. 15:351-392.

Thomas MC, Doblas-Reyes FJ, Mason SJ, Hagedon R, Connor SJ, Phindela T, Morse AP, and Palmer TN (2006). "Malaria early warnings based on seasonal climate forecasts from multi model ensembles" *Natu.* 439: 575-579.

Walse JF, Molyneux ON, and Birley MH (1993). Deforestation Effects on vector borne diseases. *Parasitol*. 106(sup): 55-75

Wetzel RG, Hatcher PG, and Bianchi TS (1995). Natural photosynthesis by ultraviolet irradiance of recalcitrant dissolved organic matter to simple substrates for rapid bacterial metabolism. *Limn. Oceanogra*. 40:1369-1380.

William DD, Travers-Cromer A, Coleman JR, Kushner DJ, and Happey-Wood CM (1994). Colonisation dynamics of algae in small artificial ponds. *Canadian J. Bot*. 72: 1654-1665

Woodruff RE, McMichael AJ, and Hales S (2006). Action on climate change: no time to delay. Global warming is real, so what are we going to do about it, who will do it, and when? *Med. J.* 184:539-540.

World Bank (1984). World Development Report 1984. Oxford University Press. New York.

***Corresponding Author: E-mail: amaechiaustine@ymail.com**