

Full Length Research Paper

Assessment of Environmental Health Conditions in Urban Squatters of Greater Khartoum, Mayo Area in the Southern Khartoum, Sudan: 1987 – 2011

Samir Mohamed A. H. Alredaisy* and Omer Ahmed A. Hayati

University of Khartoum, Faculty of Education, Department of Geography 406 Omdurman Sudan

Accepted November 06, 2012

Based on data provided by two fieldworks conducted in 1987 and 2011 in the squatter area of Mayo, in the southern Khartoum town, environmental health conditions were investigated. The objectives of this study are to judge for improvement or not in environmental health conditions and to propose a model for the promotion of environmental health conditions in this squatter area. The judgment was based on comparing demographic, socioeconomic and nutritional characteristics of the population, the residential environment characteristics including housing; water supply, sanitation and health services of the two field surveys spanned for 25 years. Results depicted that population from the study area still having high average parity, and do not practice family planning and there was no decline in fertility rate. The population is urban poor, and women and children still the main source of the household income. Educational attainment did not improve between the two surveys thus Illiteracy is still prevalent. In 2011, 84% of the households were served by water vendors compared to 95% in 1987. Calculation of the cost of water purchase during 1987 for a household was of 30 USD per month, which is seven times the cost in 2011. In 2011 the water purchased from the donkey carts was often contaminated between the source and the household. In 1987, bacteriological test of water depicted faecal contamination exceeded the limit of 10/1000 ML recommended by World Health Organization in 1983. In 2011, and similarly in 1987 open defecation is the general norm in the area. Management of solid waste is a huge challenge where piles of solid wastes are dumped at an empty and open space closer to dwellings in 2011 and 1987. In 2011, 90% people living in the area suffered a lot from lack of food as the food quality was very poor and not diversified, while in 1987, the people from 60% of the households surveyed with one meal per day. The general results show no improvement in environmental health conditions in the study area. The authors propose the “RENGES” model to help promoting environmental health conditions in Mayo area.

Keywords: urban Sudan, Greater Khartoum, squatter areas, hygiene, sanitation, nutrition, education, income, residential environment, promotion, demolition, RENGES

INTRODUCTION

Provisioning of good environmental health conditions is a challenge worldwide. Environmental health is defined by World Health Organization (1983) as “The ecological balance that exists between Man and his environment, in order to ensure his well-being. This well being concerns the “whole Man”, not only his physical health, but also his mental health, and the optimum relations within his

environment. In the same way, it concerns the “whole environment” from the individual human dwelling to the entire environment”. One of the main challenges to provisioning of good environmental health conditions is the growth of urban population. There are 3.3 Billion of the world's population lives in urban areas (UNFPA, 2008). This represents 47% of the world's population (Tajudeen 'et al' 2006), and it was predicted that by the year 2030 this number will reach five billion and 95% of this growth will take place in the developing countries. This rapid urban growth has led to the growth of informal settlements (e.g.

*Corresponding Author E-mail: samiralredaisy@yahoo.com

Babker and Alredaisy, 1997). In the year 2003, nearly one sixth of the world's total population lived in slums and this number is likely to be doubled in next 30 years (UN-Habitat, 2003). It was estimated that between 20 to 80% of urban settlements in developing countries are informal, and by the year 2030 the number of worldwide slum dwellers will reach two billion (ECOSOC, 2005). Although urban growth in sub-Saharan Africa's is higher than the world's average (Bocquier 2005), this region had experienced declining urban growth during 1990s and 2000s (Bocquier 2003; Bocquier and Traoré 2000). This suggests that migration has contributed even less to urban growth in the recent past in Africa (Potts 2006), where the events that take place in the life of an individual contribute greatly to the his decision to migrate over the lifetime (Kulu and Milewski 2006). Squatter settlements are characterized by low income groups of population as they receive rural migrants and intra-urban movements from other slum areas (Muindi et al. 2009), as well as being overcrowded and lack access to environmental health facilities (Ali et al., 2004).

Sudan urban development, vulnerability to rapid urban growth, squatter growth and physical or anthropogenic effects on squatter growth are more or less similar to those operating in Third World countries. Drought is a principal driver of urbanization in Sudan (Sara, 2011), similar to the Sahel region which has been spurred on by recurring drought and the threat of long-term land degradation (Seaquist et al. 2009, Mertz 2010). The fertility rate in Sudan was 5.9 births per woman in 1999; while annual population growth rate was 2.53 % between 2003 and 2007, and the natural rate of increase was 41.23 per 1 000 in 2006 (Ministry of Health, Sudan. 2008).

Greater Khartoum's degree of urban primacy has changed, whereas in 1955 Khartoum had 4.7 times the population of Sudan's second-largest urban centre, by 1993 this had increased to 8.9 times (Davies 2001). Generally, growth of towns and cities in Sudan has been accompanied by growing numbers of poor and vulnerable urban dwellers (Sara, 2011). Housing as a primary demand, from whose scarcity much of the causes for squatter growth could be attributed. The high demand for housing in urban Sudan was ignited by low implementation of residential urban plans, and furthermore exacerbated by lack of knowing how to manage urban development and growth because of low funding, social disruptions such as renewing wars in southern Kordofan (western Sudan) and Blue Nile (southeastern Sudan), famine and drought, future uncertainty due to climate change and rapid population growth.

The urban areas in Sudan are managed through a hierarchical administrative system. It starts from the State Governor, and descend to Administrative Officer entitled to an administrative unit in a locality. In addition, People's Committees in residential areas were entitled to do some jobs such as follow up of garbage collection, but without an entitled financial budget. The allocated financial

budget for the administrative units at the national level does not commensurate with actual needs for expenditure on services. Therefore, these administrative units, however, completely depend on collecting direct taxes from individuals (either traders or houses' owners) to spend for services, which always in deficit. In addition, local governments consider squatter areas as illegal developments. Consequently, no budget was allocated for environmental health services, although water and electricity services might be provided. Waste disposal collection, for example, depends on direct monthly payment of residents by 2 \$. Twice a week schedule for waste collection, although specified by administrative units, was not effectively executed. The other services were provided to the minimum. Furthermore, Infrastructure development in urban Sudan does not commensurate with urban population growth and new residential developments. This is one of the major causes of the existing problems of environmental health conditions in urban Sudan, particularly the squatter areas. These might be due back to financial crisis, heavy burden of foreign indebt and civil wars in Sudan.

Many countries have tried to promote squatter settlements. In the mid-eighties, India introduced a slum redevelopment strategy in Bombay, involved the demolition of existing slums and the redevelopment of new, higher density, medium-rise apartment blocks, including, entirely cross-subsidized housing for the original slum dwellers (Vinit Mukhija 2002). Tanzania has recognized squatter settlements as part of the urban fabric, provided minimum level of services, planned land and assisted through loans and house construction (Tajudeen 'et al' 2006). Sudan has established the authority for planning and reorganization of squatter areas since early eighties. Its strategy was designated to demolition new developments, translocation of some others, and promotion of the very old ones. The experience was successful in some cases, as the examples of translocation of Ishash Fellatah to the outskirts of Khartoum town, and the promotion of Cartoon Kessala into Hai Baraka in east Nile locality. But, such efforts were not always successful, when these squatter developments were associated with political issues of the conflict between north and south Sudan before Nivasha agreement in 2005.

This study objects to judge for improvement or not in environmental health conditions in the squatter area of May and based on that proposed a model for the promotion of environmental health conditions in this squatter area.

MATERIALS AND METHODS

Study area

Greater Khartoum consists of the three towns of

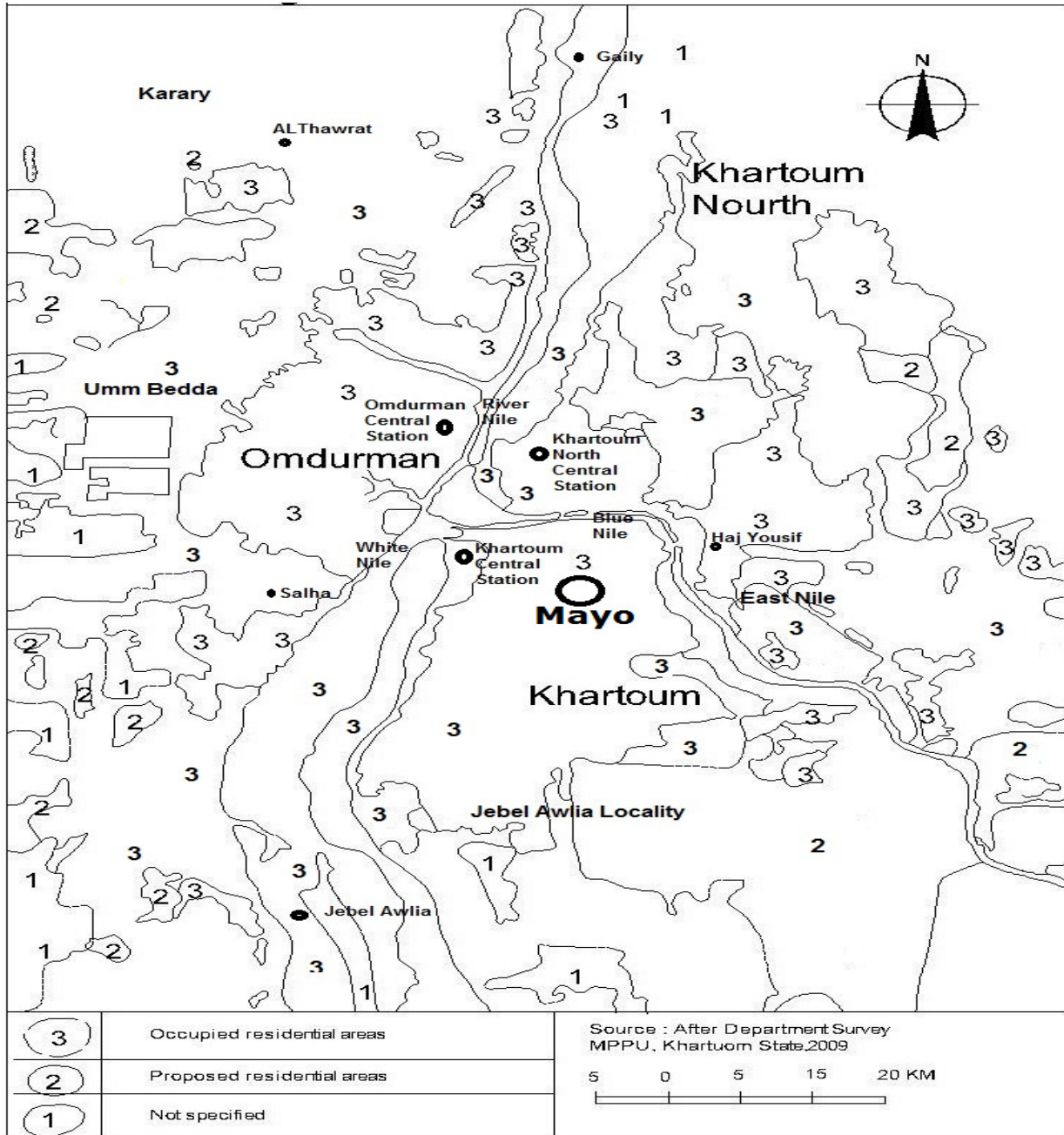


Figure1. Greater Khartoum: location and localities, and location of Mayo area

Khartoum, Khartoum north and Omdurman (Figure1). Modern Khartoum town started with the Turku- Egyptian rule in the nineteenth century and in early 20th century the Anglo-Egyptian rule re-established it as the capital of the Sudan (Walsh et al 1994). Similarly, Khartoum north started on the fringe of the right bank of the Blue Nile on a small strip (Gleichen 1905), while Omdurman developed as a narrow strip along the River Nile centred on the Imam Mahadi Tomb (Abu Saliem 1970). Through time the three towns grew rapidly due to urban residential plans, and unofficial land sale by native population

(Figure 1). There are three types of land categorization depicted by figure 1, including occupied residential areas, proposed residential areas, and not specified areas which are miscellaneous used for agricultural, residential and military purposes. Within this urban mass, older squatter areas grew, and furthermore recent growth of squatter settlements has been in areas indicated to "not specified" in figure 1.

The growth of Greater Khartoum's squatter areas was a result of many factors. Land demand for housing increased because of increase of population and

migration to Greater Khartoum. Rate of population increase in Greater Khartoum was 4.92 in 1956, and raised to 7.76 in 1973, and to 8.75 in 1983, while reached 13.7 in 1993 (MFEP, Population censuses of Sudan 1956 – 1993). Similarly, number of persons per square kilometer in 1973 was 55.6 persons, 85.5 in 1983 and 169 persons in 1993 (MFEP, Population censuses of Sudan 1956 – 1993). According to population censuses of 1983 and 1993, Khartoum state received 39% and 45% respectively of the internal migration in the country. During the period 1980-1999, Greater Khartoum received between 50-70% of the total displaced population in Sudan in 1990, where they occupied 50 locations in 1991 with a total number of 1,570,000 displaced persons (Banaga 2001). Gradually these concentrations began to be transferred into the old urban mass and old squatter settlements, where their population reached to more than 2,500,000 persons in 2001 (Banaga 2001).

Axes of squatter developments were westward, a south - westward and northward axes from the fringes of Omdurman central to the margins of Kordofan state and Nahr el Nil state (Alredaisy and Davies 2003). Another axis grew southward and south eastward from the fringes of Khartoum central to the border of the White Nile state and the Gezira state. A similar one went northward from Khartoum north central to the margins of Nahr el Nil state and north eastwards to the direction of central Butana plain of eastern Sudan (Figure 1). Within these axes, some transitional points for a further distribution of new developments of squatter settlements could be detected. The axis that emerges from the fringe of Khartoum central to the border of the White Nile state and the Gezira state is a discrete line where its central node locates after nearly 20 kilometres from the city centre of Khartoum. From this node further squatter developments made a continuous belt following Khartoum – Jebel Awlia highway and the White Nile River (Figure1).

Mayo area (Figure 1) developed as camp for leprosy patients, administrated by Ministry of Social Works in 1969. In early 1970s, it became reception area for urban squatters transferred from illegal residential concentrations developed near Khartoum Industrial area, and Alishash area which was an intra urban squatter settlement. From thereon, Mayo expanded and developed, as it hosted a wide spectrum of western and southern Sudanese tribes, as well as West Africa migrants including Hawsa, Fellata and Quran tribes. Residential demarcation is quite remarkable in Mayo area, where each residential division was mainly occupied by a particular ethnic group or a tribe and named Hai and therefore, there are Fellatah, Quran, Bellalh, Masalit, Fur, Dinka and Nuba residential divisions (Hais).

Data collection

The first fieldwork was conducted during March 1987 as

Masters Degree research project in Geography submitted to the University of Khartoum by one of the authors. The fieldwork had intended to collect socioeconomic; demographic; nutritional and residential environment data. These included monthly income or households members, marital status, number of wives, family planning, household educational level, housing conditions including number of rooms, kitchen, bathroom, latrine and its type, size of room, number of windows per room and type of ventilation, and type of water supply). Residential environment data included source of water supply, means of water distribution, cost and pricing, waste disposal system, means of garbage collection, type of food during the day, practicing of breast feeding and its duration, type of food during pregnancy and lactation, type of supplementary food and time of start giving, timing of starting weaning period, type of prohibited food, delivery conditions, practicing of family planning. The fieldwork was supported by three members of Goal Organization medical personnel working in the study area and was headed by one of the authors. The sample size was 880 household representing 10% of the total number of households in the study area according to 1983 population census of the Sudan. Each residential division was allocated by 35 samples. The panel households were chosen according to their accessibility during the fieldwork (non probability sampling procedure). The names of residential divisions were used for the sample framework where there were 16 residential divisions, including Alwihda; north and south; Fellatah north and south; Quatati north and south; Bellalah; Dirwa; Wahidwathalthin; Dink; Quran; Masalit; Tibin; Fur and Alarab. In addition, observation, three water samples were taken from the main borehole; communal water pipe and vendors, and were bacteriological tested for water faecal contamination.

The second fieldwork was conducted in October 2011 by World Vision Organization and was based on focus group discussions. Both primary and secondary data were used in this rapid assessment process. The secondary information such as previous reports, baseline surveys and various inter agency assessments was reviewed. Qualitative data collections tools were employed in order to gather more information on community needs, challenges and proposed area of interventions. Focus group participants identified with purposive sampling in consultations with the community leaders, partners and World Vision Field Staffs Each focus group included 8 - 15 participants. A complete set of open ended checklist was applied in the area of 1) food security and natural resources, 2) Water and Sanitation, 3) Health and Nutrition, and 4) Gender and Child Care. The focus group was conducted with four types of groups such as Men, Women, Boys and Girls. The checklists of the focus groups discussions were developed to identify the major findings, Food Security, Health and Nutrition, Water and Sanitation, Gender and

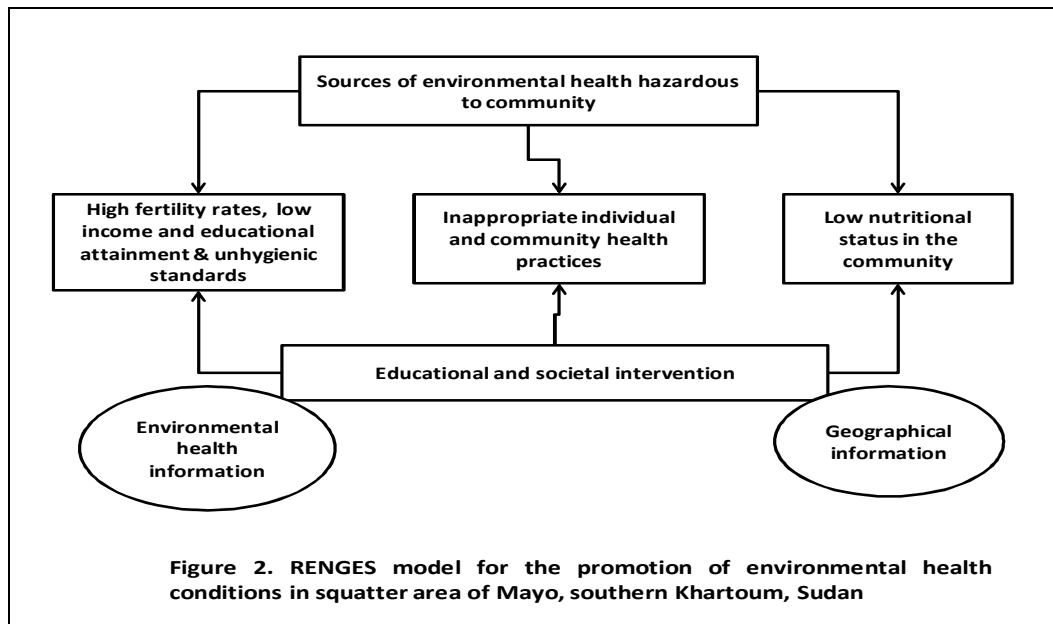


Figure 3. Mayo in 2011
Source: World Vision Northern Sudan, 2012

Child Care. World Vision staff visited the schools, health clinics and primary resource centers used by the target community in order to assess their physical condition. During the focus group discussion, around 6 basic schools and 2 secondary schools are located nearby or within the communities.

The used renges model

The objective of this study, in addition to judge for improvement or not in environmental health conditions in

Mayo area, is to propose a model for the promotion of environmental health conditions in this squatter area. The study proposes the “RENGES” (Residential Environment; Geography; Education; Society) model (see Figure 2). This model considers areas of geographic location, socioeconomic and demographic and nutritional aspects of the society, as well as residential environment characteristics. The RENGES model shows sources of environmental health conditions which are hazardous to the community, including high fertility rates, lack of adequate income, low education and unhygienic standards; inappropriate individual and community health

practices; and low nutritional standards. Intervention for the promotion of environmental health conditions, based on environmental health information and geographical information, could be done through education and building capacity of the society. The main objective of the RENGES model is to promote environmental health conditions and reduce environmental health risks Mayo area. The importance of RENGES comes from its simplicity, its potential to deal with the available resources at the grassroots level, and its affordability for use with any squatter area in any geographic setting. RENGES works like an open ecosystem, with inputs, processes, and outputs. The inputs are environmental health standards of adequate water supply, sanitation and health services (residential environment), and geographical information concerns with residential environment as well as environmental health information; and education (educational), and demographic, socioeconomic and nutritional characteristics of the population, (societal), the processes are the impacts of these inputs on environmental health conditions in the study area; and the outputs are the promotion of environmental health conditions and reduction of environmental health risks in Mayo area.

Residential environment data is essential as it provides information on appropriate characteristics of human environment, such as public health and sanitation, water supply and waste disposal systems. Geographical data include information on location, population mobility and density, congestion, and geographic proximity and the role of these factors in increasing/reducing environmental health risks. Environmental health information and geographical information have global, continental, regional, national and local scales. Determination of such geographic scales, particularly the local and national ones, provides a spatial database for dealing with negative impacts of environmental health conditions in squatter areas that will eventually promote its living conditions. Environmental health risks are highly linked with the physical environment—temperature, rainfall, and flooding or aridity which determine their severity and seasonality; the need for such data is substantial for the assessment and prevention of negative impacts of environmental health conditions in such squatter areas. Education is important in the promotion of the general residential environment and reduction of environmental health risks. An educated society will, of course, have knowledge about personal hygiene, environmental sanitation, disease transmission, and infection. Health education will create awareness of the environmental health risks and ways of avoiding their negative impacts. In addition, social capacity building through collective work and civil or voluntary organizations can work to assess and combat/reduce these negative impacts. Society building capacity includes activation of human resources for utmost management of residential environment and promotion of

living conditions. The application of RENGES model in Mayo area will be further outlined following a review of the results of these two surveys.

The major strengths of this model are its simplicity, its potential to deal with the current environmental health problems at the grassroots level, and its affordability for use with any environmental health problem in this geographic setting. However, the potential challenges one might expect in trying to implement this model might be migration, due to political instability in Sudan as well as drought, to the study area that will cause overpressure on meager environmental health services and infrastructure. In addition, since there are many gaps and divides that hinder reliable management of environmental health services in the study area, it is expected that this might challenge the application of this model. The most important of these are gaps in knowledge base and capacity development, absence of comprehensive environmental health policy; lack of coordinated decision making at federal, State, and local levels and gaps between decision makers and target groups. Also, there is a gap between decision makers and stakeholders and bridging this gap is very crucial for success of this model. This purpose could be achieved by encouraging multidisciplinary research that addresses the interests and motivations of decision makers and local society and fulfill the needs of the community.

RESULTS AND DISCUSSION

Demographic and socioeconomic characteristics

The survey in 2011 gave an average for the household size of 7.5 people per household, which is similar to the results obtained in the survey from 1987, when there was high average parity per household. In 1987, child spacing for an interval of 1 to 1½ years was practiced by 20% of the households surveyed, while 62% of them had a child every 2 years, and 18% for every 2½ years, and 85% of the households did not practice family planning. This is similar to the numbers obtained in the survey made in 2011, when women faced no family planning program and carried too many children. The study area lacks the services provided by the centres of family planning and health education. The population of the study area still have high average parity and do not practice family planning and therefore there was no decline in fertility rate. This high fertility rate proves the total fertility rate in Sudan which was 5.9 births per woman in 1999; and with an annual population growth rate of 2.53 % between 2003 and 2007 and the natural rate of increase of 41.23 per 1 000 in 2006 (Ministry of Health, Sudan. 2008). It also agrees with the slum population growth in Dhaka which has doubled within the last decade reaching 3.4 million in 2005 (CUS et al., 2006). This population increase is reflected in the expansion of the Greater

Khartoum through formal urban residence plans and informal squatter areas (El-Bushra, 1995), which agrees with the general world trend of growth in the squatter settlements which constitute 20 to 80% of the urban settlements in developing countries (ECOSOC, 2005), and with the general trend of urbanization in Sudan where the percentage of urban population is projected to be 46.4 in 2025 while, in 1994 it was 24.2 (UN, 1994).

The results of 2011 survey depicted that women are the major income source and contribute to obtain the household daily needs. More than 70 % of them are mainly involved in vending food items for school children and others, in small business, sometimes poultry rearing, and food processing activities. In addition, most of the families depend on daily labor in constructions making bricks and other petty works. 50% of the households spent up to 10% of their income for the education of their children, while 13% spent 10-25%, 17% spent 25-50% and 7% spent above 50%. The survey made -in 1987, indicated that 80% of the households surveyed depended on women as the main source of income. 56% of the total households surveyed had the lowest income of 100-300 SDG (25- 72 USD) per month, while only 10% of the total households had the highest income of 600-800 SDG (150 – 225 USD) per month. The population of the study is still urban poor, and females still the main source of the household income. The dominance of the households with a low income in the study area agrees with the figures from the Sub-Saharan Africa where about half the population is living below the poverty line, with both numbers and percentage on the increase (Alredaisy, et al., 2001). Generally, the expansion of towns and cities in Sudan has been accompanied by a growing number of poor and vulnerable urban dwellers (Sara, 2011). Although Sudan is rich in natural and human resources, 77.5% of the households surveyed in north Sudan were on or below the poverty line (MOL and ILO, 1997]. The study made by the United Nations Development Program in 2005 reported that 75% of the north Sudan population was poor and the majority (80%) is concentrating in rural areas where 30% of them suffered from extreme poverty (United Nations Development Program, 2005). The majority of the urban poor people are dependent on marginal livelihood activities from the informal economy, and their access to safe and sustainable livelihoods is extremely unstable (Sara, 2011). However, the factors influencing the income in the study area might include those operating at the national level including the absence of social development and insufficient productive capital investment (UNDP, 1998), ill-conceived development policies and armed conflicts (Zeng, 2003).

The survey in 2011 showed that, pre-schools and primary schools were not sufficient to admit all applicants. The available schools have very limited concerning the sanitary infrastructure and drinking water facilities, where pupils get water from the nearby water points that use donkey carts. The number of students in one class room

reached even 130 students. High school fees for students is one of the major reasons for school dropout and a decreased enrollment rate, and children sometimes walk 30-60 minutes to reach the nearest schools. The survey made in 1987 showed that illiterate members of the households represented 33% of the total percentage of educational attainment. Those who completed primary school were only 29%, while those who completed secondary school were only 4%. Educational attainment did not improve between the two surveys, where Illiteracy is still prevalent similar to sub Saharan Africa, where a large number of children remain out of school and for those who do enroll, less than half complete the primary education (Johnson, 2008), and nearly 78 million of the region's secondary school-aged children were not enrolled in secondary school (UNESCO, 2009).

Water and Sanitation

In 2011, 1/3 of the households had access to communal water pumps, and 84% of them are served by vendors. This is similar to the results obtained during the survey made in 1987, where 95% of the households were served by vendors, and only 3% depend on the communal water pumps, while 2% had access to home piped water supply. There was a reduction by 11% of the households served by vendor, which might be attributed to a higher access to communal water pumps in 2011. There was no indication to home piped water service during the survey conducted in 2011, although there was small portion of the population who had access to that type of service in 1987. This is similar to Dhaka, where slum population suffers from acute shortage of potable water (Akbar et al., 2007).

In 2011, there was difficult to have access to water mainly because of high costs. The estimated figures showed that the cost of water could reach up to three times the cost of the piped water in Khartoum City that was 16 Sudanese Guinea (4 USD) per month. A family from Mayo had to pay 48 Sudanese Guinea (12 USD) monthly to purchase water. This equals the water tariff for first class residential areas in Greater Khartoum. This cost, if compared to the one from 1987, when the price of water was fixed by the vendors at a quarter Sudanese Guinea (1/4 USD) for a tin of 4 British Gallons (18 litres), that was much less. The calculations made for the cost of water purchased by a household with an average of 6 members, during 1987,, gave 1 USD per day or 30 USD per month, which is seven times less the cost in 2011. Most of the households cannot afford that cost and they reduced their consumption or use communal pipes. But this is not always the case, as resulted during the survey made in 2011, when during a normal season a water tank of 216 liters costs 5 Sudanese Guinea (1¼ USD), and during rainy season, the same tank of water costs between 8 (2 USD) to 10 Sudanese Guinea (2½ USD).

Table 1. The presence or absence of faecal contamination in the water from the Mayo area in 1987

Source of sample		MPN. Coli/100 ML	E. Coli type 1 / 100 ML
1-	Borehole	14	Positive
2-	Communal pipe	7	Positive
3-	Vendor	Present	Positive
4-	Borehole	Zero	Zero
5-	Vendor	present	ve

Water provision during the rainy season is more expensive due to poor roads, bad drainage of stagnant water which causes the flooding of the water points and makes them difficult to access. This is similar to the situation in 1987, when stagnant water during the rainy season prevented the provision of drinking water provided by the vendors, as attributed to the same factors in 2011. The high expenditure for water in situations of low income, big households and spreading illiteracy has many consequences. One consequence is that in a household with a low-income a surplus of water is very expensive, representing a substantial proportion of the total income. This has important consequences for the economic appraisal of rural water supply. With regard to affordability, households are unable to pay for water at the current cost. A high proportion of people would be unable to pay the actual costs of water. The revenue that may realistically be expected to be recovered from these households in the future lies somewhere between what they are able to pay and what they are presently willing to pay. Another consequence is the lack of elasticity and the repercussions on expenditure for food, education, health, etc, would imperatively be retarded (Sara, 2011). The high price of water in urban Sudan is probably a major cause of the malnutrition that prevails in the squatter areas (Sandy et al, 1992). The inadequate water supply and high expenditure for water in situations of low income, big households, and spreading of illiteracy have many consequences. One consequence is that inadequate water supply causes water related diseases, for example, access to in-yard water sources improved child health in China; only when mothers were relatively well educated (Mangyo, 2008).

Although one-third of the households had access to clean water in 2011, they spend 40 minutes to travel in order to have access to communal pipes. This time factor was also nominated in 1987. Similarly, both investigations agreed on the time factor, even when the boreholes were the major source of water; there were frequent complaints in relation to shortage of water and long queues to get water, while more than 50% of the existing water sources were not functioning. In 2011, the poor follow up and maintenance of the water sources resulted in poor hygiene conditions and access to water supply. In 2011; only children were reported as the ones primarily responsible for fetching water, while in 1987,

both women and children performed that job.

The field investigation made in 2011 showed that the water from the donkey carts was often contaminated between the source and the household. In 1987, bacteriological test of water gave the figures shown in table 1. Table 1 shows that, faecal contamination in Mayo exceeds the limit of 10/1000 ML; documented by World Health Organization in 1983, which is unsuitable for human consumption. The boreholes are not the source of water contamination. Vendors are the main source of water faecal contamination. This is because; barrels and vendors are filthy. Moreover, while they were waiting for their turns in a long queue; animal faeces and urine enter the borehole which was improperly protected.

The investigation in 1987 showed that, the expected health effects of contaminated water on the population are related to water – borne diseases such as diarrhoea and typhoid which are responsible for 52.7% of the overall specific causes of death among children with ages between 1 – 5 years as well as malaria which accounted for 52.25% among other infections. This is similar to the results obtained in 2011, where clinical records showed that most diseases are related to the lack of washing facilities, where the diarrhoeas, eye infections and malaria, are the major and the most common diseases among children. The causes for these infectious diseases were due to the lack of a clean and hygienic environment. The comparison between the results obtained during the two investigations showed no improvement in water accessibility and affordability among the population living in the Mayo area.

In 2011, more than 60% of the Mayo population had no access to household latrines. People either defecated in open areas, in neighbours' latrines, or in public latrines. 35% households did not have separate latrine for defecation. 81% of the people with no latrine reported to use the neighbor's latrine and 19% reported to use either bushes or open places or a public latrine or pits. 88% of those who owned a separate latrine had a traditional one. For those who had a separate latrine, feces could be visible during the visit in the household over the slab or on the pan inside the latrine infrastructure. In 1987, 51.7% of the households owned private latrines, 31.39% shared common latrines, while 16.68% did not have latrines. Pit latrines or borehole latrines are the dominant types among those who had latrines. Nearly 50% of the

population were using common latrines or excreted in the open spaces. The places of defecation for those who did not own latrines included the settlement in the neighbourhood (52%), buckets (5%) or neighbours' latrines (43%). The bucket is used for defecation and when filled up, it will be disposed in the immediate vicinity of the area. Private latrines do not meet the sanitary requirements and the roofs, doors and windows do not respect the health regulations. They had no cover which made them accessible to flies and they were dug down up to 3 meters depth due to the geology of the area. In 2011, the traditional latrine was a type of pit latrine from where flies could easily come and fly to other category of latrine, which were more unhygienic than the traditional latrines. More than 55% of the population had no access to sanitary facilities and therefore they practiced open defecation. Open defecation is the general norm in the area. A special "defecation area" has been allocated. This situation might be similar to that in Dhaka, when in 1999, less than 25% of the people were served by sewage treatment facilities (Kamal et al., 1999), and therefore open latrines are also a source of surface and groundwater contamination (UNDP, 1987). Even today slum people usually build open-latrines on the roadside or near the water bodies thus, severe water pollution occurs when natural runoff drains and transports human wastes to the surrounding water bodies.

This unhygienic home environment was aggravated even more in 2011, when animals and people lived in the same space, therefore creating health problem. This situation is similar to the one in 1987, where 40% of the population used to keep goats (17%); sheep (3%); pigeons (8%); and chickens (12%), and there was no proper place to keep animals separately. Deaths of infants and young children between 1-5 years old, as a percentage of all deaths, were calculated at 62% in the households who used to have no special fence to keep animals compared to 38% of deaths recorded in households that have special places to keep animals. In 1987, 46% of the households surveyed indicated that they dispose wastes in the immediate vicinity of the area, while 32% disposed them in the street just in front of their houses, and only 21% used to burn these wastes. There was a complete absence of waste disposal system and therefore, the waste accumulated into huge piles in the streets. There were certain organic residues of distillation of traditional alcohol of liquors and beer. The odor was very strong and annoying. These wastes mixed with the rain during the rainy season and made a suitable niche for breeding of flies and mosquitoes. In 2011, there was a lack of garbage containers and when the garbage was collected there were no vehicles to take it away for disposal. The management of solid waste is a huge challenge where piles of solid wastes are dumped at an empty and open space close to dwellings. The stagnant water harboured mosquitoes and other insects and ultimately aggravated the spread of malaria and other

diseases. In 1987, during the rainy season, the severity of diseases was highly correlated with the nature of development of this area which lacked proper streets, drainage system for storm water, very narrow streets that impeded the water from the rain to drain and the stagnant rain water was a suitable habitat for mosquitoes breeding and the spread of malaria. 70% of the households surveyed indicated that rainy season was the peak for the spread of infectious diseases, in opposition to the winter season (3%) and autumn (7%). The general result of the two surveys agrees on no improvement in the residential environment. This situation might be similar to that in Dhaka where the waste disposal method practiced was open dumping on plain ground or at the outskirts of the city (UNEP, 2006), while large portion of domestic wastes remained uncollected, and over 70% of slum dwellers do not have access to safe sanitation (CUS et al., 2006). There was also noted an increase of the solid waste discharged from 1040 tons/day in 1985 to 3200 tons/day in 2004 (JICA, 2005).

Health and nutrition

In 2011, 52.5% of the women surveyed consulted traditional healers, similar to 1987 when traditional healers were consulted during pregnancy, lactation period by 73.9% of the women surveyed. Mothers consulted traditional healers to cure their ill children as they believed in folk medicine and lacked the money to cover the medical expenses. Many types of herbs were given to treat various diseases. Also, in 2011, most of the women deliver in the house with the assistance of the Traditional Birth Attendants, and in 1987, 86.38% of women interviewed stated that they delivered their children at home with the assistance of traditional midwives. In 2011, Post anti natal reproductive health care practices for women was limited; they did not go for ante-natal check-up unless there was something serious to consult the health professionals. In 1987, there was no close maternity hospital, and pre-natal care was provided by Goal Organization since 1986.

In 2011, pregnant women were suffering from the lack of a balanced diet, which is similar to situation in 1987. The food consumed by pregnant women during their pregnancy period consisted of 37.36% carbohydrates; 4.42% animal protein, and 12.5% vitamins. In 2011, pregnant women did not eat eggs as it was believed to cause sexual exposure of the baby and to cause excessive pain during the delivery of the baby, while honey may cause abortion to a pregnant In 1987, food taboos among pregnant women included the belief for 10.22% of the women that eating camel meat during pregnancy prolongs the gestational period up to 12 months, and 10.45% believe that eating eggs may cause delay of child growth, while 2% believed that some types of fish lead to child physical malformations. In addition,

40.45% of the households investigated stated that all family members eat together, while 60% said that men ate first, then the children and very few said that the children ate first.

During the investigation in 2011, infants were breast fed as initial food immediately after delivery. But due to lack of proper food and the lack of a balanced diet, the mothers had no sufficient milk to breast feed the babies. In 1987, women used to breast feed their children, but the durations of breast feeding were less than one year as stated by 13.33% of the households surveyed; one year (11.11% of the households); and one year and a half (75.55% of the households). Mothers were breast feeding their children for a long period of time as it might be culturally and nutritionally valued. Carbohydrates including local bread and rice constituted 41.38% of each food type during lactation, while animal protein and vitamins constituted 12.22% of the total food nutrients consumed by a household.

The moment when supplementary food was given to children started at the age of 7 months as indicated by 29% of the women surveyed, which was mostly of carbohydrates origin, similar to weaning food which abounded of carbohydrates and lacked proteins and vitamins. Also, the results obtained in 2011 showed that 90% of the people of living in the area suffered a lot from the lack of food and that the food quality was very poor and not diversified. In most households it was unthinkable to get vegetables and milk products as part of their meal. 56% households ate cereal food at least once a day; 52% households ate meat daily; 47% household ate vegetables at least once a day and 3% households never ate cereals during last seven days.

The general findings of this study showed that less animal proteins, vitamins, minerals and abundant cereals are consumed. In the study area, fat and carbohydrates consumed, were lower than 2041.7 calories which was recommended for population in Africa (Latham, 1979). The comparison made between the consumption of calories from the study area and the results obtained pursuant the study made by the Ministry of Agriculture and Forestry of Sudan (FSU, 2005) show that the people in the study area have a low consume of carbohydrates and lower energy intake (430.1 kcal vs. 1962 kcal In African diets, fats usually provide fewer calories than carbohydrates, perhaps only 8 or 10% of the total calories consumed (Latham 1979:50). The term fat includes all fats and oils that are edible and occur in human diets. The high contribution of cereals to energy and protein intake, in the study area, is similar to the area of rural Philippines where 361g/person/day are consumed (Florentino, 1996). Animal protein sources such as meat and milk are less (8.14 g) than the recommended value of 55.3 g (FSU, 2005). One of the main reasons for a generally declining trend in food consumption in the study area is high living costs in Sudan and big households and spreading illiteracy A

great number of people are unable to pay the actual costs of food. The revenue that may realistically be expected to be recovered from these households in the future lies somewhere between what they are able to pay and what they are presently willing to pay. Another consequence is the lack of elasticity and repercussions on expenditure for food would imperatively be retarded. The high price of food in urban Sudan is probably a major cause of the malnutrition prevalent in the squatter areas (Sandy et al, 1992). Decreasing income led to marginal or sub-optimal intakes of energy and protein resulting in more prevalence of under-nutrition in rural western Kordofan of Sudan (Alredaisy and Suleiman, 2010). Many studies in Sudan showed cases of low weight, stunting and wasting among young children because of unequal income distribution, vertically between incomes and horizontally between rural and urban areas (UNDP, 2006).

Food shortage occurs mostly during the rainy season and at the end of every month when most households experience food shortage, because most of the salaried people do not have money. And most of the households cope the food shortage season with the reduction of the number of meals per day, reducing the size of the meal. Also people use to take food on credit and borrow food. In 1987, 60% of the households surveyed have one meal per day and those who have two meals were around 40%. Survival strategies followed by the population living in the study area are the real reflection of a low income and poverty. This could make one to include the population from the study area within food insecure groups from Sudan. These groups include those people whose food intake provides a less quantity than that recommended for refugees and internally displaced groups (IOM, 1995). In addition, they include rural areas of low crop and animal production; areas of low purchasing power and education and knowledge; areas of low access to health facilities and vulnerable residents who were indirectly affected by the influx of internally displaced population in their communities.

The proposed RENGES model for the promotion of environmental health conditions in Mayo squatter area

The results of the two surveys depicted low standards in socioeconomic and nutritional characteristics, lack of basic infrastructure or healthy residential environment, which is dramatically influencing environmental health conditions in Mayo area. These results judge for no improvement in the environmental health conditions in Mayo area (see Figure 3). Based on these findings this study could build a very strong case for prioritizing improved infrastructure in addition to educating people for the promotion of environmental health conditions in Mayo squatter area by incorporating the RENGES model

(Figure 2).

Promotion of residential environment requires relevant data on the general layout of the area, in relation to topographic and climatic characteristics, housing characteristics, as well as timing of the rainy season to facilitate appropriate planning for control of the expected health hazards. There are gaps in the environmental health conditions in the study area that could be bridged by appropriate intervention. This appropriate intervention could build a case for prioritizing improved infrastructure depending on residential environment information and geographical information (see Figure 2). Residential environment information could be obtained from local administrations and field surveys executed by local government, NGOs or researchers. Geographical information should relate to population growth, increase, mobility, migration, density, and concentration in order to detect hazardous areas. Access to a map showing residential expansion and population movement within various squatter areas, and third class residential area of Greater Khartoum, can help to forecast future trends of population-movement and their consequences on public health in such squatter areas. Geographical and residential environmental information for the RENGES model can also benefit from the available infectious and nutritional diseases data, which have grown worldwide with efforts to improve disease surveillance and the initiation of population-based disease incidence studies, in addition to advances in the understanding of the age distribution of such diseases, allowing for measurement of incidence rates among narrow age cohorts to be more accurately extrapolated to the general population.

It is generally assumed that there is a need to educate people about adequate and basics of environmental health. In reality, however, people are probably very much aware of the health risks related to inadequate environmental health but, because of poor water and sanitary infrastructure and because of perhaps population density, it is very difficult to prevent the expected negative impacts. People in squatter area of Mayo can be educated about residential environment sanitation and symptoms, treatment of various diseases related to inadequate environmental health as well as prevention through school subjects such as geography and biology and also through mosques, churches, adult education, media education, mobile cinema, and distance education. In Khartoum state there is a local broadcasting and television station, many universities, and distance-education centers. All these facilities can be used to educate people about adequate residential environment sanitation and the diseases related to inadequate environmental health. Educational technologies which encompass electronic-based delivery methods and innovations in instructional design such as adult education, problem-based learning, and competency-based training can help to innovate information on residential environment sanitation, community health and

insanitary related diseases. Distance learning which includes synchronous methods that link learners who are separated by geographic distance and allow for simultaneous interaction and asynchronous methods can allow for interaction at different times. In addition, health education about personal hygiene, especially regarding hand washing after toilet use and before food preparation; use of safe drinking water; excluding disease carriers from food handling; and antibiotic treatment, family planning, is essential for the promotion of the community of such squatter area. Strategies for administration of vaccines for preventing childhood diseases should be deployed on a wide scale in RENGES model, bearing in mind that vaccines can control these diseases only to a limited extent and that the eradication of a carrier state can be difficult.

The responsible bodies for the implementation of the model might Peoples' committees; Ministry of human resource development; Ministry of Justice; and Ministry of Information. Realizing this proposed model depends on collective work by these bodies. The duties of People's Committees should focus on transferring information to local communities on innovative directions for environmental health conditions such as rational use of water and the impacts of misuse as well as health hazards related to water, through youth clubs, and religious men and women in those communities. Ministry of Human Resource Development should train local people on how to rationally manage their residential areas through community education for sustainable development (ESD). Methodology for implementing ESD should firstly, target stakeholders who could be middle leaders, including executive committee of local non-governmental organization, local public committee and official officers and teachers. Awareness creation is a step towards drawing attention and building capacities of the stakeholders to deal with the challenges of environmental health problems. Through increased knowledge and awareness, the community can be motivated to take better care of their environmental health. School teachers should be trained on environmental health education, particularly in primary schools. Introduction of education for sustainable development (ESD) into schools curricula, students' activities, mass media and youth clubs will inform the community on rational deal with their residential environment. Society capacity building and awareness in Mayo area can be enhanced through religious and cultural norms encouraging personal hygiene and neighborhood sanitation where God's rewards are endless, conscious use of herbal medicine, and the help of traditional healers and curers capable of transmitting correct information on risks to diseases related to inadequate environmental health to indigenous people. Youth clubs and school vacations can be opportunities for volunteer work in society capacity building through campaigns. Charitable donations can be used to provide

sanitary materials for poor people and for public bathrooms; posters and other materials to raise awareness about public gathering places; and funding for local people's committees, administrative localities, and youth clubs to work for environmental sanitation in their neighborhoods, including monitoring suspected insect breeding locations, for example.

The Ministry of Justice could protect any environmental health policy through legislations and management and could also execute penalties on misuse of residential environment or on corruption in the environmental health sector. But, this cannot be accomplished without the role of Ministry of Information. The motivation of the community to maintain and protect their residential environment is of critical importance through TV, Radio, and Newspapers which can transfer knowledge about adequate environmental health conditions. In addition, coordination between governmental bodies responsible for environmental health provision and management with reference to local community is essential. Participatory approach, through Peoples' Committees is important in the assessment and reduction of risks to inadequate environmental health conditions. A participating community will, of course, have knowledge about environmental health value, and rights for oneself and others, as well as the impacts of environmental health degradation on residential environment. In addition, social capacity building through participatory work and civil or voluntary organizations can work to assess and alleviate environmental health problems through innovative directions, such as waste disposal collection, nutrition awareness among households and water utilization in the study area.

The model can be implemented through two phases. In the first phase, it is necessary to provide careful assessment of the area's environmental health conditions; and local environmental legislations. The second phase includes coordination system of environmental health management; and participatory approach to its management between governmental bodies responsible for environmental health provision and management with reference to local community. A participating community will, of course, have knowledge about environmental health value, its conservation, and its rights for oneself and others, as well as the impacts of environmental degradation on water sources.

This model can be used carefully to overcome the existing environmental health conditions in the study area through adopting the proposed to phases and by considering the gaps and divides that might hinder its reliable management that have been already outlined in section 1-3 .

The application of the RENGES model in Mayo area can work to promote environmental health conditions in order to decide on appropriate methods through activation of the inputs, processes, and outputs outlined by this model, with the ultimate result of promoting environmental health

in squatter areas in urban Sudan. However, this proposed model to be more practical and effective should put consideration to challenges to implementation, gap in knowledge/work to be done/data to improve and evolve the model and Implications of future events on the model (e.g. population increase and high demand for housing).

CONCLUSIONS

- 1- A sustainable integrated model to promote the environmental health conditions is need for the urban squatter areas given the current and projected housing stress.
- 2- Environmental health conditions including social, economical, nutritional and residential environment characteristics have been assessed and a model proposed.
- 3- The model is awesome because it considers the geography and the environmental health conditions as well as the community at the grass root level.
- 4- As the model is implemented and continues to evolve the results will be shared with academic community
- 5- There is hope provided there is wise urban management in Sudan.

REFERENCES

- Abu SMI (1970). A History of Khartoum. Dar el Irshad, Khartoum, Sudan.
- Akbar HMD, Minnery JR, Horen BV, Smith P (2007). Community water supply for the urban poor in developing countries, the case of Dhaka, Bangladesh. *Habitat International* 31, 24-35.
- Ali MA, Kavita T (2004). "Migration, Slums and Urban Squalor - A case study of Gandhinagar Slum" in Martin J. Bunch, V. Madha Suresh and T. Vasantha Kumaran, eds., *Proceedings of the Third International Conference on Environment and Health*, Chennai, India, 15-17 December, 2003. Chennai: Department of Geography, University of Madras and Faculty of Environmental Studies, York University. Pages 1-10.
- Alredaisy Sa, Davies HRJ (2003). The ecology of malaria in urban squatters of Greater Khartoum, Gamier area in Omdurman., *Arab World Geographer*. Vol.6, no.3 .pp. 178-193. Autumn 2003. Canada.
- Alredaisy SMA, Sulieman HS (2011). "Assessment of nutritional status of children less than 10 years old in rural Western Kordofan, Sudan". *IIOAB Journal* 2 (4): 40-49. *An International Journal of Multidisciplinary Integrative Science and Applications*. India.
- Babker A A, Alredaisy S (1997). Evaluation of food situation and survival strategies in urban Sudan, case studies from Omdurman. *Bayreuther Geowissenschaftliche Arbeiten*, Institute of Geo-Sciences, University of Bayreuth, Vol.16:291-300, German.
- Banaga SDI (2001). Displaced People and Chances for Peace with reference to Khartoum State. Issue (39), International University of Africa, Khartoum, Sudan.
- Bocquier P (2003). Analyzing urbanization in Africa. In: Hugo, G. and Champion, A. (eds.). *New forms of urbanization*. Aldershot: Ashgate: 133-150.
- Bocquier P (2005). World Urbanization Prospects: an alternative to the UN model of projection compatible with urban transition theory. *Demographic Research* 12(9): 197-236. doi:10.4054/DemRes.2005.12.9. Beguy, Bocquier and Zulu: Circular migration patterns and determinants in Nairobi slum settlements 582 <http://www.demographic-research.org>
- Bocquier P, Traoré S (eds.). (2000). *Urbanisation et dynamique*

- migratoire en Afrique de l'Ouest - la croissance urbaine en panne. Paris: L'Harmattan.
- Center for Urban Studies (CUS), National Institute of Population, Research and Training (NIPORT) and Measure Evaluation (2006) Slums in Urban Bangladesh: Mapping and Census 2005. CUS, Dhaka.
- CUS Center for Urban Studies (2006). National Institute of Population, Research and Training (NIPORT) and Measure Evaluation. Slums in Urban Bangladesh: Mapping and Census 2005. CUS, Dhaka.
- Davies HRJ (2001). Population change in the Sudan during the twentieth century. *Sudan Studies* 27:31–55.
- ECOSOC, Economic and Social Council of the United Nations. 2005. Urban growth and land development Urban
- El-Bushra ES (1995). "Two Million Squatter Settlement in Khartoum Urban Complex. The Dilemma of Sudan National Capital" *Geo Journal*, Vol.34 #4.505-514.
- Florentino RF (1996). Contribution of major food items on calorie and protein in takes in Filipinos. Joint technical workshop of the micro impacts of macroeconomics adjustment policies and the Philippine Institute of Development Studies technical resources project, 11-12/4/1996, Calatagen, Phillip for UNCHS, Oxford.
- FSU (2005). Food security annual report. Food Security Unit, Ministry of Agriculture and Forestry, Khartoum, Sudan
- Gleichen C (1905). *The Anglo- Egyptian Sudan*, 2 vols. HMSO, London.
- Hansen N (1977). Population settlement alternative in developing countries. *Social indicators research* 4(1977) D. Reidal publications Company. Holland
- Hansen N (1977). Population settlement alternative in developing countries. *Social indicators research* 4(1977) D. Reidal publications Company. Holland
- IOM (1995). Estimated mean per capita requirements for planning food aid rations. National Academy for Science, Committee on International Nutrition, Washington, DC.
- JICA Japan International Cooperation Agency (2005) The study on solid waste management in Dhaka city. Clean Master Plan, Final Report, JICA, Dhaka.
- Johnson D (2008). The Changing Landscape of Education in Africa quality, equality and democracy. Oxford studies in comparative education. Symposium Books.
- Kamal MM, Malmgren-Hansen A, Badruzzaman ABM (1999). Assessment of pollution of the river Buriganga, Bangladesh using a water quality model. *Water Science Technology* 40(2), 129-136.
- Kulu H, Milewski N (2006). Family change and migration in the life course: An introduction. *Demographic Research* 17(19): 567-590. doi:10.4054/DemRes. 2007.17.19.
- Latham HC (1979). *Human nutrition in tropical Africa*. No.11. Rev.1 FAR, Rome. Ithaca, USA.
- Mangyo E (2008). The effect of water accessibility on child health in China *Journal of Health Economics*. Volume 27, issue 5. pp.1343-1356(2008) UNESCO,(2003): *The UN World Water Development Report*.
- Mertz O, Mbow C, Østergaard J, Nielsen A, Maiga D, Diallo A, Reenberg A, Diouf B, Barbier I, Bouzou MM, Zorom I, Ouattara DD (2010). Climate factors play a limited role for past adaptation strategies in West Africa. *Ecology and Society* 15(4): 25. [online] URL: <http://www.ecologyandsociety.org/vol15/iss4/art25/>
- Ministry of Finance and Economic Planning, MFEP (1956-1993). *Population censuses of Sudan 1956 – 1993*, Khartoum, Sudan.
- Ministry of Health Sudan (2008). *Annual health statistics report: Health statistics*. Khartoum: National Center for Health Statistics.
- Ministry of Health, Sudan. 2008. *Annual health statistics report: Health statistics*. Khartoum: National Center for Health Statistics.
- Ministry of Labor and International Labor Organization (MOL/ILO) (1997). *Trends and profiles of poverty in Sudan [1990–2008]*. Ministry of Labor and International Labor Organization, Khartoum.
- Muindi K, Zulu E, Beguy D, Mudege N, Batten L (2009). Characteristics of recent in-migrants in the Nairobi Urban Health Demographic Surveillance System. Paper presented at the XXVI IUSSP Conference. Marrakech, Morocco, September 27 - October 2, 2009.
- Potts D (2006). Urban Growth and Urban Economies in Eastern and Southern Africa: trends and prospects. In: Bryceson, D.F. and Potts, D. (eds.). *African Urban Economies: Viability, Vitality or Vitiolation of Major Cities in East and Southern Africa?* Houndmills, Basingstoke: Palgrave Macmillan: 67-104.
- Sandy C, Kinnear J (1992). Elasticity of demand for water in Khartoum, Sudan, *Social Science and Medicine*, Volume 34, Issue 2, Pages 183-189.
- Sara P (2011). Urbanization in Sudan: An Overview of International Engagement <http://www.refugeecooperat>
- Seaquist JW, Hickler T, Eklundh L, Ard'o J, Heumann BW (2009). Disentangling the effects of climate and people on Sahel vegetation. *Biogeosciences*, 6, 469–477.
- Tajudeen A, Amidu A (2006). Urban Low – Income Settlements, Land Deregulation and Sustainable Development in Nigeria. *Promoting Land Administration and Good Governance*. 5th FIG Regional Conference Accra, Ghana, March 8-11, 2006
- UNDP (1998). *Sudan- Common Country Assessment*. UNDP, Khartoum.
- UNDP (2006). *Macroeconomic policies for poverty reduction, the case of Sudan*. Khartoum.
- UNEP (2006). *Dhaka City State of Environment 2005*, The United Nations Environment Program, Dhaka.
- UNESCO (2009). *Education For All Global Monitoring Report*. UNESCO.
- UNFPA (2008): *Projections for World Population*. United Nations Population Fund.
- UN-Habitat (2003). 'The UN-Habitat Strategic vision'. The United Nations Human Settlement Programme, Nairobi, Kenya. May 2003. (www document)
- UN-Habitat (1996). *An Urbanizing World: Global Report on Human Settlements 1996*. Oxford University Press.
- United Nations (1977). *Desertification: its causes and consequences*. Pergamon, Oxford.
- United Nations (1994). *Urban and rural areas 1994*. Department of Economic and Social Information and Policy Analysis. Population Division. United Nations Publication (ST/ESA/SER.A/148). Series No. E.95.X111.6.
- United Nations Development Program (1987). *Population growth and policies in mega cities: Dhaka*, UN Department of International Economic and Social Affairs, Population policy paper no. 8. New York.
- United Nations Development Program (2005). *Human development report*. Oxford University Press, Oxford.
- Vinit M (2002). *An Analytical Framework for Urban Upgrading: Property Rights, Property Values and Physical Attributes* Habitat International, 26 (4): 553-570
- Walsh RPD, Davies HRJ, Musa SB (1994). Flood frequency and impacts at Khartoum since the early nineteenth century. *The Geographical J.*, Vol.160, No. 3, November 1994, pp.266-279.
- World Health Organization (1983). *Guidelines for drinking water quality. Drinking water control in small community supplies*. Vo. 3. Geneva.
- Zeng N (2003). Drought in the Sahel. *Science* 302: 999–1000.