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Linking between population dynamics and environmental changes in Sudan

Huda Mohamed Mukhtar Ahmed (PhD) (•)

Abstract:

This paper overviewed the different perspectives on the linkages between population dynamics and environmental changes and presents some empirical studies conducted in this regard. In Sudan, few empirical researches are conducted to examine these linkages; however, many factors found in the literature as a determinant of the linkages between population dynamics and environmental change are observed in three states. Among these factors are: population growth, migration, displacement, poverty, urbanization and the resultant impacts were deforestation, soil erosion, water and air pollution, drought and desertification. Empirically testing these linkages through rigorous econometric models is recommended.

(•) Dept, of Econometrics & Social Statistics,- Faculty of Economic & Social Studies, University of Khartoum

1-1 Introduction

There is a growing concern on population rapid growth, the resultant human activities and the pressure on natural resources since the Malthusian era. Some scholars supported Malthus in that population growth has an adverse effect in human wellbeing as resources are limited and others were more optimistic as they believed that population growth exerts a positive influence on economic development and human ingenuity would create the technology to overcome any environmental constraints to development. Though empirical studies that test scientifically, the relationship between population dynamics and environmental change are rare, still there is a wide acceptance that the two domains are linked in several ways and through multiple social and economic mechanisms, at various regional levels.

According to the 2008 census, annual population growth rate in Sudan is 2.4%, with a continuous increasing share of urban population. There is a high trend of spatial concentration and excessive migration caused by drought induced scarcity of resources. Drought struck many parts of Sudan particularly Northern Kordofan, Northern state. Northern and Western Darfur, Red Sea and White Nile

states during 1967-1973, 1987, 1989, 1990, 1991, 1993 and 2000 and the most severe drought occurred in 1980- 1984. (UNEP, 2002).

This paper is commissioned by UNEP as a background paper for series of workshops in “Linking population dynamics to environmental degradation in Sudan”.

Sudan has witnessed not only human population growth and spatial maldistribution of people, but also witnessed an exploded livestock population, from close to 27 million units to around 135 million in 2007 (UNEP, 2007).

The links between the changes in hydrological drought and climatic change is still hard to detect and may probably differ by region. Demuth et al., (2006) and Hennery et al (2007). provide a comprehensive overview of the possible observed effects of climate change on hydrological droughts, however, they revealed that detection of trends is cumbersome because long time series are needed. In Sudan, a study conducted by UNEP in 2003 in Kordofan and Darfur regions, shows that there is a 0.5 to 1.5°C rise in the average annual temperature and an approximate five percent drop in

rainfall. Simultaneous occurrence of drought and the climatic change made us also to think of relations between the two phenomena.

Drought and desertification were the main cause behind the population mobility in Kordufan region during 1984, whereas the hardship caused to pastoralist societies by drought and desertification was among the main causes of the on going war in Darfur. Despite the scarcity of researches that examines the linkages between population dynamics and environmental changes, the two domains are theoretically known to be related. However, interconnection between the two is not addressed in regard to policy formulation in Sudan.

This paper tries to shed light on the linkages between population dynamics and environmental degradation to promote awareness of the need for a comprehensive population-environment policy that takes into account the mutual influence of population and environment and how to mitigate these impacts.

1.2. Objectives:

The main objective of the paper is to understand the linkages between the population dynamics and environmental changes to help

the policy makers and planners to formulate policies that integrate population dynamics into environmental issues.

1-2-1 The specifics objectives

1- To review the diversity perspectives on the linkages between the population dynamics and environmental changes.

2-To review the population dynamics and environmental profile in Sudan.

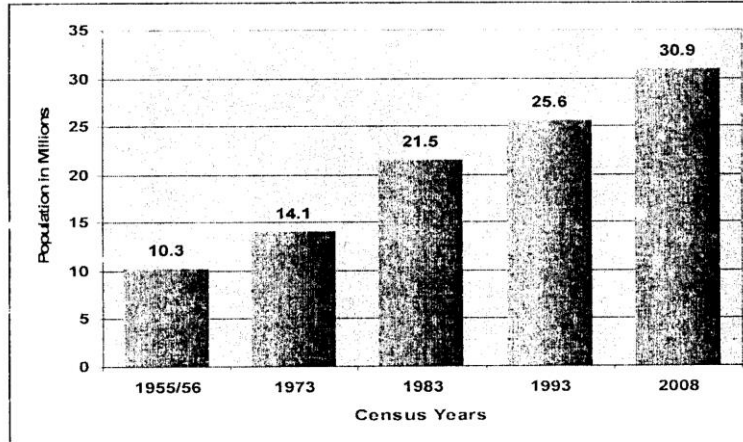
3-To assess the impact of population dynamics on environmental changes in accordance to situation analysis in three states; Al- Gadarif, North Kordofan and South Darfur

2-Population profile

2-1 Population size and trends

Documentation of population in Sudan started in 1955/1956 when the first population census was conducted. Successive censuses were conducted in 1973, 1983, 1993 and 2008. Figure (1) shows the trends in population size between 1955/56 and 2008.

Figure 1: Population Increase (1955/56-2008)



The demographic trends for Sudan reveal that the population grew almost threefold between 1955/56 and 2008. The population almost doubled between 1955/56 and 1983 a period of 27 years, and tripled in a period of 52 years. The data also demonstrate that the population increased by about 52.5% in the 1973-83 inter-censal periods, by 19% in 1983-93 and by 21% in 1993-2008. Furthermore the annual rate of population growth increased from 2.1 in 1955/56 to 2.13 in 1973, to 2.57 in 1983, to 2.88 in 1993 and declined to 2.4 in 2008 (Figure 2)

Figure 2: Annual population growth 1955/56-2008

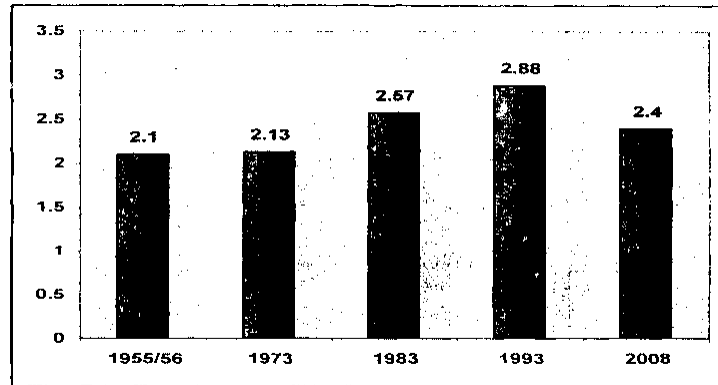
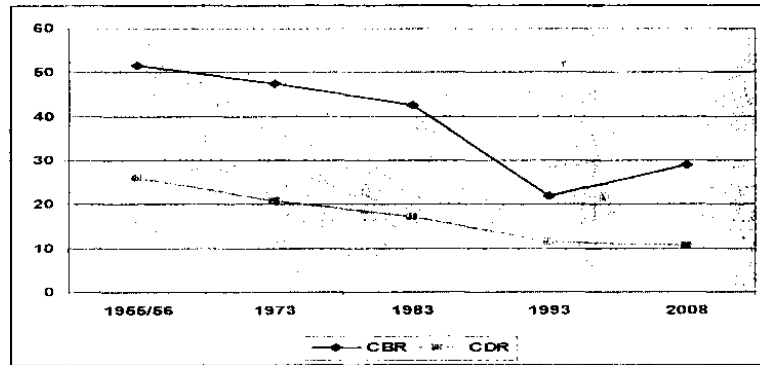


Figure (3) shows the trends in crude birth rates (CBR) and crude death rates (CDR) for Sudan during the period 1955/56-2008. A continuous decline in CDR is observed; from 26 deaths per thousand population in 1955/56 to 10 deaths per thousand population in 2008. The trend also illustrates an almost stagnant CDR between 1993 and 2008 at around 11 deaths per thousand population. Moreover, the crude birth rates (CBR) declined gradually in 1955/56-83, declined sharply in 1983-93 and increased again in 1993-2008. The gap between the birth rate and the death rate represents the natural growth rate of population. Also Sudan's population of 30.9 million in 2008 is expected to double (i.e. to become 61.8 million) by 2037 if current growth rate/ continues. From the aforementioned population analysis, it is clear that the largest census- to-census increase (52.5%) was between 1973 and 1983.

Figure 3: Trends in CBR and CDR for Sudan 1955/56-2008



The population of Sudan by state, as recorded in the 1993 and 2008 censuses, is presented in table (1). As data on population size by state for the 1973 and 1983 censuses was not available (at least during the time of writing this paper), it was difficult to assess the trend of intra- censal population growth. The data in Table (1) records a wide variation in population growth rates between states; it ranged from 0.0 in West Darfur to 5.3 in North Kordufan. The disparities in growth rate are mainly caused by variations in the rates of internal migration, and differences in natural increase which are affected by climatic conditions and differences in resource endowment. North Kordufan witnessed drought and desertification during the 1980s and was among the sending state in regard to internal migration; however, its total fertility rate was among the highest (4.9).

Table 1: Population size and the annual rate of growth between the 1993 and 2008 censuses

State	Population			
	1993 (m)	2008	Annual rate	growth
Northern	0.5	0.7	2.2	
Nahr Al- Nil	0.8	1.1	2.1	
Red Sea	0.7	1.4	4.6	
Kassala	1.2	1.8	0.3	
Al- Gadarif	1.1	1.3	1.1	
Khartoum	3.5	5.3	2.8	
Al- Gazera	2.7	3.6	1.9	
White Nile	1.2	1.7	2.3	
Sinnar	1.0	1.3	1.7	
Blue Nile	0.5	0.8	3.1	
North Kordufan	1.3	2.9	5.3	
South Kordufan	1.0	1.4	2.2	
North Darfur	1.1	2.1	4.3	
West Darfur	1.3	1.3	0.0	
South Darfur	2.1	4.1	4.5	

Source: Central Bureau of Statistics.

The desert covers the northern part of Sudan with a total area of approximately 29% of the country (Kobbail and Elfeel, 2012). This made people in the northern part of the country to reside at the sides of the Nile Bank. Other factors such as internal migration and internally displacement also added to the spatial population maldistribution. About 41% of the total population occupy 6.5 percent of the total area and concentrated around Khartoum and the Central region. Northern region on the other hand occupied 19 % of the total area and encompasses only about 6 % of the total population. In Khartoum and

the Central region the concentration of population increased from 28% of the total population in 1983 to 35% in 1993 and 41% in 2008.

Table (2) illustrates the population distribution by mode of living. During the 1960 s and 1970 s rural population was above 70%. Due to the rural urban migration, rural population declined by 20 percentage points between the first and last censuses. Conflicts over scarce resources in drought-stricken rural areas, declining agricultural productivity, scarcity of rainfall and land degradation induced internal migration and increased in urbanization; thus the urban population increased by 27 percentage points between 1955/56 and 2008. The immediate effect of the increase in urbanization is more pressure over the existing resources; (such as commodities, assets and services) and more adverse impacts on the environment. Moreover, the size of nomadic population decreased gradually between 1955/56 and 1983, suddenly declined in 1993 census and increased again in 2008 census. The 1993 data on nomadic population size is odd and inconsistent with the increase in live stock population that reached to around 135 million animals in 2007(UNEP, 2007).

Table 2: Population distribution by mode of living 1955/56-2008

Census	Population (m)	Population Distribution by mode of living		
		% Urban	% Rural	%Nomads
1955/56	10.3	8.3	78	12.7
1973	14.1	18.5	70	11.5
1983	21.5	20.6	68.5	11
1993	25.6	29.2	68.1	2.7
2008	30.9	33	58	9

Source: Central Bureau of Statistics.

There are many factors that can be responsible for the persistence of high population growth in Sudan. Among these factors are: high fertility, huge size of population at reproductive age, high but continuously declining mortality, low education attainment, and low contraceptive prevalence rate.

Migration, the third component of population dynamics, affect on population growth in different ways. Immigration impacts population size, growth and characteristics and internal migration affects population distributions. The absolute volume of inter-state migration in Sudan increased by 5 times during the last 52 years and the volume of life-time migration increased from 3.4 million in 1993 to 3.7 million in 2001. Migration streams mainly moved towards Khartoum State.

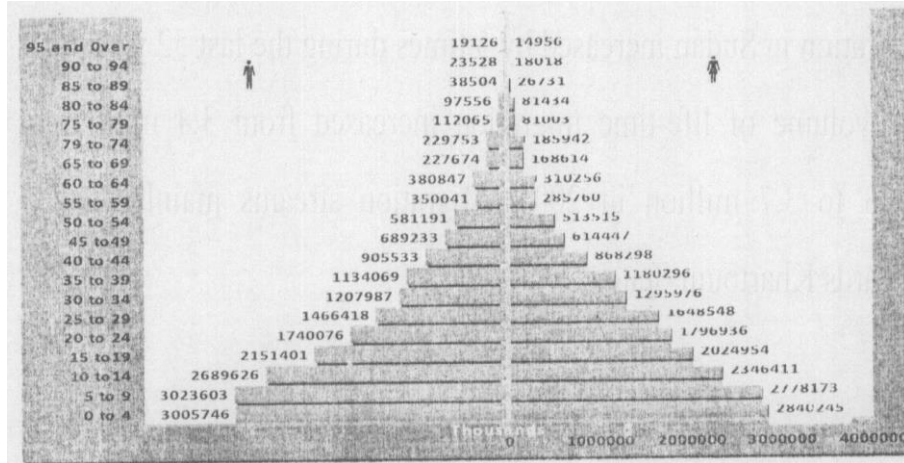
2-2- Age and sex structure of population

The 2008 census data revealed that just over half of the total population was male (51%) and 49% were female. Despite the fact that males outnumber females at early ages, the sex ratio changes in adulthood. (The sex ratio is a common measure used to describe the balance between males and females in the population. It is defined as the number of males per 100 females). This reversal in sex ratio may reflect sex differences in net migration at the peak migrant ages of 25 to 40 years.

The data presented in the population pyramid illustrates the age and sex distribution of the population. In the 2008 Census, the percent of people under age 14 was 42.6 % of the total population. The

working-age population, ages 15 to 64, made up 54.02 %. Finally, the 65 and over population was 3.8 % and the dependency ratio is 85%.

Figure 4: Population Pyramid- 2008



Source: Own construction- 2008 census data.

The wide base of the population pyramid together with the median age of 18.5 years indicates that population is young and it is likely to grow.

3- Population and economic development

The alleviation of poverty especially in developing countries is an important aspect for environmental sustainability. In the process of poverty reduction, one need to understand that population is a basic entity that determines the pace of poverty reduction. An increase in the number of people causes increased demand for food, water, land and other essential materials from the natural resource pool. It also increases pressure to environmental resources, and demand for social services that have to be financed by the national economy (Madulu, 2004).

High population growth produces a depressing effect on the gross national product (GNP) and the per capita income (Barke and Sowden, 1992, Madulu, 2004). In other words, high population growth generates an economic burden to the governments by channeling the scarce resources towards provision of social services rather than investing in the development projects. It is important, however, to note that the provision of social services needs to match the rates of population and economic growth because the higher the population growth the higher the demand for socioeconomic and environmental resources.

In Sudan, the agricultural sector was the most important economic sector (till the exploration of oil and the inclusion of oil revenue in public budget). It accounts for 39 % of the GDP, employed about 80% of population, and contributed 80% of the country's exports in the late 1990 s. Most of the agricultural activities are concentrated near the Nile River. As the irrigation system has been put in place, sorghum, wheat, and groundnuts have been planted instead of cotton in an effort to make Sudan self-sufficient and food secure. Animal husbandry also was a very important part of the national economy. Raising livestock was practiced throughout the country except in the extremely dry areas of the north and was almost entirely in the traditional sector. Livestock raising provided employment for so many people.

Fishing was largely carried out by the traditional sector for subsistence. An unknown number of small operators also used the country's major reservoirs in the more populated central region and the

rivers to catch fish for sale locally and in nearby larger urban centers. The few modern fishing ventures, mainly on Lake Nubia and in the Red Sea, were small (Metz, 1991).

The forestry subsector comprised both traditional gatherers of firewood and producers of charcoal—the main sources of fuel for homes and some industry in urban areas—and a modern timber and sawmilling industry, the latter government owned. Approximately 21 million cubic meters of wood, mainly for fuel, were cut in 1987. Gum Arabic production in 1986-87 was about 40,000 tons. In the late 1980 s, it became in most years the second biggest export after cotton, amounting to about 11 % of total exports (Metz, 1991).

Between the 1970 s and mid 1980 s, the agricultural and industrial productivity was declined in per capita terms, due to several factors. These factors include the droughts, desertification and the accompanying famine taken place in the 1980 s and 1991, and the influx of more than 1 million refugees from Eritrea, Ethiopia, Chad, and Uganda, in addition to the persons displaced by the continuing war in southern Sudan who were estimated to number between 1.5 million and 3.5 million.

4-Environmental profile

Modernization of the economy and social progress started early in the 20th century with a population size of three millions. The colonial government, with the intention of exploitation of national resources, launched huge agricultural schemes without checking the environmental impacts such as water diseases and deforestation.

According to a study conducted by El Moghraby (2003), the annual rate of deforestation is close to 504 thousand hectares; only 30,000 ha are reforested. The same study also showed that a number of wild life species is lost in the last two decades; many more are endangered or vulnerable. Also several grasses and herbs have disappeared due to overgrazing, repeated droughts and fires. Fires are responsible for the annual loss of 30 % of dry fodder otherwise available to wild life and the 103 million heads of livestock El Moghraby (2003).

Environmental degradation and wide spread poverty mutually reinforce each other. Poor people over- exploit the natural resources, they cut trees for firewood and constructing houses, have no access to sanitation facilities and utilize the open space etc. The census data demonstrated that about 62 % of the households in Sudan use wood as cooking energy and 12% use charcoal for cooking, about 49% have no sanitation facilities and 55% of nationwide population accessed clean drinking water supplied by common net work.

Environmental degradation is not only affected by the poor people but also by the rich ones as they use more technology. In this regard, the 2008 census data revealed that only 6 percent of the total population in Sudan own motor vehicle and 2 percent own motor cycle.

Environmental degradation can be viewed as an area specific; as it is caused by inappropriate land use. over cultivation, overgrazing and pollutant. Environmental impacts also depend on the available level of technology, population growth, income distribution, per capita consumption and culture Hunter (2000). The people living in degraded

environments are to some extent accountable for the degradation that is occurred, but this is often as a result of the existing social and economic problems. Accordingly, we expect variation in environmental degradation by states; since conflicts, war, displaced people, influx of refugees, migration, drought, pastoral land, and water resources are all factors that are assumed to have impacts on environment.

However, the basic environmental problems of Sudan, as summarized by El Moghraby (2003), are related to the absence of an acceptable strategic master land use plan, the growing conflicts in land use policies, the depletion of natural resources and the unchecked population growth.

5-Overview of perspectives in linkages between Population dynamics and environmental changes

There is a growing concern on population and environment, among the national and international gatherings and academic researchers, since the United Nations Conference on Development and Environment held in Rio de Janeiro in 1992. The summary statement of the conference, recommended the development and dissemination of knowledge on the links between demographic trends and sustainable development including environmental impacts (United Nations 1993). Furthermore, integrating population dynamics into development planning, including environmental sustainability was reinforced in the International Conference on Population and Development (ICPD) held in Cairo in 1994.

However, the link between population and environment is not new, it was first addressed by Malthus in 1798 and 1803, and his theory was republished in 1960. Malthus theory states that the growth of human populations always tends to surpass the productive capabilities of land resources. The result is that 'positive' checks, such as famine and increased mortality, or preventative checks, such as postponement of marriage and limitation of family size, work to reduce population growth. According to Malthus, population excess demand limits the availability of resources and the resources, in turn, place a direct restriction on population growth. However, Malthus does not account for technology and modernization and presumes that the productivity of environmental resources is fixed. Later after the agricultural revolution, Boserup (1965, 1976, and 1981) considered in her writings the technological change and suggests that population growth and the resulting increased population density 'induce' technological changes, such as the use of ploughs or fertilizer, allow food production to keep pace with population growth. Again, reciprocal linear relationships between population, technological change in agriculture, and environmental change are suggested (Marquette. 1997).

Malthus theory draws the attention of researchers on the issues of population and environment and many descriptive studies were conducted in demographic and ecological trends, among those were Brown et al. 1976; Ehrlich 1968; Ehrlich and Daily 1993; Ehrlich and Ehrlich 1977 and 1990; Ehrlich and Holdren 1971, 1974; Ehrlich et al. 1977; Eckholm 1976; Hardin 1968. Later during the 1980s and 1990s,

the concept of carrying capacity was developed and was accompanied with the several projections and modeling exercise, among these studies were: Cohen 1995; Lutz 1991; Meadows et al. 1972, 1992, and Marquette, 1997. The Boserupian perspective has also had an influence on global and regional research which examines the relationship between population growth and changes in agricultural production (Simon 1981, 1990). Some recent thoughts on linkages between population and environment, envisage the population size as interacting in a multiplicative way with other factors to influence the environment. This line of thinking was first introduced by Ehrlich and Holdern (1972- 1974) and followed by Harrison 1992; Commoner 1991 and 1992.

The multiplicative approach models the environmental impacts of population size by the following equation:

$$I = PAT$$

Environmental impacts = (Population size)* (Level of affluence or per capita consumption)* (Level of technology)

IPAT ¹ Model shows that the impact of any group of nation on the environment is given by the interaction of its population size (P), per capita affluence (A), expressed in real per capita GDP, and technology involved in supporting each unit of consumption (T).

Although IPAT model is useful to illustrate a general relation between population and environment, different versions that address policy questions were developed based upon it. For instance, Shaw (1989a, b, c and 1992) and Hogan, 1992 have proposed an alternative

multiplicative scheme in which the interactive affects between population, consumption, and technology are further specified. They distinguish between ultimate causes, or the driving forces behind environmental impacts, and aggravating factors. In the case of environmental degradation, consumption and technology are ultimate causes while population is an aggravating factor which increases the intensity of impacts which ultimate causes have on the environment (Marquette, 1997).

Other studies focus on social, cultural, political and institutional factors that mediate population and environment. For instance, Bilsborrow (1992 a and 1992 b) has elaborated a mediating frame work for understanding the relation between population growth and land use and agricultural production in rural areas in Latin America, in attemption to conceptualize to what extent socioeconomic conditions such as poverty, government policies, and market demands determine whether population growth

1-(I) Human Impact on the environment. P= Population, A= Affluence, T= Technology.

leads to technological change in agriculture, soil degradation, or emigration / out migration. Moreover, others locus on social and cultural rather that economic and policy factors (McNicoll 1990; Hogan 1992; Sahlins 1972). According to these views, the relations between people and their environment is not direct, rather it is regulated by culture and social organizations, thus environmental change is viewed as natural and social process (Schmink 1994).

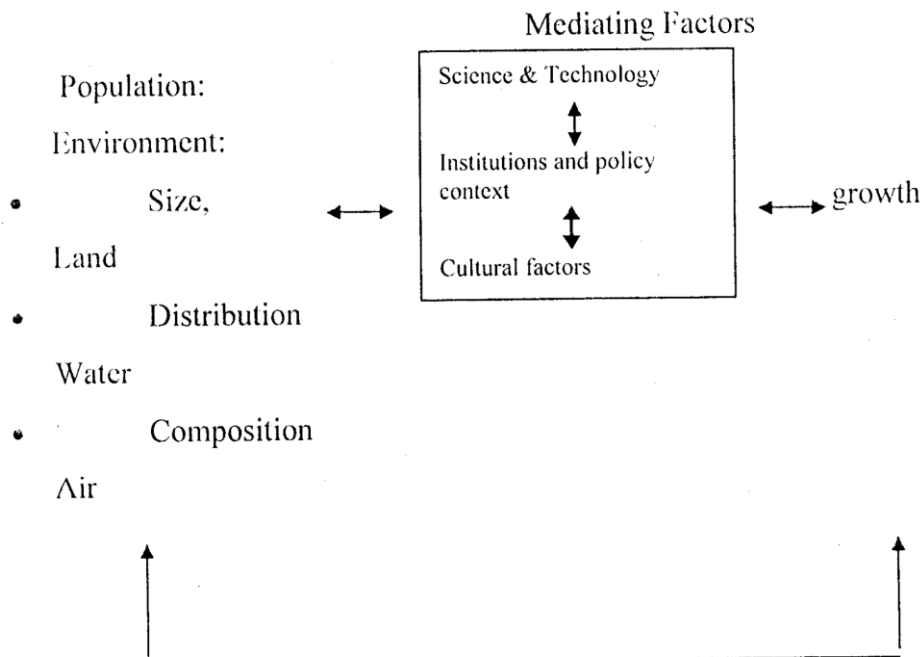
One step further, a new conceptualization that goes beyond social, cultural and institutional factors and focuses on the way how development mediate population and environment relations, was developed. This "dependency perspective" focuses on the part of international political and economic forces in shaping both demographic factors such as population growth and environmental outcomes such as degradation in developing countries (Marquette, 1997).

Other approach considers the mediating factors along with population and environmental factors in a complex way. This approach tries to understand the way the ecological and human- driven systems (socio-cultural, demographic, and economic systems) are interconnected to form larger "socio- ecological systems within which population and environment were embodied (Gallopín et al. 1988). This approach was widely adopted in studying how human systems reflect adaptations to a given ecosystem as well as how human systems may shape natural ecosystems (Drummond 1975, Hawley 1986; Netting 1986).

Each one of the aforementioned perspectives presents strength and weakness in terms of the conceptual relationships; for instance, it is difficult to operationalize Malthusian and Boserupian concepts and PAT (Population, Affluence, Technology) formula says nothing about the distribution of resources that lies behind total consumption. The relationships also can be studied on the macro and micro-levels.

For its simplicity, this study adopts the model after Hunter (2000) to review the environmental implications of population dynamics in Sudan.

Figure 5.1: Framework for constructing the relationship between population and environment



Source: Hunter (2000)

5-1 Environmental implications of some specific population factors:

This paper focuses on the impacts of demographic factors on the environment; however, the framework presented above also indicates to the reciprocal relationship between the two domains. For

instance, the arrows imply that there are also demographic implications of the environmental changes.

The socio-economic factors affect on population dynamics positively or negatively; for instance the health status of the country affects mortality rates while education, income level, among other factors, affect fertility rates and many pull and push factors affect migration rates. High fertility, low mortality, immigration and internal migration increase population size and growth and influence in population composition and distribution. As high immigration rates increase population size and growth, internal migration influences population distribution and increase in urbanization in Sudan.

5-1-1 Population size

As for population growth, no simple relationship exists between population size and environmental change. According to Gans, in countries where population growth is high it is difficult to produce enough goods to meet the basic needs. Expansion in the production of goods becomes necessary to keep people alive, yet production of goods may worsen the environmental problems, especially if they utilize more technology to produce goods. Alternatively,

environmental deterioration may increase the demand for children to help in domestic work. Population growth, economic development and environmental degradation are bound in a vicious circle and the exact relationship between them is still debatable. A growing but not sufficient number of small scale studies suggest that demographic growth is not always the major element in environmental degradation or in preventable exhaustion of resources (Tabutin and Thiltges, 1992).

Some empirical studies examine the link between population size among other demographic factors and pollution, and also considered the urbanization rate and the average household size; the findings, confirmed that population increases are matched by proportional increases in emissions and a higher urbanization rate and lower average household size increase carbon dioxide emissions (Neumayer, 2004). This finding is sensible as in urban areas we theoretically expect small family size and more consumption of energy. The results are also significant for developing countries with their high population growth rates and a trend towards urbanization and smaller household sizes. In this regard, however, Gans (2005) suggested that, by substituting goods of less polluting character for

consumption causing high pollution, could improve environmental quality even if population increases and, technical progress might reduce the amount of emissions produced per unit of output.

Some empirical studies went even further to study the impact of different groups of population. Some negative effects of rural population growth on the environment was identified by the work of (Panayotou, 2000) and in a study that examined the joint determination of population growth and environmental changes conducted by Bhattacharya and Innes (2006), their findings confirmed that environmental decline urge increased rural natural growth and increased rural in-migration which in turn prompt further environmental decline. Improvement on environment on the other hand stimulates urban natural growth and increase net urban in-migration and environmental scarcity spurs environmental improvement.

This is in line to Boserupian assumption that environmental scarcity breeds creativity, innovation and policy that conserves natural resources. However, what is true for one area may to be true for others: for instance in Sudan when Kordufan region was badly struck by drought and desertification, people out-migrated to the peripheries

of Khartoum state and this led to more soil erosion and environmental degradation in Kurdofan region as spelled out by endogenous people.

5-1-2 Population structure and mobility

The mechanism, through which population dynamics and environmental conditions are related, can also be well understood by considering some demographic factors such as; age and sex composition and socio-economic structure. For instance an increase in elderly population resulted from the rising life expectancy, increases the overall dependency ratio and accordingly there will, increase landless and poor people. Poverty in its turn leads to over cultivation of land, deforestation, lack of sanitation and water and air pollution. On the other hand, high ratio of young population and high sex ratio at birth indicate the highest likelihood of moving; because of age and sex selectivity of migration.

The relationship between migration and environment can hardly be drawn: as both of them varied and are components of equally complex economic, social, cultural, demographic, and political processes operating at a the local, regional, national, and international levels (Castles and Miller 1993, Curran, 2000). However, summary of

the findings from the empirical literature shows that: migration has an impact on environmental outcomes through its selective nature, social net work and remittances back to places of origin may play an important role in redirecting consumption in either positive or negative ways for environmental outcomes; and, migration affects the environment through land- tenure/use and poverty (Curran, 2000).

The literature on migrant selectivity has endeavored to show the differentials in migrant impacts upon the environment by comparing between spontaneous and forced migration. The findings show varying results. In some cases, spontaneous migrants appeared to cause more destruction of the environment than forced migrants. In Indonesia, spontaneous migrants were associated with rates of deforestation two times that of transmigrates (Bilsborrow and Ogendo 1992, Curran. 2000), whereas in other cases, forced migration is generally worse for environmental outcomes in places of destination than is spontaneous migration. For instance, in Mexico, resettlement schemes of the 1960s and 1970s lead to extensive deforestation (Dwyer and Minnegal 1999; De Walt and Rees 1994; Ewell and Poleman 1980, Curran, 2000). In the case of the Mexican tropical rainforest, in fact, spontaneous migrants adopted local management

practices (Dwyer and Minnegal 1999). In Zimbabwe, migrants resettled through government programs were not interested in farming and did not invest in sustainable land use practices (McIntosh 1993). Moreover, linking migrant social networks to resource use or property relations in either place of origin or destination is rarely addressed.

In Sudan, competition over resources led to armed conflicts in Darfur region and as a result so many people were internally displaced; these people cut trees for firewood, and produced charcoal to sell for subsistence. Large areas of forests were cleared in this way and this may in turn increase in land temperature and result in rainfall decline. Thus conflicts induced population mobility has contributed to environmental degradation.

Most of the perspectives on population and environment refer to environmental implications of socio-economic composition of the population. for instance, poor people lack access to clean drinking water, sanitation, and fuel for cooking, so they contribute in air and water pollution and deforestation. On the other hand, rich people disproportionately consume energy and produce waste; nevertheless, identification of the share of each group in environmental decline is still a matter of debate. Moreover, studies have failed to show a

common pattern in the relationship; some envisage poverty and inequality to reduce concern with environmental quality (Inglehart 1990, Dietz, 1994), whereas recent analyses by Dunlap et al. (1993) do not support the presumed relationship between a nation's economic prosperity and environmental concerns (Dietz, 1994). Others show that in certain situations the poor are immediately responsible for degradation while in others they are seen to take great care in maintaining or improving the environment (Grimble et al, 2002).

5.1.3 Population distribution

On the macro level, the distribution of people around the globe has three main implications for the environment. First, as less-developed regions cope with a growing share of population, pressures intensify on already diminishing resources within these areas. Second, migration shifts relative pressures exerted on local environments, easing the strain in some areas and increasing it in others. Finally, urbanization, particularly in less-developed regions, frequently outpaces the development of, infrastructure and environmental regulations, often resulting in high levels of pollution (Hunter, 2000).

High fertility and high net in-migration in some regions relative to others make diversity in population distribution among regions. Malthusian theory showed that population pressure (due to large population) results in the exhaustion of the natural resources. Thus, under Malthusian argument, two regions with similar area and natural base but one with double the population would indistinctly make the latter end up in ecological collapse more rapidly. However, this is relative to the institutional setting (land distribution, tenure among others), and also relative to the technological systems the farmers choose given the ecological and institutional constraints they face (Cárdenas, 2005). The work of (Hoon Lee et al 2005) also confirmed that country's environmental sustainability improves as the country's income per capita improves, population density declines and/or the country enjoys greater degree of civil and political liberty. Most of the studies on environmental implications of population dynamics focused on population size as the main indicator rather than population distribution.

Population patterns and dynamics can vary among different socioeconomic or cultural groups of populations. Environmental problems, on the other hand are location- specific, thus it is important

to consider variations in locations and population groups when addressing the linkages between population and environment. In Sudan no empirical studies that investigated the linkages between population dynamics and environmental changes are conducted. However, many linking factors are observed in many regions; For instance. In Al- Gadarif state, the main population dynamic component that may affect the environment is the influxes of refugees, seasonal mobility of pastoralist, rural urban migration seeking for better social services, in-migration to irrigated scheme of Al- Rahad and the recent influxes of population from different states due to the exploration of gold. In Al- Gadarif state, rapid population growth, resulted from immigration and in-migration, reduced vegetation cover (cutting firewood), over grazing, pressure over social services, lack of sanitation facilities, water and air pollution, spread of serious diseases such as HIV/AIDS, poverty and unemployment, are evident (States workshop papers).

In South Darfur, competition over resources led to armed conflicts and as a result many people are internally displaced. The participants of the state workshop held in South Darfur, on the linkages between population dynamics and environmental changes,

mentioned that the state has been exposed to environmental degradation such as soil erosion, rainfall cut-back, drought and desertification. As reported by the participants, the degradation is caused by over grazing in the already fragile lands and over exploiting agricultural land and competition over the limited sources of water.

North Kordufan is struck by drought and desertification since early 1980s and about 40% of its land is desert. The most dominated economic activities are agriculture and animal husbandry. Due to drought and desertification people move either inside the state from the desert land in the north to the arid and semi arid in the south or move to other states leaving their land exposed to more soil erosion.

Among the environmental problems spelled out in the state are: shortage of water for people as well as for animal, unorganized exploration of gold, inadequate pastoral lands and undefined pathways for pastoralist to follow in their seasonal migration from north to the south seeking water and grazing areas.

The implications of shortage of water on population dynamics and environmental degradation include; loss of 28% of pastures, mobility of the pastoralist from the north areas to the south and the

concentration of pastoralists around water catchments cause over grazing, water contamination and environmental decline. Moreover, rural urban migration during summer causes shortage of water in urban areas.

All the aforementioned population and environmental variables can be operationalized into simple measurable factors and used to examine the linkages between population dynamics and environmental changes empirically.

5-2- Mediating factors

5-2-1-Technology

The relationship between population dynamics and environmental change is also affected by technology. Sometimes, technological improvement causes greater environmental change than demographic trends alone would have led us to expect (Hunter, 2000). For instance, the demographic shifts occurred during the seventeenth and eighteenth centuries were resulted from the technology induced agricultural revolution taken place at that period. Technological development has enabled food production sufficient to feed the world's growing population.

However, technology is a double edged sword; it increase production and at the same time intensive use of resources adversely affects the environment. Among the technological changes that mostly affect the environmental conditions is the use of energy. In recent years the consumption of oil, natural gas, and coal increased dramatically even in the newly developing countries where there is increasing levels of industrialization, resulting in greater reliance upon resource-intensive and highly polluting production processes. However; improved energy efficiencies could greatly diminish the environmental impacts from energy consumption (Hunter, 2000).

5.2.2 Institutional and Policy Contexts

Institutional response is also a significant mechanism through which people react to environmental change; specifically, policy plays a key role in determining the ultimate effect of humans on the environment (Hunter, 2000). For instance, clearing trees from a wide area to introduce mechanized farming, deforestation for constructing roads and clearing green cover to construct settlements or industries affect the environment.

6-Conclusion

The population- resources- environment question is a complex debate that has widely been discussed since Malthus first wrote his theory in 1798. Some perspectives treat the environment as a limited resource and regard people as a threat to the biodiversity and ecological balance of that resource; others as Boserupian think the scarcity of resources spur innovation and technology utilization, though technology is also thought by some perspectives as a cause of environmental degradation.

Most of the empirical studies discussed the factors highlighted by the different perspectives; as linking between population and environmental change in a socio-economic-political and cultural context. Some studies ensured the positive impact of population dynamics on the environment whereas others confirm the negative association of the two domains. Accordingly, we can argue that the majority of population and environment relationships are local concern and should be first fully understood in this context.

Demographic trends and the environmental problems taking place in Sudan are; rapid population growth, conflicts, migration, over

grazing, poverty and urbanization, deforestation, limited grazing land, drought and desertification and water and air pollution.

The mediating factors such as technology, institutions and policy as well as culture are also found to be working in Sudan. Construction of transmission lines, construction of dams, exploration of gold, exploration of oil, energy consumption all affect on the environment in Sudan.

To mitigate the impact of population dynamics on environmental changes, it is important to fully understand the linkages. This understanding, however, will have to be built upon empirical evidence i.e. to make data speak for itself rather than to depend on the perspectives' assumptions.

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