IMPLICATIONS OF RAPID URBAN EXPANSION ON RURAL LAND USE IN DAMATURU, YOBE STATE, NIGERIA

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ABSTRACT

The implications of rapidly expanding cities on rural hinterlands have been documented in the literature. However, such implications are understudied in developing nations including Nigeria. This study, therefore, investigated the implications of rapid expansion of Damaturu, Yobe State, the fastest expanding state capital in northern Nigeria on rural land use pattern from 1986 to 2009.

Environmental resource carrying capacity and distance decay effect provided the analytical framework. Survey research design was employed, while sampling elements were clustered and randomly sampled. The Local Government Areas surrounding Damaturu city (Damaturu, Tarmuwa, Fune, Gujba and Kaga) were purposively selected while the four major roads linking Damaturu with the neighbouring states provided the basis for subdividing the study area into four zones. Settlements in each zone were grouped into three, based on distance from Damaturu (<15km; 15-30km; >30km). Two settlements were randomly selected from each group. Two sets of questionnaire were administered to the population (household heads and firewood merchants/local building resource merchants) to elicit information on socio-demographic characteristics (population, age, sex, income), perception of urban expansion, implications on rural land use changes, rural resources depletion and severity index. There were 8,180 residential buildings in the selected settlements, 409 (5.0%) were randomly selected from which household heads were sampled. Similarly, 10.0% of 351 firewood merchants, 652 local building resource (soil, sand, gravel) merchants were randomly sampled. Imagery data collected were analysed using appropriate software. Pre- and post-classification comparison methods were employed to measure the changes of bare surface land, built-up area, tree-cover area and water-bodies. Data were analyzed using descriptive statistics, weighted opinion assessment and Severity Index (SI) at $p<0.05$.

Over ninety percent of respondents were males; mean age was 35.27±12.98 years while mean annual Income (in thousands) was 34.75±23.44. Population increased from 363,131 (1986) to 770,550 (2009). Bare land increased from 435.1ha (1986), 1,397.3ha (1999) to 2,936.2ha (2009). Built-up land increased from 398.6ha (1986), 2,045.9ha (1999) to 3,078.3ha (2009). Tree cover land decreased from 8,420.6ha (1986), 4,597.8ha (1999) to 2,642.9ha (2009). Water bodies decreased from 256.1ha (1986), 130.6ha (1999), to 72.0ha (2009). Average percentage of SI was 62.5%; SI decreased as distance increased 97.6% (<15km), 68.5% (15–30km) and 14.3% (>30km), while mean SI was 2.16 (very severe). The implications (rapid rural land use conversion, fast depletion of local building resources, decreasing water bodies) were perceived by 85.9% of the respondents as being negative. Fire-wood merchants viewed the expansion as negative because they expended more energy and cover longer distances for same quantity of resource. Local building resource merchants viewed increasing distance and rural degradation as negative, but made more sales to physical developers. Coping strategies of the household respondents included relocation of farm sites (78.0%), intensive agriculture (14.0%) and land conservation (8.0%). Fire-wood and local building resource merchants underwent longer distances for resources.

Rapid rural land use conversion and rural resource depletion were viewed as negative implications of Damaturu expansion. Therefore, there is the need to evolve strategies to manage these negative implications on rural land use and resources.

Keywords: Urban expansion, Rural land use, Local building resources.

Word count: 492

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CERTIFICATION

I certify that this work was carried out by Mr **IKPE**, Solomon Tar, in the Department of Urban and Regional Planning, Faculty of the Social Sciences University of Ibadan, Ibadan Nigeria under the supervision of

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DEDICATION

This Thesis is dedicated to my mother Mrs IKPE, Mbatsughun

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The world urban population has continued to grow leading to physical city expansion that rapidly absorbs rural land uses and is highly resource-demanding both to build, to service and to maintain. Recent studies have shown that population, cities and the urban-resource demands have assumed faster growth rates in the second half of the twentieth century than before. For example, in 1804, the global population was one billion; in 1927, the global population was two billion; in 1960, it was three billion; in April, 1974, it was four billion; In 1987, it was five billion; In 1999, it was six billion and in 2011, the global population reached seven billion (Global Footprint network, 2011). As population continued to increase, urbanization process among other factors redistributes population into cities, many of which are growing on areas that were once fertile and rich in natural ecological communities.

A careful survey of literature on urban population growth shows that in 1800, the cities that had population of over one million were Ancient Rome, Constantinople, now Istanbul; Shajahanabad (Old Delhi), Edo (Tokyo's predecessor) and Peking, now Beijing (UN World Urbanization Prospect Report, 2002). By 1900, there were 16 of such cities; while in 2000, there were over 400. In terms of percentage growth of global urban population, it is recorded that by 1957, 30% of the global population lived in cities; this grew to 47% in 2000, and an estimated 60% is projected to live in cities by 2030 with a higher rate of this occurring in developing countries (UN Population Division, 2002). This growth of urban population has been noticed to be universal; occurring in both developed and developing nations. In the 1990s, the rate of urbanization in Nepal (6.6% per annum) was among the highest in the Asian Pacific Region, higher than in Sri Lanka (2.2%), India (2.9%), Pakistan (4.4%), Bangladesh (5.3%) and Cambodia (6.2%) (Portnov, Adhikari,

Schwartz, 2007). In Africa, urban population grew from 32million in 1950 to 102million in 1975, to 295million in 2000 and estimated 787million in 2030 (UN, 2002). The UN World Urbanization Prospect Report (2002) observed that the Sub-saharan Africa has long been one of the least urbanized regions of the world, but the change in its rate of urban growth in the past 50 years shows that in 1950, only 15% of this region's population lived in towns and cities. By 2000, 38% of the region's population lived in urban areas with Nigeria's urbanization being more widespread than anywhere else in Sub-saharan Africa (UN, 2002). Such rapidly urbanizing regions have promising opportunities and daunting challenges to sustainability of cities. Rapid urban physical expansion concentrate human population that exert severe implications on rural land use conversions and natural resource depletion; these combine to weaken the productive capacity of the biosphere.

Urban population growth leads to city expansions, which highly depends on exploitation of natural resources in developing countries. Considering urban population growth and its implication on the surrounding rural land use, the UN Report (2002) observed that population growth impacts on the surrounding environment primarily through rural land use absorption, depletion of natural resources and waste disposal. These exert adverse consequences on the valued environment such as increased pressure on arable land, impoverishment of biodiversity, air and water pollution among others. According to the UN Report (2002), the expanse of the implications of city expansion on the surrounding environment in such areas as rural land absorption, over consumption of the natural resource and deterioration of the socio-economic conditions have also been increasing over the years. In 1800, the ecological footprint (extent to which a city impacts on its surrounding as it seeks to meet its space and resource-demand) of 100 cities of the world that had 20 million inhabitants extended just a few thousand hectares. In 1990, the ecological footprints of the 100 largest cities extended some hundred thousands of hectares and the trend has continued to increase. For instance, the population of metropolitan New York grew by only five per cent in the last 25 years, yet its surface area has grown by 61 per cent, consuming much forest and farmland in the process. Los Angeles is a famous mega-city with a population of 11million people and an area coverage that measures three times larger than London that has a population of seven million (Giradet, 2000). Applying this trend to the interaction of multiple elements in

human system such as population, resource depletion and socio-economic status shows that, city residents depend on the biosphere for steady supply of the basic requirements for living such as energy for warmth and mobility; wood for housing, furniture and paper products. They also depend on the bio-capacity for quality and sufficient food and water for healthy living, on ecological sinks for waste absorption and on other non-consumption life-support services (Redman and Jones, 2004).

Investigating the sustainable prospect of cities, Kitzes, Peller, Goldfinger and Wackernagel (2007), observed that the expansion rates of urban centres will soon become one of the greatest challenges to ensuring human welfare and a viable global environment as long as it continues to deplete natural resources to invest in new infrastructure and institutions. Consequently, the resource-demand by human population will continue to dominate that of other life species on earth as human-being increasingly funnel resources from all over the biosphere into cities (Herbert, 1999). Collaborating these views, Redman *et al* (2004), state that cities occupy 4% or less of the world's terrestrial surface, yet they are home to almost half the global population; consuming close to three-quarters of the world's natural resources and generating three-quarters of its pollution and waste. In his investigation, Herbert (1999) argues that cities support large population and by that protect world's natural resources; adding that sound economic policies can also promote and finance environmental improvements far beyond city boundaries. Mateo (2003) posits that cities have positively influenced the economic life and standard of living of the world's population living in them; he argues that the concentration of population, production and consumption activities in cities affords urban dwellers the enjoyment of per capital cost advantages. He also states that, the readily available transport facilities and services and compact design enhance cheap and quick access to a great range of locations as well as other services. He concludes that the social status of many urban dwellers promotes a rich social economy among others.

On the other hand, cities have been implicated for rural environmental degradation, income as well as social inequalities between urban and rural residents, and corrosion of rich cultural and social fabrics (Simon, 2008). Cities are also blamed for their ever-increasing population, high urban resource-demand beyond the regenerating capacity of the regions where they are located. Urban areas are further accused of high generation and

improper management of urban waste, which ends up in the regions surrounding the cities (Seto and Shepherd, 2009). Growth of cities exerts consequences on the finite natural space and resources as cities' expansion takes place mainly on the country's fertile farmlands. Thus, large scale urbanization is highly resource-demanding and large cities are costly to build, administer and maintain. Furthermore, cities generate conflict if their resource-demand exceeds the productive capacity of their habitat. Besides, increasing resource-demand of urban dwellers changes the structure, function and dynamics of the surrounding ecosystem (Mateo, 2003).

Mateo (2003) states that unplanned physical expansion occur where there are weak urban growth control measures, causing land and ecosystem fragmentation, modification and conversion; it influences scarcity of resources and rising cost of land, land related resources and depletes rural open spaces. The extent to which a particular city impacts on its surrounding in this way is called its ecological footprint (Rees 1992). Ecological footprint affects diverse aspects of ecology; thus, it is difficult to examine and analyze all the implications of urban physical expansion on the surroundings in a single study. This study, therefore, concerned implications of urban expansion on selected rural land use and resource extraction environments to determine how to manage the urban expansion and its attendant shortcomings.

1.2 Statement of the Problem

Physical planning finds its expression in space and its impact on environmental components including man; therefore, planning is not an end to itself. The ultimate purpose of planning (co-ordination of space and activities, facilities, transportation, physical environment among others, in a time-dimensional order) is for the convenience and health of man. Therefore, physical planning seeks to provide for and enrich ecological environment to ensure balanced components for human interest. Human or development activities tend to undermine the essence of planning if they do not promote or provide for the convenience of some people. Similarly, it is not comprehensive if it provides for convenience of some or areas at the detriment of others. The physical expansion of cities in the twentieth century brought about a variety of daunting environment-related problems in areas such as space, environmental and resource sustainability (Nunan and

Satterthwaite, 1999), socio-demographic/economic (Mateo, 2002; Simon, 2008; Briggs, 1999; UN population Dision, 2002) among others. Consequently, many researchers have tried to tackle the multi-faceted problems of urban expansion dynamics through studies that explain urban evolution using theoretical constructs (Hoyt, 1939), urban population increase (Portnov, Addhkari and Schmitz, 2007; Gadaret, 2000; Redman and Jones, 2004); urban growth processes (Tunner,1990), space and environment (Hardoy, 2001; UNCHS, 1996; Redman, 1999; Bruce, Prez-Padilla, Albalak, 2002; Jinadu, 2005). Other studies investigate urbanization in relation to aspects such as poverty, income inequalities, forest and farm lands (Stern, Dietz,Kalof,1990; DeFries, Rudell, Uriate and Hansen, 2010; Durkheim, 1964; Adesina, 2005; Oluwabusola1998; Popola, 1998). According to Alibeli and Johnson (2009), building, administration and management of urban centres and their infrastructure consumes different resources such as land and soil that are non-renewable according to human time scale. The document added that urban physical expansion causes loss of farmland and land cover, and thrives well under weak spatial planning framework resulting in spontaneous settlements at the urban fringes. In contrast, it is often addressed on local rather than regional scales. Researchers have also documented studies that analyse the dynamics of large cities (Cheng and Masser, 2004; Xie, Yu, Tian and Xing, 2006), but little has been done to understand the evolution and implications of urban expansion on the surrounding settlements and resources (Sui and Zeng, 2001; Pinto and Antunes, 2007). Worse still, urban consumption of power and natural resources has continued to grow, especially in developing nations, because urban development in such countries depends heavily on natural resources. Tilton (2001) stated that humankind has consumed more aluminum, copper, iron and steel, phosphate rock, diamonds, sulfur, coal, oil, natural gas, and even sand and gravel over the past century than all earlier centuries put together, the pace continues to accelerate, so that today the world annually produces and consumes nearly all mineral commodities at record rates. The increasing magnitude and intensity of these environment-related problems is generating a global environmental concern as they undermine the purpose of urban development.

Environmental concern refers to the degree to which people are aware of problems regarding the environment and support efforts to solve them and or the indication of their willingness to contribute personally to their solution (Dunlap and Jones, 2002). There

have been investigations with diverse findings and conclusions on issues of environmental concern. Studies on environment include those on such facets as (i) Attitudinal studies that examine differences in opinions about the environment based on respondents' demographic and socioeconomic characteristics (e.g. location of countries, gender, age, race, social class and income; (ii) Experimental and quasi-experimental surveys that test hypotheses derived from social and psychological theories such as norm-activation theory among others; (iii) Applied researches that investigate into environmental attitudes and social behaviours or factors include littering, recycling, and energy conservation (Buttel, 1987) .

A cursory review of the literature also showed location (rural, urban, cultural) gender, social class, and education as important factors that affect people's awareness of environmental problems; these also shape their efforts to solve environmental problems; and influence their willingness towards solving environmental problems. For example, according to Dunlap & Jones (2002), Inglehart (1995), thorough and extensive cross-cultural studies showed high levels of concern about the environment in both rich and poor countries This led Dunlap *et al* (1993) to question the validity of the 'conventional notion that 'concern' about the environment is limited to developed and industrialized nations. Investigation on this showed that environmental problems are important issues of concern in both wealthy and poor nations, and residents in poor nations expressed as much concern about environmental quality as do those living in wealthy nations. Bell (2009) posited that in both poor and wealthy nations, such strong support for the environment is an indicator of a paradigm shift in the relationship between society and the environment (Bell, 2009). According to Bell (2009), paradigm shift theory suggests that in response to discrepancies between evidence of environmental threats and ideologies that do not consider environmental implications, people are slowly but steadily adapting views or methods that are more environment-oriented in different locations of the world. In addition, a paradigm shift theory implies that people are becoming more aware of the real material effects that industrial life has on the environment, and their ideologies are beginning to change to match this new understanding.

Inglehart (1995) further investigated the nature of environmental support in rich and poor nations and its driving forces. He found that public support for the environment

in the developing world is anthropocentric and reactive support that is driven by objective factors like air and water pollution and environmental threat to survival as opposed to its proactive and eco-centric nature in developed nations. In addition, developing economies rely heavily on the extraction of natural resources like oil and underground water. Consequently, concern for the environment and restrictions over the use of natural resources might be viewed as a direct threat to their economic survival and their affluent lifestyles. Based on Inglehart (1995), Tuna (1998) and Ohman (2006) strong support for the environment in the West is associated with a cultural shift from a materialist culture focusing on economic and physical security to a post-materialist culture focusing on freedom, self-expression, and quality of life like clean and aesthetic environment.

In addition to studies on countries' support and nature of the support for the environment, there are studies on gender and environment. Some studies poised that gender has been one of the most salient factors predicting environmental behavior and attitudes. However, literature on the relationship between gender and environmental concern is inconclusive because different studies have yielded different outcomes. For instance, McEvoy (1972), Arbuthnot (1977), and Arcury (1990) contended that men are more active, more knowledgeable, and more concerned about the environment than women. In contrast, Stern, Dietz, & Kalof (1993; Zelezny, Chua, & Aldrich, (2000); and Uyeki and Holland (2000) indicated that women are more concerned about the environment than men. On the other hand, Arbuthnot (1977); Arcury (1987); Mohai (1991); Hayes (2001) argued that gender does not influence environmental concern and women are not more concerned about the environment than men.

In terms of age cohorts, the literature associates the middle class with environmentalism and environmental concern (Buttel & Flinn, 1978a, 1978b, Buttel, 1987, Van Liere & Dunlap, 1980, Mohai, 1985, Morrison & Dunlap, 1986). All these studies posited that the middle class has expressed strong support for the preservation of the environment and the conservation of natural resources, but the literature is not clear as to whether environmentalism is a middle class value or whether class differences in concern is due to the influence of middle class attributes such as education, income, occupation, and social activism. According to Buttel & Flinn (1978b), the middle class environmental concern might be due to factors like education, income and occupation

rather than to class per se. Furthermore, Mohai (1985) argued for an intervening variable, that the link between the middle class and environmental activism is a connection between socio-economic status and factors of political activism, rather than a link between the middle class and environmental concern. The environmental activism of the middle class is believed to be the result of greater access to resources as well as greater sense of personal efficacy. Hence, those with limited access to resources and low confidence in their ability to influence the political system will be discouraged from taking political action regardless of their environmental concerns (Mohai, 1985). Other studies provided results concerning the effect of family income on environmental concern (Arcury, Johnson, & Scollay, 1986, Arcury & Johnson, 1987). Researches also indicate that higher income people tend to support, fund, and commit to environmental organizations (Mohai & Twight, 1987). Other researches pointed out that financial support might reflect individuals' financial ability to pay dues and fees to environmental organizations more than their concern about the environment (Olsen, Lodewick & Dunlap, 1992).

Finally, literature indicates a positive relationship between educational attainment and environmental concern. The results show that educated people are more likely to show higher levels of environmental concern than the less educated; and as the level of education increases, so do environmental concern (Arcury, Johnson & Scollay, 1986, Arcury & Johnson, 1987, Buttel & Flinn, 1974). Investigating into the consequences of urban physical expansion, Kwasi (2004); Kolawole (2001); Liu, Zhan and Deng (2005) corroborate that the rapid conversion of farmlands and watersheds exerts negative consequences on food, fibre, wildlife security, potable water and health of the native population. The literature understudied the implications of urban expansion on surrounding land uses and resources of cities and the quantification of the severity of such expansions.

The last two decades have witnessed rapid population growth and outward urban physical expansion that have combined to affect the environment, particularly the existing spatial pattern and functional stability of the rural land use in the adjoining regions surrounding Damaturu, the capital of Yobe state (Fig 1.1). In these years, the outward physical expansion and its implications have continued to increase in magnitude and intensity. The disturbing issue is that the implications of the physical changes due to urban

expansion have remained understudied. More insightfully, its dynamics such as the trend, driving forces, consequences and severity; the perception and response system are not empirically evaluated and documented for managing the implications on the rural land use, natural resources and socio-economic well-being of the residents in the adjoining rural areas. The study investigated what will be the perception of the rural indigenes of the urban physical expansion that does not seem to trickle down the benefits to them. If this trend of expansion, rural resource depletion and the reactionary environmental management programmes of the town are confined within the city boundaries, what will become of the welfare of the rural residents and resources? This corroborates the finding of Mateo (2003), that urban authorities accept responsibility for the welfare of the population within their boundaries, but not of those from whose lands they draw resources with damaging ecological consequences. The rapid urban physical expansion in Damaturu is seemingly exerting rapid consequences on the rural land use variables as people poise to optimize space and resource use.

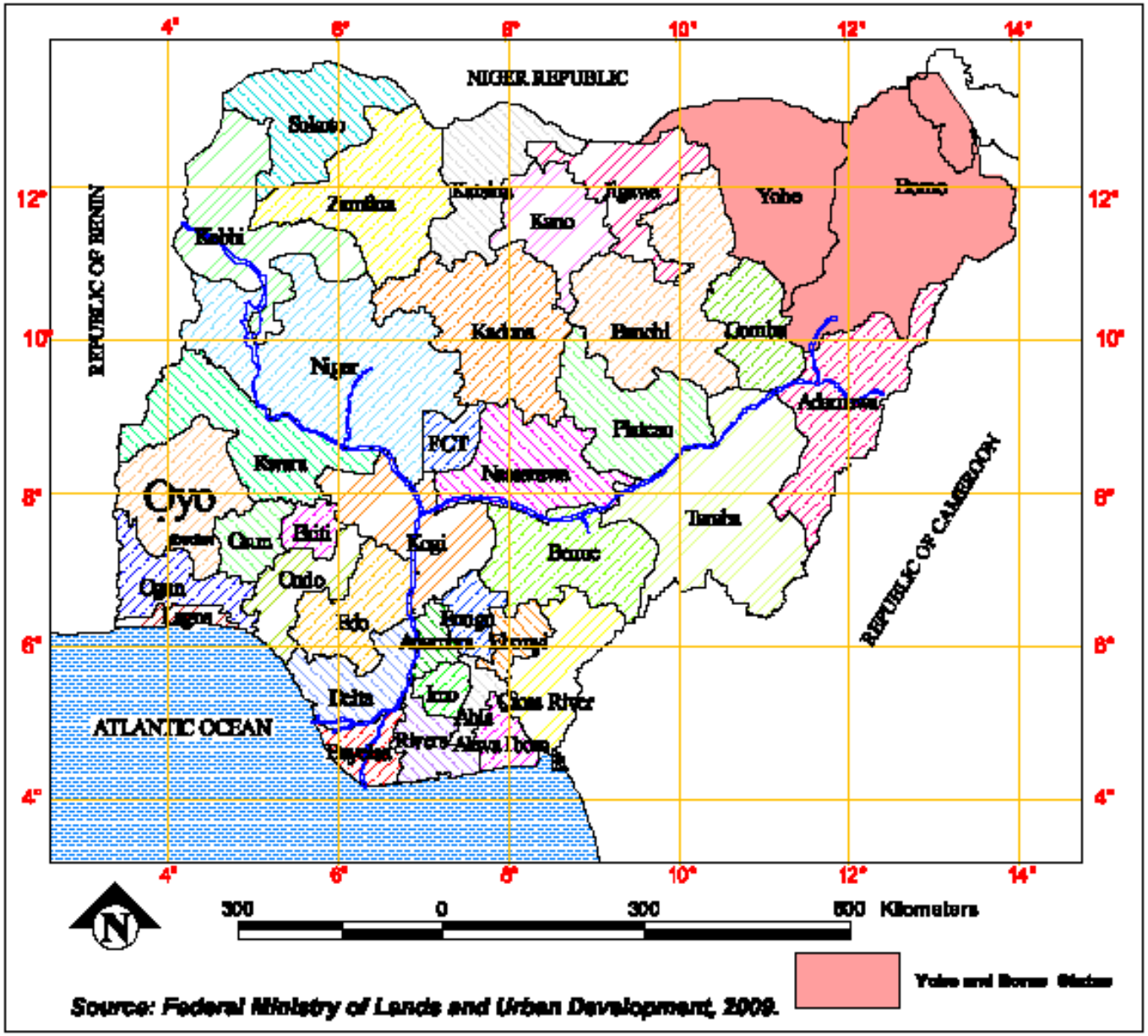

Figure 1.1: Yobe and Borno States in the Context of Nigeria.

It suffices to poise such questions as (i) where does urban expansion occur? Which urban areas have expanded more rapidly? What are the driving forces behind the expansion? What are the implications on rural land use and natural resources beyond the city boundaries? Which rural land uses are poised to the threat of urban physical expansion? Does the rapid urban expansion leaves time for the natives and government to appropriately respond to the challenges it presents? How can the challenges be managed? What policy instruments can be used to manage the expansion and its implications? The problem of this investigation stems from the above background.

One may argue that the burgeoning population and rapid urban expansion in Damaturu is being achieved at the expense of vast rural land use and resources. This does not preclude that the rural residents do not use resources or do not generate waste. The rural settlements effectively use their indigenous technological and institutional mechanisms of waste management, resource and land management that cannot cope with urban waste generation and new forces of urban expansion and resource demands. Moreover, literature affirm that the use of rural land and resource by rural dwellers are minimal and gradual; their waste is usually less complex, smaller in quantity with larger proportion of biodegradable content and it spreads over a larger space than urban (Mateo, 2003).

This study aims at examining the trend of expansion, the driving forces of the urban expansion, the dimensions (physical and socio-economic) that expansion has affected as well as the severity of the consequences on rural land use absorption and natural resource consumption. It examines the perception of the natives and their response strategies. This informs the choice of suitable planning to determine the policy instruments suitable to manage the implications of the rapid urban physical expansion on the semi-arid regions that surround the city.

1.3 Research Questions and Hypotheses

The following questions are pertinent to providing answers to the research problem

To what extent and in what pattern has the urban physical expansion occurred?

(i) What are the forces driving the expansion?

- What are the implications of the urban physical expansion on the adjoining rural land uses in Damaturu

(ii) How severe are these consequences on the adjoining rural land use and natural resources?

(iii) How do the rural residents perceive these consequences?

(iv) What and how effective are some of the response mechanisms employed to mitigate the impact of the consequences?

(v) What are the socio-economic and physical planning policy-implications of these changes?

Three hypotheses are tested in this study. These are:

1. Rural land use changes are not significantly related to urban expansion (Ha).
2. Loss of area under forest (m^2) is not a function of urban physical expansion (m^2).
3. Loss of farmland (Ha) is not a function of increase in built-up area (Ha).

1.4 Aim and Objectives

1.4.1 Aim: The aim of the study is to analyze the implications of urban physical expansion on adjoining rural land uses in Damaturu, Yobe state with a view to providing findings that could inform the choice of sustainable planning and policy instruments to manage the implications of the rapid urban physical expansion in the study area.

1.4.2 Objectives: To achieve this broad goal, the specific objectives are:

i. To examine the trend in physical expansion of Damaturu from 1986 to 2009.

ii. To explore the factors driving the urban physical expansion of Damaturu.

iii. To identify and examine the consequences of the urban physical expansion on Rural land use and natural resources and

vi. To assess the perception of the urban physical expansion and its implications by the rural residents where natural resources are being extracted.

1.5 Research Justification

It shows from previous studies Rees (1992); Chambers, Simmons, Wackernagel (2000); Rees and Wackernagel (1996); Bright (1999); Jinadu (1995); Kwasi (2004) that there is consensus on the reality of urban expansion and its implications on proximate hinterlands. Some documented implications of cities expansion on rural hinterlands are in the areas of changes in ecological balance (Xie, Yu, Tian, Xing, 2006; Popoola, 1998); encroachment or loss of agricultural land (Jaiyebo, 2003; Adriana, 2003) and pollution of the peri-urban areas where urban wastes are deposited in the rural regions (Hardoy, 2001; UNCHS, 1996; Redman, 1999; Bruce, Prez-Padilla, Albalak, 2002; Jinadu, 2005). There are studies carried out on urban expansion and the attendant environmental implications on quality and morbidity (McMichael, 2000). Furthermore, Kwasi (2004); Kolawole (2001); Liu, Zhan and Deng (2005) affirm that the rapid conversion of farmlands and watersheds for residential purposes exerts negative consequences on food, fibre, wildlife security, water supply and the health of the local population. Assessing the relation between urban expansion and natural resources, Nunan and Satterthwaite (1999), posit that expanding cities draw on natural resources but without empirical data that computes the severity of any city.

It can be inferred from the foregoing that the studies on rural land use planning are often undertaken to promote rural economic development, reduce poverty and social inequalities, with little or no consideration for rural land use and resource management. Thus, studies that empirically ascertain the implications of urban expansion on the rural land use and resources of the suburbs are needed.

The fact that urban physical expansion substantially occurs in different forms and sizes, and exerts varying implications on the surrounding physical conditions necessitates city-specific studies such as this one on Damaturu. Besides, the peculiar location of Damaturu in an arid region with low rainfall makes the natural resources marginal, fragile and unstable. Also, the consequent pressure on the fragile natural resources as the population continues to rapidly grow increases the per capita resource requirement in the face of decreasing ecological productive capacity. Therefore, this thesis analyzes the implications of rapid urban physical expansion on rural land use in Damaturu, an area with marginal and fragile ecology.

1.6 Significance of the Study

The recognition that urban physical expansions are exerting adverse implications on their rural physical environments is no longer confined to the industrial nations, but has now become evident in developing nations. Thus, the relevance of empirical analysis of the study of rapid urban physical expansion of growing town such as Damaturu and the implications for the rural hinterlands is imperative. Urban expansion, its processes and consequence is not a new issue-area in planning. There are studies on theories of urbanization, the pressure of urbanization on land use changes (Bello, 2001); agricultural farmlands (Popoola, 1998); forest lands (Oluwabusola,1998; Adejumobi, 1994); economic earnings and more recently, food security, social status, and cultural tourist resources among others. Therefore, this study of the urban expansion of Damaturu and its implications for the rural land use is important as it provides not only the basis for preparing measures that improve both rural and urban livelihoods and environments, but also informs decision to reduces adverse implications on rural land use and resources, and support sustainable regional planning and development. Ignoring research on rural-urban relationships implies loss of the above mentioned opportunities, which will contribute to the hardship of the people living in adjoining rural areas and the people on marginal earnings (McGranahan, Satterthwaite, Tacoli, 2004). This researcher believes that the findings in this thesis, which is specific on Damaturu, will go a long way in educating the rural residents to take responsibility of their local environmental resources and will help the urban managers to evolve strategies that will ensure sustainable development of regions around cities, because what happens around cities affects the peace, reputation and residents of such cities. This investigation is significant in the sense that the data-based findings will (i) empirically enrich the knowledge on the urban physical expansion of Damaturu (ii) expose the implications of the urban expansion and (iii) inform the decision for policy and management instrument to regulate the expansion and its consequences, which government, formal enterprises and rural residents can adopt for sustainable rural land use transition and natural resource management.

1.7 The Study Area Location

The study area is located between Latitude 10^0 75' and 12^0 00'N and longitude 10^0 75' and 12^0 50'E. (NASRDA, 2009). It is delineated from Yobe and Borno

States. These northern parts of the states are exposed to effects of Sahara desert and constitute one of the major areas with sand dunes and sand deposition from the Sahara. The sandification makes the area dust-loaded and adds to the extreme heat between March and May; and cold during Harmattan that characterize the region. Damaturu and its surrounding environmental resources are part of the Savanna region located in a semi-arid zone with low rainfall and resilience that makes it vulnerable to unregulated rapid expansion.

With regards to its climatic conditions, the area is dry and windy. Precipitation ranges between 70 and 80 per cent during summer season. Mean annual rainfall is about 750mm. The annual mean temperature ranges from 29^{o}C to 32^{o}C, with high daily and annual ranges. Aridity is also remarkable. Windiness is an important factor: average wind velocity ranges from 2.0 to 4.3 metres per second (m/s), occurring during early rainy seasons. Spring is the windy season and 40 per cent of the strong-wind days of the year fall between May and July. Surface water is scarce in the area especially during dry season. Groundwater depth is not less than 20 -30m. There are no aqueduct wells except boreholes that are drilled to ground water level. Vegetation varies with climate and surface land cover, which increases as one move southward from the Sahara desert.

The study area with regards to its socio-economic status is naturally a marginal and economically backward area, characterized by semi-arid, windy, and sandy natural conditions. It has a low-level agricultural economy and a tangential relationship with other regions. The economy of the local government areas and the region rests primarily on local resources; light industries are strongly oriented to local resources. Agriculture practices (grazing and cultivation) are significant source of regional environmental degradation. Material exchange with other regions is very limited. Output from the area consists mainly of product from animal-husbandry products such as hides, skins, and local cereal especially beans, whereas imports from other regions (as shaped by the economy) are mainly tubers, fruits and financial aid. In terms of its political administration, the area contains five local government administrative areas, namely Damaturu, Tarmuwa, Gujba, Fune, and Kaga, each of these administrative units comprises urban and rural settlements.

Population density largely varies between urban and rural areas. While urban density is high, the rural is low as people live in dispersed settlements over the vast pasture land, with several kilometres between settlements being quite common. This sparsely populated area has a larger rural than urban land, and much of the rural lands that surround the settlements are farm plots. This implies that the major human activity of the rural residents is rain-fed agriculture. Sustainable development will promote planned development of settlements within the regions around the urban centre; enhance rural resource and environmental management. A survey of the area revealed low educational level and high illiteracy, especially among the farmers, females and shepherds.

In terms of Environmental change, the major forms of environmental change include sandification (a process by which utilizable land is covered by or converted to sandy land, leading to soil coarsening, enlargement of sand cover, and declining productivity), degradation of vegetation, soil erosion, and soil degeneration. Many of the environmental problems in the area are mainly non-point problems, with some induced by land exploitation. Although these changes are closely interrelated, each has some distinctive properties. Vegetation changes are characterized by degradation through pasturing activities, which leads to a decline in land cover and height; simplification of species composition, reductions in high-quality plants and increase in poor-quality species.

The extent of urban expansion of Damaturu in the last two decades and its implications on the rural land uses and resources has been significant to attract empirical studies of this level and magnitude. Damaturu, with fragile resources and ecosystem base is the fastest expanding capital in northern Nigeria after Abuja. Its resource-base reflects more daunting susceptibility and challenges to sustainability than stable resource-based cities in the region. With the observed consequences, the investigation is more needed and urgent in the immediate and adjacent areas of the city where the implications are most concentrated. Besides, Damaturu's growth took place under weak spatial planning framework and without a regional development plan. Urban pressures on the rural resources is being regulated by traditional resource management instruments that are not sufficient to regulate the urban pressure, its urban management relies heavily on local planning and not addressed from a regional perspective.

The investigation is designed to cover Damaturu and the surrounding local government areas (Fig.1.2). The local governments are Tarmuwa local government which bounds the northern part of Damaturu local government area; the western side is bounded by Fune local government and the southern part is bounded by Gujba local government. The Eastern part and northeast is bounded by Kaga and Magumeri local governments respectively. Magumeri local government is exempted from the study because it is located far from Damaturu and it also lacks direct link with Damaturu town. The implication of the urban physical expansion of Damaturu on this local government is likely to be statistically insignificant. This study therefore, covers five local government areas, four from Yobe state and one from Borno state (Fig.1.2). However, the area delineated for the analysis of the implications of Damaturu and its environs is located on Latitude 11^0 40' .00'' and 11^0 48'.00''N and longitude 11^0 52' .00'' 12^0 00'. 00''E. This is the area where the implications of the expansion activities on the rural land use and resources are intensive.

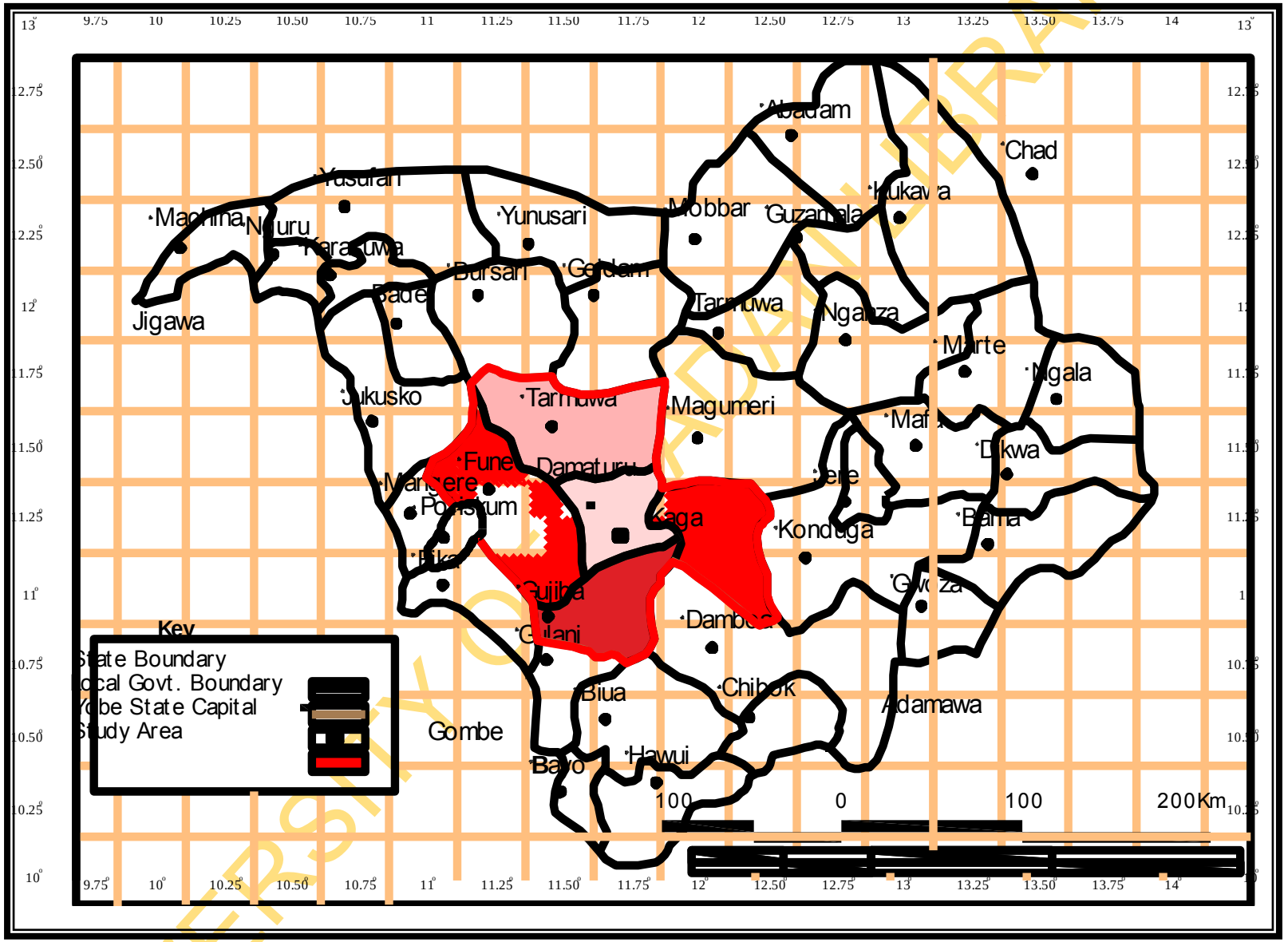

Fig .1.2: Map of the Study Area in their State Context. **Source:** Ministry of Lands and Solid Mineral Resources, Yobe State.

1.8 Operational Definitions

Settlement: Based on the index size of measurement, the settlements considered are those with population size above 100 persons, and these are 204 in number.

Urban physical expansion: refers to increasing change in space or number of new units of urban land that is transformed from non-urban resources; when there is transition from non-built-up to urban.

Sensitivity (or susceptibility): the degree of change of ecosystem or ecosystem component associated with a given degree of human-induced stress;

Resilience: the ability of a particular ecosystem to maintain the basic structure essential to support human uses during perturbations and to recover from such (and especially damaging) changes.

Fragility: the sensitivity of a particular ecosystem to human-induced perturbations and its resilience to such perturbations.

Life-support environment: that part of the earth that provides physiological necessities of life, namely, food and other energy mineral nutrients, air and water, and a term for the environment, organisms, processes, and resources interacting to provide these physical necessities.

Environmental impoverishment: refers to situations in which the trajectory of environmental degradation threatens in the medium to longer term to preclude the continuation of current human-use systems or levels of well-being and to narrow significantly the range of possibilities for different future uses.

Environmental sustainability: refers to situations in which nature-society relations are so structured that the environment can support the continuation of human-use systems, the level of human well-being, and the preservation of options for future generations over long time-periods.

Land use: the use that a piece of land is allocated to.

CHAPTER TWO

2.0 LITERATURE REVIEW AND THEORETICAL/CONCEPTUAL FRAMEWORK

2.1 Literature Review

This literature review section sets out to review related and empirical works on urbanization, trends of urban expansion, the implications on rural land use and emerging responses; the perception of the expansion with the attendant implications and coping strategies. It examines the implications of the consequences on the future planning and policy strategies in the study area.

Researchers over the decades have related urban physical expansion to carrying capacity and sustainable human settlement. Nunan and Sattertwaite (2004) posited that good urban governance could be an effective instrument to regulate negative implications of city-expansions. Coale and Hoover (1998) attribute the impact of cities on their surrounding (ecological footprint) to population, environmental and socio-cultural variables and further concluded that urban population affect city expansion and the later heavily draws on natural resources thereby promoting ecological footprint of cities.

2.2 Urbanization and Urban Expansion

Urbanization is defined as a process in which an increasing proportion of an entire population lives in cities and the sub-urbs of cities and is measured as a percentage of the population residing in urban areas of a region (Allen, 2009). Urbanization is also defined by the United Nations (2004) as movement of people from rural to urban areas with population expansion equating to urban migration. It connotes that physical expansion of urban areas transforms a traditional agricultural society to a modern metropolitan society with major changes in social, economic structures and ecosystem function. Urban expansion is the most easily identifiable indicator in urbanization process in the spatial dimension that affects land cover and use (Ewing, 1994). Examining the causes influencing urbanization, this study identifies the opportunities for jobs, economic

prosperity and health care services in the urban areas for which people move into cities. There are also varieties of entertainments and better quality of education. Urban areas also have diverse social communities allowing people to find other men of their levels. These factors, among others, attract large population into cities and redistribute rural population to urban areas, which in turn, affect the urban resource-demand and enlarge the ecological footprint of cities (Liu *et al*, 2005). The rapid pace of urbanization usually leads to rural land use conversion, resource depletion and environmental degradation among others. These have now become major constraints to achieving sustainable urban development in many regions including Damaturu.

Historians argue that, urbanization is connected with industrialization. However, the experience of urbanization in Africa has been unique in this dimension as it occurs without the industrial base to take care of its implications on the rural land use, resource and residents. In Nigeria, the growth and complexity of human settlements and the process of urbanization have been rapid. For example, in 1950, the percentage of the total Nigerian population living in urban centers was less than 15 per cent. By 1975 it rose to 23.4 per cent. By 2000, the proportion had gone up to more than 43.5 per cent and has been projected to be more than 50 per cent by the year 2010 (Thematic Committee, 2001). As the urban population increases, urban land enlarges over the rural land depleting its arable land and natural resources (Heimlich and Anderson, 2001). The consumption of arable land affects the ecological sustainability either directly through rural land use conversion or indirectly as a result of changes in the landscape (Simon, 2008).

It can be inferred from the foregoing discussion that urbanization remains one of the human activities that create enormous impacts on the environment and the resultant land use pattern reflects the underlying human activity processes and influences the impact that the cities exert on the surrounding hinterland. For example, the United States and the United Kingdom have a far higher urbanization level than China, India, Switzerland and Niger, but a far slower annual urbanization rate, since much less of the population is living in rural areas (Wikipedia, 2010). The United Nation's World Urbanization Prospects Report (2004) states that the global proportion of urban population rose from 13% (220 million) in 1900; it rose to 20% in 1920 and to 29% (732 million) in 1950. It further rose to 49% (3.2 billion) in 2005, and is projected to rise to 60% (4.9

billion) by 2030. This rise is through net migration and the natural increase of population living in cities.

Between 1950 and 2025, urban populations in developing countries is projected to grow from 200 to 3150 million people, a rate of 16-fold. Conversely, the industrialized nations of today experienced a slower expansion rate of urban populations than when they were developing. Between 1840 and 1914, urban populations increased by a mere 5-fold (Singh, 1992). The World Bank (1979) succinctly describes such differences in expansion saying that whereas urbanization in the industrialized countries took many decades, permitting a gradual emergence of economic, social and political institutions to deal with problems of transformation, the process in developing countries is occurring far more rapidly, against the background of higher population expansion, lower incomes, and fewer opportunities for international migration.

In the mid 19th century, rapid urbanization produced unique settlement morphologies in peri-urban areas, especially in China and parts of Europe, in a pattern characterized by an intensive combination of agricultural and non-agricultural activities (McGee, 1989, 1991; Lin, 2001); and through that, transformed the peri-urban lifestyles and activities into urban varieties with the aid of technologies (Xie *et al.*, 2006). It was different from the usual movement from the countryside to the towns with outward expansion as obtained in many developing countries (Kloosterman and Musterd, 2001). Urbanization is an ongoing dynamic process, and it is a dominant occurrence in all developing countries (Thapa et al, 2008). As cities expand; the increasing concentration of population and economic activities demands that more land be developed for public infrastructure (roads, water facilities and utilities), housing, industrial and commercial uses among others.

Therefore, urbanization is regarded as the major visible transformation of rural landscape into urban forms; exerting various impacts on ecosystem structure, function and dynamics (Weng, 2007). This land use change processes that increase climate and ecological problems require consistent monitoring of urban expansion indicators to help detect and predict the dynamic process of land use changes at different times.

Remotely sensed data provide a large amount of cost-effective, multi-spectral, and multi-temporal data to monitor alteration in landscape features and in the processes of

estimating biophysical characteristics of land surfaces (Herold *et al* 2003; Tang *et al*, 2005; Jensen, 2007). It constitutes a powerful and effective tool to detect land use and land cover changes, however, to fully understand the process of urbanization, it is equally important to investigate the social, economic, and institutional backdrop against which the land use changes have taken place.

Various studies on rates and patterns of urban land expansions and arable land losses, to establish and address the accompanying income and facility inequality, have been carried out in different city-regions of the world, which manifest different urban development parameters, including the rate of urban land expansion, growth rate of urban land per capita, and so on. Tan *et al* (2005) found that the urban land area in the Beijing-Tianjin-Hebei region expanded by 71% between 1990 and 2000. Luo and Wei (2009) found distinctive local patterns and effects of urban growth in Nanjing, shaped by local urban spatial and institutional structures. This study also showed the importance of policy studies and fieldwork in the interpretation of results generated from statistical and geographic information systems (GIS) modelling. Based on the empirical data, Han *et al* (2009) predicted the urban area of Shanghai to increase at an annual rate of 3% (1,474 km2 by 2020). Spatially, the new urban land is most likely to expand around the vicinity of city center or sub-centers.

2.3 Urban Physical Expansion

Urban physical expansion refers to the increasing number of new units transformed from non-urban resources, and is linked with regional economic vitality. It is the spreading out of a city and its suburbs towards non–built-up areas at the periphery of an urban area, which indicates the occurrence of urbanization. Urban physical expansion process involves fragmentation, modification and total conversion of rural land uses into urban landscape. Urban expansion is the overall measure of urban land expansion and the actual amount of land that has been urbanized, usually in three directions: in (by crowding); up (into high-rises) and outward (to the periphery). The outward mode of urban growth befits a nation with abundant space, a young and expanding population, increasing energy resources and a dynamic economy. Expansion is a space-time process and its consequences extend beyond changes in landscape pattern, to natural phenomena, ecological structure, functions and dynamics (Weng, 2007).

A study on uncontrolled physical expansion of cities by a UK-based organization (Ideaconnection) in 2011, reveals that in many developing countries, inter-city and rural-urban migration coupled with the natural growth of the urban population are causing cities to expand faster than the municipality authorities can cope. This trend leads to unplanned urban expansion characterized by informal settlements, unplanned land use transition and reduction in rural land uses. This rate of expansion also covers more than the 'social space' to include the land that people occupy (own) or use, and other lands that are influenced by individual and broader social units through the power and influence of their decision-making. According to Cheng *et al* (2010), the causes of urban expansion include: (i) increase in population, (ii) high demand for residential, industrial, commercial and other land use activities, (iii) government's intense economic activities and land fragmentation without protection of rural open spaces. Rakodi (2001) posits that effective control of urban physical expansion promotes sustainable development, urban management and land use planning.

When one considers urban expansion as a complex system that causes changes in space (from rural to urban), and the functional change in major activities (land uses), one will agree that space and activity should be the basic elements for understanding urban expansion. Another characteristic is the temporal scale of urban expansion that enables measurability in any given period of time, for example, from 1986-2009. Suffice it to say that, the complexity of urban expansion, its consequences on land use planning, city development and resource management need not only global concern, but more importantly, city-specific studies to provide solutions to its physical, temporal and decision-making process.

Cheng *et al* (2010) summarized the principle for analyzing and understanding urban expansion into five:

(i) Policy: The level that shows the most influential factor or driving force of urban expansion at macro scale

(ii) Actor: This refers to the agents of behaviour

(iii) Behaviour: This comprises the actions of the actors involved,

(iv) Process: This indicates the dynamics of urban expansion, and

(v) Pattern: The direct observable outcome which is the lowest level.

2.3.1 Urban Expansion as Indicator of Urbanization

Population growth and migration from rural to urban areas combine to visibly transform rural landscape into urban. In developing countries, including Nigeria, the rapid pace of urban expansion and the severity of the underlying processes of city expansion are bound to increase, particularly in the urban areas of small and medium-sized cities (Adeboyejo and Abolade, 2007); by this, urban expansion is the spatial identifiable indicator of urbanization.

2.3.2 The magnitude of Global Urban Expansion

Review of literature on urban expansion shows that it aggregates population and increase per capita energy consumption (Liu, 2009). This results in various effects on the structure, function and dynamics of ecological system such as loss of arable land, habitat destruction and decline in natural vegetation cover (Tang, Engel, Pijanoushi, Lim, 2005). According to Angel, Sheppard, Civo, Buckley, Chabaeva, Giltlin, Kraley, Parent , Perlin (2005), the population of cities in developing countries is expected to double in the next thirty years from some two billion in year 2000 to four billion in 2030. They further state that in year 2000, more than 100,000 cities had population of 1.7 billion people and their total built-up area at average densities of some 8,000 persons per square kilometer, was of the order of 200, 000 square kilometers at that time. If the average densities continue to decline at the annual rate of 1.7%, as they have been declining during the past decade, the built-up area of cities in developing countries will increase to more than 600,000 square kilometers by 2030. That is to say, by 2030, these cities may triple their land area, with every new resident converting, on average, some 160 square metres of non-urban to urban land.

In parallel, the urban population of industrialized countries is now expected to grow by 11% in the next thirty years from some 0.9 billion to one billion (Angel *et al*, 2004). According to the UN *World Urbanization prospect* (2004), cities with population in excess of 100,000 contained some 600 million people in year 2000, and their total built-up area, at average densities of almost 3,000 persons per square kilometer was of the order of 200,000 square kilometers at that time (Angel *et al*, 2005). The implication is that, if average densities continue to decline at the annual rate of 2.2%, as they have during the past decade, the built-up area of cities in industrialized-countries will increase to some

500,000 square kilometers by 2030. In other words, by 2030 these cities will increase their population by 20% and their land areas by 2.5 times, with every new resident converting, on average, some 500 square meters of non-urban to urban land.

According to Global Rural-Urban Mapping Project GRUMP (2003), the total urban built-up areas in the world consumed some 4,000,000 square kilometers in 2000, or 0.3% of the total land area of countries. The land taken up by cities amounted to some three per cent of arable land, estimated at four million square kilometers in 2000. Cities are now expected to grow 2.5 times in area by 2030, consuming some one million square kilometers, or 1.1% of the total land area of countries. Cities may consume up to five to seven per cent of total arable land, depending on the future rate of expansion on arable land, which is currently two per cent per annum (World Bank, 2005). The summary is that, urban built-up areas in the World consumed 400, 000square kilometers in year 2000 or 0.3% (130 million km^2) of the total land areas of countries. As cities are expected to grow at 2.5 times in area by 2030, they may consume as much as 5-7% of total arable land.

In Nigeria, the exodus of people into the urban areas is attracted by wealth, political power, prestige and learning institutions in the cities. The growth rate of urban population in Nigeria in 1986 was estimated to be close to 6 % per year, more than twice that of the rural population. Between 1970 and 1980, the proportion of Nigerians living in urban areas was estimated to have grown from 16 to 20 per cent; by 2010, urban population was expected to be more than 40% of the nation's total population (World Bank, 2005). The document further states that there were twenty one state capitals in Nigeria, each estimated to have more than 100,000 inhabitants in 1990. More than 15 of these cities probably had more than 200,000 populations. Virtually, all these were growing at a rate that doubled their size every 15 years. If one added the urban centres with more than 20,000 inhabitants, and other larger centres throughout the country, the urbanization in Nigeria was probably more widespread than anywhere else in sub-Saharan Africa.

2.3.3 The Form of Urban Expansion

Urban physical expansion occurs in different forms. In any given city, new urban expansion may take place at equal, lower or higher densities (persons per square

kilometer) as those prevailing in existing built-up areas (Angel *et al*, 2005). Physical expansion also takes place through redevelopment of built-up areas at higher densities, through in-filling of the open spaces in already built-up areas, or on virgin areas in non-urban use. The expansion of urban areas on virgin green-fields or at the urban fringes may either be contiguous with existing built-up areas or may leave swaths of undeveloped land that separate it from existing built-up areas that is, leapfrog from the existing town. The expansion may grow in all directions that result in large-scale urban sprawl and changes in urban land use that is classified as contiguous/concentric expansion. Urban physical expansion is described as linear if the expansion occurs along the main transportation axes (for example, highway, expressway, river), linking the urban areas in a long narrow strip. Also, a city may have more than one center apart from the Central Business District (CBD); this is known as multi-nuclei expansion. In this expansion, the junctions of major roads in the outer parts of urban areas act as the nodes of activities. The form of expansion of Damaturu possessed these characteristics.

As a city expands, it may encroach upon wetlands, watersheds, forests, and other sensitive environments that need to be protected as well as upon farms and orchards surrounding the city. New expansion may contain higher, equal or lower employment opportunities. New employment opportunities as well as new residences may be centralized in a small number of locations or spread out over entire newly urbanized areas along transport corridors resulting in a star-shaped or linear/elongated city, or in areas closest to the city center, resulting in a more-or-less circular city. New land development may be legally sanctioned, conforming to strict zoning for separate land uses or to mixed zoning for mixed land uses. It may also be largely illegal, entailing squatter invasions, informal land subdivisions, non-compliance with the zoning and building codes, or construction both on steep slopes and in flood plains. The form of urban expansion will determine the policy strategy. Examining the changes caused by urban expansion, Tang, Engel, Pijanoushi, Lim, (2005) submitted that changes in urban landscape pattern significantly influence the maintenance of ecological integrity; and these processes and functions are tightly inter-related with the landscape and the mosaic landscape.

2.3.4 The Forces Shaping Urban Expansion

Drivers of urban expansion are well known and can be grouped into economic factors (globalization, establishment of economic institutions, rising living standards, increasing urban land prices, national policies such as investment), demographic factors (age, gender), investment policies (housing, industrial, estates transport networks) social aspects (housing preference, social status), and regulatory frameworks (development control, land ownership, tenural system) (Alibeli and Johnson, 2009). All these elements act and interact at different scales and are modulated by local specificities. The conventional view of human factors blames subsistence farmers for deforestation, soil erosion, and associated resource degradation. The other view, instead of blaming human activities, projects resource degradation as a consequence of the natural process of mass wasting. According to Allen (2009), the reality lies somewhere between the two schools of thought.

The focus of this investigation is to analyse the role of human interference in environmental conditions. It should be stated that a society's inability to live within the usable limits of the biophysical resource-base of its habitat is the major cause of environmental degradation. Though, the resource demand and the living standards of people living in an area may be similar, the tolerance limits of their habitat via-a-vis the intensity and variety of human interventions may differ based on the specific characteristics of their ecosystems. In fragile resource zones, for example, such limits are narrower than in relatively stable zones of high productivity. Hence, resource-use patterns that can be considered normal in the latter case may prove environmentally degrading in the fragile areas.

A cursory look at the driving forces of urban expansion enhances the choice of appropriate action and policy to improve use-pattern and management. Angel et al (2005) identify six factors that influence the form of urban expansion. These are (i) the effects of the natural environment (ii) the effects of demographics (iii) the effects of the economy (iv) the effects of the transport system (v) the effects of consumer preferences for proximity and (vi) the effects of governance. According to Jodha (1992), it may not be possible to fully capture all the causative factors and relate them to the degree of

environmental changes as more than one factor may contribute to an environmental change.

The facets of natural environment that may influence the form of urban expansion include those of climate, slope, insurmountable barriers and the existence of drillable water aquifers. The demographic effects may include rural-urban migration and natural population expansion in the city. The aspects of the economy that affect urban expansion include the level of economic development, differences in household incomes, exposure to globalization, the level of foreign direct investment, the degree of employment decentralization, the level of development of real estate finance markets and the presence of cycles of high inflation.

Aspects of the transport system that affect urban expansion include the introduction of new transport technologies and most notably the private automobile, transportation costs vis-à-vis household incomes, the level of government investment in roads construction, the existence of city centers that were developed before the advent of the automobile and the existence of a viable public transport system. Consumer preferences that may affect the form and pace of physical expansion include: preferences for proximity to natural open space, preference for single-family dwellings, or home ownership; preferences for urbanism as a way of life, for proximity to other people and to urban amenities or proximity to one's place of work and preferences for flight from blight or its converse.

Variations in the form of governance that shape the form of urban physical expansion include the country's land laws as well as its democratic dividends. Others are the number of independent municipal governments in the metropolitan area, the share of the metropolitan area not incorporated into towns, the share of land in the metropolitan area in public ownership, the existence of an effective metropolitan planning agency, the type, strictness and quality of enforcement of various urban development control measures.

The effectiveness of response to these driving forces lies in institutional ability to manage the forces, which shows up in pricing, regulation and in mal-administration of power and resources that empower the voice of progress at the expense of environmental stability.

The issue of governance is particularly important to be addressed in the process of urbanization, especially in terms of co-ordination of urban planning for the urban center and that of local planners within the surrounding fringe zones. However, the issue of co-ordination of urbanization process is complex in terms of planning and management of urban ecosystems. This is because many urban ecosystems encompass complex jurisdictions of sub-national planning responsibility, such as those associated with large urban areas to local villages, which in turn, may lie within the planning area of another regional, provincial or special development zones. This system is further complicated by the emerging planning issues that incorporate unprecedented growth in urban populations, urbanization, globalization, climate change and ecosystem degradation.

2.4 Urban –Rural linkages and Natural Resources in the Surrounding Regions

The linkages and interactions between a city and its country-side are recognized as a central factor and one of the driving forces that exerts significant impacts on the physical, social, economic and cultural status far beyond the administrative boundaries of the cities (Simon *et al,* 2004). Consequently, when the linkage is weak and the rate of development of a city is more rapid than that of its planning and control, unplanned development at the urban fringes precipitates. Rapid urbanization coupled with unplanned development means that many of our cities are facing enormous pressure to keep pace with the needs of their swelling population such as the space-needs of people and infrastructure. As a consequence, the suburbs outwardly expand over rural land use and local building resources are rapidly depleted.

2.4.1 The Peri-urban Interface

This concept of the peri-urban interface explains the impact of an urban area on the environment, ecology and natural resources in terms of "appropriated carrying-capacity" often well beyond its boundaries. In further explaining this, Simon, Mcgregor and Gyabaah (2004) describe the peri-urban interface as an area characterized by strong urban influence, easy access to markets, services and other inputs, ready supplies of labour but relative shortage of land, and risks of pollution and urban growth. The source further sub-divided the peri-urban zone into two: first is the zone of direct impact (the part that is closer to the town), which experiences the immediate and direct consequences of land demands by urban growth for most construction activities; thus, it is the most active area

of construction and conversion, usually with adverse consequences and land use conflicts, during the periods of fast urbanization. This leads to emergence of unplanned land use changes, waste disposal centres and pollution sources. According to Simon (2004), this zone functions as a source and sink. As a source, resources (including people, construction materials, fuel-wood and other energy sources, food and water) from the region are supplied to cities and as a sink, urban manufactured products, services, effluents and wastes are dumped or diffused elsewhere. The second is the wider market zone of influence, recognized in terms of handling of agriculture and natural resource products.

The extent of the positive and negative consequences, their spatial extent and severity in this zone, vary in intensity, over time and among locations depending on (i) the physical conditions,(ii) existing rural institutions, (iii) cultural resource-perception and (iv) values among others. Sensitive as this zone appears to be, it has not received sufficient empirical studies that will proffer adequate solution to its associated consequences. Until the publication of *A Tale of Two Cities;* the DFID's peri-urban interface research programme in Kumasi and Hubli–Dharwad, not much study was carried out on this actively urban-encroaching area with construction and land use changes. Even today, little attention is devoted to peri-urban zones; both in journal articles and individual chapters in edited books. Concerning the study of peri-urban interface of African cities, the notable study is that of Marshall and Roesch on land tenure and food production in the *zonas verdes* (green zones) surrounding Nampula in Mozambique, which examines how many predominantly Female Producer Cooperatives (FPC) gained access to high-quality land to supply the urban market successfully before the wave of land privatization during the 1990s (Marshall and Rosech, 1993). More recently, attention has also been devoted to the emergence of formal and informal land markets and the related land-use changes in peri-urban areas (Briggs *et al*, 1999). The findings in the above studies reveal that the adjoining rural lands to urban centres have variously experienced one or more of the following:

i. Land loss to housing, economic transformation from agriculture, agricultural intensification and commercialization.
ii. Reduction in farmland and agricultural decline without replacing alternative

economic activities contribute to rural poverty and food insecurity.

iii. Livelihood framework that recognizes strategies that embrace different social groups in the urban, peri-urban and/or rural areas.

Urban physical expansion relates to four basic processes: rural to urban migration, natural increase, cross-border immigration and reclassification of rural areas into urban categories. Its adjoining areas raise obvious boundary and definitional difficulties through its characteristic processes of occurrence and fuzzy boundaries (Briggs and Mwafupe, 1999).

2.4.2 Implications of Urban Physical Expansion on Future Development and Resources

The rate of urban expansion at any level has implications on the future urban and rural development policies of such area, but many nations are unresolved as whether to welcome rapid urban expansion or to discourage it. Angel *et al* (2005) observe that, while many will readily agree that urban expansion is an issue of serious concern, there is no consensus among scholars, policy makers on whether further urban expansion should be restricted or encouraged.

Given the high rate of sprawl in developing countries and the reality that much data on its causes and consequences, is only available in industrialized countries, there is the danger that our understanding of urban expansion and the actions chosen to contain it will be unduly influenced by tested policies that are largely irrelevant to cities in developing countries. Helmich and Anderson (2001) observe that the management of public and private resources, the development priorities and modes of governance in the cities of developing countries vary from those prevailing in the industrialized countries. DeFries *et al (*2010) in examining the relationship between urban population growth and loss of tropical forest states that it is no longer a surprise that the loss of the tropical forests of the world is positively correlated with urban population growth and exports of agriculture productions. This investigation in forest resources shows that urban sprawl also create heavy demand on timber consumption, biomass for heating, settlements recreation, tourism and employment, which combine to exert varying pressure on forest. This necessitates empirical studies on the key variables as well as the forces that are regionally and locally driving expansion so as to adopt the appropriate policies that will promote

sustainable use of forest resources in developing nations, while keeping in mind that such policies may be quite different from those available or of interest in cities of developed countries.

2.5 Urban Physical Expansion and Natural Resources of Regions

Having examined the global and regional trends, this section discusses the rapid urban expansion and the implication on rural resources. Rapid population growth; infrastructure development and socio-economic transformation forces have combined to facilitate urbanization and conversion of natural environment, especially, with the emerging developments at the city fringes. Such rapid environmental changes as a result of rapid population growth in a sensitive ecology with weak land use planning practices have resulted in unplanned rural land use changes and exert stress on the ecosystem structure (Angel, 2005). Besides, studies reveal that much of the land for agriculture and forests has been converted into urban areas in the past few decades.

The investigation of Durkheim (1964) investigates the implications of urban growth on the supply of renewable resources such as forests, fisheries and non-renewable resources, such as minerals and energy. Oluwabusola (1998) examines the effect of physical development on selected forest reserves in Ondo State. The study finds that population growth has significant depleting effect on forest resources. Popoola (1998) examines urban encroachment on agricultural lands in Ogbomoso and the result shows that urban encroachment affects farming and food production. Coale *et al* (1998) carry out a study on population growth and welfare; examining if population growth generates problems to which price mechanisms and human ingenuity may not provide solutions. The results corroborated the earlier findings and concluded that there is adverse effect of population growth on resources and welfare.

Oluwabusola (1998); Popoola (1998); Coale and Hoover (1998) find that slower population growth might improve the efficiency of resource use. However, in terms of adequacy of resource supply, Coale and Hoover (1958) argue that factors other than population growth, particularly institutional arrangements, are more important than population size in determining the adequacy of resource supplies. From the works that have been reviewed, it is clear that studies on the relationship between population and human welfare are more than those on effects of population growth on the biophysical environment.

2.6 The Social Structure and the Environment

The social structure of a region also influences its expansion and environmental impact; the likely mechanism is that poverty and inequality reduce environmental quality (Inglehart, 1990). Recent analysis by Dunlap et al. (1993) does not support the presumed relationship between a nation's economic prosperity and environmental concerns. Poverty is to some extent captured by national product per capita. But distribution of income and land are more important factors that aggregate income in the concept of disarticulation Amin (1974, 1976, 1977); Stokes and Anderson (1990) is closely related to inequality (it is usually conceptualized as sectoral inequality) and is likely to have a strong link to environmental impact. According to Stem *et al* (1993), there is seemingly substantial evidence for gender differences in environmental concern at the individual level and this may translate into a link between gender stratification and the environmental policy of nation-states.

2.6.1 Environmental and socio-cultural variables

Examining the relationship between environment and Culture, the WCED (1987) define culture as an attribute of groups, and this can mean society as a whole (e.g. national culture), groups within society (sub-cultures), or even groups of societies and nations (trans-national culture). The culture of a people influences the population size and growth rate. Population in turn, affects urban expansion rate and the later undermines social cohesion and constitutes a melting pot for traditional culture or way of life as interaction deepens and people from diverse cultural backgrounds introduce new ideas and experiences, such as new styles of music and values. The socio-cultural values influence environmental concern, that is, the degree to which people are aware of problems regarding the environment and their supportive efforts to solve them. The concern manifests in willingness to contribute to the solution, but where there is prevalent poverty, regards to environmental conservation will be undermined (Dunlap and Jones, 2002). The work of Buttel (1987) reveals that research on environmental concern includes (1) Attitudinal studies that examine differences in opinions about the environment based on respondents' demographic and socio-economic characteristics such as social class, income, race, gender, and age; (2) Experimental and quasi-experimental surveys that test hypotheses derived from related theories; and (3) Applied research on environmental

attitudes and behaviours which investigate social factors related to behaviour associated with the environment such as littering, recycling, and energy conservation. The emerging support for environment is an indicator of a paradigm shift in the relationship between society and the environment (Bell, 2009).

Buttel (1978); Bell(2009) state that environmental concern identifies countries, gender, social class, and education as important factors that affect people's awareness on environmental problems, shape their efforts to solve environmental problems, and influence their willingness to contribute to solutions to environmental problems. For example, thorough and extensive cross-cultural studies revealed high levels of concern about the environment in both rich and poor countries (Dunlap et al., 1993, Inglehart, 1995). These examined the nature of environmental support in rich and poor nations and its driving forces. According to Inglehart (1995), public support for the environment in the developing world is an anthropocentric and reactive support that is driven by objective factors like air and water pollution, and other environmental threats to survival, while public support for the environment in the developed world is proactive and eco-centric in nature.

Tuna (1998); Olofsson and Ohman (2006) supported Inglehart's findings. Tuna's study on environmentalism in 18 developed and developing countries showed higher levels of anthropocentric (human oriented) environmentalism among less developed countries compared with higher levels of eco-centric environmentalism among the more developed countries. Olofsson and Ohman (2006) reported more concern about the environment among those with post-materialistic and collective beliefs than those with individual materialistic ones. In addition to country-based studies, gender has been one of the most salient factors predicting environmental behavior and attitudes. However, literature on the relationship between gender and environmental concern is inconclusive because different studies have yielded different outcomes. For instance, McEvoy (1972), Arbuthnot (1977), and Arcury (1990) contend that men are more active, more knowledgeable, and more concerned about the environment than women. On the other hand, Stern et al (1993); Zelezny et al (2000); Uyeki and Holland (2000) indicate that women are more concerned about the environment than men. In particular, Uyeki and Holland (2000) reported that women are more concerned about the environment, nature,

and animals than men. In contrast, Hayes (2001) argued that gender does not influence environmental concern and that women are not more concerned about the environment than men. Finally, Arcury *et al* (1987) and Mohai (1991) state that no definite conclusion can be drawn about gender effect on environmental concern.

Furthermore, Buttel *et al* (1978a, 1978b); Buttel (1987), Van Liere and Dunlap (1980), Mohai (1985), Morrison and Dunlap (1986) all associate social class levels with environmentalism and environmental concern. According to the studies, the middle class has expressed strong support for the preservation of the environment and the conservation of natural resources. In addition, the middle class has led the environmental movement in its efforts to preserve wilderness, to conserve natural resources, to raise public awareness about environmental problems, and to lobby policy makers to curb air and water pollution. Yet, the literature is not clear as to whether environmentalism is a middle class value or whether class differences in environmental concern is due to the influence of middle class attributes such as education, income, occupation, and social activism. According to Buttel and Flinn (1978b), the middle class environmental concern might be due to factors like education, income and occupation rather than to class per se.

Related studies provide interesting results concerning the effect of family income on environmental concern (Arcury, Johnson and Scollay, 1986; Arcury and Johnson, 1987). Mohai and Twight (1987) posit that higher income people tend to support, fund, and commit to environmental organizations. However, Olsen, Lodewick and Dunlap (1992) opined that financial support might reflect individuals' financial ability to pay dues and fees to environmental organizations more than their concern about the environment. In that view, educated people are more likely to show higher levels of environmental concern than the less educated. Furthermore, the history of the environmental movement in the United States illustrates the importance of the role played by educated people like college students. Since the 1970's, college students have created popular concern about the environment through their large-scale participation in environmental and ecological debates (Dunlap and Rutherford, 1973; Dunlap, 1975; Bowman, 1977; Blum, 1987). The issue of consumer preferences for single family buildings, flight from blight, home ownership by individuals, and preference for natural ecosystem all contribute to rapid expansion.

2.7 Emerging Environmental Changes and Change Detection

Environment is a joint product generated by the composition and interactions of different biophysical variables in a given ecological context. In the process of interaction, socio-economic factors influence the interactive patterns of biophysical variables and there occur a change in the environmental parameters that may be in a tangible or abstract form. More importantly, the biophysical factors generating environment as a joint product are not only contributors, but products of the environment (Jodha, 1990). The interaction of the products that results to environmental change can be seen in terms of changes in the status of biophysical variables such as land, water and plants among others. Also, as urban expansion absorbs functional activities (rural land uses), tangible changes occur in the ecological community and land uses. Some of these changes may manifest themselves as impacts or consequences, whereas others form part of on-going processes of change, which can be quantified or measured.

Environmental change refers to alterations in environmental components or parameters that exert consequences on the ecology and human-beings. The abstract consequences are more difficult to measure than the tangible changes. Another important aspect of environmental change is that they are multi-level and may differ in terms of their degree of visibility (Jodha, 1990). While some (such as the extent of soil erosion) are directly visible, others (such as replacement of cattle by small ruminants due to the decline in carrying capacity) may be concealed by human responses to the change. Similarly, depending on whether the change takes the form of an impact or a component process of change, the nature of its visibility will differ and the methodological approaches to assess it will also differ in line with the choice of indicators of the change. Change detection is the process of identifying and establishing the magnitude, pattern and quantitative variation within a particular period in a given environment.

The existing statistical practice that emphasizes so much standardization of data-gathering procedures and listing of variables, often fails to capture rural level evidences of change, thus, the emergence of less statistical methods such as the Rapid Rural Appraisal (RRA) the use of GIS among others. Environmental change affects rural land use distribution, stability of ecosystem, local building resources and depletes the environmental resources thereby, bringing changes. Using this framework, this thesis

analysed the implications in the city's rural region such as rural land use conversion, abandoned resource sites and burrow pits, resource mines, increasing distance to resource sites and increasing urban land among others. It also analysed the background upon which these changes have taken place, detected the trend; identified the driving forces; evaluated the existing consequences of rapid expansion; examined the perception and the response strategies and assessed the policy implications.

2.7.1 Land Use Change

Land use refers to man's activity pattern on land. It refers to activities that are directly related to the land (Clawson and Stewart, 1965). The purposes for which lands are being used commonly influence the types of land cover, whether they are forest, agricultural, residential, or industrial. Land cover therefore, describes the vegetation and artificial constructions covering the land surface (Burley, 1961). Land use change is a general term for the changes in human activity pattern on the land surface usually with marked boundaries. This natural and human modification of earth's terrestrial surface has been increasingly driving changes in the ecosystem influencing environmental processes such as loss of rural land uses, vegetation and natural resources among others. The processes of monitoring land use for change detection requires technical skills, and the results are used to mediate the negative consequences of on-going land use changes, future land use transition and sustainable production of essential resources as well as enhance land management. Commenting on the physical condition of the study area, Ayuba (2008) observed that the land use within the study area is dominated by agricultural use, mainly arable crops (millet, guinea-corn and beans), grazing and cattle routes are preserved for the cattle and other domestic mammals. As an agriculturally dominated area where majority of the population directly earn their livelihood from natural resources, the environment and society tend to be closely linked, communal and individual ownership of land is predominant. Agricultural practices produce rain-fed crops that are determined by subsistent and market forces. Conversion of rural to urban land-uses reduces availability of farmlands, and this affects the traditional source of livelihood.

Identifying the causes of land-use change requires an understanding of how people make land-use decisions and how various factors interact in specific contexts to influence decision making on land use. Decision-making is influenced by factors at the local,

regional or global scale. Direct or proximate factors that cause land-use change constitute human activities or immediate actions that originate from intended land use and directly affect land cover (Ojima, Galvin, Turner, 1994).

Proximate causes generally operate at the local level (individual farms, households or communities). By contrast, underlying causes may originate from the regional (districts, provinces or country) or even global levels with complex interplays between levels of organization. Underlying causes are often exogenous to the local communities managing land and are thus, uncontrollable by these communities. Proximate causes demonstrate the natural capacity or predisposing conditions for land-use changes. The set of abiotic and biotic factors that determine this natural capacity vary among localities and regions. Trigger events, whether these are biophysical (drought or hurricane) or socioeconomic (war or economic crisis) also drive land-use changes. Changes are generally driven by a combination of factors that gradually work and factors that intermittently happen (Lambin, Turner, Agbola, Angelson, 2001).

2.7.2 Land Cover Change

Land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil and/or artificial structures. It is defined by the attributes of the earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human structures. Land cover change is a general term for the physical and biological changes of both natural and artificial features on the land surface with marked boundaries. Land cover change is of two types: (a) *Land cover conversions* (the complete replacement of one cover type by another). These are measured by a shift from one land-cover category to another, as is the case in agricultural expansion, deforestation, or change in urban extent. (b) *Land cover modifications* (the more subtle changes that affect the character of the land cover without changing its overall classification, which may be human or nature-induced, or a combination of both). Measurement of land cover change using remotely sensed time-series data reveals that land cover changes do not always occur in a uniform progressive and gradual way, but they may show periods of rapid and abrupt changes that may be followed either by a quick recovery of ecosystems or by a non-equilibrium trajectory. Short-term changes caused by the interaction of climatic and land-use factors exert adverse consequences on

ecosystem processes. In terms of comparison, land use is a more complicated term than land cover; natural scientists define the later in terms of syndrome of human activities such as agriculture, forestry and building construction that alter land surface processes including bio-diversity. Social scientists and land managers define land use more broadly to include the social and economic purposes for which land are managed or left unmanaged) such as subsistence versus commercial agriculture, rented versus owned, private versus public lands. While land cover changes can be observed directly in the field or by remote sensing, observations of land use generally require the integration of natural and social scientific methods (expert knowledge, interviews with land managers) to determine which human activities are occurring in different parts of the landscapes, even when land cover appears to be the same (Delchman; Balk; Yetman, 2001). It is estimated that one to two million hectares of cropland are being taken out of production every year in developing countries to meet the land demand for housing, industry, infrastructure, and recreation (Simon, 2008)

Since more and more rural land uses are being converted into urban areas and human settlements, quantifying the land use patterns and analyzing the changes over time are essential for monitoring the urbanization and environmental consequences to detect and predict the dynamic process of land use change and pattern at different times in any study area.

However, the traditional method of manually collecting and analyzing data to reveal the physical pattern of landscape changes and environmental consequences at physical and temporal scale had been time-consuming and labour-intensive. Nowadays, the use of remotely sensed images from airborne and satellite sensors now provide large amount of cost-effective, multi-spectral, and multi-temporal data to monitor alteration in landscape features and in the processes of estimating biophysical characteristics of land surfaces (Herold et al 2003; Tang et al, 2005; Jensen, 2007). In addition, it is equally important to look into the social, economic, and institutional backdrop against which the land use changes have taken place to make studies more relevant to their societies.

2.7.3 Bio-diversity Change

This describes the richness of animal and forest species existing in an area. However, when land is transformed, from a primary forest to farm, the loss of forest

species is immediate and complete in such deforested area. The habitat suitability of forest and other ecosystems surrounding those under intensive use are also impacted upon by the fragmentation of neighbouring habitats into smaller specie-units, which exposes forest edges to external influences and decreases core habitat area. Smaller habitat areas generally support fewer/smaller species and for species that require undisturbed core habitat, fragmentation can cause local disappearance and even general extinction.

2.7.4 Urban Expansion and the Emerging Implications on Rural Land uses

The implications of urban physical expansion that relate to rural land use changes included decline in rural land uses, loss of farmlands as the core means of livelihood among others. The dimension of these changes on bio-diversity is in the areas of decline in wildlife habitat and disappearance of indigenous plant and animal species as observed by the residents. Furthermore, literature review shows that the consequences on rural land uses and settlements is due to variation in efficiency of the rural institutional response to the consequences, the physical environmental conditions, poverty level and bad governance. While some rural land uses are severely affected by the forces of urban expansion, some are more severely affected by resource abstraction activities than urban physical expansion. Also, among the settlements susceptible to the consequences of urban expansion, there are settlements that are affected by loss of farmlands more than loss of tree cover land. Similarly, some settlements are directly affected by the forces of urban expansion more than the adverse activities of resource exploitation. Among the adverse effects exerted by resource merchants are noise, bad roads, ecological devastation and loss of farmlands.

Despite the widespread indicators of environmental changes and their felt impacts, it is difficult to measure and quantify precisely the degree of severity of the entire situation. This thesis employs the weighted-opinion assessment approach to analyse the decaying effect as the distance increases from the source; the nearer the distance the more severe is the critical level.

In many developing cities in Nigeria, the increasing pace of urbanization, the extent and severity of the consequences of city expansion such as fragmentation, modification and conversion of rural land uses and land cover are bound to increase in the adjoining rural areas (Adeboyejo and Abolade, 2007). This makes the study of the

consequences of urban physical expansion on rural land use, building materials and vegetation, relevant both for policy-making and implementation on rural land use conservation. Moreover, using local data to analyse and provide solution to local problems makes it less coarse for improvement of such areas than employing international data (Boyle, 2005).

2.8 Vegetation

Vegetation refers to the mass of plants growing in a particular place, covering the surface of the earth and keeping the top-soil in place to prevent erosion (Bellamy, 2007). Vegetation as the ground cover provided by assemblage of plants is regarded as the plant life of a region. It is a general term, without specific reference to particular taxa, life forms, structure, physical extent, or any other specific botanical or geographic characteristics. Perhaps, the closest synonym is plant, but *vegetation* can, and often does, refer to a wider range of physical scales than the term plant community does. Vegetation constitutes the most observable element of the landscape and also reflects environmental and climate conditions.

First, it is of great importance in promoting local and global energy balances and supports the critical flow of numerous biogeochemical cycles such as those of water, carbon, and nitrogen. Such cycles are important not only for global patterns of vegetation, but also for those of climate (onlinenigeria, 2010). Second, vegetation strongly affects soil characteristics such as soil volume, chemistry and texture with a feed back that affects vegetation characteristics, productivity and structure. Third, vegetation serves as wildlife habitat and the energy source for the vast array of animal species on the planet including human being that feed on these.

There is hardly any vegetation that has not been affected by human activities in the world. Farming, logging, grazing, hunting, urbanization and other development activities by the rapidly expanding population have together reduced natural vegetation cover to patches on the surface of the earth. In Nigeria, 400,000 hectares of vegetation cover is annually lost (Adesina *et al*, 1999). A large portion of this vegetation is usually removed to make way for mineral exploiting, development of infrastructure such as roads and railway, and expansion of settlements (Adesina, 2005). Also, many households and

restaurant in urban areas across the nation have continued to rely on fuel woods for cooking and domestic energy supply.

The loss of natural vegetation has great implications. Adesina (2005) listed some of the implications which include;

i. Destruction of wildlife habitat; (ii). Depreciation or outright wiping off of genetic species;

iii. Loss of food and medicinal herbs; (iv). Promotion of desertification and drought, and (v) Building up of Green House Gasses. In the study area, much of the vegetation is consumed through grazing, civil construction and generation of local energy.

The entire study area is located in the Sudan savannah vegetation zone, with mean annual rainfall of 750mm, which influences the sparse vegetation. Vegetation cover in the northern part of the study area is generally scanty, during dry seasons, the ground surface is bare sandy and dusty. This climatic condition is not capable to support large and tall trees. According to Gambo (2008), the largest trees are usually thorny acacias, especially Acacia *tortilis* and *Commiphora Africana*.

The Southern part of the study area is a belt dominated by species of the family *combratacae*, hence it is known as mixed combrateceous woodland within and around most settlements in the southern parts of the study area *Azadiracthta indica* (Neem tree) is the most common trees, which is typical of Sudan savannah vegetation. In most parts of the study area, the form of vegetation is largely a reflection of the impact of man and his livestock. It is very difficult to obtain climax vegetation in the region. Two main vegetation belts are observed in the study area. The first is the patch lands, which are areas of long standing cultivation with only re-grown few shrubs, and scanty mature economic trees. The second is the tree and shrub savannah, which results from shifting cultivation and less grazing. These constitute rural vegetation belts in the study area. The fertility of the soil appears to be higher in the southern local governments of the state. The common farming system in practice here is the type in which crops are rotated on farm fields around settlement. The limiting factor to crop farming is rainfall, because it only lasts from June to September, and this permits only one cropping season. Other human activities such as cultivation, construction, fuel wood exploitation and grazing contribute to deforestation in the study area.

2.8.2 Measurement of Forest

Measuring forests is difficult because of the dynamism of vegetation. Consequently, ecologists often measure its surrogate, plant *cover*, which is defined as the percentage of the ground surface area that has plant biomass (especially foliage) vertically above it. If the vertical distribution of the foliage is broken into defined height layers, estimate can be made for each layer, and the total cover value can therefore be expressed in per cent. In other words, the values range from zero to 100. The measure is designed to be a rough, but useful, approximation of biomass (Onlinenigeria, 2002).

Assessing the rate of its exploitation in the study area, Archibong (2007) concluded that a huge industry has evolved around the fuel-wood trade. Day and night, huge trucks and other antique vehicles over-loaded with fire-wood ply Borno State. This experience is also common in the neighbouring states, namely, Bauchi, Gombe and Yobe. Archibong (2007) also added that, aside woodcutters, a chain of haulage/transportation operators, distributors, hawkers and petty traders now make a living of this trade through forest depletion.

2.8.3 Vegetation-related Changes and Consequences

The vegetation-related consequences of urban expansion comprise felling of live trees, disappearance of some indigenous herbal plants, unsuitable habitat for animal species, exposure of the soil to erosive forces and desertification, which impose adverse effects on the hydrological cycle. Rapid depletion of trees results in increased distance and time in collecting the same quantity of fire-wood, and this leads to increase in cost per man-powered truck. Consequently, the use of charcoal is gradually becoming another source of cooking energy in the study area. The merchants in bid to maintain their daily supply started hauling of live-trees, which implies reduction in tree cover and specie-composition. Interview of the household heads shows that there have been cases of villagers and government's Forest Officers resisting the practice of felling live-trees for fuel wood by the sellers.

2.8.4 Changes and Consequences on Local Building Resources

In assessing the effects of human intervention in environmental resource change, Briggs and Mwafupe (1999) observe that a society's inability to live within the usable

limits of the biophysical resource base of its habitat is the major cause of environmental degradation. The increase in population and resource-demand has brought a significant draw-down on the ecological stock of the region. It is an accepted norm that behaviour is a function of the interaction of organism and the environment, where the socio-economic well-being of the people is not improved upon; their desperate effort to glean natural resources will further impoverish the environment. Men, like animals and plants draw on their environment for sustenance and may be impoverished or enriched by it.

It is in this view that Mateo (2003); Simon (2005); Herold (2003) posit that research on rural land use planning is often undertaken to promote rural economic development, reduce poverty and social inequalities, with little or no consideration for rural resource protection and management. Although, the work of Rees (1992) on Ecological Footprint (EF) focuses on the depletion of global resources, it is area-based and it aims at quantifying global resource depletion to reveal whether, and by how much, human being is over-taxing natural resources. As the work explains, if the ecological footprint of the residents within a region exceeds its bio-capacity, the region is said to be in ecological deficit. This thesis submits that not much analytical work has been done to ascertain the environmental consequences of ecological footprints of cities in the savannah belt on their suburbs. It therefore, aims at analyzing the urban expansion and the implications on rural land uses and natural resource use. This study draws on 24 settlements in the study area, where it collects empirically verifiable data on the implications of urban spatial expansion of Damaturu on its sensitive rural ecological setting. Thus, this study did not only focus on the population-concentration advantages of the urban dwellers, but also include the assessment of resources necessary to sustain the existing and future population and development within and around Damaturu.

In assessing the natural building materials, this section defines natural building material as any substance that can be used for construction purpose. Many naturally occurring substances such as clay, soil, sand, gravel, wood and rocks, even twigs and leaves have been used to construct buildings. They provide the make-up of habitat and structures including homes (Wikipedia, Free encyclopedia, 2007). Building materials can be generally categorized into natural and synthetic. Natural building materials are those that are unprocessed or minimally processed by industries such as lumber or grass. In

almost all localities, nature has provided some natural materials with which to build. The advantages of these materials is that they require little processing and short-distance transporting; their environmental and economic costs are lower as compared to manufactured products, which makes cheaper their production, transportation costs and pollution (World Resource Institute, 1982) . They offer the opportunity to construct a home with renewable resources (like trees and straw), and some may be so abundant that their supply may seem inexhaustible (like rocks and sand). The beauty of building with local materials is that they naturally seem to fit well with the feeling of the place. Many of these materials require little construction knowledge to build; they are also inexpensive and energy-efficient. The resources can be harvested, and processed in a customized fashion for specific needs (Molly, 2010).

It can be inferred from the foregoing discussion that, a culture that relies on its raw materials to provide shelter and other necessities of life has a large stake in protecting those resources and will likely develop effective harvesting methods that will ensure long-term sustainability. However, the urban-residents outside these communities are not usually mindful of sustainable reaping methods. Thus, the harvest of natural building materials becomes unsustainable when the rate of harvest exceeds the annual yielding capacity. Similarly, urban expansion becomes uncontrollable when the growth of urban populations and the resultant expansion is occurring at a faster rate than the capacity to plan, build and manage formal urban construction demand (Molly, 2010). This means natural building materials are being overtaxed, as the majority of the new housing stock in the study area is being informally built with largely local building materials. Although, informal settlements are often built with substandard materials and without sufficient infrastructure to meet the standards for the health, safety and sanitation of its residents, they satisfy the huge demand for low-income housing units, a market often neglected by the formal housing sector.

Architectural evidences in the building industry show that, the use of locally harvested and manufactured materials have long been in existence, and people of low income status have used if to build their houses. Similarly, public buildings are largely built from materials available in their local environment. For example, in the heavily forested northern part of the U.S., they use wood frame homes, in the southwest, they use

adobe bricks for building adobe flats. In parts of mountainous Peru, stone houses are predominant, and in areas of tropical Southeast Asia, traditional native housing has been built largely of local woods, grasses, and bamboo (Hopkins, 2010). In the study area, building materials such as clay, staves, sand are being used. The development of local building materials can be encouraged and local building regulations could be applied to suit local affordability levels to permit the use of local building materials for construction of houses.

This has become necessary because, conventional building materials are tied to international market forces which often render housing unaffordable to low-income groups and are climatically inappropriate in hot arid regions such as Damaturu. The unsustainable use of available local building materials such as sand, clay, stone, rocks, gravel, trees, brushes, thatch to mention but a few, for construction has an adverse implication on the vegetation and environmental quality around the city. Heimlich and Anderson (2001) rightly observed that some of the worst sites of ecological distress are found around cities. Degraded environment often affect the quality of life of the people who depend on the resources. It also directly affects the biogeochemical cycle (Asthana and Asthana, 2005). This thesis submits that man and the ecological resources are inter-dependent and man must sustain the relationship to reap the dividends of inter-dependence.

A broader survey of the use-pattern of natural resources in Damaturu shows that the environment is being degraded, because the urban resource-demand has exceeded the bio-capacity, and its urban population cannot live within the useable limits of the biophysical resource-base of the habitat. Therefore, population, low technology and unsustainable consumption habit are the major causes of resource depletion and environmental degradation around Damaturu, where the intensity of exploitation is fast exceeding the yielding capacity of the building resources. The area has some arid characteristics (environmental fragility, resource marginality, vulnerability to irreversibility and to damage, low resource carrying capacity), which population and demand pressure tend to ignore. In addition, marginal income-earners that are usually prone to neglect by decision-makers tend to over-exploit these natural resources through self-sustaining activities that fragment or destroy existing ecological niches. However, even in semi-arid zones; if

harvest activities adapt to ecological and environmental conditions of the semi-arid area, they may not be harmful and destructive to environmental/resource condition.

Reconnaissance survey in resource sites shows that it is the mismatch between the ecological resources and the insensitiveness of the human activities to the critical importance of the marginality of the resource-base that leads to environmental degradation. Technical efficiency is required especially in this fragile resource ecosystem where the environmental resource productivity and resilience are far lower than those in more ecologically stable zones of high productivity. The natural resource merchants in the region are covering longer distances to harvest same quantities, which implies decline in quantity. Also, abandonment of resource sites points to decrease in the rural resources. Components of the processes of resource regeneration or re-growth that interlink the diverse systemic environmental resources such as replanting and conservation were minimally reported, but cases of erosion, bad roads, over-exploitation that inform resistances from communities were reported.

2.8.5 Urban Physical Expansion and implications on the Surrounding rural land Use

Urban physical expansion has created many issues in ecological environments, while its ever-expanding population has brought a range of problems to both the surrounding natural and built environments. For example, the natural environment suffers as more space is required for the construction of houses and the development of infrastructures and amenities. As more ecosystems are disrupted and wild habitats are destroyed, urban growth reduces (either through depletion or relocation) the biodiversity of areas surrounding the cities. The problems of pollution and sewage disposal are also made worse by increase in population size. The consequences include; rural land use depletion, decrease in farm, forest lands and source of livelihood, increased food insecurity and famine. Destruction of natural resources that engender environmental degradation and resource conflicts between communities and states. It also affects ecological function and related geophysical cycles such as hydrological, rock and carbon, among others. These translate to socio-economic stress of varying scales.

2.9 The Consequence of Rapidly Depleting the Natural Resources

The role of natural resource variables in the expansion of urban areas and the rural societal welfare is very significant and needs to be considered in the discourse of their development. The world has a limited supply of productive land for growing food and timber, limited supplies of fish, finite quantities of oil, gas, metals and other non-renewable resources, and a limited capacity to absorb waste. If we overload the earth's capacity, or use up resources faster than they can replenish themselves, then the natural systems that support life on earth will break down. Moreover, scientists tell us that we share the planet with over ten million other species upon which our survival ultimately depends. Therefore, it is not possible to use the entire bio-productive ecological space of the planet solely for human consumption. It is doubtful that the human species itself could survive if it used all productive resources for its own needs at the expense of all other species. Conservative biologists recommend a minimum set aside of 30% for biodiversity preservation, so the 12% set-aside is politically deemed feasible based on international agreement (WCED, 1987). This will only ensure minimal ecological security projected by many scientists. The actual biodiversity preservation required for self-preservation of the human species and to slow the current rate of species extinction will likely require greater land protection.

Researchers at the University of British Columbia having set aside the 12% for biodiversity as recommended by the Brundtland Commission, further divided the remaining 88% only to find that our current global resource consumption and waste production requires 2.8 global hectares per person. This represents the average ecological footprint of a human being on the planet earth as at 2000, which has been gradually decreasing as population continues to increase. In other words, human beings are in a state of overshoot, depleting resources faster than they can regenerate and producing more waste than the earth can sequestrate.

Just like the present generation is paying for over-spending of the 1970s and 1980s with higher tuition and reduced government services; the future generations will soon inherit the ecological debt of current ecological overshoot. We have already begun to see its effects in the collapse of Atlantic ground-fish stocks, global warming, higher child asthma rates, and new environmental illnesses. According to Global Footprint Network

(2011), all ecological footprints are not the same size. 30% of the world's population consumes 70% of the world's resources, and produces 70% of the world's waste. The average African ecological footprint is just 1.3 ha. per person, and the average North American footprint is 11.8 ha per person. The richest one-fifth of the world's population consumes 45% of all meat and fish, 58% of all energy and 84% of all paper, and owns 87% of all cars. The poorest one-fifth consumes just 5% of all meat and fish, less than 4% of energy, 1.1% of paper, and less than 1% of all cars. Ecological footprint is considered as one of the Indices of sustainable development because it assesses whether current production and consumption patterns can be sustained over time without depleting our wealth (our natural, social and produced capital) and without denying a decent standard of living to our children and to others in the world. By this, it has proven to be one of the best measurement indicators of the 21st century because it:

i) assesses the demand side of the sustainable development equation as well as the supply side and places the onus for sustainability on the consumer as well as on the producer.
ii) challenges fundamentally the economic growth paradigm and the assumption that "more" is necessarily "better." In ecological footprint analysis, a smaller footprint is a sign of sustainable resource-use.
iii) links environmental sustainability clearly and directly with social justice and equity.
iv) links local consumption patterns with global consequences.

To promote the usability of ecological footprint, Bicknell, Ball, Cullen, Bigsby, (1998); Feng (2002), Lenzen, Murray (2001, 2003), McDonald, Patterson (2004) interpret the ecological footprint concept as an indicator concept and not as a tool for environmental policy analysis itself. Feng (2007) incorporates this indicator concept in a general equilibrium model for environmental policy analysis in order to quantify the impacts of policies that reduce the Energy (Carbon) Footprint.

2.10 Land Use Planning for Development Control and Environmental Management

The patterns of land uses naturally arise through cultural or customary practices, but the cultural norms are not sufficient to regulate modern large scale land use. Thus, it

becomes necessary that land use will also be formally regulated through zoning, and planning permission. Land use is the dominant human activity that expresses itself on or is assigned to particular parcels of land. It refers to deliberate apportionment of the best land use option or approval of uses that are to legally operate on zoned parcels of land to meet economic and social needs of the people while safeguarding future resources. It is a public policy exercise that designates and regulates the use of land in order to improve a community's physical, economic, social efficiency and well-being. It helps to identify the preferred land use that will support local development goals through the evaluation of socio-economic trends, physical and geographical features (such as topography and ecology). The final outcome is allocation and zoning of land for specific uses, regulation of the intensity of use, and formulation of legal and administrative instruments that support the plan (The World Bank 2010). Through this, land use development in urban growth is put under control.

A land use plan may be prepared for an urban area, a rural area, or a region encompassing both urban and rural areas. Such zoned uses are usually backed by laws and are implemented within the purview of such laws. Land use zoning and development influence the stability of land cover, ecology and ecosystem. Land use and land management practices also exert significant effects on natural resources including water, soil, nutrients, plants and animals. In the planning process, natural resource conservation and cultural imperatives will find reflection in land use zoning. Thus, the relevance of land uses planning to ecological preservation studies.

According to FOA Report (1998), land degradation has been exacerbated where there has been inefficient or absence of land use planning. This emphasizes the need for integrating land use planning and management to control urban expansion to ensure a long-term quality of land for human use, prevent the social conflicts related to land use and promote conservation of high bio-diversity value.

2.11 Distance Decay Effect of the Consequences of Urban Physical Expansion

Distance Decay Effect is a geographical concept that emanated from Tubler's (1970) idea that 'everything is related to everything but near things are more related to each other'. It states that, there is loss of effect on cultural or physical interactions; or between any two or more observations, as the distance between them increases. That is, as

two factors interact in a locale, the intensity of the effect decays as the distance between them increases. Distance decay is the lessening in force of a phenomenon or interaction with increasing distance from the location of maximum intensity. Therefore, distance and intensity of effect are inversely related. The essence of employing this concept is to (i) understand how similarity changes with distance in biological communities and (ii) use it as a quantitative technique to explore and describe the lessening consequences or severity as distance increases away from the source of the study area.

In his neutral theory, Hubbel (2000) proposed that distance decay effect is slower if the meta-cities are linked by high rates of dispersal. Neutral theory predicts that distance decay vary among different community-types. In the same vein, Nekola and White (1999) explored how distance decay effect varies regionally and by species composition.

The concept is graphically represented by a curving line that swoops concavely downward as distance along the x-axis increases. The steepness of these curves is a function of resource extraction/urban physical expansion activities. It is mathematically represented by the expression $I=1/d^2$ where I= interaction, d= distance (Condit, Pitman, Leigh, Chave, Terborgh, Foster, Núñez, Aguilar, Valencia, Villa, Muller-Landau, Losos, and Hubbell, 2002). The concept is employed in this thesis to show the variation of the negative effect of physical urban expansion of Damaturu, as it relates to resource exploitation and rural land use as distance increases.

2.12 The Perception of the urban physical expansion, the implications and Coping Strategies

Human activities such as diverting rivers, clearing forests, and depletion of natural resources to interruptions of natural chemical flows of the biosphere and introducing new synthetic substances have always changed the physical environment, but the scale and rate of impact vary from one activity to another, Such changes have threatened to damage valued environments, deplete essential resources, agriculture and other socio-economic activities where they concentrate. The awareness and perception of the severity of these sorts of problems to both environmental degradation and associated socio-economic deterioration often influence response practices.

It is revealed in the foregoing discussion, that some of the second- or third-order changes in the status of environmental resources are manifestations of impacts of people's

adjustment to environmental changes. Thus, it is difficult to separate the socio-economic impacts resulting from environmental changes and those resulting from the forces underlying environmental change because socio-economic impacts are products of overall transformation processes, which involve both the environmental variables and the factors affecting them. Hence, the study analyses the physical and socioeconomic implications of the transformation process using environmental indicators. First, the transformation processes have disrupted the overall production base and inter-linkages of land-based activities, which evolved through adaptations to specific conditions of semi-arid habitat. Infeasibility of several traditional production and resource-management practices due to environmental changes may be treated as manifestations of socio-economic vulnerabilities in the changed status and productivity of environmental resources as important indicators.

The second impact of transformation processes via environmental changes relates to the diversity of studied resources, which revealed the impacts and related socio-economic vulnerabilities according to the resource type and endowments of resources and people within a given area. The transformation process created are indicated by (a) rapidly commercializing areas, and (b) stagnant areas still dominated by subsistence agriculture that transacts at unequal terms of exchange. The former, which include the physically and economically better-endowed areas that benefit from the development interventions do better despite the marginalization of traditional farming systems.

Third, the environmental awareness and responses to transformation processes, usually negative changes, differ greatly between the micro (community settlements) and macro (policy, planning) levels. This difference is a product of the variations in perception, time-horizon, capabilities, and mechanisms of information collection and communication. Another important factor that differentiates farmers and policy makers is the degree of closeness to the phenomenon of change and their stakes in its consequences. Accordingly, a farmer whose survival strategy is closely linked to the environmental resource would exhibit perspectives markedly different from those of the chief of the environment department in the government, whose professional concerns for the environment may not converge with personal priorities. In keeping with such differences, the type of response and the time-lag between awareness and response would also differ. This section examines awareness and response issues separately for the two groups (i.e.

farmers and policy makers) and summarizes the major issues in terms of identification of environmental concern, expression of awareness and concern to signals of environmental change, and timely response (coping) mechanisms.

2.12.1 The perception of environmental change and response (coping) strategies

Discussions of environmental change often express particular concern with irreversible change. The definition of particular environmental changes as problems often rests less upon the magnitude than on the value-judgment and acceleration of change. In particular, the judged relationship between relative rates of environmental change and the estimated time needed for society to respond through prevention, adaptation, or adjustment has gained recognition as an important variable. Not only does this possibility have far-reaching implications for the establishment of knowledge bases and assessment methodologies, it also suggests that human institutions and management strategies that assume linear change will face intrinsic difficulties in anticipating and interpreting environmental change. This is because environmental change and its consequence embody assessments of losses and harm arising from alterations in nature-society relationships, which cannot be restricted to disruptions in productive systems or economic loss but involve broader effects on human values about nature. Societal capacities to respond and subjective human perception and interpretation of emerging changes concentrated in space and time are important in regional context as these influence the promptness and effectiveness of the response systems. Thus, the ecologic-symbolic approach of Kroll-Smith and Couch (1990) conceptualizes change in terms of upset in society-environment relationships.

2.12.2 Awareness and response systems of farmers/village community

Community farmers and natural resource reapers who do not have technical knowledge to detect environmental changes, indicate awareness of the consequences of their actions, when they are faced with the fast disappearance of production options that sustainably supplied them in the past. The reality of emerging environmental change is felt when there are negative changes at the resource base and production performance as well as changes in the quality and quantity of inputs and products harnessed from crops and non-crop lands. When this happens, people adapt diverse responses to such changes.

The method employed to assess people's awareness and perception of environmental change was to assess their responses to change such as alterations in their resource-use practices through the Weighted Opinion Assessment (WOA) method. Unlike at the policy level, the time-lag between environmental awareness and response at the community level is often short and sometimes imperceptible. At the settlement level, one can easily notice differences between rich and poor farmers with reference to most of the response mechanisms. Whereas the rich may adopt high-payoff options to withstand environmental change, the poor have to live with the marginalization of traditional mechanisms and attempt through over-extraction of environmental resources to retain their means of livelihood or relocate their farmlands and or residences.

2.12.3 Awareness/response at the policy-making level

First, some features of awareness and response to environmental changes are immediate by the rural respondents, routine discourses on periodic environmental crises foster awareness to the policy makers. Second, for the reasons of awareness fostered through periodic crises, awareness of environmental change and responses to at macro levels are quite different from those at the settlements levels. For example, the community level user-group initiatives reflect the "awareness/ response" situation. These may be initiated as development activities but have strong environmental contents (Fisher, 1991). Region-based studies that manually collect local data and remotely sensed data present environmental changes in more concrete terms.

When there is awareness, rural responses may be in form of projects to treat specific environmental resources, to mobilize resources or induce villagers to practice resource conservation. Analysis of awareness/response in the study area reveals the followings:

First, it shows low awareness and education on environmental change and severity of the consequences. There is scarce documentation and discussion of various aspects of environmental change in Damaturu. Thus, there are no local and international inducements to support research initiatives that will help to proffer strategies for nature conservation to community forestry programmes in different settlements of the study area.

Second, despite the awareness of the marginality of resources available in the semi-arid zone and the growing environmental degradation, resource miners still over-tax

the natural resources for lack of feasible substitutes. This involves both intensification of resource use and acceleration of resource extraction with environmental degradation as a side-effect.

Third, owing to its scarce resources, land-locked situation with stagnant and underdeveloped economy, the residents emphasize activities that can help generate maximum current revenue such as overexploitation of fuel-wood, building resources, which may have adverse environmental effects. Thus, despite the awareness of environmental change, it is practically difficult to formulate appropriate policy responses that will curb resource over-exploitation.

Fourth, most of the environmental protection and conservation initiatives are not only confined to the urban boundaries, they also lack concern for the rural well-being. Most of the initiatives neglect the totality of the rural situation, including balancing conservation and production needs. This results in the poor response of rural communities to such programmes as ceremonial annual tree-planting campaign (Fisher, 1991).

Fifth, as a characteristic, sustainability attempts to handle environmental issues largely from the supply side, without effectively controlling the demand-side variables. This is particularly true of the basic driving forces that put increasingly higher pressure on natural resources with growing environmental degradation. Lastly, the capacity to respond to changes or to generate and use new opportunities is lacking. The development of human skills is limited and the institutional frameworks to strengthen these skills are scarce. This is also responsible for the limited substitutable technology.

2.12.4 Response (coping) systems

Environmental changes, as explained are interactive phenomena that can be assessed by examination of the contributing factors (driving forces) at work in a particular landscape and culture. These factors include natural variability, human-induced stresses, the sensitivity and resilience of the ecosystem, the vulnerability of the population, the goals and capacities of response and management systems among others. These societal response systems are embedded in political economies and cultures. In many developing countries, unabated and conscious exploitation and extraction of resources has continued despite empirical warnings and emerging signals. Similarly, in the study area, environmental degradation is being driven by state policy that emphasizes a willingness to

exploit nature's assets for short-term gain or focus on intensive political resource-use than other societal priorities.

Analysis of response systems will certainly assess political relations that characterize decision-making structures at various levels to address the adequacy of various knowledge systems on how alerting occurs, what catalysts for action occur, how problems and data are constructed, how interventions and management strategies evolve, and how social learning occurs (Glantz 1988; Lindblom and Cohen 1979; Ravetz 1986). Therefore, the degree to which emerging environmental degradation deepens depends on the resources and societal capabilities that can be brought to bear on the political will and response to ameliorate the emerging changes.

A key consideration will be the comparison between trajectories of growing environmental damage and changing societal capability to intervene, mitigate and alter the basic regional trend to environmental damage; a situation in which growing environmental degradation eventually surpasses society's ability to substitute productive systems or to intervene to mitigate the damage. Failure to bring the trend under control results in a situation where environmental degradation eventually surpasses the societal capability. At this point, international rescue efforts may be necessary to avert an environmental disaster. Since time is a key ingredient in the mobilization of society's latent response resources, the rates of environmental change and the rates at which resources can be mobilized are important aspects of trajectories of regional change.

The consequence of neglect and time lags in societal response deserve detailed attention in the analysis of regional dynamics of change, because the regional journey to environmental criticality will not occur without warnings. As environmental degradation proceeds, various events and indicators of change will prefigure the movement to greater damage and greater future risk. Such events and indicators signal to the society and various managers of impending damage. How such warning systems work, how they connect to management systems, and how and why appropriate responses do or do not occur are questions fundamental to understanding trajectories of change and diagnosing the outcomes that emerge along the trajectories.

In the same vein, the nature of societal responses in the face of emerging trajectories of environmental change requires careful attention as an element of the

dynamics. One key aspect of this analysis is the differential responses at various levels of managerial loci. Such assessments are characterized by the types, number, and effectiveness of responses undertaken at these various levels as well as the options; the constraints under which they operate are viable and comprehensive enough to address the complexity of factors influencing the changes and the range of societal response that occurs.

2.12.5 Regions and the Regional Response Approaches

In practice, environmental problems are not distributed uniformly across the earth and peculiar adverse environmental situations are often concentrated in regions (a continuous portion of the earth's surface, characterized by a rough match between a distinct physical environment and a system or set of systems of human use). Admittedly, the region-based studies offer advantages for the study of severe environmental changes. The substantial variation in environmental setting, process, impact, and inability to respond across the earth's surface makes a meaningful global aggregate assessment problematic on one hand and on the other hand, findings derived from local or micro-scale studies may thwart generalization because of their peculiarity.

2.12.6 Promotion of self-help responses to environmental crises

The need to promote local self-help responses as coping strategy cannot be under estimated in a fragile environment like that of Damaturu. This communal and local self-help groups and other similar groups of traditional origin that include the vulnerable women, children and youth often take responsibility for development and conservation efforts in rural communities. Their functions usually include rural land conservation, reforestation (tree groups), on the farm tree-planting for ecological survival, rural land use and resource conservation activities. Through such groups, the women groups often help the feminine gender to gain access to shared resources that were once beyond their reach. By policy, these groups should not only be promoted but also linked to planning and policy decisions at the local, states and national levels.

2.13 Implications of the Environmental change for related Policy and Legislation

Rational policy formulation involves making appropriate public decisions which maximize social welfare within the context of scarce social and natural resources. Olokesusi (2006) defines policy as a broad guiding decision applied to a class of decisions expected to ensure that certain decisions of the institution, country or sector adhere as closely as possible to its objectives. According to Osoko cited in Agbola (2006) environmental law is a system of rules of social control aimed at achieving certain goals relating to the environment and the universe, and securing obedience to them to create order out of chaos.

In Nigeria, there are no policies that integrate rural and urban planning, however, there are a number of policies that underpin urban land management that have been articulated and implemented. These include the Land use Act of 1978, Urban Development Policy of 1992, Urban and Regional Planning Act 1992 as well as the Housing and Urban Development Policy of 2002 among others.

In rapidly urbanizing cities such as Damaturu, rural land absorption and natural resource depletion individually and collectively are the ever-growing challenges to regional and urban planners. In such areas, traditional planning issues of governance, funding, rapid growth (geographic and population), increasing need for support infrastructure (transportation, water, sanitation), expanding social services, pollution among others) exacerbate the need to fully manage the direct and indirect impacts of environmental changes and ecosystem loss in the planning process.

Two issues not overlooked in national, regional and urban planning activities but not yet considered to the extent of their impacts, particularly in regional and rural urban planning are (1) the rapid expansion of urban centers into their "fringe zones" (peri-urban, peri-agricultural, agricultural and undeveloped land) and (2) the impact of urbanization on ecosystem sustainability. Both issues are of critical and increasing importance to sustainable urban development, however, they are poorly understood by fringe-zone residents due to the complex constituent parts, poor delineation in terms of its geographic boundaries, and under-valued in terms of monetary and non-monetary benefits. All of these issues result in the "benign neglect" of ecosystems in urban planning, but they have increasing importance, particularly to sustainable urban planning and development.

Consequently, the loss of agricultural and other undeveloped lands, unauthorized urban development and natural resource depletion; environmental degradation and alteration are significant to ecosystems as well as the city surrounding regions.

The transformation of the urban fringe zones to urban use is potentially the most serious aspect of the rural-urban transformation and the resulting impacts are, in many cases, irreversible as well as have broad complex linkages throughout the urban environment, but are at present largely unrecognized in ecological studies.

Consequently, the Nigerian environmental policy has taken the form of laws, legislations and regulations and may be defined as a set of rules and programmes addressed specifically to activities that have the potentials of affecting the quality of the environment. Therefore, environmental policy should contain some derivatives for management of the natural resources, agriculture, rural land uses, biodiversity among others. Appropriate legislation binds policies and standards, provide the base for substantive and procedural regulations and create institutions to implement the policies and enforce rules such that environmental regulations and administration enforce each other. In this context, policies combine planning and control function for a particular sector, institution or body.

Environmental policies are associated with a high degree of uncertainty and conflicting interest. Mankind has been inundated with warnings on the imminent calamities that would occur if no mitigating measures to secure the environment or reduce practices that threaten the stable and healthy state of the environment are taken. However, persistent environmental impoverishment reveals that no matter the standards of policy frameworks, governmental policy interventions to protect the environment and technological sophistication or scientific services they cannot effectively protect the environment without calling in the legal system to sustain them. Moreover, the theory and practice of environmental management are associated with the problem of control measures, enforcement mechanism and application of legal provision relating to environmental laws.

It is in this view that environmental laws seek to protect the welfare of ecological organisms and enforce their adequate health and proportional balance. Nigeria is confronted by an array of environmental challenges, which environmental laws have not

been able to comprehensively and effectively address. Thus, Okorodudu-Fubara (1998) stressed that the language of the policy goals merits close study and analysis from a legal perspective. She further elaborated that the goal of national policy on environment is to achieve sustainable development in Nigeria. The 1984 Koko toxic waste dump instigated the adoption of a national policy on environment and the enactment by the Federal Military Government of the two basic environmental protection statutes (i) the harmful waste (special criminal provision etc) Decree No 42 of 1988 and (ii) the Federal environmental protection agency Decree No 58 of 1988. The Federal Environmental Protection Decree No 58 1988 was the statutory threshold of a national policy on environmental protection in Nigeria.

Prior to the 1988, the legal administrative measures only covered protective and preventive measures relating to environment and public health; these land administrative measures on environment were designed to simply preserve the utility of the nation's air, land and water, and were not promulgated essentially as comprehensive environmental protection laws. The national environmental policy thrusts are to: (i) secure for all Nigerians a quality of environment adequate for their health and well-being, (ii) conserve and use the environment and natural resources for the benefit of present and future generations (iii) restore, maintain and enhance the ecosystems, and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainability yield in the use of natural resources and ecosystems, (iv) raise public awareness and promote understanding of essential linkages between environment and development, to encourage individual and community participation in environmental improvement effort, (v) co-operate in good faith with other countries, international organizations/agencies to achieve optimal use of trans-boundary natural resources and effective prevention or abatement of trans-boundary environmental pollution.

Leniency in enforcement of environmental policies and laws especially in the study area is due to overriding concern for the quantitative aspects of human requirement of more food, more water, more energy and more extraction of environmental resources as opposed to qualitative aspects. This has been a common phenomenon in the developing era of many towns. In their pre-development era, many urban centres relied on established

social norms for management of their environment, which in the wake of their urbanization; such social norms are insufficient to meet the avalanche of urban space-need, environmental use and resource control. Large scale physical, socio-economic and infrastructural establishments increasingly call for substantive policies and measures of protection against environmental impoverishment that often undermine the well-being of the rural and sometimes urban inhabitants.

There is policy-lag in addressing most environmental problems that exert impacts outside the city boundaries, but which are caused by city-based demands for resources and or wastes from city households, businesses, enterprises and industries. The city-based institutions draw on natural resources and services, increasingly inhabit rural open spaces and use same in environmentally damaging way as sinks around the city. The powers that do these are generally greater than that of rural inhabitants or local authorities where the impacts of these are most felt. Pathetically, there are no policy instruments to restrain or compel urban-based authorities to adequately manage the environment around such activity areas to ensure the welfare of the rural residents. The urban municipalities capitalize over this gap in the policy linkage between municipal policy and national or state level on one hand and municipal and rural/regional settings on the other hand, to demonstrate an ostrich disposition to rural impoverishment despite their high consumption of the natural resources and use of the rural environment.

In summary, literature review has established that there has been fast growth of urban population in the study area. Similarly, the urban physical expansion of Damaturu is rapidly increasing with myriad of implications on the rural land uses and natural resources as exemplified by rapidly diminishing rural land uses and natural resources. If these changes are left unmanaged, the environment will continue to deteriorate. This thesis submits that analysis of urban expansion, its characteristic form, driving forces and consequences will enable the formulation of appropriate mitigating or coping strategies for the negative implications. This will facilitate achievement of the Millennium Development Goal (MDG) of long-term environmental sustainability.

Literature evidence also shows that, rapid urban expansion affects the future rural and urban development and management if there is no proper policy control to regulate the rural land use changes and resource exploitation. Damaturu and its environmental

resources are located in a harsh climatic zone with low rainfall and low resilient ecosystem that is highly vulnerable to negative implications of rapid urban expansion. Thus, the findings of this investigation help to mitigate the potential consequence, ease urban and rural policy formulation, promote orderly development of settlements within the regions of the city and enhance rural resource and environmental management.

2.14 Theoretical /conceptual framework

This section review and identifies the suitable theoretical framework and discusses some relevant concepts that anchor, guide and also make significant explanatory contributions to the contextual understanding of the scope, functions and implications of urban physical expansion on the rural land use and resources that sustain life on this planet. Through the review of theoretical, conceptual and empirical literature, it made reference to theories, methodologies and data-based findings of previous works carried out on urban physical expansion, its forces, implications and perceptions of the natives; it established the existing gap and positioned this investigation.

2.15 Theory of the Carrying Capacity

2.15.1 Origin of the Carrying Capacity Theory

The origin of the carrying capacity theory is uncertain to researchers. One source opined that it emerged from the context of international shipping in relation to the disparity introduced into tariff laws during the advent of steamboat (Tiffen, Mortimore, Gichuki, 1994). However, Karl (1994) asserts that the theory was first established in laboratory experiments with cultured micro-organisms during the nineteenth century, but he provides no scholarly support for the claim. Another source finds the first use of the term in the 1845 report by the U.S. Secretary of State to the Senate. The Secretary reported that the previous duty (sixty cents per ton on sailing vessels, thirty cents on steamboats) had been imposed according to registered tonnage, whereas the new law would be applied to steamboats according to their carrying capacity only (Sayre, 2008).

Another school of thought states that the theory was first advanced in ecology and was extended to livestock and human population, whichever is the source, it is increasingly used in terms of the optimum number of space users, facilities and resources.

Carrying capacity was employed by neo-Malthusians to predict the pending catastrophic food crisis; affirming that there is a limit to the number of human-beings that the earth can support. From the last decade of the twentieth century, it has been applied to natural resource management in relation to the resource available, population-specie, consumption habits overtime and prevailing regulating factors.

2.15.2 Definitions and Application of the Carrying Capacity

Carrying capacity theory has been variously defined with varying professional emphasis. Biologists define carrying capacity as the maximum population of a given species that can survive indefinitely in a given environment (Odum, 1989). This applies to population-environment such as number of sheep, deer and cattle that can be maintained on a grazing land without degrading the land so that it could no longer support the animals. Cairns (2004) observes that people are in the habit of over-exploiting anything that is free in order to maximize individual advantage, which entails a cost to the society as a whole. In line with this observation, Cairns (2004) defines carrying capacity to mean the number of any organisms that can live sustainably in a particular environment without destroying its resources. Rees and Wackermangel (2006) define carrying capacity as the maximum rates of resource-harvest and waste generation (the maximum load) that can be indefinitely sustained without progressively impairing the productivity and functional integrity of the ecosystems, wherever they are located on the earth. This implies that sustainability of urban areas should be viewed not only from population and space factors, but also from the perspective of the resources to sustain them and their suburbs. Richard (2002) clearly defines carrying capacity as the maximum load (not population only) that can safely be imposed on the environment by people. This load is a function of both population and per capita consumption, with the latter increasing more rapidly than the former due to expanding trade and technology. Many factors regulate carrying capacity at different times and places. They include the physical conditions, the quantity of resource available in a specific area including food and water supply, the consumption habits of the species considered, the suitability of habitat as well as its waste absorption capacity; the availability or non-otherwise of predators and ecological resilience among others. Suffice it to say that population in turn, is a function of technological sophistication and the mean per capita material standards.

2.15.3 Propositions of the Carrying Capacity

The theory of carrying capacity is a suitable theoretical premise for this study. It lends theoretical propositions that anchor this investigation such as those of uncontrolled population growth, resource depletion, and systemic collapse. It has location components such as planet, land, social, energy, human and biophysical among others, whose functions and interaction offer consistent explanations relevant to the attributes of urban physical expansion and its implications (ecological footprints) such as the driving forces, the resource depletion (local building resources, vegetation and rural land use conversion); the implications on future rural land use stability, the worsening urban and rural resource management and eventual collapse of the entire ecosystem.

This theory also relates closely to that of sustainable development as both carrying capacity and urban sustainable development emphasize resource conservation and stress the need to reserve annual yield and not just the capital stock. However, while the origin of sustainable development is traceable to the Brundtland report (WCED 1987), that of carrying capacity remains obscured. Analyzing the methodology of carrying capacity, Helmich and Anderson (2001) opine that the methodology of carrying capacity incorporates the notion of limits imposed by the earth's natural system, which increasing species can overshoot. DeFries, Rudel Uriatte and Hansen (2010) posit that carrying capacity is determined jointly by human choices and natural constraints; thus, the question of how many people can the earth (or space) support, does not seem to have a single parameter. According to Rees (1996), the social nature of human being, trade and technology tend to undermine the resource and space constraint of the theory as applicable to animals.

2.15.4 Application of the Theory of Environmental Carrying Capacity

The application of the theory began in mechanical engineering to the attribute of manufactured objects in the context of international shipping in 1840 (Sayre, 2008). It has also been applied to the attribute of living organisms and natural systems in the 1870s and was further applied to range and game management in the early twentieth century. It was later applied to the intrinsic limit of population increase in organisms, used by population biologists since the mid-twentieth century (Odum, 1989). It is being applied to planet

capacity, environmental sustainability, energy distribution and consumption, land resource-use among others.

2.15.5 The Planet's Carrying Capacity

The planet's carrying capacity refers to the number of people that can live on it without threatening its future. Given the rapid population growth on a finite planet and the present inability to meet even the basic needs of much of the population, the human carrying capacity of the earth has become a significant issue for study. To help discover and control human contribution to the collapse of the planet's carrying capacity, the ecological footprint has been developed as a measure to estimate carrying capacity and the share of each person.

2.15.6 Environmental Carrying Capacity

Rees (1996) defines the carrying capacity of an environment/ecosystem as the maximum population size of species that the ecosystem can support without reducing its ability to support the same species in the future. Also, biological studies of population change typically demonstrated that once the carrying capacity of an ecosystem is exceeded, the resources will be depleted and there will be a severe crash or collapse of the population as a consequence (Odum, 1989; Ogundipe, 2006).

In the same vein, when human-beings become so overbearing on the environmental resource system, the system collapses. Therefore, urban authorities, enterprises and rural residents need to know and understand the implications of their activities and the consequences on the environment so as to regulate their activities (resource consumption habits, waste disposal methods, rate of pollution and so on) to be in harmony with the resource-yield and absorption.

2.15.7 Biophysical and Social Carrying Capacity

This theory was applied to human population in the 1960s and it was observed that the consumption habits of human-beings are much more variable than those of other animal species, which makes it considerably more difficult to predict the carrying capacity of the earth for human-beings. However, investigations on carrying capacity demonstrate that if per capita consumption levels are high, a smaller population can be supported

(Rees, 1996). If technologies increase or decrease overall consumption, it will also affect carrying capacity. The methodologies of carrying capacity incorporate the concept of limits of the earth's natural system, which increasing species can overshoot.

While other biological species can easily reach their carrying capacity in their environment, the sustainable carrying capacity for the human species on the earth, like urban physical expansion and its consequence, differs due to variation in resource-endowment, consumption habits, cultural regards towards natural resources and the level of economic development. For example, it is on record that Gilland (1983) calculated a global carrying capacity of 7.5 billion as far back as 1983; however, improvements in food production have permitted the world population to reach seven billion in the year 2011 without the estimated increase in mortality. Two measures of human carrying capacity are: (a) the biophysical carrying capacity - a maximum population that can be supported by the resources of the planet at a given level of technology and (b) the social carrying capacity - the number of human-beings, social organization, including patterns of consumption and trade that can be sustainably supported at a given standard of living in a given biophysical carrying capacity. Therefore, this social carrying capacity must be less than the biophysical, if this relationship will account for quality of life. There are signs that the social carrying capacity has exceeded the biophysical carrying capacity of many parts of the planet. Consequently, some of the severe human crises since the Rio summit (1992), in countries like Haiti, Rwanda and Somalia serve as underlying causes behind obvious political and ethnic divisions. High increase in population, poverty, and shortage of essential environmental resources, indicate a drop in per capita food production. These may be initial illustrations of the consequences of excess social carrying capacity over the environmental capacity of the regions (Mathews, 1994; Atwood, 1994). The increase in environmental refugees who leave their homes because existing local resources can no longer support them is another symptom of this problem. Against this background, the International Conference on Population and Development in Cairo in 1994, recognized the need to integrate population, environmental issues and poverty eradication scheme in sustainable development policies and programmes (UN, 1994).

2.15.7 The Energy Carrying Capacity

The amount of energy from the sun is the driving force of the earth's ecosystems. Solar energy generates atmospheric processes that influence wind, energy, freshwater, plants, trees and crops that are consumed by all living things. This implies that plants and animals receive energy from the sun; therefore, the amount of energy consumed per person per year is a useful measure of the standard of living. The per capita energy consumption measured in KW/person includes energy for industrial uses, transportation, home heating and cooling, electronic entertainment, food production among others. According to Richard (2002), the United States of America consumes an average of twelve times more energy per capita than developing nations. North America's per capita energy use is more than twice that of Europe, more than ten times that of Asians and more than twenty times that of Africa. This indicates that human-beings are heavily drawing from the energy-source, and in return, emitting into the atmosphere gaseous substances that destroy the atmospheric elements, which is another method of high energy consumption.

2.15.9 Land Area Carrying Capacity

This can be used to estimate the carrying capacity, either as a metric for other resource-use or as a measure itself. Using land to compute carrying capacity is to presume a population density for a given area and compute the total number of people that the region can support. If the population is more than the land capacity, congestion will occur, which will require physical expansion and the consequences will be rapid depletion of rural resources. This will further increase the cost of the resources and raise the cost of living in such area.

The limitations of this theory stem from the premise that, it is difficult to estimate the carrying capacity of the planet across generations as this depends on the technologies available, efficiency in the use of resources, and the acceptable standard of living. However, Rees (1992) shows that the world is already over-populated, and that the future population must be reduced to achieve sustainability. Earlier predictions of limit to growth and decline in civilization have not been realized, but we may have exceeded the limits; the consequences are being cushioned only by the time lags between cause and effect (Meadows, Meadows, Randers, William Behrens, 1972).

The use of animals in a confined environment as experimented by Rees (1992) is a limitation of the theory. First, human population can import scarce resources through trade, and are not confined to resource availability in an environment. Second, human beings have the unique ability to eliminate competing species, modify the environment, improve technology for food and increase the energy production. These unique abilities combined with the inherent social nature of human beings and globalization complicates the estimation of the human carrying capacity of the planet. Third, the number of people that can live on a piece of land depends largely on their culture, which determines both their needs and their ways of life. The nature and success of their farming systems, for example, cannot easily be predicted in advance on the model of exogenous cultures. Fourth, estimating the carrying capacity of the earth may be a difficult task as it involves value-based decisions and assumptions. For example, it is not clear at present whether the future of the earth includes a dense population of humans with reduced bio-diversity and degraded environmental quality or whether more materials will enter the resource realm and there will be a smaller human population sustainably living on diverse resource-base. Fifth, carrying capacity in a given land will largely depend on what happens outside the borders of the land; upstream deforestation will affect water level, quantity and associated uses, global or commodity price fluctuations, greenhouse gas emissions, acid rain among others. However, whenever the carrying capacity of a place is exceeded, resource use and development are not likely to be sustainable. Thus, the concept of sustainable development is inextricably linked with the theory of the carrying capacity and the idea of carrying capacity relates closely to that of sustainable development, because both emphasize prudent resource-use for future generation. The concept of ecological footprint as an area-based indicator quantifies the intensity of resource use and waste discharge activity in relation to a region's carrying capacity. This helps to explain the quantity of natural resources that cities consume from their surrounding hinterlands and therefore, gives a quantitative measure of sustainability.

2.16 Conceptual Anchors

These refer to the concepts that give this research the needed framework that guide its direction and scope. Such concepts will be discussed in the next sections.

2.16.1 Sustainable Development Concept

The term, 'sustainable development' first came into use as a concept during the early 1980s. It gradually replaced earlier concepts such as the eco-development approach, which focused on scientific principle rather than political applicability, and had limited potential to gain widespread acceptance (Lélé 1991). The recent role of sustainable development as an integrative concept originates from its adaptation in the UN-initiated Brundtland Report '*Our Common Future'* (WCED 1987) and its subsequent elevation to a guiding principle during the 1992 Rio de Janeiro Conference on Environment and Development (UNCED). The relative success of the concept appears to hinge on its openness and capability to be interpreted to the needs of each proponent group; however, it does not hide the fact that it had been popularized by a commission whose members represented the governmental and economic mainstream of the late 1980s rather than environmental experts. The concept evolved to address environmental threats and concerns to prosperity, but at the same time recognize the need for development. The paradox of its paradigm is that while it remains a hotly contested concept precisely because of the simplicity of its definition and its wide interpretability, it has not failed to provide a persistent umbrella vision for a host of different stakeholders in the debate, from governments, business and civil society alike (Jacobs 1999). Sustainable development requires that we live responsibly and with awareness, so as not to deplete our natural wealth and leave a poorer world for our children and others to inherit. As a basis for ecological footprint, sustainable development requires that; (i) we do not consume more resources than the planet can provide, and that we do not produce more waste than the planet can assimilate; (ii) we live in such a way that the next generation will not be worse off than we are; and (iii) we do not consume resources at the expense of others' basic survival and livelihood.

The range of dominant schools of thought in sustainability interpretation according to Turner (1993) can be classified into 'weak' versus 'strong' sustainability or 'shallow', 'intermediate' and 'deep' sustainability.

The starting point of the paradigm of 'strong' sustainability is the observation of absolute scarcity of certain natural resources that leads to binding resource constraints (Daly, 1990). The potential of substitutability between natural and man-made capital,

which is the core of the 'weak' sustainability paradigm is therefore limited to binding resource constraints. The model of 'Shallow' or 'weak' sustainability unreservedly agree with the notion that a traditional economic growth model was imperative both for overcoming poverty in the developing world and for releasing resources for a transition towards sustainability in the wealthy countries, and it remains applicable into the foreseeable future. The shallow/weak sustainability model aims to incorporate environmental issues into economic processes by recognizing natural resources as assets and integrating their value in human welfare. These two aspects are interpreted as mutually substitutable (Hamilton, 1997b). Intermediate sustainability also embraces the concept of economic growth, but concedes that growth must change fundamentally in quality to attain the goal of reconciling human activities and the biosphere. At the core of this qualitative change is the twin prerequisite that natural wealth must not further decline, but rather be consolidated and enhanced; and that poverty, which is always seen as a prime cause for environmental degradation, must be alleviated through sound economic instruments, particularly in the developing world (Zethoven, 1991).

'Deep' or 'strong' sustainability, in contrast, presumes that all human activities, including the economy, are principally a subset of the biosphere, and contends that since the latter constitutes a finite system, unlimited growth therein is inherently impossible (Hamilton, 1997b). Propounding this view, Michael (1999) links this assumption to the concepts of carrying capacity, by estimating the maximum number of species that an ecosystem can support, and that of maximum sustainable yield, establishing a limit to the human use of any renewable resource without long-term depletion of its stock. The implications these have for future development vary with respect to the concept of wealth and the role of economic activities. However, in their subservience, human and environmental needs are regarded inseparable. Sustainability is conceived to enhance a future that promotes better harmony between human activities and the life-support systems of the biosphere. Review of the range of schools that have emerged over this period offers diverging perspectives on the sustainability debate, some contesting, some complementing each other. Despite the broad interpretability of sustainability, it constitutes a relative consensus between global actors. On the issue of possible resource constraints, the concept of 'efficiency revolution' promoted by Weizsäcker (1997) attempt

to build an economic case for reduced resource use from the nexus with natural carrying capacity (Rochström, Steffan, Noone, Persson, Chapin, Lambin, Lenton, Scheffer, Folke, Schellhuber, 2009).

In terms of measurement, Richard (2004) posited that measurements of sustainable development generally look at the supply side of the equation, that is, whether we are harvesting our fish, logging our forests, and growing our food in sustainable ways and by that it puts the whole onus for sustainable development on the producers. Natural resource accounts for forests, fisheries, soils and agriculture. For example, it assesses whether current harvesting practices are sustainable. Ecological footprint analysis, apart from examining the sustainable supply, also shifts responsibility to consumers by assessing the impact of consumption patterns on the natural resources. The ecological footprint perspective cuts through the tendency to blame farmers, loggers, fishermen and businesses for the depletion and degradation of natural resource stocks, to placing greater responsibility on the demand that consumers generate, which producers aim to meet. The critical importance of this component is to make the sustainability challenge a shared collective responsibility of producers and consumers.

Therefore, while the sustainable development concept focuses on the supply side of the sustainable equation only, the ecological footprint looks at both the supply and the demand side of the equation and places the responsibility for sustainable development equally on the consumer. Integrating the supply and demands sides of resource sustainable development components helps to balance the sustainable development assessment. To express sustainability in quantitative terms, ecological footprint as a tool is drawn to bear on the measurement.

2.16.2 The Concept of Ecological Footprint of Cities

Ecology is the scientific study of interaction between living systems and their environment. It unveils the relationship between living things and their environment and how the interaction affects the environment and vice-versa (Odum, 1989). For example, cities interact with their environment to promote development. Through the interaction, cities harvest resources such as sand, granite, timber, water, food, energy and fibre from the hinterland, and also require their surrounding land, sea areas and air-sheds for the absorption of waste materials. The extent to which a particular city impacts on its

surroundings in this way is called its ecological footprint (Rees, 1992). The carrying capacity concept has been the foundation for the Ecological Footprint (EF) proposed by Rees and Wackernagel (1992). This concept attempts to quantify the ecosystem resources in terms of biologically productive space that would be necessary to supply all the resources a nation's population consumes and to absorb all the waste that it generates. It describes the impact of urban agglomerations beyond their administrative boundaries, in terms of consumption of natural resources and environmental disruptions and measures the resource constraint. The ecological footprint concept is therefore used not only as an environmental policy advice but also as an indicator for measuring overuse of natural capital by economic activities. The use of the word footprint in ecological context recognizes the two characteristic elements of size (in terms of expanse or coverage) and intensity (in terms of the intensity of the effects on ecological and other environmental resources).

This concept as an area-based indicator quantifies the intensity of resource use and waste discharge activity in relation to a region's carrying capacity and helps to explain the quantity of natural resources that cities consume from their surrounding areas. According to Kitzes e*t al* (2007), this indicator gives a quantitative measure of sustainability. Its calculations are based on two simple facts: First, we can account for most of the resources we consume and the wastes that we generate. Second, we can convert this resource consumption and waste generation into the biologically productive area necessary to sustain these functions. Therefore, the ecological footprint of any defined population (a single person, household, province, country) refers to the biologically productive area that the population requires to:

1) Produce the food, wood, energy and all the other resources that humans consume,
2) Provide room for infrastructure such as buildings and roads, and
3) Absorb the wastes, carbon dioxide and other pollutants that result from human activity.

To provide results in comparable units of measure, all components are adjusted for their biological productivities. This means that land with higher than average productivity resources is advantageous in footprint accounts than land with poor resources. Corroborating these views, the Global footprint network (2011) states that inasmuch as

the resources we consume come from different parts of the planet and the waste we generate impact on distant places, ecological footprint analysis considers the sum of all our ecological impacts no matter where they occur on the planet. Thus, ecological footprint is a resource accounting tool that helps countries to understand their ecological balance sheet and gives them the data necessary to manage their resources to secure their future.

2.16.3 Methodological Approaches to environmental and social performance

One problem that societies wishing to improve environmental and social performance have been facing is the lack of reliable methods of monitoring and measuring their ecological performance. Over the years, a wide range of methods and approaches have been employed to quantify the capacity of nature to regenerate resources and produce life-support services for the living species. According to Cohen (1995), attempts to estimate the biosphere's capacity dates several centuries ago, and ecological footprint method builds on a wide range of earlier methods to assess the capacity of nature to regenerate resources and produce rich life-support services.

Reviewing the earlier attempts, Cohen (1995) affirms that much intellectual ground work was laid in the last three decades of the 20th century. For example, Howard Odum's energy analysis examined systems through embodied energy flows (Odum, 1994); Forrester's attempt on modelling the world resource dynamics (Meadow et al 1972); Hodren's and Ehrlich's I=PAT equation (Hodren and Ehrlich, 1974). In the context of the International Biological Programme, Whittaker's calculation of Net Primary Productivity of the world's Ecosystem (Whittaker, Lieth and Whittaker, 1975). The last two decades have witnessed exciting new developments; Life Cycle Assessment (Abel *et al*, 1990); Lifestyle Energy Assessment (Hofstetter, 1991); Environmental space calculations building on the ideas of Opshoor (Buitenkamp *et al*, 1992); Human appropriation of Net Primary Productivity (Vitousek *et al* ,1986); Documentation of regional and industrial metabolisms (Ayres *et al*, 1994); Mass Intensity Measure such as mass intensity per unit of Service (MIPS) (Schimidt, Bleek,1994). Measures of human process such as Sustainable Process Index SPI (krotschek and Narodoslaawsky, 1996); National Resource Inventories (as performed by Norwegians and the French); Resource Accounting Input-Output Models (Dutchin and Lange, 1994); Computer-Based Gradient

Models for analyzing land use development and ecological potentials (Hall, 1996) and the Polstar's Scenario Model (Galloping *et al*, 1997 among others.

2.16.4 Methodological Application to Ecological Footprint

The recognition that human-beings are adversely impacting on the bio-physical environment, a perception once confined to the industrial nations, has now reached virtually the entire globe (Dunlap et al. 1993). No one would deny the importance of empirical analysis of the anthropogenic linkages and causes of environmental impacts. But while there is a singular vision of a common destination, there continues to evolve a considerable debate about the best method and metric to comprehensively analyze this array of consequences. Literature review reveals that some precursors applied the stochastic models that have substantial advantages, but have little use to date. For example, according to Ridker (1972), only one study used this approach. Hoch's analysis (1972) used regression models to estimate the effects of the population size and density of U.S. urban areas on air pollution levels, wages and crime rates. His analysis was described as a fit into a small tradition that attempts to determine urban size effects in sociology, geography and economics (Applebaum 1978; Appelbaum et al. 1976; Duncan 1951; Singer 1972). The result of the investigation of Hach (1972) shows that population size and density have adverse effects on its dependent resource variables.

Studies reveal that the stochastic modelling (S/M) approach has been used most often in studies of deforestation (Allen and Barnes 1985; Dietz et al. 1991; Popoola 1998). Despite using slightly different specifications and data sets, all the three studies find that population size; growth and density rates have a stronger effect on deforestation than economic activity. Rudel (1989) also finds that population growth has a stronger effect than a common measure of trade dependency. These preliminary applications and their findings suggest that the use of stochastic approach in assessing the impacts of population, affluence, technology and other factors on the environment is a useful way to ground the debate about driving forces in stronger theory with empirical evidence.

Several strategies have also been used to assess the impact of population and urban growth on environmental resources. Thus, since the early 1970s, one report after another has warned that unlimited growth of human population and consumption of natural resources is not sustainable. The most prominent of such reports are *The Limit to*

Growth (Meadows et al 1972), the Brundtland Commission's Our Common Future (WCED, 1987), Millennium Environmental Assessment (2005) and the World Watch Institute's Annual State of the World Publications. Despite these warnings, the human economy has continued to expand, with more people, more consumption, more waste and more poverty on one hand; on the other hand, there has been less biodiversity, less available fresh water, less fossil oil in the ground and less productive ozone in the atmosphere (World Resource Institute, 1994; 1996)

Hans (2011) assessed the ecological footprint in terms of its effectiveness as a concept and as a tool for measuring sustainability. He defined sustainable state to include safe operating space for humanity as determined by the nine planetary boundaries that must not be transgressed. His results show that, out of the nine planetary boundaries, three (biodiversity, nitrogen cycle and climate) have been overstepped. Since these planetary boundaries are not independent, but strongly linked; if one boundary is overstepped (if natural resources are exploited more than the permanent yield of its natural capital), then other boundaries are also brought under serious risk. He concluded that combining other factors of sustainable measurement (such as Human Application of Net Primary Product (HANPP), Environmentally-Weighted Material Consumption (EMC), Land and Ecosystem Accounts (LEAC)) with the ecological footprint yields a more comprehensive result. This is because HANNP calculates the contribution of human intervention into nature to the reduction of land and water area yield. EMC is a weighted indicator of material consumption based on environmental impact, while LEAC accounts for the interaction between nature and society on the bases of detailed grid (1kmx1km) for land use and land cover changes. In terms of measurement of sustainable yield, he integrated the EF with other Sustainable Process Index (SPI) and the Dissipation Area Index (DAI). While DAI calculates the soil and water areas needed to provide the raw materials and energy demands as well as dissipation of pollution waste in a sustainable way, the SPI assesses the waste quality and substances to be distributed so that they do not exceed the local consumption capacity.

The issue of how much consumption is sustainable also needs to be addressed and to quantify resource targets. Ecological Footprint Analysis (EFA) tool approaches the issue of sustainability by considering the overall 'carrying capacity' and relating it to the

resource supply of the planet and human demand. The ecological footprint has also integrated the production and consumption sides to reveal the impact, unlike sustainability that focuses on the supply side. Thus, it is able to link individual behaviour to wider institutional targets, using concepts such as the earthshare - the average sustainable bio-productive capacity available per person.

The Ecological Footprint Analysis, by recognizing explicitly the relationship between income, consumption and environmental impact, empirically links environmental sustainability to social equity clearer and more directly than any other component of sustainable index. The attempts to compute ecological footprint as a measure of sustainable development have produced a variety of approaches, such as (i) summation of agriculture productivity in various regions of the earth to obtain total productive area and land capability; (ii) determination of human carrying capacity (the number of people that can be supported by a given area of the earth's surface) among others. Ecological footprint as one of the approaches inverts the carrying capacity process. Instead of asking how many people can live in an area, it estimates the area of the earth's surface required to support a given human population.

Since the size and weight of ecological footprint combine to determine the scope and intensity of impact on the area that supports the footprint, it implies that if human footprint is so large and weighty, it cannot be sustained by the planet for a long time. The concept therefore, does not only serve as a conceptual tool to understand how different human activities have different 'loads' - footprints - on the supportive environment, but also as a practical tool for measuring human impact on the Earth's resource-base. In this context, it is both a concept and a methodology that measures the amount of renewable and non-renewable ecologically productive land area required to support the resource demands and absorb the wastes of a given population or activity. The concept is rooted in the fact that all renewable resources (the air we breathe, the water we drink, the diverse population of plants and animals) upon which human civilization depends, come from the earth and is finite in quantity. Therefore, as human beings consume nature's products and services, they exert impact on the ecosystem resources and services. Apart from the communal impacts, our personal ecological footprint corresponds to the amount of nature we use or occupy in order to live. However, this is accepted as long as the human load

remains within the nature's carrying capacity (the ability of the natural world to support human activity and renew itself without depleting natural resource stocks). The sustainability challenge, therefore, is to attain a high quality of life for the residents of the area under study while ensuring that their resource consumption and waste generation remain within the carrying capacity of their natural habitat. Thus, ecological footprint links the production of ecosystem services with their consumption by societies with the overlapping goal to promote sustainable use of ecosystem services such that their production rates are not compromised. From this perspective, Wieldman and Barret (2010) define it as an indicator that accounts for human demand on global biological resources as it compares the level of consumption with the available amount of bio-productive land and sea, and is designed to show a possible excess or otherwise of this sustainability threshold.

Ecological footprint is further defined as the land and water area that is required to support a defined human population and material standard indefinitely, using prevailing technology and resource management skills (Wackernagel *et al*, 1996). It implies that despite our technological and economic achievements, attainment of sustainability requires human beings to regard themselves as ecological components as long as they depend on nature both for basic needs and material resources; and also they do return their residue in degraded form to the ecosphere as waste (Rees 1992). This is because human enterprise through the industrial economy has become the dominant consumer of the earth's major ecosystems (Richard 2002). Daniels and Daniels (2003) find that human beings appropriate 40% of net product of terrestrial photosynthesis, and 25-35% of coastal shelf primary production and these are described as unsustainable proportions. This corroborates the account of Rees *et al* (1996) that, global fishery yields have fallen since 1989, and at the same time, the global waste sinks seem full to overflowing. The ecological footprint of any specified population is the total area of productive land and water required on a continuous basis to produce all the resources consumed and to assimilate all the wastes produced by that population, wherever on earth that land is located. Through this, the concept of ecological footprint of cities enhances the understanding of how cities are impacting on the natural resources and ecosystem (Wackernagel and Yount, 1998). Initially developed as an indicator of the environmental

impact of individuals, communities and nations, it is increasingly being tried as an indicator of organizational and corporate environmental performance and as an indicator of the sustainability of products (Wieldman and Barret, 2010).

Comparing ecological footprints with the real ecological capacity of the earth allows assessments of whether and by how much, human beings are overusing natural systems. To calculate an ecological footprint, human consumption is divided into different categories (food, living, transport, etc.) and then converted into land use. The annual ecological production (bio-capacity) is also measured as a component of the ecological footprint. The resource and regenerating capacity of our planet cannot be adequately calculated in monetary terms, as climate stability and soil fertility are not reflected in market prices. Biophysical units, rather than money, are therefore used to measure the human consumption of materials, energy and land area. Bio-capacity and ecological footprints are measured in global hectares (gha). Global hectare is an area-normalized unit of productivity, equal to the annual productivity of one hectare of biologically productive land or sea with world-average productivity.

The use of global hectares (gha) as a productivity measure allows world-wide comparison of bio-capacity and demand, while recognizing large differences in ecosystem productivities (Kitzes, Peller, Goldfinger and Wackernagel, 2007). The gha is normalized to have the world's productivity of all biologically productive land and water (both marine and inland) areas that support significant photosynthetic activity and biomass accumulation that are used by human beings) in a given area. It considers average biological capacity needed to produce resources or goods and services and absorb waste by residents of that place. Therefore, if the ecological footprint of a region exceeds its bio-physical capacity, the region is said to be in ecological deficit. The ecological footprint analysis demonstrated by Rees (1996) was done by dividing the 11.2 billion hectares available by the then global population. This gave averagely 1.9 bio-productive hectares per person on the planet to maintain resource flows and offset contributions to global warming without considering land needed to be set aside for conservation. In 2003, the world's bio-capacity was 11.2bn equivalent to 1.8gha per person based on the then population, but the established average ecological footprint is 2.2gha per person (Kitzes *et*

al, 2007). This overshoot means that it took approximately 15 months for the globe to produce the resource needed and to absorb the waste generated in the year 2003.

The *Living Planet Report* (2004) indicates that the actual biophysical capacity (the capacity of ecosystems to produce useful biological materials needed for a given time and to absorb waste generated by humans using current technologies) was 13.5 billion global hectares or 2.2 global hectares per person, which indicates 25% overshoot (a term used when ecological footprint exceeds available bio-capacity). The gha reduces as the population reaches seven billion on Oct 31, 2011. Examples of urban ecological footprints include the conversion of arable land for agricultural expansion, construction of water dams for water supplies and generation of energy through Hydro-Electric Power, exploitation of natural building materials, vegetation, the concentration of chemicals, the increase in sediment and waterborne nutrients from human waste products, to mention but a few. In this view, ecological footprint is a conceptual tool for understanding cities as drivers of land use change and ecological resource depletion, its analysis computes the amount of ecologically productive land area required to support the resource demand of a population in terms of energy, food, and other resources at a certain level of consumption, and to absorb the waste of the population or specific activity (Feng, 2007). Consumption of such resources provided through trade also affects ecosystems in other cities. In this context, Rees (1992) observes that high–density human settlements no longer have boundaries that coincide with land needed for their daily activities, because the growing 'ecological footprint' of contemporary urban centres is typically many times their total administrative area. For example, London's ecological footprint is 120 times the area of the city itself; and Tokyo needs 1.2 times the land area of Japan to sustain its levels of consumption (Rees, 1996).

Ecological footprint is a 21st century tool for measuring how our lifestyle affects not only the plants and other wild species, but also other people by calculating how much productive land area is needed to feed us and provide all the energy, water and other materials that we use in our everyday lives. It also calculates the emissions generated from the oil, coal and the gas that we burn at every increasing rate as well as determines how much land is required to absorb our waste. Ecological footprint is termed unsustainable when one considers the current status of countries such as Canada, Australia, Sweden,

Brazil, USA and Russian Federation with 15. 9, 14.7, 7.9, 6.3, 6.0, and 5.1 (gha) respectively (Kites *et al*, 2007).

Richard (2002) computes the ecological footprint of nations and concludes that, it is now greater than the land area of the earth. This analysis suggests that consumption in cities, largely those in the developed world, are drawing down the natural capital of the planet. To promote the sustainability of cities, studies need extend beyond measuring local environmental quality, to considering the environmental effect of ecological footprint on immediate and distant regions. The concept has three specific aims: (i) to quantify the ecological footprint of urban centres and to evaluate the implications for sustainable urbanization; (ii) to complement research on land-to-coast interactions with a detailed examination of the consequences of expanding urban centres and (iii) to elucidate the complex feedback between expansion of cities and the consequences on the surrounding regions. The Ecological footprint has also proven to be one of the most successful indicators for communicating the concept of environmental sustainability and the resource carrying capacity of our planet as it takes into account available technology, resource management conditions of both land and water surfaces. Humanity's Ecological Footprint can be expressed in terms of the "number of earths" theoretically required to support human resource use and waste generation (Feng, 2007). If the ecological footprint of a people within a region exceeds its bio-capacity, the region is said to be in ecological deficit. Such a deficit at the global level is called ecological overshoot. In 2008 for instance, the "World Overshoot Day" was reached on October 6. This date signified the point at which human-beings' consumption of natural resources in 2008 matched those provided by ecosystems for the entire year. Consequently, from that day forward resources which could not be reproduced in the same year were used, leading to a reduction in the planet's bio-capacity. Assessing this trend, Global Footprint Network of scientists and economists conclude that the facts about the coming catastrophe are so obvious. Our planet's natural resources can reasonably support about five billion people, but now have seven billion (footprint network, 2011). This demonstrates an excess of two billion. With more people sharing the planet, there is inevitably less planet and planetary resources per person, and we are consuming natural resources at a rate faster than the earth's annual regeneration. Since the 1970s, humanity has been in 'ecological overshoot'

with annual demand on resources exceeding what the earth can regenerate in 365 days. It now takes the Earth one year and six months to regenerate what we use in a year (Global Footprint Network, 2011).

Urban resource demand cannot be met, given the resources within the urban habitat. Thus, it exerts pressure on rural sources such as lakes, rivers, air, land and energy, especially, in today's world, where human population and humanity's resource demand already exceeds planetary limits. This implies that, the demand for ecological assets is becoming more critical than ever (Wackernagel, 2006). Besides, each country has its own ecological risk profile; with many countries running ecological deficits larger than their own ecological capacity. Others depend on resources from elsewhere, which implies that such nations are under increasing pressure and their resources will be heavily overtaxed. In some regions of the world, the implication of ecological deficit can be devastating, leading to natural resource loss, ecosystem collapse, debt, poverty, famine and wars.

In 2002, the global Ecological Footprint was 13.5 billion global hectares, the humanity's Ecological Footprint exceeded global bio-capacity by 0.4 global hectares per person, or 23% and the overshoot dates have continued to shift backward. According to Global footprint network (2011), the 1987 global overshoot occurred on December 19; in1990, it occurred on December 7; in 1995, it was on November 21; in the year 2000, it occurred on November 1. It occurred on Oct 20, and September 23 in 2005 and 2008 respectively. It occurred on August 21 and September 27 in 2010 and 2011 respectively. In overshoot, nature's capital is being spent faster than it is being regenerated and overshoot can permanently reduce ecological capacity and resilience.

2.17 Urban and Human Ecological Footprints

Urban and human ecological footprints models determine the impact that a defined human population exerts upon its surrounding environment. It is an indicator in the assessment of sustainability of a population. Urban ecological footprint does this by providing an approximation of the total amount of land required to provide a city with the resources it needs to sustain its population. Such amount of land may exceed its administrative boundary. In addition to accounting for the food, water and other natural resources that people consume, the footprint also includes the space required to dispose of all the waste that the population generates. Through this, it is found that the two-third of

the world's ecosystem are now severely damaged; mostly due to urban consumption and waste disposal (Chambers *et al.*, 2000). The more urbanized parts of the world have significantly larger footprints. The average in Africa and North America is 1.1 and 9.4 l global hectares per person respectively.

The human ecological footprints of individuals within a defined geographical area, such as a country, can also be calculated and compared with other countries around the globe, which indicates our degree of unsustainable consumption pattern and the impact we exert on surrounding environment. Our human footprint consists of our annual consumption of renewable and nonrenewable. If our consumption of renewable resources is higher than their rate of annual regeneration; we will run out of food and fibre. However, if we deplete natural resources at a rate that is lower in comparison to the rate of regeneration and available stocks, the ecosystem will sustain us for a relatively longer time. On the contrary, highly populated and larger cities demand more energy and space, which taxes more heavily, our already scarce natural resources such as water and energy.

2.17.1 Differentiating the Concept of the Carrying Capacity and the Ecological Footprint

The difference between Ecological Footprint Analysis (EFA) and the classic Carrying Capacity (CC) becomes obvious when we look at the physical units that these two concepts measure. Carrying capacity explains how many individuals sustainably live in a defined spatial area, with a corresponding unit of individuals 'per area'. Ecological footprint analysis, on the other hand, is an area-based indicator that inverts this relationship and uses the units 'area per individual', and makes *hectares per capita* a standard unit. The Ecological Footprint successfully communicates the concept of environmental sustainability and the physical limits of our planet. The Ecological Footprint is therefore the measure of how much ecologically productive land and water a population unit needs to support its current consumption and to take care of its wastes without compromising its productive capacity. What differentiates ecological footprint is the way it interprets throughput analyses of human activities; it aggregates human impacts on ecological basis, expressing them in mutually exclusive ecological spaces, which are

appropriated to provide the functions and services of nature. By this, EF is called appropriated carrying capacity.

Ecological footprint quantifies for any given population the mutually exclusive biophysically productive area that must be in continuous use to provide its resource supplies as well as assimilate its wastes by measuring the nature's supply, consumption levels and waste treatment behaviour of these populations. Thus, the population units considered in ecological footprint may vary between individuals, communities, nations and even the whole planet. Ecological Footprint Analysis converts these measurements into land area equivalence required for this consumption and the corresponding waste assimilation. However, all land areas are not productively the same; the Ecological Footprint Analysis takes account of these differences by dividing up land into several separate categories: fossil energy land, arable land, pasture, forest, built-up land, and sea, among others and normalizes them.

One of the early limitations of this ecological footprint paradigm lies in its one-way definition (cities are seen as "predators"), which has always ignored the potentials of the urban settlement to protect the world's natural resources, through their ability to support large number of people while limiting their impact on the natural environment. Besides, sound environmental management policies improve the well-being of people and protect the natural resources. In the same vein, economic development based on sound urban policies can promote and finance environmental improvements and protection of ecosystems well beyond the city boundaries. Moreover, as much as urban activities exert ecological footprints on resources outside the urban area, measures undertaken to protect and use urban resources in a sustainable way can also yield gains in adjacent rural communities. The challenge lies in the adoption of urban planning and management approaches which embody the principles of sustainable human settlements for development.

A situation where environmental resources are abstracted from the rural areas for urban development and the urban environmental management policies exclude such rural areas where the land is degraded is miscarriage of policies. In a related development, where some nations, communities or individuals suffer disproportionate environmental risk (adverse effects of environmental impact of development, discrimination or lack of

fair consideration on the basis of location, colour, race and gender among others) while others enjoy its benefits is gross injustice.

2.18 The Concept of Urban Land Governance

Governance is the science of decision-making. The concept refers to the complex set of values, norms, processes and institutions by which society manages its development and formally or informally resolves conflicts. It involves the state and the civil society at the local, national, regional and global levels. Governance provides the institutional framework within which the civic public realm is managed. It is about the way power structure of the day and the operational framework of civil society are managed so that together these two inter-dependent elements can make up a robust and healthy civic realm (Devas, 1999). Whereas, governance refers to the whole range of relationship between civil society and the state, government primarily refers to the state. Efficient urban governance of cities is concerned with; who makes decisions and how; who influences decisions and who benefits from the outcomes of such decisions. This corroborates the inextricably decision making process outlined by Cheng, Massser, Ottens (2010) that starts with (i) policy - the driving force of ecological footprint (ii) actors - agents of behaviour, the wider the scope, the more complex the number of actors (iii) behaviour – the actions of the actors involved in decision making process such as land use planning (iv) process – the dynamics of ecological footprint and (v) pattern – the directly observable outcomes at a temporal and physical scales.

In some part of the world, urban government concerns itself with the process and outcomes of city development and the services provided, particularly for the urban residents. Administrative governance tends to fail if urban authorities are not accountable to citizens for their policies and expenditure priorities. Many urban environmental problems arise from the failure of the urban authorities to carry out their responsibilities of providing the basic infrastructure and services, and to provide the framework for NGO, community and private sector partnership. Due to weak governance, each city has its own myriad of environmental problems, in part linked to its own unique local environmental context, the factors that shape its development, and its existing demographic, economic, social and cultural base (DANIDA, 2000). Assessing the effectiveness of urban governance as a key factor to urban environmental sustainability, Redman and Jones

(2004) argue that for the benefits of urban governance to outweigh the continuing urbanization and for the benefits to be widely shared as well as maintain the valued aspects of the environment, government institutions and policies must be adaptive, participatory and effective.

Suffice it to say that lack of good governance to provide the basic felt-needs of the people compels them to compromise the use of air, water, land and also compels the poor to over-use the finite natural resources available, which eventually causes environmental degradation. Degradation reduces opportunities and productivity, which directly affects the poor and impose further constraints on the household food security. The causes of environmental damage is the misery of the poor who are compelled to cut down any tree, poach any animal, deplete any resource, and excavate anywhere, provided it fetches something to satisfy their basic needs regardless of the long-term consequences. This makes the poor, the architects and victims of environmental degradation. However, this is not to say that the poor have intrinsic propensity to degrade environmental resources, because many poor traditional communities have demonstrated admirable environmental ethics and have developed effective resource management regimes. Moreover, there is no clear evidence that the poor (rural or urban), when offered appropriate environment, still pursue resource-degradation (Nunan and Satterthwaite, 1999). Efficient urban governance that adequately provides for urban basic services will reduce the degradation of environment on one hand; on the other hand, the failure of urban governance to provide basic needs that forestall unsustainable resource reaping, environmental degradation and mitigation of the adverse environmental conditions such as aridity, desertification and erosion among others predisposes the surrounding regions and communities to environmental risks. Furthermore, the use of natural resources in the rural areas by the urban institutions without management of the consequences as is the case in Damaturu is unfair to the surrounding rural communities.

It can therefore, be seen from this discussion that helping cities to address their environmental problems will significantly contribute to achievement of Millennium Development Goals (MDGs) on poverty reduction, sustainable development and environmental quality.

2.19 The Concept of Environmental Injustice

Environmental injustice exist when members of disadvantaged, ethnic minority or other groups suffer disproportionately at the local, regional (sub-national), or national levels from environmental risks or hazards; or suffer disproportionately from violations of their fundamental human rights as a result of environmental factors. It reflects in denial of access to: (i) environmental benefits, resources and information; (ii) participation in decision making; and (iii) access to justice in environment-related matters. The root causes of environmental injustice include institutionalized racism; the co-modification of land, water, energy and air, without management; it manifests in unresponsive, unaccountable government policies and regulation; and lack of resources and power in the affected communities (Schlosberg, 2007).

Environmental discrimination is an issue that environmental justice seeks to solve as racism and discrimination against the minorities is becoming more evident in participation in public decisions, resource distribution and maltreating others based on assumed racial superiority. However, a part of racism that is used in environmental discrimination is using racial advantages and privileges. These privileges, in combination with aforementioned racial prejudices, are the potential causes of waste and pollution being located in areas with high concentrations of minorities. This can be seen by the numerous minority communities, such as Warren County, which have many landfills, incinerators, and other potentially toxic facilities near communities (Skelton 2005). The existing racial prejudices along with policies that take advantage of racial privileges lead to environmental discrimination.

Environmental discrimination is historically associated with different kinds of sites, such as waste disposal, manufacturing, and energy production. Transportation infrastructures, including highways, ports, and airports, have also been charged with creating environmental injustices. Among the earliest documentation of environmental racism was a study of the distribution of toxic waste sites (Chavis *et al,* 1987). Since then, waste dumps and waste incinerators have become the target of environmental justice lawsuits and organizations (Cole 2001). Energy production has also been a significant source of environmental discrimination, with communities of colour and poverty. Rural communities most affected both by energy extraction—coal mining, uranium mining and

enrichment, oil drilling and refining, unconventional oil and gas-flaring, coal production, power plants and nuclear reactors. Alternative energy sources, including solar, wind, biomass, natural gas, and clean coal, promise to reduce greenhouse gas emissions, ameliorating the disproportionate burdens that global climate change will place on poor communities. On the other hand, integration of the indigenous communities in resource management shows environmental justice.

2.20 The Concept of Environmental Justice

The environment is not only about animals and plants. It is also about the places where we live and work, the air we breathe, the water we drink and the land we live on. This implies that the resources needed for development come from the environment. If the environment, including people is destroyed, the possibility of development is also destroyed. The concept of environmental justice emerged in the United States in the early 1980s, as fueled by a mounting disdain within African-American, Hispanic and indigenous communities that were subjected to hazardous and polluting industries located predominantly in their neighborhoods (Rhodes, 2003). The concept does not only relate environmental abuse to social injustice, it also helps us to understand that unequal power relations in society undermine the people and their environments. Therefore, environmental justice is defined as the fair treatment and meaningful involvement of all people regardless of race, colour, sex, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies (Schlosberg, 2007). Its proponents generally view the environment as an encompassing place, where we live, work, and play (sometimes to pray and learn is also included) and seek to redress inequitable distributions of environmental burdens (pollution, industrial facilities, crime) and benefits. The United States Environmental Protection Agency defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work (USEPA, 2009).

Participants of the Central and Eastern European Workshop on Environmental Justice Budapest (2003), explain environmental justice as a condition when environmental risks and hazards, investments and benefits are equally distributed without discrimination. That is, when access to environmental investments, benefits, and natural resources are equally distributed; when access to information, participation in decision- making and access to justice in environment-related matters are enjoyed by all.

The quarterly newsletter of the South Africa "Environment Justice Networking Forum" defines Environmental Justice as a concern for social transformation directed towards meeting basic human needs and enhancing our quality of life such as economic quality, health care, housing, human rights, environmental protection, and democracy. It further defines environmental Justice as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations irrespective of race, ethnicity, and socio-economic status. This concept applies to governmental actions at all levels such as local, state and federal; as well as private industrial activities. In linking environmental and social justice issues, environmental justice approach seeks to challenge the abuse of power which results in poor people having to suffer the effects of environmental damage caused by the greed of others, usually the rich (McDonald, 2002). The advocates of environmental Justice posit that everybody has a right to clean water and clean air, and nobody has a right to degrade and destroy the environment. It emphasizes healthy communities where we can send our children out to play, where we can live and raise our families knowing that everybody is doing his/her part in using and disposing of toxic chemicals properly.

From the foregoing, promoting environmental justice includes a guarantee of equal access to relief and meaningful community participation in government and decision-making on environmental issues such as industries. Schlosberg (2007) analyzes myriad definitions of environment justice and posits that environmental justice incorporates four major ideas: the equitable distribution of environmental risks and benefits; fair and meaningful participation in environmental decision-making; recognition of community ways of life, local knowledge, and cultural difference; and the capability of communities and individuals to function and flourish in society. Where this fails, it implies there is injustice in environmental equity.

2.21. The concept of Ecological Resilience

Deliberate progress towards achieving the Millennium Development Goals (MDGs) on long-term environmental sustainability partially depends on the scientific understanding of the systemic linkages of social, environmental and ecological variables. The concept of socio-ecological resilience holds promise for this synthesis. Resilience is a concept that explains the capacity of an ecological unit to absorb perturbations without necessarily undergoing fundamental changes. Ecological disturbance, depending on the resistance of the ecosystem and the severity of the perturbation, can destroy the resilience and change the whole state of an existing natural ecological system into a new one. This implies that, an ecosystem that looses too much of its resilience, through human and nature-induced activities, would break down under a disturbance that it would have absorbed. In assessing the sensitivity and resilience of ecological systems, Blake and Brookfield cited in Ogundipe (2007) used sensitivity and resilience of ecologies to categorize ecosystem into four: (i) Ecosystems with low sensitivity and high resilience: these types of ecosystem suffer degradation when poorly managed or when there is a natural catastrophe. These are the ecosystems that can be stretched to improve production of food and other commodities, (ii) Ecosystems of low sensitivity and low resilience: these can only resist degradation for a period of time, but when these ecosystems breakdown, it is very difficult to revive or restore them, (iii) Ecosystems of high sensitivity and high resilience: these ecosystems suffer degradation easily, but respond to management and restoration efforts, (iv) Ecosystems of high sensitivity and low resilience: these degrade easily and do not respond to management or restoration strategies. Once these ecosystems have been degraded, it is advisable to leave them or change them radically for a more resilient type. Relating this classification to Damaturu and its surrounding environment, it can be observed that the study area located in a semi-arid zone with low rainfall, scarce and fragile ecological resources, this description, therefore, makes it fit in the fourth category.

2.22 Ecological Stability, Sensitivity, fragility and vulnerability

An integrative and systematic approach to environmental change must not only view a particular human-environment situation from historical and spatial context, but it should also examine human and physical dynamics that have contributed to such

situations. According to Kasperson and Turner (1995), these attributes include sensitivity, fragility, resilience, and vulnerability; the nature of environmental change; threats and disaster; life-support systems; intergenerational export of damage; and societal response systems. The review of these ecological attributes helps to conceptualize areas of emphasis.

The dynamics of ecological or rural land use change reflect the extent to which urban interaction stresses the surrounding ecosystems and erodes their stability (propensity of a system to attain or retain an equilibrium condition of steady state or stable oscillation). The rate of the impact of environmental change on the ecology is a function of the stability or sensitivity of the environmental base. Sensitivity (the degree to which a given land system undergoes changes due to natural forces, but more importantly, human interference) is often used to measure the magnitude of impacts on environmental change. Measurement of such changes embodies the assessment of the characteristics of the physical and social systems, groups, and individuals that add to the set of processes that contribute to differential susceptibility to environmental changes.

Sensitivity also measures fragility (the sensitivity of a particular ecosystem to human-induced perturbations). Fragile environments degrade more readily under mismanagement and exert higher societal costs of management or for substitution. More robust and stable environment may not degrade so rapidly and may respond more economically to substitutes. It should be noted, however, that less fragile environments are those under the most human stress, hence most subjected to mismanagement (Kasperson et al, 1995). Vulnerability refers to the differential susceptibility of both social and biophysical systems, which share concerns with the level of impact of change and the ability to cope with the stress and to continue functioning. In this study, vulnerability refers mainly to the social dimension and is viewed as a product of three dimensions: exposure, resistance (the ability to withstand impacts), and resilience (the ability to maintain basic structures and to recover from losses).

It is established that, capabilities of ecologies on stable environments are often, more resilient than those in unstable or fragile environment. Blaikie and Brookfield (1987) use the terms sensitivity and resilience to describe the quality of land systems and therefore explains that fragility combines two dimensions: the capacity to be wounded by

a particular environmental perturbation (either nature - or human-induced), and the ability to maintain structure and essential functions and to recover from perturbations.

Further expanding the set of relationships between nature and society, Green (1990) explains the characteristics of vulnerability in discussing the diverse consequences of environmental change. He describes vulnerability as a relationship between changing conditions and normal use-patterns and characterizes it as a function of susceptibility (the extent to which the presence of water will affect inputs or outputs of an activity); dependency (the degree to which an activity requires a particular good as an input to function normally); and transferability (the ability of an activity to respond by deferring demand, using substitutes or relocating). These characteristics are central in discussing the consequences of environmental change. Cannon (1994); Downing (1991); Liverman (1990) in examining the factors that contribute to vulnerability, enumerated social relations (particularly race, ethnicity, class, and gender), institutional characteristics, demographic attributes (such as age and reproductive status), individual decision-making and perception, types of technology employed, and political-economic relations.

2.23 Carrying Capacity of Life-Support Systems

Among the threats to the environment, the most central is the consequence effect on the ability of the life-support environment to sustain human life or itself over a long-term; Life-support system according to Kasperson *et al* (1995) is sometimes expanded to include such concepts as basic functions, basic needs, and human well-being. In a broader sense, life-support system is understood to incorporate the environmental resources that sustain the economy. These include ecological elements such as water, land and air - that provide the basic needs that support life in the surrounding environment. More insightfully, Stewart (1985) and Streeten (1980), include non-environmental attributes such as participation, political rights, cultural identity, and a sense of purpose in life as basic needs. This implies that literature on life-support systems strains definitional limit by opening to cascading sets of issues such as ‘basic needs’ that are neither environment-based human needs, nor measurable at this time.

Measurement of basic needs and quality of life views life-support capacities of the nature-society relationship from the social side. Beginning on the physical side,

researchers have used various measures to indicate the degree of change in the environment or the consequent decline in productivity in order to identify areas whose life-support systems are threatened. The variables measured include species composition or biodiversity, crop production, and land/ground cover that translate into a decline or increase in human wealth or well-being (Kasperson et al, 1995).

Environmental degradation often undermines life-support systems in a variety of ways. The first case is the continuous mining of a finite resource, such as coal or oil. Severity manifests when the resource becomes scarce or depleted when there is limited knowledge of the resource base, market constraints, and/or technological limitations. In the second case, criticality occurs after the rate of exploitation of a renewable resource (e.g. soils, groundwater, fisheries) exceeds the rate of renewal. The third case reaches criticality when the demand for disposal exceeds the assimilative capacity of the environment. It can therefore, be inferred from the foregoing discussion that though human welfare and the environment are fundamentally related, the relationship is complex. Declines in human well-being may even occur for reasons entirely unrelated to environmental degradation. Taken human welfare indices alone would be inadequate to underpin the judgement of environmental criticality as it may be purely physical measures of change.

Examining the factors that undermine the capacity of life-support system such as, severity due to resource depletion or limited knowledge , excess consumption over regeneration capacity and excess disposal over assimilative rate, Daly (1990) puts forward the basis to begin to operationalize notions of sustainable development using three guidelines: (1) rates of harvest should not exceed regeneration rates (sustained yield); (2) rates of waste emissions should not exceed the rates of the assimilative capacity of the environment; and (3) for quasi-sustainable use of non-renewable resources, the harvest of these resources should be paired with compensating investment in a renewable substitute. Mismatch/Gaps in these relationships suggest differing situations in which trajectories in human-environment relations may lead to severe condition that may incapacitate productivity of the biophysical entity, limit the environmental resource-use and reduce the socio-economic well-being of the support communities.

Jodha (1992) posits that it is possible to deplete resources within an area without major social consequences as long as the deficit can be made up from elsewhere, hence, the exogenous linkages of an area with other regions are of no small importance. He further states that most regions are sustained to some degree by inputs from elsewhere and for a region whose economic base is substantially disconnected from local physical resources, even substantial transformation of the environment may pose little threat to its life-support system. On the other hand, in a regional economy that depends on regional natural resources, its rates of depletion will exceed that of natural replenishment; which may progress to severity if the costs of resource substitution through imports become so high as to make the linkage unsustainable. A region's consequences of environmental change would enter a state of severity if its environmental change undermines the productive activities that sustain its population to the point that the costs of substitution for essential inputs from outside can no longer be sustained. In addition to the above, if no feasible societal responses that are capable of mitigating an ongoing degradation are put in place to sustain the same level or quality of habitation (as influenced by size of population and level of human well-being), the environmental change will eventually reach a critical state.

Since this investigation seeks to analyze the implications of urban physical expansion of Damaturu on its rural land use (environmental life-support resources), it is designed to address not only the pattern, forces and magnitude of environmental degradation but also the stakeholders who are contributing to the urbanization processes that is shaping the change within the region.

2.23.1 Implications of Environmental Resource Depletion for the Future Generation

Different studies have universally concluded that the present rate of consumption is rapidly drawing-down the capital held in nature and reducing the resources available to future generations in meeting their needs and aspirations. These intergenerational cost impositions occur in three major ways: (1) depletion of resources; (2) degradation of environmental quality; and (3) discriminatory access to the environmental resources and resource-benefits enjoyed by previous generations. In proposing an innovative set of principles to guide intergenerational equity, Weiss (1990:7) argues that:

Every generation receives a natural and cultural legacy in trust from its ancestors and holds it in trust for its descendants. This trust imposes upon each generation the obligation to conserve the environment, natural and cultural resources for future generations. The trust also gives each generation the right to use and benefit from the natural and cultural legacy of its ancestors. These rights and obligations, which may be called planetary rights obligations, form the corpus of a proposed new doctrine of intergenerational equity in international environmental law.

2.24 Conceptual model

The study of regional environmental changes addresses the fundamental issue of rural land use changes, natural resources and the capacity of the environment to assimilate wastes and resource-demand of the population. In most cases, environmental change has occurred as a result of excess consumption over regenerative capacity of a life-support environment due to disregard to physical space conditions and limiting characteristics of natural resource such as fragility, marginality, irreversibility among others. Such semi-arid characteristics are interrelated in terms of common biophysical causes or shared consequences, which obstruct a clear separation of the relative influence of the forces that drive environmental degradation.

The theories and concepts that have been discussed in the preceding section have enhanced a broad understanding of the processes associated with society-environment relationships that lead to physical environmental changes and how they undermine the capability of life-support environments in various ways. The theories and sets of concepts have also helps to anchor and explain how environmental changes limit the capacity of the society to respond either through substitution in the productive system or through additions to the buffering capacity of the ecosystem to sustain a nature-society relationship. The human driving forces of change such as, population growth rate, its space and resource demand, market integration, and technological as well as institutional interventions, have not only operated simultaneously, but some have also reinforced the impacts of others. For instance, new technologies enhanced resource extraction capacities and accelerate the population pressure on natural resources, leading to overexploitation of natural resources. Population-induced poverty prompted increased state intervention through welfare and development activities, which in turn, focused on infrastructure and

the market integration with other regions. Similarly, state policies and market forces have helped each other to produce higher resource extractions that produce adverse environmental consequences.

Next is the scale of consequence of forces behind the change, which owes partly to the interrelationships and partly to temporal and spatial lags between causes and effects. The operation of various proximate causes and basic driving forces is more visible at the macro than micro level. Consequently, a precise one-to-one association between the driving force of change and its impacts is difficult to capture at a micro level, yet some idea of the relative role of different driving forces emerges from the distribution of proximate causes of environmental changes.

The theories and concepts facilitate the explanation of the causes and dynamics of rural land use and resource depletion in Damaturu region in relation to the changes arising from nature-society interaction. The driving forces that facilitate the changes in the region (population growth and its demands, technological innovation and institutional rigidity) have combined to produce more negative than positive outcomes for both human-beings and nature. The study assesses the consequences and degrees of severity such as the resultant rural land use conversions, resource depletion and reduction in the socio-economic well-being. It also assesses the perception of the urban expansion, its implications and responses to the rural land use conversion. It also examines the coping strategies and planning policy implications on the environmental resources and socio-economic well-being of the rural residents.

2.24.1 Components of the Conceptual Model

The causes and consequences of human-induced environmental change are not evenly distributed over space. They converge in certain regions where their impacts threaten the long-term or even the short-term sustainability of human-environmental relationships. The changes vary depending on the dynamics of the causatives, which take different forms and arise from different circumstances in diverse regional context. An integrative approach to environmental change assessment must examine theories and concepts that explain the nature-society relationships. These theories and concepts underpin studies on the earth's carrying capacity, city expansion, environmental injustice and justice, ecological resilience, life-support systems and societal response systems among others.

Environmental change depends on these basic properties of human-ecosystem interactions, and in conceptualizing its model, an assessment of the human and physical factors that are concerned with the level of change and the ability of the ecology to cope with the stress and to continue functioning or supplying its inevitable ecological services.

The sensitivity and fragility characteristics explain several considerations useful in conceptual models of urban expansion and environmental change. Such models are used to explain environmental changes at local and global levels by assessing the interaction of multiple elements in human systems such as population, economic growth, pollution and resource depletion. It is therefore necessary that both human and physical changes require assessment for establishing causal relationships (driving forces) at varying degrees of disruptions. In this context, this research is particularly interested in human-induced stresses that erode irreversibly, the extent of rural land use tending to make the environment incapable of supporting human productive systems and life.

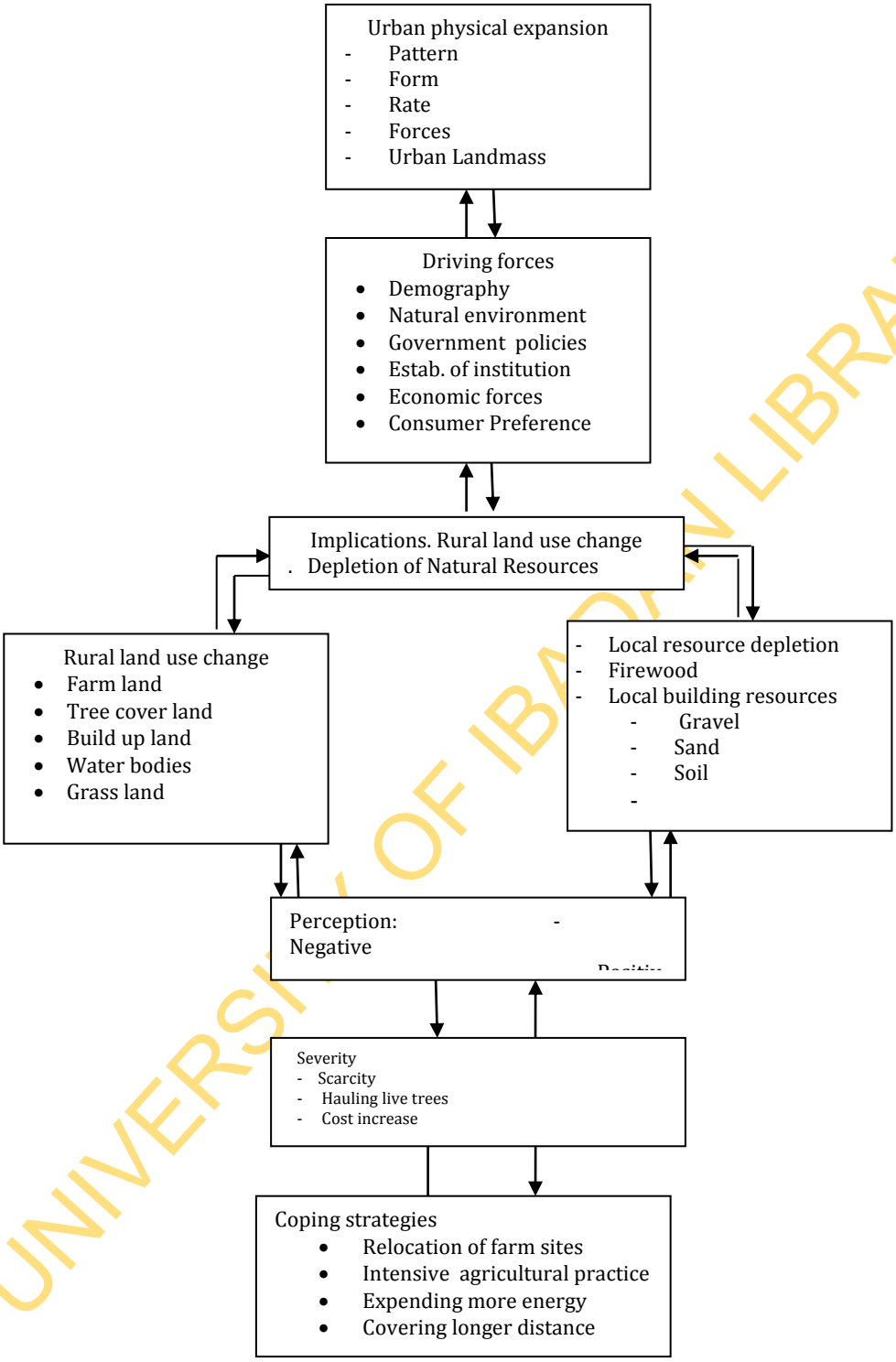

Fig 2. Society – Environmental Relationship

Source: Turner (1995) adapted and modified after Turner 1976.

CONCEPTUAL/ THEORETICAL FRAMEWORK

CHAPTER THREE

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design

The study of urban physical expansion of Damaturu and the implications on surrounding rural land use and resources employs a survey research design to enable the researcher to generate quantitative data from the primary source on the key variables. The variables generated for this study best represent the area and generated data sets that provided answer to the research questions and also capture the research objectives. The key variables are urban expansion pattern, driving forces of the expansion, the dimensions affected by the expansion, implications on rural land use, local building resources, severity index, the perception by the respondents and the coping strategies.

3.2 Methodology

The magnitude of data that are used in planning is enormous and complex, occurring in spatial and temporal scales. The process of collecting data for this investigation involves identification of data type and sources, determination of sample frame and size, sampling procedure, tools with which data can be sourced, specified, defined, processed and analyzed. This section of the research presents the data sources described in details, the methods as well as instrument used in data collection and analysis with a view to capturing the research aim and objectives on one hand, and unbundling the research problem and aiding decision rule while testing the hypotheses on the other hand.

To ensure the collection of appropriate data, the researcher identified and collected data on variables that orchestrate abrupt land use and land cover changes due to urban physical expansion, rather than gradual changes that are components of natural on-going process of change.

Various methods of detecting environmental changes had been identified. These include image differencing (Toll, 1980), image rationing (Nelson, 1983); pre and post-classification comparison method (Howarth and Wickware, 1981), masking method

(Pilon, Howarth, Ballock, 1988) and Principal Component Analysis (Fung and LeDrew, 1987) among others. However, to accurately and consistently measure the urban physical expansion in quantitative terms, remotely sensed data sets (land sat images of 30m and 32m moderate resolutions for 1986, 1999, 2005 and 2009 respectively, were acquired with heterogeneous land use components for analysis of spatio-temporal change detection of rural land use and land cover changes.

Remote sensing data, provides consistent historical time series data with physical and temporal processes of urban expansion and land use change. Remote sensing imagery also provides synoptic view with high physical and temporal accuracy that revealed land-use changes, land cover encroachment, and expansion of urban infrastructure (Lillesand, Keiler, Chipman, 2008; Herold, Goldstein, Clarke, 2003). It captures for analysis, the physical components in their heterogeneous pattern such as diversified agricultural cultivation, new urban development, and encroachment on rural land use pattern and agricultural land (Yeh and Li, 1997.; Webster, 1995.; Mesev 2003). Furthermore, Yeh *et al* (1997) observe that the combination of remote sensing with spatial metrics provides more physically consistent and detailed information on urban expansion and rural land use changes than either of these approaches used independently. The methods of data sourcing include procurement of map-input data to detect the existing environmental and rural land use status and reconnaissance survey to observe changes that have taken place on ground. Another method is administration of questionnaire to collect data on human activity variables that are not visible on image, such as methods of resource harvest and use, socio-environmental consequences and their severity indices.

3.3 Data Type, Sources, Instruments and Analysis

3.3.1 Research Data

This study collected and analyzed secondary and primary data that provided answers to research questions and realize the objectives as well as aid decision rule on the framed hypotheses.

3.3.2 Secondary Data and Sources

The secondary data are the remotely sensed data, map inputs and literature materials that relate to urban physical expansion. The four imageries were the 1986

Landsat imagery, which was acquired by Global Land Cover Facility (GLCF) on October 2, 1986, the 1999 and 2005 were acquired on November 11, 1999 and October 30 respectively. However, the 2009 (Nigerian Sat 1) image was mapped on January 01, 2009 by National Air Space Research and Development Agency (NASRDA). From these imageries, the relevant themes were identified based on their registered spectral signatures and were extracted in line with the need of the research. The geometric rectification process had been carried out by the companies that acquired them using image enhancement to improve the visual interpretability of the image. Contrast stretching and false colour composites were performed to increase the apparent distinctions between the features. The Land sat imagery by Global Land Cover Facility are 30m resolution, while the Nigeria's sat1, by National Air Space and Research Development Agency (NASRDA) is of 32m resolution, both of which are high enough to provide information on urban physical expansion, land use changes and resource exploitation. These imagery data provided information on the rate and the extent of the urban expansion and how it has affected the rural land use pattern and revealed the periodic rural land use loss to urban expansion, depletion of natural resource, differentiated the types, sites and other aspects including data on abandoned, existing sand mines, and their distances, periodic rural land use conversion, fire-wood resource and local building resource depletion.

3.3.3 Image Classification

The image was classified according to its multispectral property. The process included sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. Whenever a pixel satisfied a certain set of criteria, the pixel was assigned to the class that described and depicted a particular rural land use change in Damaturu. This process is also referred to as image segmentation.

Based on the information needed for spatial analysis in this study, information on built up areas was extracted from the original data; the classes were associated with known features on the ground. This is presented as output of the maps showing different rural land use/cover classifications such as built-up areas, area under forest/tree cover land, bare land, shrubs with dominant grasses, water bodies and farmlands in Damaturu and its environs.

3.3.4 Supervised Classification

Supervised training was closely controlled by the analyst. In this process, pixels that represent patterns or land cover features that were recognized with the help of other sources, such as aerial photos, ground truth data, or maps were selected. Knowledge of the data and of the desired classes was helpful for classification. With successful pattern identification, the computer system was instructed to identify pixels with similar characteristics. This was employed to ensure accurate classification. The resulting classes are presented in figures 5.1; 5.2; 5.3; 5.4 and 5.5.

3.3.5 Sample Set

Prior to an image classification, sample pixels or training pixels were selected in a sample set. A sample set was created through map list and a domain was specified and class-names were assigned to groups of pixels that represented classes of rural land use such as built up areas, farm areas on the ground and other similar pixels that have similar spectral values in the map list. A sample set has two components (i) a reference to a map list, which is the set of images employed to classify images employed in this study. The spectral values of the images in the map list, at the position of the training pixels provided the basis on which conclusions were made in the classification. During sampling, these values were inspected in the sample statistics of each class of training pixels, and were visualized in feature spaces and (ii) a reference to a class domain, (which is the collection of class names that were assigned to the training pixels), was obtained from the classification. The representation of this domain determines the colors the training pixels displayed during sampling.

Another aspect of secondary data was population in the local government under study, which was acquired by the National Population Commission, Yobe and Borno State offices. The researcher collected the data on population in the study area from these authentic sources.

3.4 Primary Data

The primary data (raw data collected on the field through observation, administration of questionnaire) collected enhanced the researcher to analyse the forces of urban expansion, its perception, severity and the emerging coping strategies. It also

sampled the actions of the resource merchants who have been contributing to the urban expansion processes and influencing the rural land use change within the region.

3.4.1 Field Observation: The observational tool was employed to supplement the data acquired through questionnaires; the researcher made use of photographs and scanned objects to corroborate data presentation and findings.

3.4.2 The Questionnaire Method

In order to collect relevant data from the target respondents, two sets of questionnaire were designed and administered. The first questionnaire, which was administered on the household heads in the 24 sampled settlements, enabled the researcher to assess the perception of the implications of rapid urban physical expansion on the land uses and livelihood of the villagers. These were used to supplement the results of the remotely sensed and cartographic map. The items on the first questionnaire generated quantitative data on the socio-demographic variables (population, age, gender, income), the forces, the perceived implications, severity indices. It also helped in identifying the coping strategies.

The second questionnaire was designed to elicit data from the resource-merchants such as their population, methods, daily quantity harvested, distances to resource sites, abandonment and treatment of resource sites and so on.

3.4.3 Sampling Procedure

In order to achieve the aim of this study through a representative data collection from the study population, the Local Government Areas surrounding Damaturu city (Damaturu, Tarmuwa, Fune, Gujba and Kaga) were purposively selected out of the 17 local government areas; while the four major roads linking Damaturu with the neighbouring states provided the basis for subdividing the study area into four zones. Settlements in each zone were grouped into three based on distance from Damaturu(<15km; 15-30km; >30km). Two settlements were randomly selected from each group and the clustered sampling elements were randomly sampled. Two sets of questionnaire were administered to the target population (household heads and fire-wood merchants/local building resource merchants) to elicit information on socio-demographic

characteristics (population, age, sex, income), perception of urban expansion (positive or negative), implicating changes on rural land use (segmentations, modifications, total conversion), rural resource depletion (fire-wood, local building materials) and severity index. Observing that the driving forces of urban expansion and their consequences may not significantly vary within the study area, the researcher sampled 5% (409) of the 8,187 residential buildings in the 24 selected settlements from which household heads were randomly sampled using questionnaire. Similarly, 10% of 351 fire-wood merchants, 652 local building resource (soil, sand, gravel) merchants were randomly sampled with the assistance of the chairmen of the associations. Imagery data collected were analysed using GIS (Ilwis3.6) software. Pre- and post-classification comparison methods were employed to measure the changes of bare surface land, built-up area, tree-cover area and water-bodies. Data were analyzed using descriptive statistics, weighted opinion assessment and Severity Index (SI) at $p<0.05$ significant level. The choice of six settlements from each zone was arrived at because that was the maximum settlements in North-east zone of the study area that had the specified population and resources, and to maintain equal number of settlements with resource sites from each zone. The procedure considered three settlements within Damaturu local government area (within 15km) and another three (more than 15km) from the neighbouring local government as presented in (Map 1.3).

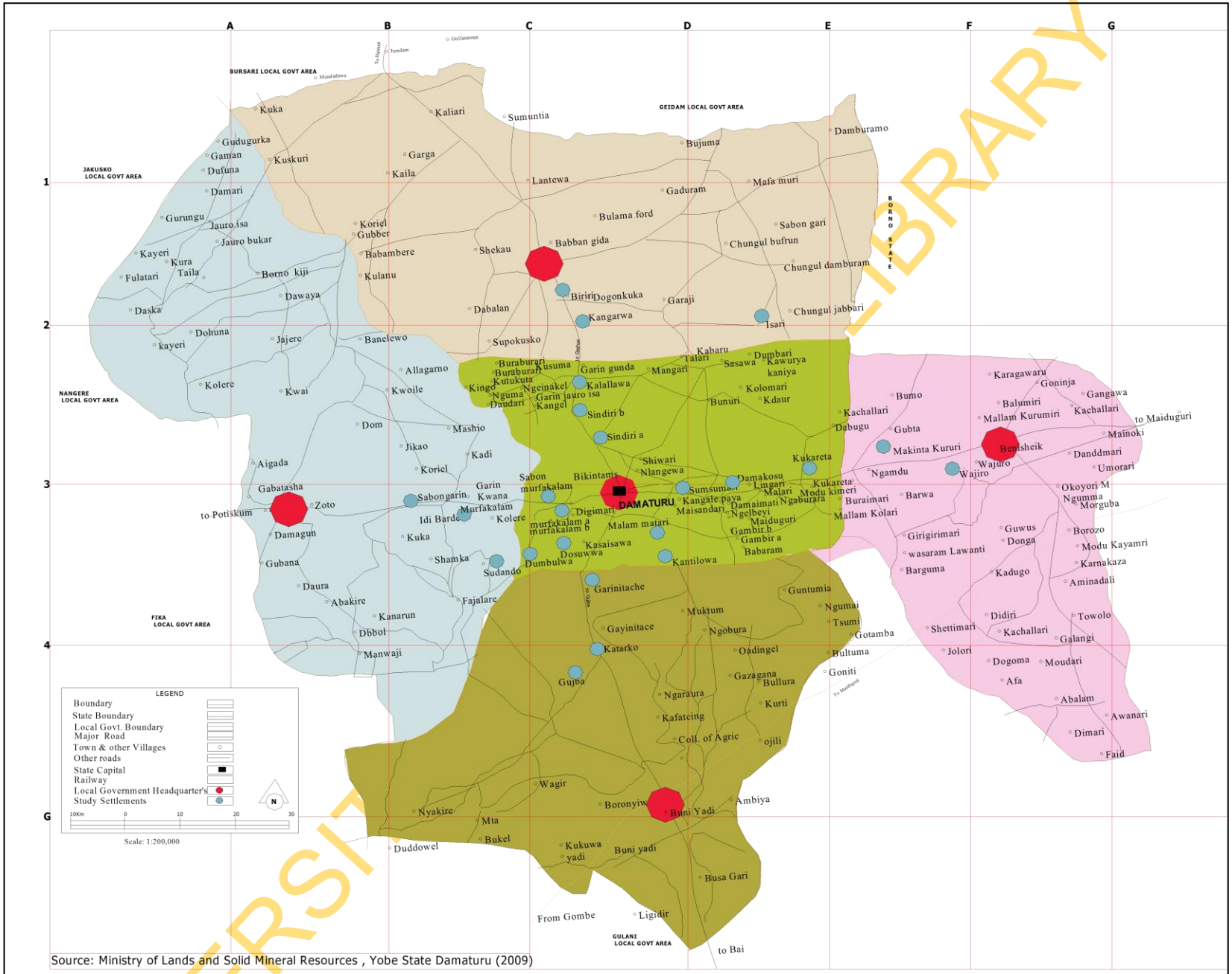

Fig 3.1: MAP OF LOCAL GOVERNMENT HEADQURTERS AND THE SAMPLED SETTLEMENTS

This gives a total of 24(12%) sampled out of the enumerated 204 settlements. In terms of index of size measurement, 13 were hamlets that occupied between one to five hectares, eight were villages covering five to ten hectares, one was a medium class settlement occupying 10-15 hectares and two were high class settlements occupying more than 15hectares.

Similarly, 8180 residential buildings in the settlements were enumerated and 5%(409) were selected from which household heads were randomly sampled. This implies a combination of clustered sampling methods and random. Besides, 10% of 351 fire-wood merchants, 652 local building resource (soil, sand, gravel) merchants were randomly sampled with the assistance of the chairmen of their associations to generate data on variables that could not be captured by remote sensing.

Table 3.1 Population of the selected local government areas

S/No	Local Government	Total population	Urban population	Rural population
1	Damaturu	100, 998	65, 494	35, 502
2	Fune	333, 457	20, 146	313, 311
3	Gujba	144, 230	36, 890	107, 340
4	Kagga	103, 272	14, 030	89, 242
5	Tarmuwa	88, 593	7, 233	81, 360
	Total	**770, 550**	**143, 795**	**626, 755**
	Percentages		**19%**	**81%**

Source: NPC, 2006 projected to 2009)

Table 3.2 The Sampled Settlements

DAMATURU – KAGA ROAD

	Location						Resource				
S/No	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**	**S/No**	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**
1	DTR	Kukareta	2133	267	13	1	DTR	Sunsuma	632	79	4
2	DTR	Damakosu	3322	415	21	2	DTR	Demaimati	290	36	2
3	KGA	Ngamdu	15675	1959	98	3	KGA	Makintakuriri	1144	143	7

DAMATURU – GUJBA ROAD

	Location						Resource				
S/No	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**	**S/No**	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**
1	GJB	Gari-Itache	966	121	6	1	GJB	Gujba	2356	295	15
2	GJB	Buni gari	9911	1239	62	2	DTR	Malumtari	440	55	3
3	GJB	Katarko	3965	496	25	3	DTR	Kantula	721	90	4

DAMATURU – FUNE ROAD

	Location						Resource				
S/No	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**	**S/No**	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**
1	Fune	Ngelzerma	16247	2031	101	1	DTR	Dumbuluwa	690	86	4
2	Fune	Idi Barde	1228	153	7	2	Fune	Sudande	1054	132	6
3	DTR	Murfa	1314	164	8	3	DTR	Sabon-murfa	285	36	2

DAMATURU – TARMUWA ROAD

	Location						Resource				
S/No	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**	**S/No**	**L.G**	**Settlements**	**Pop**	**R.Bdg**	**5%**
1	DTR	Kalalawa	626	78	4	1	DTR	Sindri I	298	37	2
2	TMW	Kangarwa	430	54	3	2	DTR	Sindri II	165	21	2
3	TMW	Biriri	900	113	6	3	TMW	Isari	699	87	4
Grand Totals			**65491**	**8187**	**409**						

Source: (NPC, 1999, 2006 projected to 2009). KEY: DTR = Damaturu; GJB = Gujba; KGA = Kaga; TMW = Tarmuwa. R.Bdg = Residential Buildngs. Pop = population.

3.4.4 Questionnaire Distribution

A random sampling method was applied to sample the household heads living in the 8187 residential buildings in the 24 sampled settlements. This gave 409 questionnaires that were administered to the heads of the household. Another group of respondents that were classified into centres in their respective local governments were the resource merchants. These were stratified based on resource-type(fire wood merchants and natural building resources). In this group of respondents, 10% of the 1003 (351 fire-wood and 652 local building resources) of the two types of resource merchants were obtained and randomly sampled with the assistance of the chairmen of the associations. The distribution was proportionate to their population at each centre and local government headquarters. This excluded those who go to harvest for their domestic use. However, only 100 questionnaires were collected as presented in table 3.3.

Table 3.3: Questionnaire Distribution to Resource Reapers

S/No	Description of centres	Fuel wood		Building Sand		Gravel	Sand for backfilling	Granite	Total
		Man-powered Trucks	Vehicle	Bullock powered Trucks	vehicle	vehicle	Vehicle	Vehicle	
1	Gujba Rd	4	3	4	2	1	1	1	16
2	Gashua Rd	4	2	6	1	1	1	1	16
3	Potiskum	2	2	2	3	1	1	1	12
4	Tashan Tifa	0	0	0	10	1	0	1	12
5	Buniyadi	4	2	3	3	1	1	1	15
6	Damagum	3	2	2	2	1	1	1	12
7	Babangida	2	1	2	1	1	0	0	07
8	Benesheik	3	1	3	2	1	0	0	10
Total		**22**	**13**	**22**	**24**	**8**	**5**	**6**	**100**

Source: Fieldwork 2011

3.5 Data Analysis

Analyzing the implications of the rapid urban expansion on the rural land use and resources depends on the data collected on the study indicators. The analysis includes that of expansion pattern, the driving forces of the expansion; measurements of temporal land use change as captured through remote sensing, the implications of the change of rural land use and resources. As a framework to ease interpretation of the data, the study employed the pre- and post-classification comparison methods, which successively compare the selected study variables imaged at four different points in time. Remotely sensed data on features of the earth surface include built-up lands, grassland/shrubs areas, water bodies, forest vegetation, arable farmland areas, bare land among others. This analysis enhanced the classification of the changing degree of landscape elements of individual land uses, settlements and the overall change. It also quantified the expansion and change-variation of specific rural land uses between specific timeframes under study. Thus, analysis of the urban expansion and the implications in terms of land use (human activity or economic function associated with specific pieces of land), land cover (the type of feature on the surface and near-surface of the earth) were accomplished.

The Pre- and Post-Classification Comparison Method is one of the most widely used methods of change detection applications and it provides a complete matrix of change information (Jensen, 1996; Mas, 1999; Liu, Linderman, Ouyang, An, Yang, Zhang, 2001). Liu *et al.*, 2003). Martin (1989) finds that the comparative analysis approach of separately classified imageries produce a high level of change detection accuracy. The classified imagery of 1986, 1999, 2005 and 2009 were analyzed using a post-classification comparison method to generate a land use/cover change map of the study area. Three change detection tables for (1986 and 1999; 1999 and 2005; 2005 and Nigerian sat1 imagery of 2009) were produced from the imagery data. The change detection map based on the six land use/cover variables (Farmlands, forest lands, shrubs/grasslands, open space, built-up areas and water bodies) were produced by comparing the land use classes of the later dates with those of the previous dates. Cross-tabulation analysis was carried out to determine which land-use of the earlier date has been replaced by a new land-use and in what quantity. This helped to determine and explain the specific and overall physical land use changes under study. However, the

spectral signature for institutional, recreational, commercial and residential land uses that constituted the built-up area in Damaturu were not analysed in detailed. This is because the urbanized area was not the focus of this study, but the implications of the rapid urban expansion on the rural land uses.

The Landsat imageries used for analysis were those acquired in 1986, 1999, 2005 and 2009. For precision in the analysis, a GIS software (Ilwis3.6) was used to thematically classify the rural landscape elements. The updated 2010 cartographic land use map of Damaturu was used to present the extent of change and to complement the change detection and measurement in 2010. However, since the sensors do not record on-going human activities directly, the researcher used questionnaire tool for collection of data on socio-economic effects of the implications of rapid urban expansion on the rural land use. In analyzing the data quantitatively, descriptive and inferential statistics were used to analyse the data to supplement explanations of findings on the remotely sensed data. Descriptive statistics were used to compute the mean age and mean annual income from the frequency tables and the computation of the severity index of the consequences. Variables include demographic, (population, age, gender), socio-economic (income), opinion assessment, among others. From the tables, the empirical interpretations were also deduced and elucidated on the study variables based on the data presented. Options in the questionnaire items were rated 'a' to 'd' and attached values one to four in ascending order (the greater the score, the higher the effect). The response values were analyzed using Statistical Package for Social Sciences (SPSS) to explain the implications of the rapid urban physical expansion, the perceived implications and severity on rural land uses and resources. Other variables analyzed include the dimensions of the expansion, natural resource-use, socio-economic factors that influence people to embark on desperate resources depletion and environmental degradation.

The inferential statistics employed to test the hypothesized relationship between urban physical expansion and rural land use depletion; the nature and strength of the correlation using the Pearson Product Moment Correlation. The second hypothesis tested the relationship between the urban expansion and the decrease in area under forest in the adjoining rural environment. The third hypothesis tested if there was significant relationship between urban expansion and reduction in the size of farmland. Other

procedures applied in the process of hypothesis testing are the test of significance and the decision rule to accept or reject the computed results.

3.5.1 Questionnaire Items

Two sets of questionnaire were designed, administered and a total of 509 questionnaires were collected. One set was designed to collect detailed information on the implications of rapid urban expansion (the driving forces, the dimensions and severity) on rural land uses. The targeted respondents of this questionnaire were the heads of household in the study area. The second questionnaire was designed to collect data on rural resources (fire-wood, local building resources), the population of the resource merchants and the methods of abstraction. Also collected and analyzed were data on the demand, supply and cost, the rate of resource depletion, environmental conditions of mining sites among others. Items in each of the two sets of questionnaire were classified into sections, to address the key indicators. Variables were generated under each key indicator and there were options from which the respondents chose. The options for the questions were majorly 'close-ended' and 'open-ended'. The closed-ended types have four types of option-format, namely:

(a) The dichotomous options rated on (a) No = 0 and (b) yes = 1. The values chosen by the respondents were harvested into the statistical software for analysis.

(b) There were questions with multiple options (a-d). These options were arranged in ascending order and were attached values of one to four. The corresponding values of the option ticked were harvested for analysis.

(c) There were questions that demanded stating the degree of agreement, dislikes, adversity, severity or intensity of a variable, the options of such were arranged on a Likert scale to reveal the degree of magnitude or severity in ascending order. The variable values of one to four were attached in ascending order, and the selected values were gleaned and imputed for analysis.

(d) There were questions whose range of options was not exhaustive in scope given the limitation in the knowledge of the researcher. The researcher gave 'others' as the last alternative. The answers supplied in this 'others' option were thematically grouped and attached values for analysis.

(ii) There were open-ended questions that allowed the respondents to supply detail information in their expression. The answers supplied were classified into broad themes and range of options 'a' to 'd' with values one to four attached to each option, the preferred option by the respondents were extracted for analysis.

Part A: Socio-economic Variables

i. Gender: It is presented on a categorical scale with options (a) male =1 (b) Female = 0

ii. Age structure of respondents: This categorical variable was classified into four and assigned values (a) <20years of age =1 (b) 21 - 40 years =2 (c) 41-60 years =3 (d) >60 years =4

iii. Marital status: dichotomous variable (a) married =1 (b) unmarried = 0

iv. Educational qualification: categorical variable categorized into four (a) Arabic education =0 (b) Primary certificate =2 (c) secondary level =3 (d) Post-secondary =4

v. Occupational Distribution: This categorical variable was classified into five and assigned values (a) farming =1 (b) trading =2 (c) civil servant =3 (d) artisans =4 (a) others = 5

vi. Annual income from farm produce: Categorical variable categorized into six classes (a) 10,000.00- 20,000.00 =1 (b) 21,000.00- 40,000.00 =2 (c) 41,000.00-60,000.00=3 (d) 61,000.00-80,000.00= 4 (e) 81,000.00-100,000.00=5 (f) >1000,000.00 =6

Hypothesis 1

H_0 Rural land use change is not significantly related to urban physical expansion (Ha).

Urban physical expansion (km^2) = X- variable and Y = Rural land use ($Hectares^2$)

In hypothesis one, Pearson Moment Correlation Coefficient (PMCC) was used to test the relationship between rural land use decrease and urban expansion in the study area over time. It also tested whether there was either positive or negative correlation and if it

is statistically significant. The formula for the PPMC is $r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$ Where x = $\left(X - \overline{X}\right)$ and y = $\left(Y - \overline{Y}\right)$; and for statistical significance

$$t = r\frac{\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where **r** = the value of the correlation coefficient,

n = the total number of cases,

2 = the degree of freedom this is a constant since there are only two cases **x** and **y** in the correlation.

Hypothesis 2

H_0 Loss of area under forest (m^2) is not a function of urban physical expansion (m^2)

Physical expansion = X-variable (in km) and forest vegetation cover = Y variable in hectares

In hypothesis three, The Pearson Product Moment Correlation was used to test the relationship between the area under forest and urban physical expansion.

$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$ Where x = $\left(X - \overline{X}\right)$ and y = $\left(Y - \overline{Y}\right)$; and for statistical significance

$$t = r\frac{\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where **r** = the value of the correlation coefficient,

n = the total number of cases,

2 = the degree of freedom this is a constant since there are only two cases **x** and **y** in the correlation.

Hypothesis 3

H_0 Reducing size of farmland (Ha) is not a function of increasing built-up area (Ha)

In hypothesis four, the correlation co-efficient was used to test relationship between increase in the built-up area and loss of area covered by farm. The formula is

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$ Where x = $\left(X - \overline{X}\right)$ and y = $\left(Y - \overline{Y}\right)$; and for statistical significance

$$t = r\frac{\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where **r** = the value of the correlation coefficient,

n = the total number of cases,

2 = the degree of freedom this is a constant since there are only two cases **x** and **y** in the correlation.

3.6 Research Scope and Delimitation

3.6.1 The Scope

Rapid urban growth without efficient land use control and good governance that provide basic urban facilities as is the case of Damaturu has different consequences on the physical, economic and the social life of the people. The analysis of the implication of rapid urban expansion on rural land use in Damaturu is poised to examine the trend of urban physical expansion of Damaturu, the driving forces of the expansion, the emerging changes of the rural land use and natural resources, the consequences of the changes as well as the severity and the policy implication of the expansion on both aggregate and specific rural land use and land cover stability.

The researcher's choice of Damaturu and the surrounding local government areas for the study is due to the rapid urban expansion recorded in this semi arid region, and the intensive harvest of the scarce, fragile and marginal environmental resources in this low resilient ecological region that deserve careful resource management

3.6.2 Research Delimitations

Urban expansion affects social, economic and physical aspects of an ecological setting. This study focuses on the implications of urban expansion on the rural land use such as depletion of rural land (farmlands, Tree cover lands, grass lands, bare lands and water bodies), fire-wood as a resource for many rural residents and local building materials (sharp and plastering sand, local gravel). It investigates how the rapid urban

expansion has affected these as their source of livelihood and welfare of the respondents in the rural settlements.

The physical expanse was limited to five local government areas; namely Damaturu, Fune, Gujba, Tarmuwa and Kaga (Figure1.2). In terms of the study variables, the study considers built-up area, bare surface land, farmland area, shrubs/grassland area, tree-cover land and water bodies.

CHAPTER FOUR

4.0 THE PERCEPTION OF THE IMPLICATIONS OF THE URBAN PHYSICAL EXPANSION BY THE RESIDENTS

4.1 Introduction

This chapter elicited information on the socio-economic status and perception of the urban expansion and its implications on the rural land use changes that could not be captured by the remote sensing instruments. This has helped to understand the economic position of the population, their perception of the consequences and also explain the human-environment interaction that has led to rapid urban physical expansion and its growing severity. It also helps to explain the responses to the emerging degradation of the rural land and how these have affected the socio-economic well-being of the household heads (rural residents) on one hand and the well-being of the resources merchants on the other hand. Respondents' views and opinions emerged from their observations and perceptions of the physical conditions in the study area over time.

Questionnaire tool was used for data collection; the weighted opinion assessment method was used to weigh the opinion of the respondents on the urban expansion, changing rural land uses, its severity on the rural land use and socio-economic well-being.

(a) The socio-economic aspects include population and age distributions, educational status, occupational distribution and income earning opportunities that constitute the core livelihood-base and accessibility to local building resources as these may influence their perception of the urban physical expansion and its consequences.

(b) Natural resource variables include: rural land use, type of resources endowed, distances to resource sites, frequency of harvest and resultant depletion, mode of transportation, sites and road maintenance, and

(c) Dimensions and severity of effect on these variables such as the scope, spread and degree of severity.

4.2 Socio-economic Variables

The assessment of the consequences of urban expansion on socio-economic well-being requires ascertaining the population growth and structure, age cohorts, educational status, occupational distribution, proximity as these may influence their economic welfare and perception of the consequences.

4.2.1 Population Growth

Using the 2006 census as a basis for projection, it is observed from the population sources that the population of the study area has been increasing consistently with variations among the timeframes, according to 1991 census, the population increased from 363,131 to 435,432 (20%) between 1986 and 1991. From 1991 to 1996, it further grew from 435432 to 551580 (26%). From 1996 to 1999, it increased to 653214 (18%). From 1999 to 2001, it further increased from 653214 to 701558 (7.4%). From 2001 to 2005, it increased from 701558 to 718305 (2.4%); and between 2005 and 2009, it increased from 718305 to 770550 (7.3%). As the population was increasing, the urban demand for space to accommodate physical, infrastructure and economic facilities was also rapidly increasing, thus there was continual corresponding increase in the built-up area that was exerting implications on the rural land uses and natural resources.

Table 4.1 Population Growth of Damaturu and its Environs

Years	Population	change	Percentage
1986	363131		
1991	435432	72301	20%
1996	551580	116148	26%
1999	653214	101634	18%
2001	701558	48344	7.4%
2005	718,305	16947	2.4%
2009	770550	52245	7.3%

Source: NPC 2006 Projected to 2009.

4.2.2 Age Structure of the Heads House hold Respondents

The age distribution data show that 68.7% (281) of the respondents aged between 20-39 years. 7.1% of the heads of household are less than 20 years of age due to early marriage in the northern Nigeria. At least more than 75% of the population is below 40 years. The implication of this cohort being heads of house hold is that such young men of less than 20 years old and those in their early twenties, especially, in poor rural community clearly reveals that they had married early without acquiring appreciable education or not schooling at all. It is also likely that they will reproduce more children than those that marry at later age and will have many children, especially where family planning is negated on religious or other cultural beliefs. The fact that they did not attend schools means they are not educated for self-employment and cannot be employed in a well-paid job, but will be doing some menial work that cannot sustain their large families. The next cohort is ages 41- 60; this constitutes 20.8% of the respondents and is partly within the reproductive age. This explains the factors for the rapid population growth in the study area, the high unemployment level and the poverty-ridden nature. The mean age of the respondents is 35.27±12.98.

Table 4.2 Age Structure of Respondents

Description of Age	Frequency	Percentage
<20	29	7.1
20-39	281	68.7
40-59	85	20.8
60 and above	14	3.4
Total	**409**	**100**

Source: Fieldwork 2011

4.2.3 Educational Qualification

Data collected on their educational qualification of the respondents show that 49.1% (201) of the respondents have acquired only Arabic education. 19.6% (80), acquire only primary school certificates. By deduction, at least 68.7% of the respondents did not go beyond primary education. Thus, they may not have learnt any scientific environmental and ecosystem management. This implies low awareness, low human and intellectual skills for environmental management, low efficient rural institutions to effectively respond to the consequences of the urban physical expansion and unsustainable resource-abstraction and use. When a people employ indigenous norms that are based on cultural values that vary among societies and from place to place, environmental resource control becomes unbalanced as some people believe that all environmental resources are meant for consumption without limit, this leads to unsustainable use and ecological impoverishment.

Table 4.3 Educational Qualification

Educational Qualifications	Frequency	Percentage
Arabic	201	49.1
Primary Cert	80	19.6
SSCE/GCE	76	18.6
Post Secondary qualification	52	18.6
Total	**409**	**100**

Source: Fieldwork 2011

4.2.4 Occupational Distribution

In assessing the occupation of respondents (heads of households), table 4.3 shows that 46 % (189) of the respondents are farmers. This is a typical characteristic of rural settlements population. Farming of rain-fed crops in semi-arid zone is extensive, but do not yield sufficient produce to satisfy the consumption demand. The growing population in this region, given its agricultural practices, demands much land for agriculture. In contrast, there are adverse consequences of urban physical expansion which include rapid conversion of rural land uses (farm and forest lands) that has been negatively affecting their agricultural practices, economic and stability of their source of livelihood. The respondents are compelled to device other survival strategies such as sell of fire-wood, excavation of sharp sand and water using trucks and other grueling jobs that may not be environmentally-friendly. The population of respondents who are artisans and traders is 22.4% (92), which is very close to the total heads of household that are in the civil service. This explains the high illiteracy and the reason for embarking on menial jobs such as selling of water and fire-wood for survival.

Table 4.4: Occupational Distribution

Description of Occupations	Frequency	Percentage
Farming	189	46.2
Trading	64	15.6
Civil Servant	93	22.7
Artisan	28	6.8
Others	35	8.6
Total	409	100

Source: Fieldwork 2011

4.2.5 Annual Income of Respondents

Table 4.5 shows the classification of the income earned by the sampled farmers in the study area. This gives the picture of the total earnings and the well-being of farmers. The percentages show that the annual income of (43.2%) respondents is between 10,000.00 to 20,000.00 thousands naira. When the input is subtracted, their real income value will be less than 20,000.00 naira, which is seemingly insufficient for the up-keep of their large families. It is observed in the study area that many of the farmers and some of the low income earners have more than one wife and the practice of family planning is against their religious beliefs. This makes them to have large families; consequently, they usually engage in other menial jobs such as selling of fire-wood, water and also engage in street begging to augment their small income from their farm produce. This leads to over-exploitation of rural resources (felling of live trees, excavation of earth and sand mines) to earn their daily living. This has adverse implication on the environmental quality.

Table 4.5 Annual Incomes of Respondents

Annual Income of Respondents	Frequency	Percentage
10,000.00-20,000.00	181	43.2
21,000.00-40,000.00	93	22.7
41,000.00-60,000.00	64	15.6
61,000.00-80,000.00	35	8.6
81,000.00-1000,000.00	28	6.8
>100.000.00	8	2
Total	409	100

Source: Fieldwork 2011

4.3 The Perception of the Resource Merchants

Resource merchants comprise one of the components of the stakeholders whose environmental resources extraction activities are found to have influenced the environmental change and resource depletion. Consequently, a separate questionnaire was designed and administered to them. Through this set of questionnaire, data on their socio-economic activities, socio-environmental interaction in resource extraction, the severity of the consequences, the perception of the consequences and policy implication of such consequences on their environment and well-being were collected, analysed and presented in the frequency tables.

4.3.1 Age Distribution of Resource Merchants

Analysis of the data reveals that more that 34% of the respondents (resource merchants) are below 30years of age. This group that is within the school-going age is rather into this menial work. 8% of the respondents are below 20 years of age; while 26% aged between 20 -29 years. This explains the reasons for high illiteracy and poverty in the study area.

Table 4.6 Age Distribution of Resource Merchants

Age Description in Years	Frequency	Percentage
<20	8	8.0
20-29	26	26.0
30-39	22	22.0
40-49	24	24
>50	20	20
Total	**100**	**100**

Source: Fieldwork 2011

4.3.2 Educational Qualification

Analysis of the educational qualification of the resource reapers shows that 74% attended only Arabic school; (18%) have primary certificates. The implication of this low level of educational status on resource reaping is seen in the intensity of the unsustainable methods employed in abstraction of the natural resources as their core means of survival. This calls for the need to educate them on the symbiotic relationship between natural resources and other environmental components to sustain the biosphere.

The low educational qualification or status of the respondents and the dominant youthful age variables show that some teenagers of school-going age have rather taken to menial jobs, which implies that if no policy instrument addresses these low qualification and abandonment of schools by teenagers for menial jobs of natural resource extraction, the intensity of resource depletion will continue into the future.

Table 4.7 Educational qualifications

Educational Qualifications	Frequency	Percentage
Arabic	74	74.0
Primary Cert	18	18.0
SSCE/GCE	8	8.0
Total	**100**	**100.0**

Source: Fieldwork 2011

4.3.3 Number of Years Resided in the Study Area

Analysis of data on how long the resource merchants have been residing in the study area reveal that 42% have resided in the study area between 5-10 years while 28% are less than five years. This shows that many of the resource merchants have been on this job for long, either as a result of their love for it or for lack of alternative work. It can also be inferred from the frequency table that some of the merchants come from other neighbouring states and go back to their states after the peak season for the resource with which that they are trading. This makes their period of stay in the study area to be less than five years.

Table 4.8 Number of Years Resided in the Study Area

No of Years	Frequency	Percentage
< 5 years	28	28.0
6-10	42	42.0
11-15	4	4.0
16-20	26	26
Total	**100**	**100**

Source: Fieldwork 2011

4.4 Natural Resource Variable

4.4.1 Type of Natural Resource Supplied

In assessment of the type of natural resource being supplied, the table shows that (35%) of the respondents supplies fire-wood. This is partly because it is one of the resources that do not require high capital investment, which one can engage oneself to earn a living. About 46% supplies building sand (Soil, sharp and plastering), 8% supplies gravel, 6% supplies granite and 5% supplies other local building materials.

Table 4.9 Types of Natural Resources Supplied

Types of Resources	Frequency	Percentage
Fuel wood	35	35.0
Building Sand	46	46.0
Gravel	8	8.0
Granite	6	6.0
Others	5	5.0
Total	**100**	**100**

Source: Fieldwork 2011

4.4.2 Distances to Resource Sites and Quantity Supplied

The distance to resource sites and quantity supplied show that distances to resource sites have changed over the years. The changes vary with resource types and settlement locations. The respondents recognized this change in distance which is partly due to resource depletion and it is a likely contribution to the rising cost of the resources as more time and energy now reaps the same or even lesser quantity than before. The table shows increasing distances and a corresponding decrease in quantity of building materials supplied for each year under observation (1986, 1999, 2005 and 2009).

Table 4.10 Distances to Resource Sites and Quantity Supplied

Years	Average distance (in Km)	Quantity supplied (Tons)
1986	3	3.0
1999	8.5	3.0
2005	13.5	2.0
2009	18	1.0

Source: Fieldwork 2011

The trend of the two variables (the independent distance and the dependent quantity supplied) is graphically presented to show at a glance, the diverging and inverse trend over time (figure. 4.1).

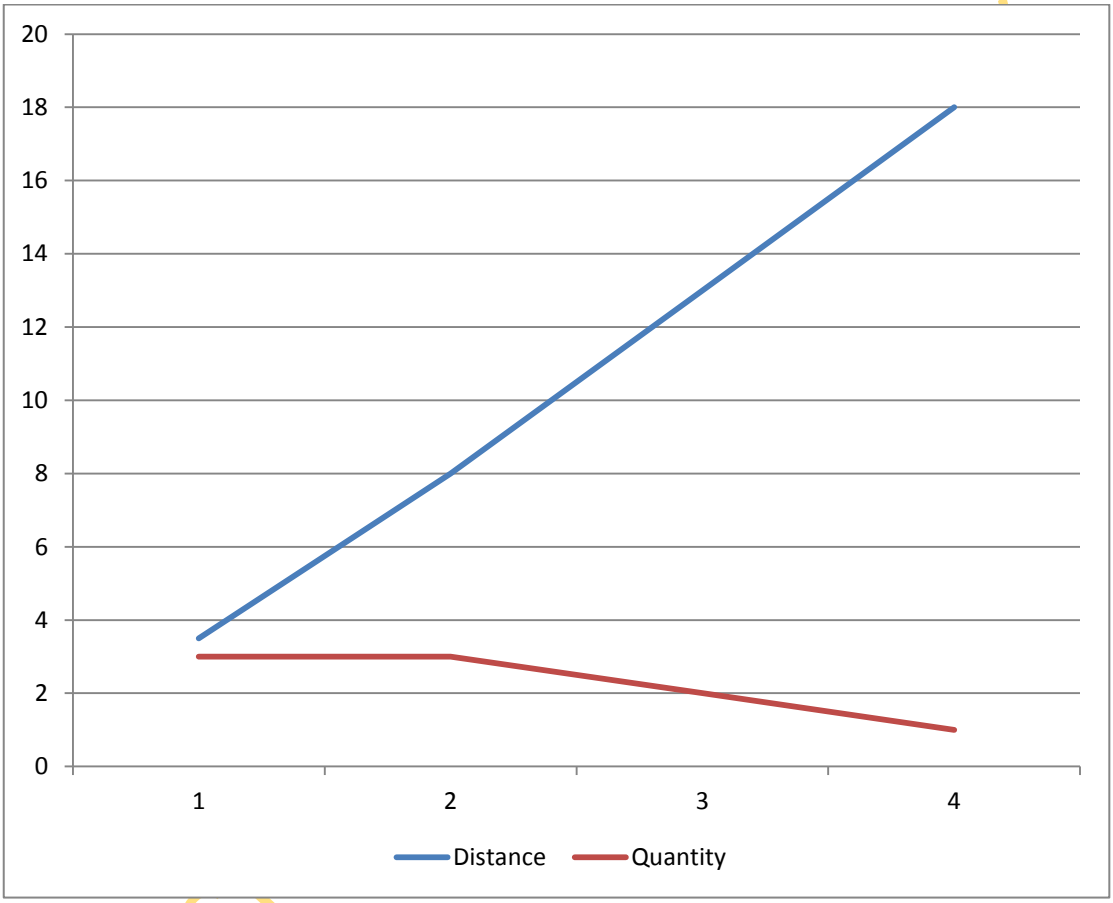

Fig. 4.1 Diverging relationship between distance and quantity of Building Materials supplied

The independent distance variable on the dependent quantity of local building materials harvested yield the equation y = -0.145 + 3.796 where R^2 = 0.91. This implies a negative trend (-0.145) and R^2 = 0.91 distance explains the change in quantity.

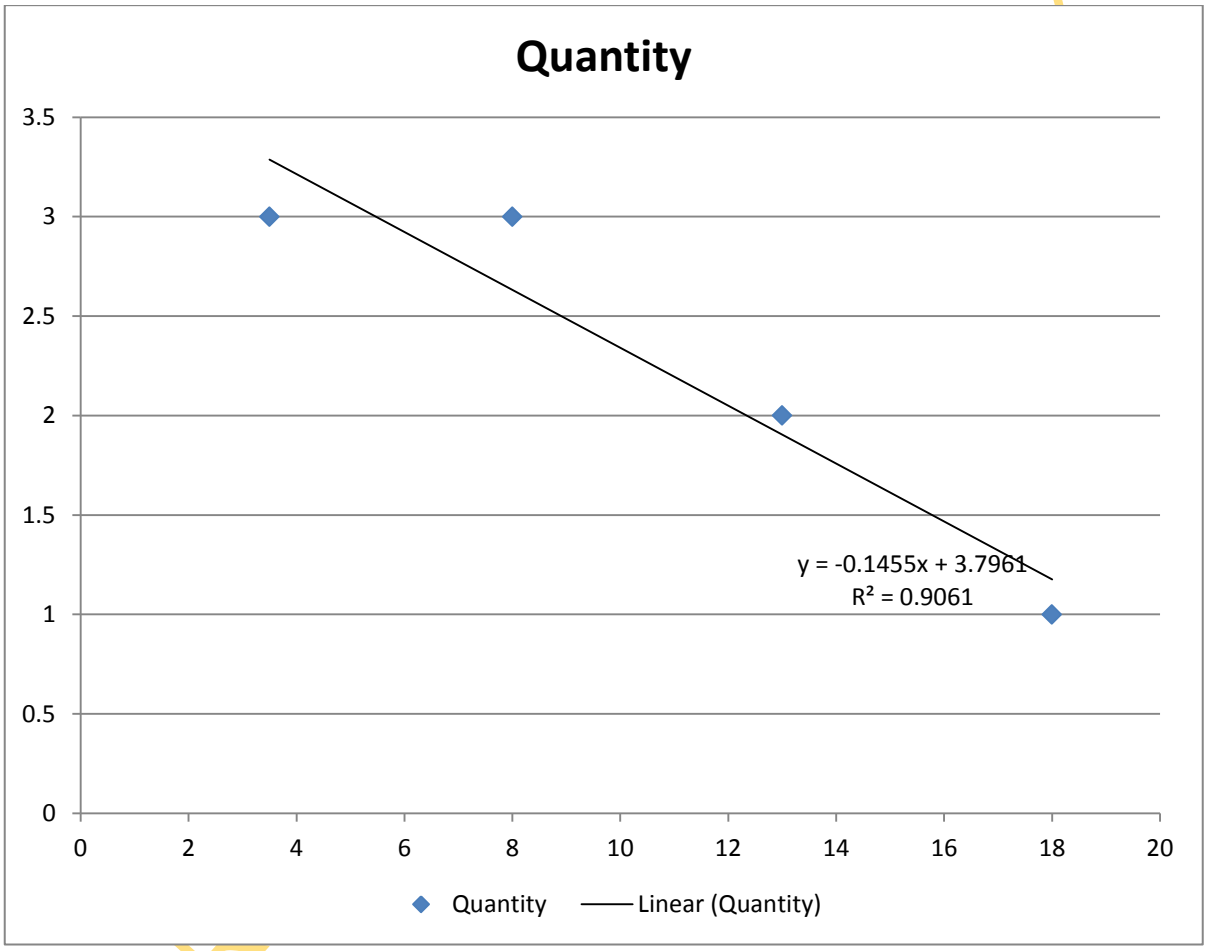

Fig.4.2 Increasing Distance and Decreasing quantity Supplied

4.4.3 Mode of Transport used for the Supply of Natural Resources

Natural resources are transported from the rural sites to the urban area using different means of transport such as man-powered, fuel-powered, bullock-powered and other trucks. This has implications on the supply capacity, income generation and road condition. In assessing the mode of transport used by the resource merchants, the following data were obtained; 42% indicates that they use man powered-trucks, this is majorly fuel-wood suppliers; 20% uses fuel-powered trucks, 32% uses tipper vehicles while 6% uses animal-powered trucks to convey the natural resources to the town for sale.

Table 4.11 Mode of transportation use for the supply of Natural Resources

Mode of Transportation	Frequency	Percentage
Tipper Vehicles	32	32.0
Fuel powered Trucks	20	20.0
Animal Powered Trucks	6	6.0
Man powered Trucks	42	42.0
Total	**100**	**100**

Source: Fieldwork 2011

4.4.4 Reason for Abandonment of Resource Sites

In abstraction of resources, a time comes when the resource sites may be abandoned for reasons such as the resource exhaustion, discovery of a better substitute, government ban on the harvest of a resource for conservation and for economic reasons among others. Observation shows that there are abandoned sites of earth-mines, sand-mines and depleted sites of fuel-wood. Assessing the factors responsible for abandonment of resource sites in the study area presents the decision in table 4.12. From the frequency table referred, 62% indicates that the abandonment was due to extinction of the resource, 20% indicates that it was due to government's ban while 14% indicates that it was bad road. The implication is that these untreated abandoned sites contribute to ecological degradation in the study area. The government's supervisory agencies seem to be weak in enforcing the rules regulating resource harvest and site treatment before abandonment.

Table 4.12 Reasons for Abandonment of Resource Sites

Reasons	Frequency	Percentage
Extinction of resources	62	62.0
Government's ban	20	20.0
Bad Roads	14	14.0
Others	4	4.0
Total	**100**	**100**

Source: Fieldwork 2011

4.4.5 Estimated Tree-Loss Due to Urban Expansion

One of the methods the researcher employed to assess the intensity of the consequences of resource depletion due to urban expansion was to estimate the tree-loss per acre in the study area. This method was used because there were no established standards of number of tree-stands per acre in the Sudan region in Nigeria. The researcher manually sampled the tree-stands at six areas of two hectares each at specific distances of 10, 20 and 30kilometres north and same distances south of the town. The researcher considered trees of at least three metres high with useable stems, trees that cannot be eaten up by grazing cattles and other herbivores and the following data was obtained: Grand Average 15 tree stand per hectare. This average is assumed for the whole study area, and the total rural land converted to urban within the period of investigation is 2,802. Multiplying this by the obtained average gives 42,030 tree-loss. The consequence of this huge tree-loss is significant given that the study area is located in a semi-arid region where it is difficult to grow plants and trees in particular.

Table 4.13 Estimated Tree-loss Due to Urban Expansion

Mode of Transportation	Estimated Tree – stand at Kilometre 10	Estimated Tree – stand at Kilometre 20	Estimated Tree-stand at Kilometre 30
Damaturu to Tarmuwa (North)	16	21	22
Damaturu to Gujba (South)	34	40	47
Average	12.5	15.5	17.25

Source: Fieldwork 2011

It can be seen also that each of the four zones in this study area has experienced significant environmental alteration through increased human use, but every zone also enjoyed some degree of improvements in per capita wealth and well-being, especially traders and those employed in the civil service. The common yardstick for judging the state of each zone is the sustainability of the present society-environment relationship and the severity of the consequences as well as the livelihood and management options available to current and future residents in the study area. These options vary with both the physical, institutional, governance and socio-economic environments. For example, the resource base may continue to be severely degraded if the regional economy is sufficiently robust to provide substitutes or if it becomes increasingly disengaged from dependence on the natural resources and sinks of the regional environment. However, no economy is infinitely robust, that is, if environmental degradation increases, a point must eventually be reached at which substitution becomes uneconomical. At this point, the assimilative capacities of the environment are exceeded, and/or the rate or scale of degradation outpaced the capacity of society to respond, which worsens the rural environment. In such cases, major restructuring or human adjustment is required, usually with severe, but transitory, impacts on human convenience.

4.5 Major Challenges to Urban Planning and Policy Implications

Content analysis of literature show that there are multitude of challenging reasons why traditional planning does not commonly and fully integrate and capture regional ecosystems changes. Such reasons include: (i) the dearth of data on the complex process of urbanization as it affects the regional ecosystem (ii) Data on the environment and boundary problem of the ecology of the fringe area (iii) lack of adequate information on the "value" and "place" of ecosystems in urban planning, and (iv) the interaction of climate change and cities (Kapperson *et al*, 1995).

The difficulties identified in the study area include: first, the challenges of implementing environmental policies in a community where the majority is not only illiterate and poverty-ridden, but the environmental resources are also not stable. The second is the weak or near-absence of rural institutions that will respond to the emerging consequences. Third is the weak urban development control and governance, while the

fourth is the absence of a regional development plan to coordinate the growth in the region. Last but not the least is the rapid loss of biodiversity through the removal of unaccounted environmental asset, through grazing, farming and felling of trees, which has long-term regional implication.

It suffices to emphasize the need for formulation of adequate regional planning policy and its effective implementation to adequately address these challenges. If there is no policy-review to reduce the time-lag between the occurrence of adverse environmental changes and the institutional or group response mechanisms, the consequential implications will continue to worsen large-scale resource-collapse and degradation of the regional environment and economy.

Another physical planning implications for the city, like many other cities is that, as it experiences rapid growth, the majority of new dwellings are being built on Greenfield sites at the urban fringe, thus, converting fertile green fields to urban use, with some of the conversions unplanned. Such emerging unplanned land uses are not only currently incongruous, but also not compatible to future land use planning and development. The study of the spatial growth of the city over the years has revealed that the built-up area has spread along the four main transportation corridors, namely; Maiduguri road, Potiskum road, Geshua and Buni roads. The investigation is not emphasizing that rural land uses should be held sacred, neither is it absolutely condemning urbanism, but the annual rate of (28.0%) expansion appears to have outpaced the planning of the town, and there is need to prudently regulate rural land use/cover conversion. In addition, the expansion is taking place where there is no regional development plan to integrate both rural and urban for a wholistic development. In terms of resource-use, policy interventions such as nationalization of forests, establishment of conservation areas, land banking, privatization of community pasture and forests to reduce urban access to natural resources may help in regulating resource-harvest and common property resources.

Therefore, it can be deduced from the content analysis that to meet the challenges of this rapid urban expansion, there is need to step up planning instruments such as demarcation of layouts, land use planning, control of development, sustainable natural resource management that will cope with the expansion rates or the pace at which the city

is being constructed and inhabited to produce future compatible development. Besides, the absence of current development plan that specifies land uses and integrates new development as the town is elevated to state capital has contributed to the nature of the urban layout. In summary, the investigation provided answers to the research questions raised earlier. The investigation begins with the patterns of change due to nature-society relationships in the study area and the generic issues connected with this pattern. It revealed the major human driving forces of change relating them to ecosystem vulnerabilities. It further assessed the human and the physical changes and the implications of these on rural land use and welfare. Furthermore, the investigation examined the societal perception of the consequences, the status of the institutional responses to emerging environmental degradation. It captures the sources of exploitation, timely response or delay, concern or neglect for land use and resource depletion, effective or ill-conceived adjustments and adaptations. Finally, it examined the copping strategies for the implications of the urban physical expansion.

CHAPTER FIVE

5.0 THE TREND OF URBAN EXPANSION, RURAL RESOURCE AND LAND USE CHANGES IN DAMATURU AND ITS ENVIRONS

5.1 Introduction

This chapter presents the analysis and results of secondary data (remotely sensed images and land use map). The first section presents the remotely sensed data, its findings and discussions. The imageries were acquired from the Global Landcover Facility (GLF) and National Air Space Research and Development Agency (NASRDA). The second part is the 2010 up-dated land use map of Damaturu, acquired from the town planning department of Yobe state ministry of lands and solid mineral resources.

In this first section, the first part presents the analysis of the imagery data for each of the four years selected and sampled for the study. Each later sampled year was compared with the previous one to detect the change and the results were presented as change detection tables. The researcher used Geographic Information System (GIS) software to analyze the imagery data and presented it in its processed form. The results are presented at four levels; the first being the analysis of individual images of the sampled years (1986, 1999, 2005 and 2009). The second level is the presentation of overlaid images compared progressively every two consecutively sampled years to bring out the changes between them. The extent of expansion in each sampled year is presented in figures 5.1; 5.2; 5.3 and 5.4. Change detection tables containing actual hectares and percentages of the various rural land use variables of every two consecutive years sampled are presented in tables 5.1; 5.2; 5.3 and 5.4. The third level overlaid figures 5.1 to 5.4 to produce fig. 5.5 and table 5.5. The fourth level used the 2010 updated land use map of Damaturu and computed the land use changes that occurred in 2010 (fig.5.6). The results are comprehensively integrated and discussed.

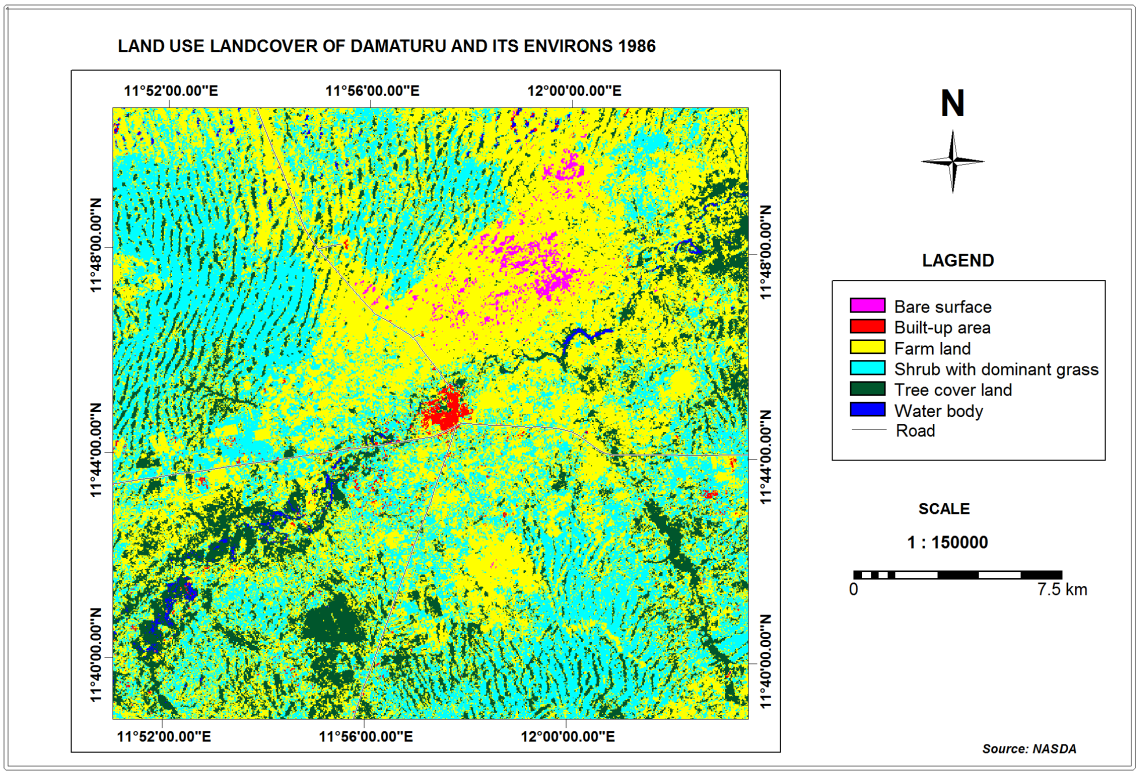

Figure 5.1: Land Use/Land Cover of Damaturu and its Environs 1986.

Source: Global Land Cover Facility

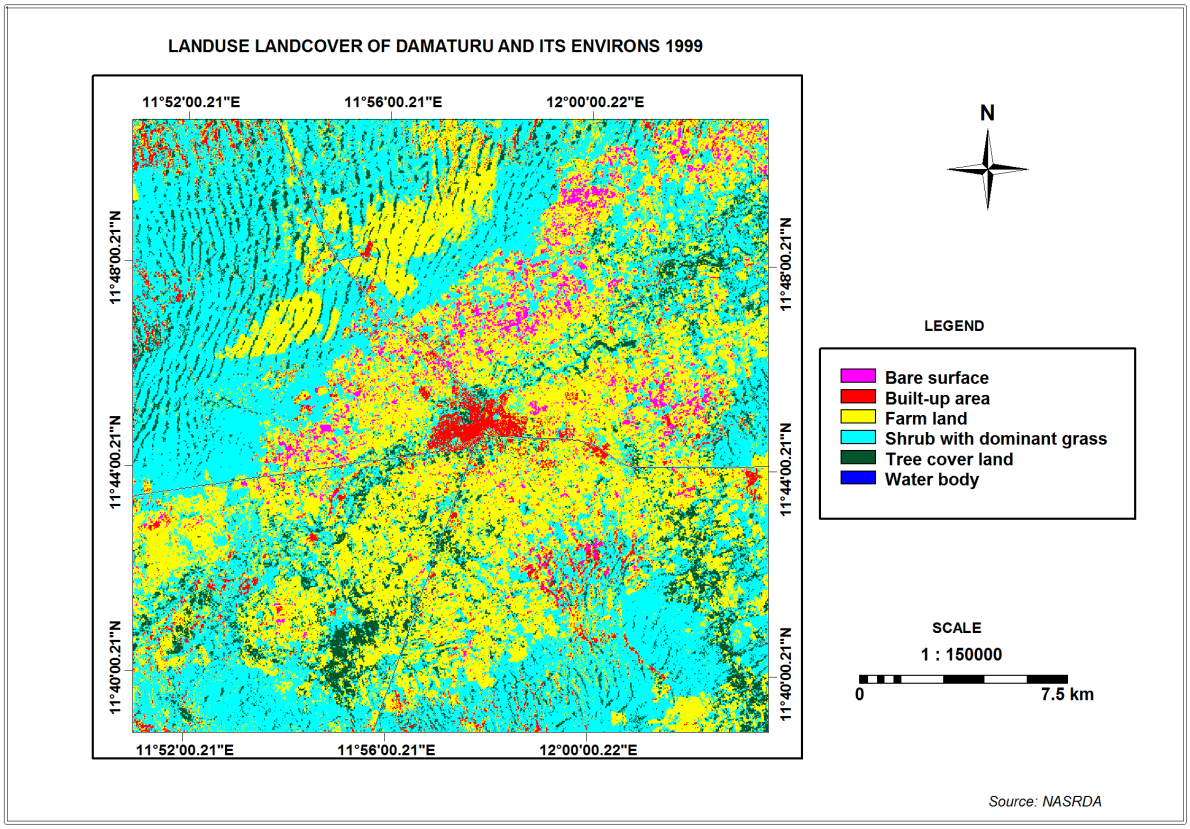

Figure 5.2: Land Use/Land Cover of Damaturu and its Environs 1999.

Source: Global Land Cover Facility

5.2 Comparison of 1986/1999 land use/land cover change of Damaturu and Its Environs

A comparison is made between the first (1986) and second (1999) sampled years; between the second (1999) and the third (2005) sampled years, and between the third (2005) and the fourth (2009) sampled years. This progressive comparison produced change detection tables between each period of comparison to obtain the emerging trend. The first comparison between 1986 and 1999 revealed that there was negative change in farmland by 17.8% (from 24237 to 199915.2ha). Tree-cover land decreased by 79.2% (from 8420.6 to 4597.8ha), while water bodies decreased by 49% (from 256.1 to 130.6ha). The reduction in farmland was due to large initial acquisition and conversion of lands for the establishment of ministries and other agencies that are needed in a state capital, while reduction in tree-cover land occurred because of high consumption of fuel-wood, felling of trees for civil construction and furniture as the population increased abruptly.

On the other hand, bare land surface increased by 221.1% (from 435.1ha to 1397.5ha); built-up area increased by 412.7% (from 398.6ha to 2045.9ha) while shrubs with dominant grassland increased by 33.3% (from 17009.4ha to 22670.1ha). The positive change in bare-surface is attributed to the change in status of Damaturu in 1991. This was the year Yobe state was created and Damaturu town was made the state capital. During this time, there was much land clearance for development of infrastructures in the state capital. There was increase in built-up area. Similarly, the shrub areas increased, because many of the farm areas that were taken over by government for development were left uncultivated, and the government had not developed these plots. Thus, the shrubs with dominant grass land increased. These increases negatively affected the rural land use, thus the reason for the overall rural land use decrease in the study area.

Table 5.1 Comparison of 1986/1999 Land use/cover of Damaturu and its Environs

S/No	Land Cover description	Area(ha)1986	Area(ha)1999	Change	%change
1	Bare Surface	435.1	1397.5	+962.4	221.1
2	Built-up area	398.6	2045.9	+1645.3	412.7
3	Farmland	24237	19915.2	+4321.8	17.8
4	Shrubs with dominant Grass	17009.4	22670.1	+5660.7	33.3
5	Tree cover land	8420.6	4597.8	-3822.5	79.2
6	Water bodies	256.1	130.6	-125.5	49.0

Source: Fieldwork 2011

5.3 Comparison of 1999/2005 Land use/cover Change of Damaturu and its Environs

The comparison between 1999 and 2005 based on the satellite data, presents positive (increase) and negative (decrease) values. Farmland increased by 28.5% (from 19915.2ha to 25582.7ha).This increase was because people who were dispossessed of farmland found alternative places and more civil servant joined in farming to augment their income. Similarly, built-up land increased by 37.1% (from 2045.9ha to 2802.4ha)

On the other hand, shrubs with dominant grassland decreased by 24.1% (from 22670.1ha to 17187.9ha). Tree cover land further decreased by 38.6% (from 4597.8ha to 2823.5ha) and water bodies decreased by 25.6% (from 130.6 to 97.1) built-up land expanded over farmlands, and farmlands in turn, encroached on forests areas in the face of increasing population. As more people got involved in the use of tractor services for hallowing, more rural land areas were converted to farming and farmland continued to increase significantly.

Table 5.2 Comparison of 1999/2005 Land use/cover of Damaturu and its Environs

S/No	Land Cover description	Area(ha)1999	Area(ha)2005	Change	%change
1	Bare Surface	1397.5	2262.9	+865.4	62.0
2	Built-up area	2045.9	2802.4	+758.5	37.1
3	Farmland	19915.2	25582.7	+5667.5	28.5
4	Shrubs with dominant Grass	22770.5	17187.9	+5482.2	24.1
5	Tree cover land	4597.8	2823.5	-1774.3	38.6
6	Water bodies	130.6	97.1	-33.5	25.6

Source: Fieldwork 2011

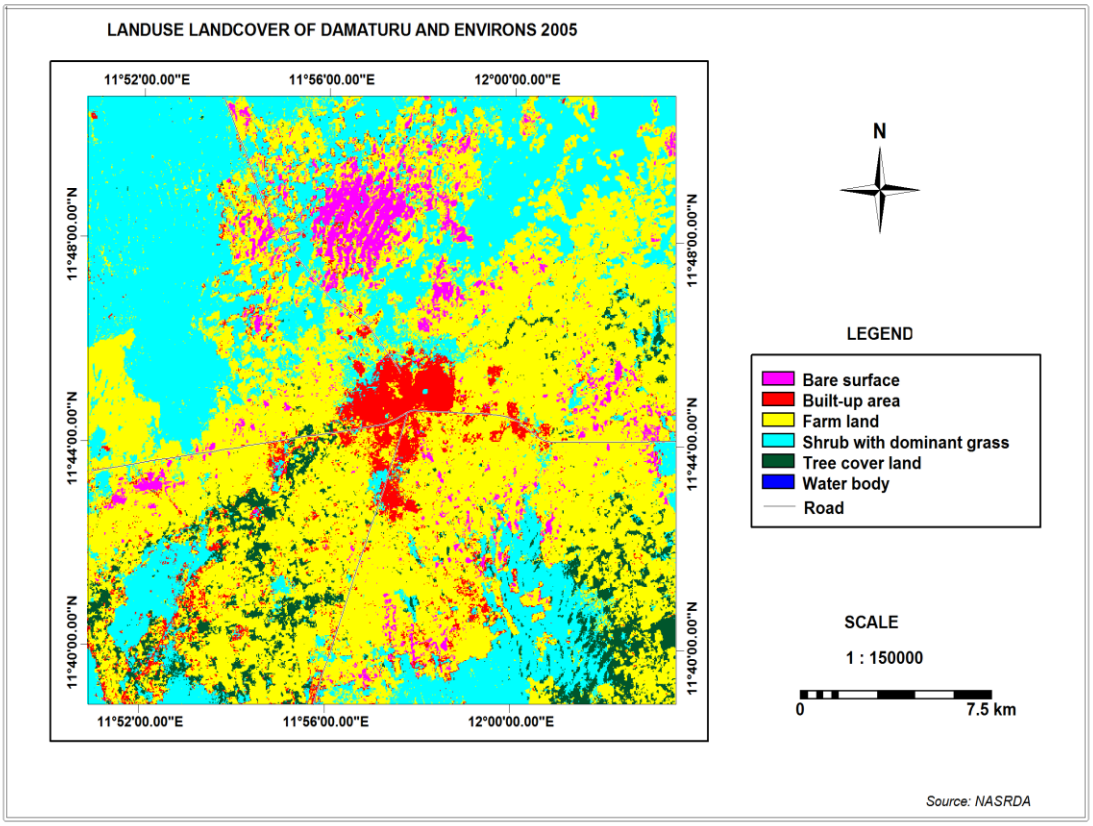

Figure 5.3: Land Use/Land Cover of Damaturu and its Environs 2005.

Source: Global Land Cover Facility

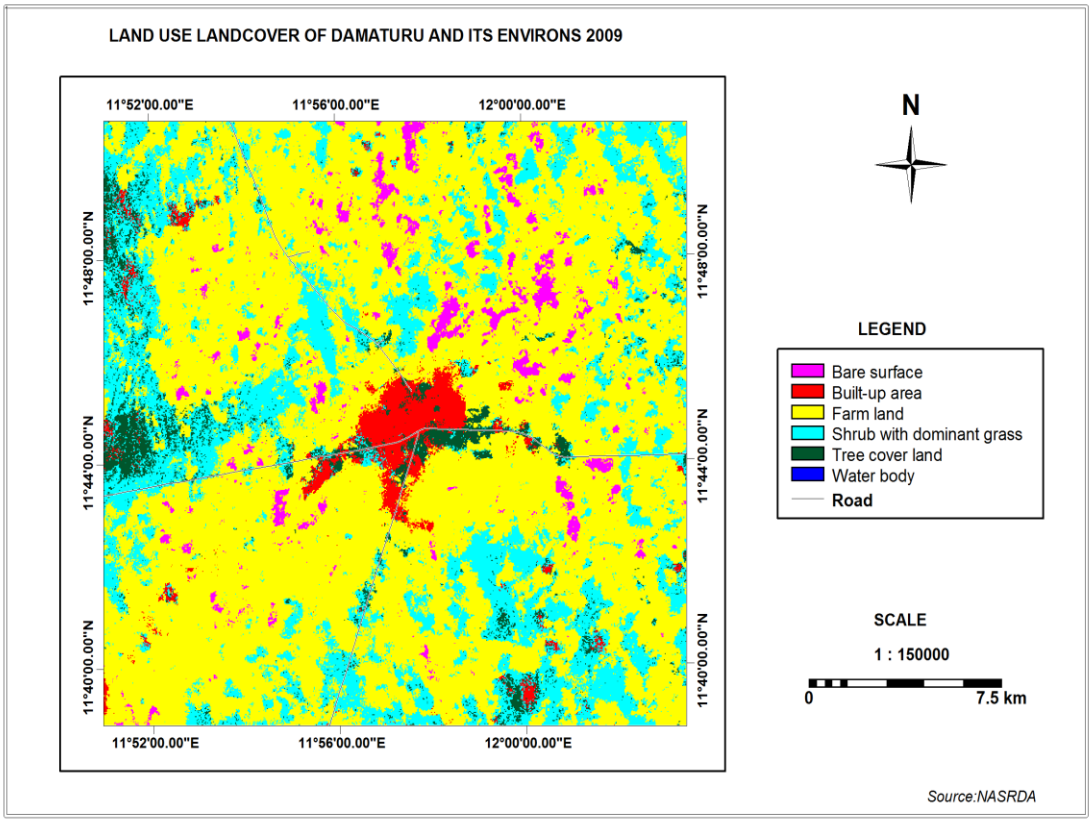

Figure 5.4: Land Use/Land Cover of Damaturu and its Environs 2009.

Source: National Air Space Research and Development Agency (NASRDA)

5.4 Comparison of 2005/2009 Land use/cover Change of Damaturu and its Environs

Comparison of 2005 and 2009 satellite data showed an increase in bare land surface by 29.7% (from 2262.9ha to 2936.2ha); as more rural land was converted to urban development and farms. Built-up land increased by 9.8% (from 2802.4ha to 3078.3ha) while farmlands increased by 14.8% (from 25582.7ha to 29379.6ha). On the other hand, shrubs with dominant grass also decreased by 26.4% (from 17187.9 to 12647.5ha). This was because more land was converted to grazing, farming activities and forest depletion, tree cover land decreased by 6.4% (from 2823.5ha to 2642.9ha) while water bodies decreased by 73.8% (from 97.1 to 72.0ha) due to variation in the imaging time of the satellite. Post rainy season is usually considered as the best time for satellite imaging, but when the imaging period is far from the rainy season, there may be no natural water bodies in semi-arid areas such as Damaturu. The first satellite was imaged on October 2, 1986; the second was imaged on November 30, 1999; the third image was sensed on October 30, 2005, all by Global Land Cover Facility while the fourth was imaged on January 1, 2009 by National Air Space and Research Development Agency (NARSDA). Apart from the continuous increase in population that exerted pressure on water resource, other human activities such as waste dumping in the existing water pond, filling of depressed areas for construction of infrastructures, clearance and cultivation for farming activities have contributed to the rapidly decreasing water level. Moreover, the progression into dry season is another likely reason for the successive decrease in water bodies in 2009 as there are no rivers that could retain water throughout rainy season in the study area.

Table 5.3 Comparison of 2005/2009 Land use/cover of Damaturu and its Environs

S/No	Land Cover description	Area(ha)2005	Area(ha)2009	Change	%change
1	Bare Surface	2262.9	2936.2	+673.3	29.7
2	Built-up area	2802.4	3078.3	+275.9	9.8
3	Farmland	25582.7	29379.6	-3796.9	14.8
4	Shrubs with dominant Grass	17187.9	12647.5	+4540.4	26.4
5	Tree cover land	2823.5	2642.9	-180.6	6.4
6	Water bodies	97.1	72.0	71.6	73.8

Source: Fieldwork 2011

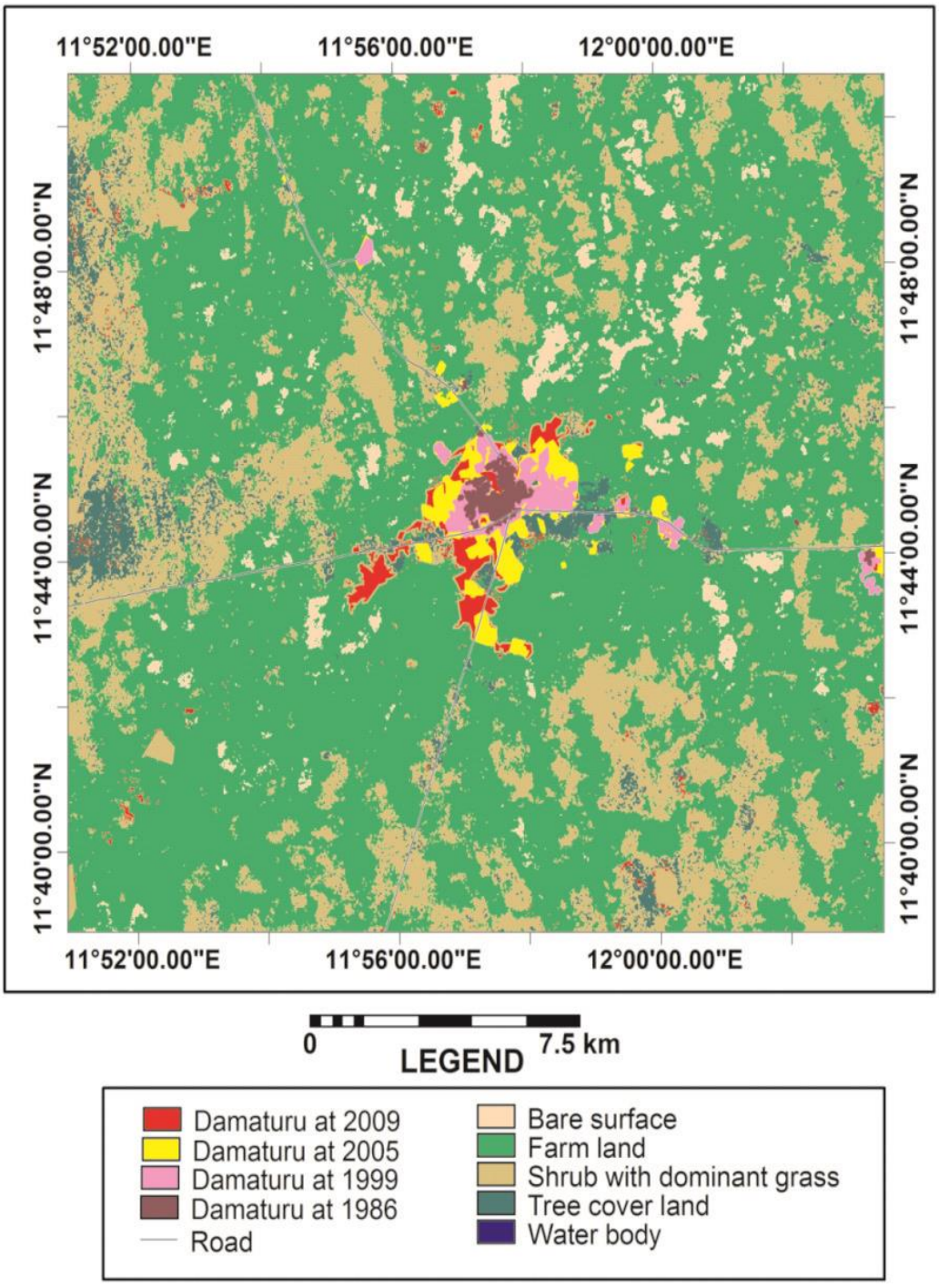

Figure 5.5: Overlay of Land Use/Land cover Changes of Damaturu 1986-2009

5.5 Comparison of Change Based on Land use Classes between 1986 and 2009

Investigation revealed a significant human population increase and physical changes in every land use class in the study area. For example, Human population increased by 112.2% (from 363,131 to 770,550) between 1986 and 2009. In the same period, bare land increased by 574.8% (from 435.1 to 2,936.2ha); built-up area increased by 672.3% (from 398.6 to 3078.3ha); Farmland increased by 21.2% (from 24237 to 29379.9ha); shrubs with dominant grassland decreased by 25.6% (from 17009.4 to 12647.5ha), tree-cover land decreased by 68.6% (from 8420.4 to 2642.9ha) while water bodies decreased by 71.8% (from 256.1 to 72.0ha). These results showed glaring implications of rapid urban expansion on rural land use and theses resultant significant changes of rural land use were perceived by the respondents as being more negative than positive. While the well-being unsustainably extracted and directed towards developing the urban centre and increasing the well-being of the urban residents, the development of such infrastructure that will improve the well-being of the rural areas where the resources were being extracted was neglected or undermined.

Table 5.4 Comparison of change per Land use class between 1986 and 2009

S/No	Classes of land use	1986	2009	Actual change in (ha)	%change
1	Bare land	435.1	2936.2	2501.1	574.8%
2	Built-up land	398.6	3078.3	2679.7	672.3%
3	Farmland	24237	29379.9	5142.9	21.2%
4	Shrubs/grassland	17009.4	12647.5	4361.9	25.6%
5	Tree-cover land	8420.4	2642.9	5777.5	68.6%
6	Water bodies	256.1	72.0	184.1	71.8%

Source: Fieldwork 2011

5.6 Actual and Percentage Overall Changes of each Land use/cover class of Damaturu and its Environs 1986 -2009

The presentation of actual and percentage land use classes shows the status of each of the six land use classes at each year of comparison (1986/1999; 1999/2005 and 2005/2009) and the percentage increase or decrease for that period. The comparison of land use status of every two sampled years helped to reveal at a glance the actual and percentage changes at each period of comparison in each land use class. The revealed change in the comparison is described as either positive or negative depending on the nature of change in such a land use in that comparison. This revealed decrease or increase of each land use class enables the computation of the individual and overall land use loss and gain. The overall increase of bare land was by 574.8% (from 435.1 to 2936.2ha); built-up area increased by 672.3% (from 398.6 to 3078.3ha); farmland increased by 21.2% (from 24237 to 29379.6ha), tree-cover land decreased by 68.61% (from 8420.6 to 2642.9ha); shrubs/grassland decreased by 25.6% (from 17009.4 to 12647.5 ha); while water bodies decreased by71.8% (from 256.1 to72.0ha).

Table 5.5 Quantitative and Percentage Change in Individual Land Use Classes from 1986 to 2009

Description	1986/1999		actual	%	1999/2005		actual	%	2005/2009		actual	%
	1986	1999			1999	2005			2005	2009		
Bare surface land	435.1	1397.5	+962.4	221.1	1397.5	2262.9	+865.4	62.0	2262.9	2936.2	+673.3	29.7
Built-up land	398.6	2045.9	+1647.3	413.2	2045.9	2802.4	+756.5	37.0	2802.4	3078.3	+275.9	9.8
Farm land	24237	19915.2	+4321.8	17.8	19915.2	25582.7	+5667.5	28.5	25582.7	29379.6	-3796.9	14.8
Shrubs with grass	17009.4	22670.1	+5660.7	33.2	22770.5	17187.9	+5482.2	24.5	17187.9	12647.5	-4540.4	26.4
Tree-cover land	8420.6	4597.8	-3822.5	45.3	4597.8	2823.5	-1774.3	38.6	2823.5	2642.9	-180.6	6.4
Water bodies	256.1	130.6	-125.5	49.0	130.6	97.1	-33.5	25.6	97.1	72.0	-25.1	25.8
	50756.5				**50756.5**				**50756.5**			

Source: NASRDA 2011.

5.7 Urban Physical Expansion and its Effect on Specific Land Use Classes

The four satellite images, the updated cartographic land use map and the two sets of questionnaire have all shown that there have been significant implications of the rapid urban physical expansion of Damaturu from 1986 – 2009. This has not only negatively affected the stability of the rural land use pattern, but the decrease in the adjoining rural land uses also has affected the farming activities (traditional means of livelihood) of the rural residents. The decrease in areas under forest in such a semi-arid zone has exacerbated desert encroachment. Decease in water bodies subjects the area, animals and birds to a more intense dryness and lack of water.

In terms of the pattern of expansion, literature on the physical urban expansion of Damaturu shows four major forms namely: concentric, Leapfrog, linear and multi-nuclei characteristics. Figures 5.1; 5.2; 5.3; 5.4 and 5.5 present the pictorial details of the urban physical expansion of the sampled years; the specific and the overall land use changes of the selected rural land use classes were computed from the figures.

5.7.1 Total and Mean Annual Urban Physical Expansion in Actual and Percentage

The remotely sensed data shows that there has been an overall consistent increase in urban physical expansion in table 5.5. Between 1986 and 1999, urban land increased by 412.7% (from 398.6ha to 2045.9ha), between 1999 and 2005, it increased by 37.1% (from 2045.9ha to 2802.4ha), and between 2005 and 2009 it increased by 9.8% (from 2802.4 to 3078.3ha). As the population, economic and construction of infrastructure activities continued to increase, urban area correspondingly expands outwardly to accommodate them. Subtracting the urban land in 1986 (398.6ha) from the total urban land in 2009 (3078.3ha) gives a total land change of 2,679.7ha; dividing this change by the 24 years (the duration of the study) gives a mean annual change of 111.6ha. In terms of total and mean annual percentage, the total percentage change is 672.3%. Further dividing this by the 24 years (study period) gives a mean percentage increase of 28%.

However, mean annual rate is not uniform across the period but rather it varies between time periods. The data show a higher rate of physical urban expansion in the early years. For example, between 1986 and 1999, it was computed to be up to 32% largely due to extensive acquisition of rural land and constructions to accommodate

federal and state ministries and other agencies in the state capital. It decreased to 7.4% between 1999 and 2005 and further decreased to 2.5% between 2005 and 2009.

5.8 Quantitative Changes in Individual Land use Classes from 1986-2009

This section analyzes and quantifies the amount of change in each of the six study element at each of the three different phases within the study period and these produced the three change-detection columns of the elements at each comparison as presented in table 5.5. Details in the table are discussed in sections 5.6.1 to 5.8.

5.8.1 Bare land

Bare land increased consistently during the sampled years, between 1986 and 1999, it increased by 221.1% (from 435.1ha to 1397.5ha); between 1999 and 2005 it increased by 62.0% (1397.3ha to 2262.9ha) while between 2005 and 2009, it increased by 29.7% (from 2262.9 to 2936.2). The acquisition and clearing of land for farming, development, infrastructure and institutions with intensive grazing explained the consistent increase in bare land.

5.8.2 Built-up land

Satellite data show consistent increase in built-up land; between 1986 and 2009, built-up land increased by 413.2% (from 398.6 to 2045.9ha); between 1999 and 2005, it increased by 37.0% (from 2045.9 to 2802.4ha) while between 2005 and 2009, it increased by 9.8% (from 2802.4 to 3078,3ha). This explains the continuous spatial expansion of the urban land use as the population continues to increase with diverse economic, infrastructure and housing needs. The demand for land continued to increase and more rural land was converted to urban for infrastructure, economic, recreational, commercial among others. This requires that pragmatic planning policy and instruments should be employed to manage the emerging environmental consequences of rapid rural land use changes.

5.8.3 Farmland

Imagery data showed that farmland decreased by 17.8% (from 24237 to 19915.2ha) between 1986 and 1999; between 1999 and 2005, it increased by 28.5% (from

19915.2 to 25582.7) while between 2005 and 2009, it increased by 14.8% (from 25582.7 to 29379.6ha). This is attributed to the increase in the intensity of farming activities in the study area in response to the increasing food demand of the growing population. In addition, the acquisition and clearing of larger farmlands with the use of tractor services as was being provided by the Yobe State Ministry of Agriculture, Yobe State Agriculture and Mechanization Agency (YOSAMA) and Integrated Rural Development (IRD) among others. Besides, those that had been displaced by urban expansion; civil servants and other support population that joined farming to augment their earnings contributed to the rapid increase in farmland.

The Pearson Product Movement Correlation was used to test the hypothesis that urban expansion does not affect farm land showed a negative coefficient relationship of -0.116 and P-value of 0.019 < 0.05, which is enough statistical evidence to reject the null. This result is not consistent with the pattern of the results depicted by the imagery, but corroborated the respondents' perception of the urban expansion as indicated in the frequency tables, which show that there are severe consequences. The reason being that, the boundaries of these rural land uses are not fixed, therefore, as the urban land use was taking over farmland, farm activities were converting other rural land uses at a higher rate than the built-up area was taking from the farm. This does not only vitiate the effect of urban expansion on farmland, but caused an increase in farmland.

5.8.4 Shrubs/Grassland

Similarly, between 1986 and 1999, shrubs and grassland also increased by 33.2% (from 17009.4 to 22670.1ha). However, between 1999 and 2005, it decreased by 24.5% (from 22670.1 to 17187.9ha) while between 2005 and 2009, it decreased by 26.4% (from 17187.9 to 12647.5ha). This decrease is attributed to the pressure from urban demand and agricultural farmland that converted the shrubs/grassland.

5.8.5 Tree Cover Land (Forest)

Tree cover land decreased consistently across the period. Between 1986 and 1999, it decreased by 45.4% (from 8420.6 to 4597.8ha), between 1999 and 2005, it decreased by 38.6% (from 4597.8 to 2823.5ha), and between 2005 and 2009, it decreased by 6.4% (from 2823.5 to 2642.9ha). As urban spatial expansion converts farmland to urban,

agriculture (farming, grazing) encroaches on forests. In addition, the increasing number of both fuel-wood merchants and users combined to heavily tax the tree cover land. Besides, desertification has been affecting the tree cover land use. The Pearson Product Moment Correlation was used to test the relationship between urban physical expansion and reduction of the tree-cover land. The result yielded a negative correlation coefficient -0.122 indicating that as urban expansion increases, tree land cover decreases. The P-value = 0.015 < 0.05, which is significant at 0.05 level, and does not give enough statistical evidence to accept the null. Consequently, the alternative that the loss of area under forest is a function of urban physical planning is not rejected.

5.8.6 Water Bodies

Water bodies decreased between 1986 and 1999 by 49% (from 256.1 to 130.6ha), between 1999 and 2005, it decreased by 25.6% (from 130.6 to 97.2ha) while it decreased between 2005 and 2009 by 25.8% (from 97.1 to 72ha). This is due to increased water uses by the increasing urban population, the filling up of Bindigari and Pompamari water ponds in Damaturu with waste and the months that the elements were imaged were farther into dry season in the area, such as October 2, 1986; Nov 11, in 1999, January 1, 2009.

5.9 Actual and Percentage Land Decrease and Land Increase per Land Use from 1986-2009

The analysis of imagery data reveals the positive and negative changes in the land use classes. The negative sign attached to farmland, tree cover, shrubs/grassland and water bodies imply decrease in such rural land use at that period. Among the rural land use classes that decreased were farmlands, which reduced by 17.8% (from 24237 to 19915.2ha) largely due to the initial large acquisition of farmlands for development. It thereafter increased as more alternative farmlands were acquired and more people joined farming including civil servants and other support population to augment their income. Besides, the use of tractors became more available to farmers as the Yobe State Ministry of Agriculture, Yobe State Mechanization Agency, the Integrated Rural Development Agency took off. Farmlands then increased by 28.5% (from 19915.2ha to 25582.7ha). Although, 90% of individual respondents indicated that the consequences of urban spatial expansion on farmlands were adverse, it was not the same with the satellite data as

farmland rather increased by 28.5%. Similarly, between 2005 and 2009, farmland increased by 14.8% (from 25582.7ha to 29379.6ha). This implies that while the urban spatial expansion was converting farmlands, farming activities were also converting more of other rural land uses such as tree cover land, which consistently decreased; it decreased by 45.3% (from 8420.6 to 4597.8ha), 38.6% (from 4597.8 to 2823.5ha) and 6.4% (from 2823.5ha to 2642.9ha) between 1986/1999, 1999/2005 and 2005/2009 respectively. Similarly, shrubs/grassland decreased by 33.2%, 24.1% and 26.4% between 1986/1999, 1999/2005 and 2005/2009 respectively. Therefore, the overall farmland did not reduce. The consistent decrease in shrubs/grassland were partially because the farmers that were dispossessed of their farmlands vacated such farmlands, which were taken over by grazing activities.

5.10 Land Use/cover Change Detection Table of each Comparison (1986/1999; 1999/2005 and 2005/2009)

The land use/cover change detection refers to the process of establishing the quantitative change (positive or negative) that has occurred between two periods. Table 5.6 presents the quantitative changes that occurred between 1986/99, 1999/2005 and 2005/2009.The changes reveal the magnitude of change that has taken place in all the land use and land cover classes at each comparative instance. This is helpful where the changes are used to compute the overall land that is either gained or lost in the whole period of an investigation.

Table 5.6 Land Use/cover Change Detection at Each Comparison (1986-2009)

S/No	Land Cover description	1986/99 Area (ha)	1999/05 Area (ha)	2005/09 Area (ha)
1	Bare Surface	992.2	865.4	673.3
2	Built-up area	1647.3	756.5	+275.9
3	Farmland	-4321.8	5667.5	-3796.9
4	Shrubs with dominant Grass	5660.7	5482.2	4540.4
5	Tree cover land	3822.5	-1774.3	-180.6
6	Water bodies	-125.5	-33.5	-25.1

Source: NASRDA 2011.

5.11 Ecological Footprint of Yobe State and the Study Area

The ecological footprint of Yobe State, given its productive land area of 45,502,000km^2 and a population of 2,504,600, gives an average global hectare (gha) of 18.17hectare. The ecological footprint condition of the state is far above the average 2.8 global hectare per person, which implies encouraging ecological condition. However, the demarcated 50,756.6 hectare region of Damaturu and its population has a worsening deficit global hectares values as the population changes over the years. The footprint of the area under study has been computed and the values of the gha/person from 1986 to 2009 are far below the average global hectares. Based on the gha/person values, it can be inferred that the condition will continue to worsen as the gha keeps reducing. This implies that the study area has been experiencing a growing ecological deficit or overshooting the regenerative bio-capacity of its habitat as the population continued to increase. The overall population increase in the study area was by 112.2% (from 363331 to 770550).

Table 5.7 Population and global hectares of the Study Area (1986-2009)

Year	Population	Global hectares (gha)
1986	363131	0.14
1991	435432	0.12
1996	551580	0.09
1999	653214	0.08
2001	701558	0.072
205	718305	0.070
2009	770550	0.066

Source: (NPC, 1991 and 2006 projected to 2009)

Based on the analysis from the table 5.7, it is evident that population growth, environmental change and ecological footprint expansion are consistently increasing, while the global hectares (gha) slacks within the study area and period. However, the id to regulate resource exploitation, promote sustainable resource-use and land management strategies that better attune to the environment have continued. It is expected that fostering the slower pace of change, improvements in land management, and an enhanced ability for sustainable land use development will eventually reduce the associated consequences for different social groups. Since the initial rush to develop the city, sustainability of use has decreased markedly in resource extraction. However, if appropriate and suitable methods of resource extraction, sustainable resource use are properly applied, it may portray a classic case of a frontier that experiences a transition to a more settled and sustainable conditions. However, it depends on appropriate choice of the intervention policy and implementation strategies.

This study of the implications of urban physical expansion has shown the likelihood that worsening trends will continue except they are altered by feasible adjustments, but whether such human adjustments are possible in a time-frame to prevent the growing severe consequences, is yet to be determined. It is needful to explore and integrate environment-based and human-related methods to reduce the consequences of the expansion on both physical and human dimensions.

5.12 Ranking of the Most Affected Rural Land use Variables

To assess the rural land use variable that are most affected by the urban physical expansion of Damaturu, the respondents were asked to rank the rural land use variables most affected by the urban physical expansion in Damaturu, based on their assessment, the result presented in table 5.8 was obtained. Details from table 5.8 show that 194 (47.0%) of the respondents indicated that the tree-cover land was most affected; 73 (19.0%) indicated that farm lands were most affected, 61 (14.0%) of the respondents indicated that grassland was the category of rural land use that was most affected; 45 (11.0%) of the respondents indicated that water bodies were the most affected, 21 (5.0%) indicated that bare land variable was most affected, while 15(4.0%) indicated that the building resource sites were the most affected. This result corroborated the results

obtained from the 2010 up-dated land use map of Damaturu and the results from the imagery data, which also showed consistent decrease in tree-cover areas in Damaturu region from 8,420.6 to 2,642.9 (68.61%) in 1986 to 2009 respectively. Water bodies also decreased from 256.1 to 72 hectares from 1986 to 2009 respectively. There is one fact that string across the respondents that all the rural land use variables are affected in varying degrees by the urban physical expansion of Damaturu as reflected in table 5.8.

Table 5.8 Ranked Rural Land use Variables Disturbed by Urban Physical Expansion in Damaturu.

Description	Frequency	Percentage	Valid Percentage
Tree-cover land	194	47.0	47.0
Water bodies	45	11.0	11.0
Bare land	21	5.0	5.0
Pasture/grassland	61	14.0	14.0
Farm land	73	19.0	19.0
Building resource sites	15	4.0	4.0
Total	**409**	**100.0**	**100.0**

Source: Fieldwork 2011

5.13 Key Determinant of Changes in Specific Land Use Classes

The change and impact of change in environment is expressed on some environmental indicators. These changes on the indicators usually provide the basis for measuring and explaining such environmental changes and the consequences of such changes at both spatial and temporal scales. In this study, such key variables are identified to include built-up areas, bare land, farmland, pasture/grassland, tree cover areas, water bodies, local building materials and fire wood. Satellite data on these were collected and the appropriate GIS software was used to analyse them. The use of GIS software provided detail and precise information on the variables for the quantification and measurement of the changes on each variable. The factors that have influenced the changes were also examined through administration of two sets of questionnaire to the respondents. The data collected from the respondents on the factors that influence the rapid expansion included the jurisdictional elevation to state capital; economic development activities, investment policies on residential, transport networks especially, the ring road that provided a wide range of accessibility to areas that were not accessible before among others. Ranking of the variables showed the variation in the strength of influence of the variables as shown in table 5.5. The directions were vividly described and the rates were analysed and quantified based on the up-dated land use map of Damaturu. Data from the respondents also showed that urban physical expansion of Damaturu was influenced by socio-cultural factors such as religion, which determine the acceptability or otherwise of the non-indigenes, preference to single-family apartment, recreational activities and population growth. These explained why the land use change has been increasing as the urban expansion was increasing.

From the foregoing analysis, the correlation between urban physical expansion and some selected rural land use variables were tested. The results of the hypotheses as presented in appendix iii showed a negative correlation of -0.116, which implied that the urban physical expansion was negatively affecting the rural land use variable. The test yielded a negative value of -0.116; and a p-value of $0.019 < 0.05$, which did not provide enough statistical evidence, consequently, the null was rejected. This has the potency of contributing to the degrading of natural environment and the decreasing human well-being.

5.14 Urban Physical Expansion and Natural Resources of Damaturu.

In assessing the influence of the driving factors of the urban expansion, table 5.7 showed that 41 (10.0%) of the respondents indicated that availability of natural building materials has also significantly contributed to the rapid expansion of the built-up area in Damaturu. Furthermore, reconnaissance surveys to resource sites showed intensive strip-mining of these resources, and these are being used for the development of the urban areas. This intensive harvest without maintaining the sites and the abandoned sites has significantly contributed to impoverish the ecological richness and integrity. This rapid spatial expansion and the resultant unsustainable resource extraction without management of the resource sites and conversion of rural land combine to weaken the ecological resilience and exacerbate erosive forces around the resource mines (Plate 2.1).

PLATE 5.1: The Researcher Observing Ecological Degradation at Dumbuluwa Sand Mine

Source: Fieldwork 2011.

Apart from the rural land use conversion and resource depletion, there is high generation and disposal of non-degradable waste such as empty bags of pure water, polythene and other plastic materials into borrow-pits at the outskirt of the town along major routes that constitute eye-sore and reduce the environmental integrity at the suburbs of the town (Plate 2.2).

These existing borrow-pits that are incidentally converted to waste disposal centres had no initial planning consideration for waste management. Such borrow-pits quickly get filled-up and their waste is littered about by wind. The borrow-pits also constitute breeding-grounds for rodents and the stinking odour from such places close to major roads is unhealthy.

PLATE 5.2: The Researcher at Solid Waste Disposals in Borrow-Pits (urban solid waste footprint)

Source: Fieldwork: 2011

5.14.1 Historical Development of Damaturu

Damaturu is located within the South-Eastern part of Yobe state within the Sudan savannah vegetation zone and it is a nodal town on Kano-Maiduguri regional express Road and Geshua–Buni-Yadi/Biu Road (Fig. 2.3). Damaturu town had been the headquarters of Damaturu Local Government since 1976, but when Yobe State was created on August 27, 1991; Damaturu was named the state capital. Located in a less developed area of the North-Eastern region, Nigeria, it has witnessed rapid population and urban growth in the last two decades. According to the physical assessment from office of the state's surveyor general (2007), Damaturu now covers an area size of over 2713.39km^2 and has continued to outwardly expand at an average annual rate of 28.2%. Such rapid urban expansion, in a developing country like Nigeria, places high urban resource-demand on the surrounding finite natural resources that results in intensive exploitation of natural resources with adverse implication on the adjoining rural environment. It is for this reason that the study covers the five surrounding local governments (Fune, Gujba, Kaga, Tarmuwa and Damaturu) from which resources are being harnessed.

5.14.2 Damaturu Urban Development and Supervisory Agencies

Over the last two decades, Damaturu has witnessed a tremendous increase in the proportion of its urban land. This development is carried out by both the public and the private sectors. The public sector comprises the Federal, States and Local governments, which develop academic institutions, construct roads; build office complexes and residential estates, while the private sector comprises formal private sector (Banks, learning and other institutions, enterprises and non-governmental organizations) and the informal private sector consists of individual estate developers, families and households. Both the public and private development sectors use local building materials, but import the building materials that are not found within the local setting. The supervisory agencies that oversee urban development include professionals in environmental development from the Federal, State and Local government Ministries of Works and Housing, State Ministry of Lands and Solid Mineral Resources and Public Health. The planning department has planning instruments that can be employed to manage the expansion and its consequences as well as natural resource extraction. Such instruments include the followings: Land use

allocation, development control, regional planning that can assess and incorporate all the surrounding settlements, urban growth boundary that helps to monitor the extent of urban development, land use conservations among others. They can liaise with the state government to make laws to regulate the extraction of natural resources that degrades the environment.

5.14.3 The Emerging Urban Development Structure

The development of Damaturu can be classified into planned areas, partially planned areas and unplanned areas. The planned areas include the GRAs, government built estates, planned areas are usually developed under the strict supervision of the Development Control Officers. The partially planned areas are occupied mainly by the indigenes that usually fence and develop their plots during weekends when they are sure that the development control officers will not come around. The layout of plots and roads in these areas are planned, but many of the elements of the structures inside the plots are not guided. This includes places such as Bindigari and Pawari. The unplanned areas are those that were developed before the creation of the state but have now been engulfed by expansion of the town and these include Shuwari, Dikumari, Mesandari Maiduri among others.

5.13.4 Urban Physical Expansion and Directions of Development in Damaturu

Cities keep expanding outwardly to absorb immigrants and facilities and by that take over farmlands, forest areas, wildlife habitat, rural open space among others. Rapid expansion manifests relatively permanent unplanned land use changes that affect future sustainable land use transition. It is therefore imperative to identify the trend and direction of expansion, factors and forces that drive urban expansion so that appropriate planning and policy tools will be applied for management. Furthermore, there is need to identify and quantify the key variables and the secondary variables under them. The quantification of the sub-variables of the driving forces provided a basis for explaining their influence on the urban physical expansion and ranking of the various key variables based on their degree of influence on the urban physical expansion of Damaturu; it also provides an empirical basis for quantifying the consequences of the urban physical on the individual

rural land use variables. The influence of the key variables is presented in table 5.9. From table 5.9, it can be seen that 160 (38.0%) of the respondents indicated that investment policy variable is the highest influencing variable to the urban physical expansion of Damautru. This was followed by socio-economic variables 102(25.0%); the socio-demographic variables has 86 (21.0%), proximity to local building resources has 41(10.0%); while 20 (5.0%) of the respondents indicated for jurisdictional factor. The sequence of this result seem to corroborate the one obtained from the analysis of the 2010 up-dated land use map of Damaturu, where residential (part of policy investment) contributed up to 53% of the total 3078.3 urban land. Establishment of institutions (part of socio-economic) contributed 19.67%; religious (part of socio-demographic) activities contributed 4.03%; while other factors contributed 3.03%. The results have also provided information to decide on which management tool, process and policy instrument that can be adapted for the management of the urban physical expansion.

Table 5.9 Ranking the Key Variables that Influenced the Urban Physical Expansion of Damaturu

Description	Frequency	Percentage	Valid Percentage
Jurisdictional elevation	20	5.0	5.0
Socio-demographic factors	86	21.0	21.0
Investment policies	160	39.0	39.0
Proximity to local building resources	41	10.0	10.0
Socio-economic variables	102	25.0	25.0
Total	**409**	**100.0**	**100.0**

Source: Fieldwork 2011

The pattern of urban expansion, direction and the implications on rural land use in Damaturu can be explained majorly from the perspective of the above listed key variables. These variables have also influenced the direction and development pace of Damaturu. For example, the Northern part of the town experiences the slowest rate of expansion. The Southern and the Eastern parts of Damaturu have recorded the fastest rates of expansion while the Western part ranks average. The expansion and its pattern are influenced by socio-economic factors (location of institutions) socio-cultural factors (the motive for plot acquisition by the people: indigenes or non indigenes- that acquire, own and control the plots and so on. Therefore, it is not wrong to posit that jurisdictional factors (development of federal and state offices to accommodate federal and state ministries), demographic factors (population growth), proximity to resource sites (accessibility to building resources) and socio-cultural factors such as religious practices, hoarding of acquired plots of land; socio-economic factors (establishment of educational, health facilities) government investment policies (land use allocation, development of road-network, residential estates) have significantly influenced the development structure of Damaturu town. For example, it is observed that places where land parcels are owned and kept for family members or for sale do not develop as fast as those where plots are statutorily acquired by non-indigenes for development. The form of development tends to linearly expand quicker and faster along the major transportation corridors and around major public institutions. The cases of Sabon Pegi, located beside the Federal Polytechnic; Nasarawa area beside the State Specialist Hospital, and more recently, the State University are ready examples. The extent of the urban land use expansion of Damaturu as at 2010 is up-dated and presented in the land use Plan of Damaturu (Fig. 5.6).

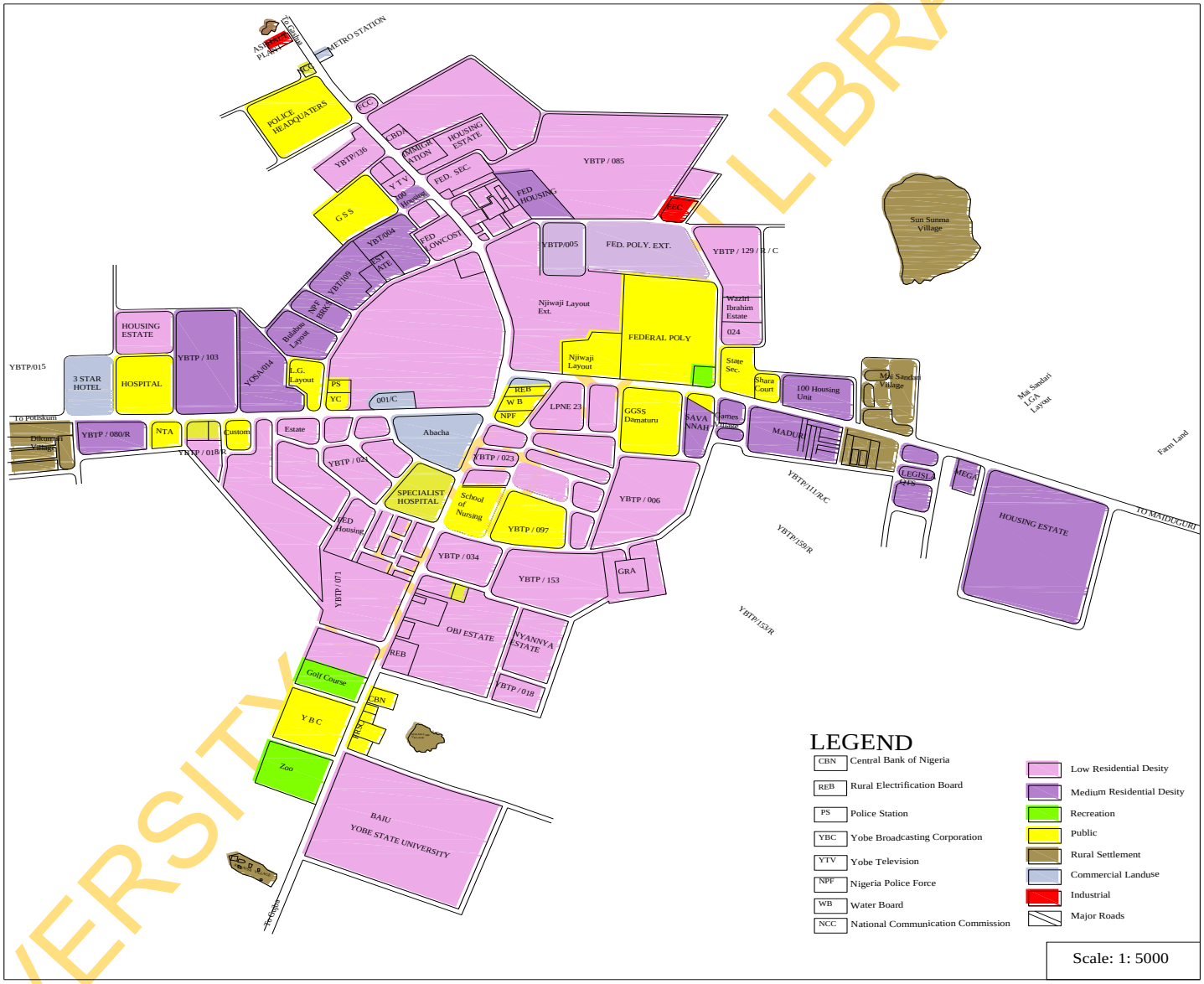

Figure 5.6: Damaturu Landuse Plan, 2010. Source: Yobe State Min. of Land and Solid Mineral Res., 2010.

5.13.5 Exploration of the Factors Influencing the Physical Expansion of Damaturu

The factors that have influenced the expansion pattern are majorly human-induced, such as the elevation of the town to a state capital. To ensure its take-off as the state capital, more office shopping and residential complexes were being constructed by the federal, state, local government, formal, informal enterprises and individual developers were also constructing residential apartments for habitation and rental purposes. Rapid population growth implies demand for more land to accommodate more residential, recreational facilities and infrastructure. This has also contributed to the rapid physical expansion of Damaturu.

Proximity to local building resources such as sand and gravel mines in Dumbuluwa, Sudande and Gujba among others is a factor for urban expansion. However, the urban resource-mining is blamed for the environmental degradation of the mining sites as they leave open borrow-pits without managing it. The burrow-pits initiate flooding of the road, erosion, accidents and worsen the condition of feeder roads.

Regional and ring-roads help to create accessibility to new areas, and in the conveyance of imported building materials that are not produced within the locality of Damaturu. However, the emissions of carbon monoxide from heavy-duty trucks that convey both local and imported building materials to Damaturu pollute and degrade the atmospheric condition of the area.

Physical planning instruments such as land use planning and allocation have also contributed to the rapid rate of expansion. For example, the locations of housing estates that leave swaths of undeveloped lands facilitate expansion. Observation of development pattern in Damaturu reveals that plots of land allocated for residential use are developed faster than other land uses. Thus, urban land use outwardly expands to engulf farm and forest lands, open spaces and wildlife habitat.

Religious and cultural factors: Segregation of non-natives on religious and cultural factors results in stunted development in areas occupied by natives who are peasant farmers, whereas areas allocated for non-natives such as Sabon Pegi, New Jerusalem areas experience faster growth than the indigenous areas. Closely related to the above is the motive for acquisition of plots. For example, plots acquired by many natives are not for immediate development, but for speculation or to keep for their children or other family

members. On the contrary, the non-natives and institutions such as banks, schools and so on quickly develop their plots. Therefore, the demand for, and establishment of private schools by the non-natives where patronage is high, enhanced rapid expansion in non-native areas.

Investment in estates development and transport: Development of housing estates such as 3-bedroom, Dabo Aliyu, Ibrahim Waziri, Bukar Abba, Ali Malami, 500-Bedroom, Ibrahim Abacha estate among others, tend to expand linearly along the corridors of the traversing regional roads, which gives the city a star-shaped form. Similarly, the ring-road constructed in 2009 has made more areas accessible than before and this has rapidly spurred up new residential developments and significantly influenced the pace of development and shape of Damaturu town.

Government's investment policy on infrastructure development: The construction of office apartments, institutions and other infrastructure such as Specialist hospital with its school of nursing campuses, academic institutions such as Federal Polytechnic, Damaturu; Bukar Abba University, Damaturu; government and private secondary schools, commercial land uses such as market places, shopping complexes, banks and open recreational facilities have greatly influenced the expansion of the town. Empirical investigation shows that the contractors that carry out the construction works freely harvest the local building resources, but they fail to manage the resource sites before abandonment. They use heavy duty vehicles to convey local building resources to urban area and through that degrade the condition of the feeder roads that link the settlements to resource sites and Damaturu.

The forces that shape the expansion of Damaturu are social forces, physical conditions, environmental resources, economic, institutional facilities and change in jurisdictional status. Leaps in population growth have increased competition for environmental resources and as the population continues to grow unabated, the depletion of existing rural resources become more competitive and tends to collapse, if not regulated. It is clear that these issues have facilitated development. Relating the issues of environmental concern to the study area, the following scenarios evolve. First, the relationship between the environment and the physical characteristics, which include physical attributes such as the flatness of the land without obstructive natural features (mountains, rivers) that may inhibit or facilitate development. Second, the relationship between the physical development and the

availability of natural resources- whether the endowed natural resources is richly impacting on development process and if the natural building resources are being easily and cheaply harvested to promote physical development. Third, the environment and the economic activity, which enhance increase in employment and income, investment in real estate, and opportunities for self-employment and farming activities among others. Fourth, the relationship between environment and investment that encourages purchase of private auto-mobiles, governments' investment in road construction and housing estates, and their impact on environmental development are applicable to Damaturu.

The relationship between cities and the richness of rural resources in their surrounding hinterlands are inextricably linked as rural areas and ecology are brought under the pressure of urban expansion. The realization that the environment is not an end to itself (not something to be protected from development), but as a source that should be sustainably managed while developing the urban areas is a welcome paradigm that is being factored in the sustainable human settlement development. Furthermore, urban development depends on the natural resource-base available to a city, which in turn has an impact on the state of the resources. It is therefore crucial to improve understanding of the two-way relationship between environment and development, which should take cognizance of the available resources to take care of the urban residents. Where the population and exploitation exceed the carrying capacity of the habitat, it results in unsustainable human settlement development.

CHAPTER SIX

6.0 IMPLICATIONS OF URBAN EXPANSION ON RURAL LAND USE AND THEIR SEVERITY INDICES

6.1 Introduction

Environment changes either as a result of a natural on-going process of change or as a result of human-induced activities. When such changes are not to the benefit of the human beings or the ecological communities, they are termed to be negative. On the other hand, when such changes are beneficial to the environmental components or improve the socio-economic well-being of the surrounding residents they are said to be positive. The proceeds of the changes may be termed the consequences of the environmental changes which may be direct or indirect.

In the study area, the consequences of the rapid urban expansion, which has negative implications for the rural land use and residents, include the significant decrease of natural land cover and un-built natural areas (forests, pasture and arable land), degradation and impoverishment of natural and landscape values in the surrounding of the city. By definition, expansion of urban areas entails the building of new residential, commercial areas and transport infrastructure that consume rural land uses/land cover and the associated natural resources (local building and energy resources). Use of land and soil is of special concern because they can be considered non-renewable resources, at least in human time scales.

The result of the emerging changes (fragmentation, modification and conversion) of wildlife habitat as experienced in the surroundings of bigger cities of the country, including Damaturu, has impoverished the biodiversity in the surrounding of such cities. The reduction of specific land cover types (forests, pastures), persistent increase in bare surface land might cause soil erosion and contribute to the growing risk of flood disasters. The growing need for transport (due to the separation of places) causes growing

greenhouse gas emission, and other harmful elements to increase air, soil and noise pollution, heat island effect as negative implications of the resultant climate change.

Increase of artificial land cover from new residential estates, infrastructure services and commercial, recreational, educational development with great territorial needs have negative consequences such as upset water balance, problems of deposition of growing quantity of solid and liquid waste, and the declining quality of public services as the population continues to increase. If the negative environmental or social impacts exceed the benefits, one may say the phenomenon is not a positive process.

The intensity of the consequences of environmental change due to urban expansion may vary significantly depending on characteristics such as the base-conditions, the physical features, and intensity of extraction. Others are the population density and the proportion of land area that is sealed. The varying intensity of use and the existing social institutions within the city influence the differing environment-related implications. For example, soil-sealing (the level of impermeability of the ground) implies very intense urban use, reducing the availability of green areas and biodiversity. It also reduces water infiltration and exacerbates cities' "heat island" effect, as artificial surfaces absorb more solar heat than green areas. Cities with high soil sealing can still have a low level of soil sealing per inhabitant if they are compact and dense. The population and expansion of cities are not entirely negative if the expansion is coordinated, but where co-ordination is inadequate, it causes unplanned land uses that defy regional development planning.

6.2 The Consequence of Rapid Urban Expansion on Rural Land Use

The consequence of urban physical expansion of Damaturu on the rural land use is said to be negative. As gleaned from the frequency tables, 26.4% and 67% of the respondents indicate that the implications on the rural land use, resources and residents are adverse and very adverse respectively. This implies that more than 90% of the total respondents indicate that the consequence is at least adverse on rural land uses. This corroborates the result of the remotely sensed data which show consistent decrease of the rural land uses over the study period. Similarly, using the relevant question on the severity of the effects to compute the index, the computed severity index was 62.5%, which is

significantly high. The computed mean severity index was 2.16 on a range of 0-3 where three, is the maximum (very severe) value. These adverse consequences call for identification and application of efficient strategies for rural land use management so as to reduce the severity of the adverse consequences of urban expansion on rural land use, resource exploitation as well as on the socio-economic lives of the residents.

Table 6.1: The Consequences of Rapid Urban Physical Expansion on Rural Land use

Description	Frequency	Percentage
Very not Adverse	15	3.7
Not adverse	12	2.9
Adverse	108	26.4
Very Adverse	274	67.0
Total	**409**	**100**

Source: Fieldwork 2011

6.3 Consequence of Urban Physical Expansion on Farmlands

Analysis of the implication of urban physical expansion on farmlands shows that 51.3% (210) and 38.6% (158) indicates adverse and very adverse consequence respectively. This implies that 89.9% of the respondents indicate that the consequence is at least adverse as farmlands are being taken over by urban land use. This explains the initial loss of 4321.8 hectares of farmland and the individual farm sizes that have been affected by the urban physical expansion. The increase of farmland after 1999 is attributed to lack of clearly demarcated boundaries of the different rural land uses. Consequently, as the farmlands were being taken by urban physical expansion, farming activities were also taking over other rural land uses at a faster rate, thus, overall farmland continued to increase while other rural land use decreased consistently. The consequences on socio-economic status include low land yield, food insecurity because of low technology to immediately improve on new lands to make them productive farm sties. Besides, unplanned relocation to other areas results in temporary separation of family members among others.

Table 6.2 Consequence of Urban Physical Expansion on Farmlands

Description	Frequency	Percentage
Very not Adverse	24	5.9
Not adverse	27	6.6
Adverse	199	48.7
Very Adverse	159	38.9
Total	**409**	**100**

Source: Fieldwork 2011

6.4 Consequence of Urban Physical Expansion on Tree-cover Land

The analysis shows that 48.7% and 38.9% indicate adverse and very adverse consequences of urban physical expansion respectively. This implies that 87.6% indicates that there are adverse consequences of Damaturu physical expansion on the tree-cover areas as both tree-cover land and forest resources are being heavily overtaxed. Correlating the frequency values with the results of the imagery analysis revealed a consistent decrease of the tree-cover land. From 1986 to 1999, it decreased by 16.59% (8420.6 to 4597.8ha); it further decreased by 9.50% (4597.8 to 2823.5ha) and 2005 to 2009, it decreased by 5.6% (from 2823.5 to 2642.9ha). This explains that more forest land is being depleted and more hectares of land are being exposed to erosive, desertification forces and infertility. This is also making the area more vulnerable to persistent increase in bare land surface.

Besides, the respondents indicated from their experience over the years that common tree species of economic and herbal values have been fast disappearing, and the cost of forest resources including fuel-wood has been increasing as more effort, energy and resources are being invested to reap same quantity.

Table 6.3 Consequence of Urban Physical Expansion on Tree cover lands

Description	Frequency	Percentage
Very not Adverse	24	5.9
Not adverse	27	6.6
Adverse	199	48.7
Very Adverse	159	38.9
Total	**409**	**100**

Source: Fieldwork 2011

6.5 Consequence of Urban Physical Expansion on Prices of Local Building Resources

Local building resources influence the housing productivity of an area. The study investigates how physical urban expansion has affected the building resources and their sites in the study area. From the data collected, 44.7% (183) indicates that the consequences on the sites of local building resources are very not good. About 39.1% (160) indicates that the adverse consequences of the urban physical expansion on the sites of local building materials are significant. This is due to degradation through excavation of earthen soil for filling, sand from sand mines and local gravel; deforestation for fuel-wood and for other local civil construction purposes. Reconnaissance to some sites of the local building resource affirms that some sites have been abandoned due to depletion of the resource. It also reveals that the sites are not being treated before abandonment. Besides, the roads to the sites also lack maintenance. The implication of the consequence is that as the population increased, the demand for building resources also increased. As extraction of resources intensified to meet the demand for local building resources, some sites get exhausted and this compels the resource merchants to travel longer distances, expend more energy and resources to reap same quantities. This led to the increase in the prices of the local building resources across the study period as presented below.

Table 6.4 Average Prices of Local Building Resources (1986-2009)

Year	Sharp Sand (tons)	Earth for Backfilling	Local Gravel	Water (Per Tanker)
1986	1000.00	400.00	7000.00	200.00
1999	4000.00	600.00	7000.00	500.00
2005	11,000.00	2000.00	15,000.00	2000.00
2009	15,000.00	7,000.00	40,000.00	5000.00

Source: Fieldwork 2011

6.6 Consequence of Urban Physical Expansion on Ecological Footprint

The consequence of urban physical expansion on the ecological community is described as very adverse by 44.3 % of the respondents while 41.6% described it adverse. At least, more than 85% of the respondents describe it adverse while less that 15% describes it as not adverse. This agrees with the data from the imageries that show very low values of the area's global hectares/person, which indicates ecological deficit of the study area.

In testing the hypothesized relationship that urban expansion is not significantly related to the ecological footprint, the PPMC test produced a positive co-efficient of 0.41, and P-value of 0.045 < 0.05; this is significant at 0.05 significant level. Consequently, there is no enough statistical evidence to accept the null. The alternative that ecological footprint is significantly related to urban physical expansion is therefore not rejected.

Table 6.5: Consequence of Urban Physical Expansion on Ecological footprint

Description	Frequency	Percentage
Very Adverse	181	44.3
Not adverse	170	41.6
Adverse	53	13.0
Very Adverse	5	1.2
Total	**409**	**100.0**

Source: Fieldwork 2011

6.7 Interactive Variables

Human interaction with some environmental variables results to changes in rural land use. Interactive variables, therefore, refer to human-induced factors that facilitate land use change. For example, the urban areas expand as more structures are being built, this interaction results to conversion of un-built plots to urban built-up. Other interactions are government's investment policies (residential, transport network and other infrastructure), the pace of land provision for development and regulation of natural resource harvest among others. The data show that these have also contributed to the rapid urban physical expansion and the intensity of their degree of occurrence influence the severity.

6. 8 Severity of Urban Physical Expansion on Selected Variables

The severity-assessment considers four categories. The first relates to the current status of a specific negative change such as elimination of vegetative cover in arid region. The change is assessed in terms of its severity, spread, and irreversibility. The remaining categories relate to the potential or actual adverse effects of a negative change on (i) the biophysical resource base or environmental parameters and their interaction patterns such as decline of natural vegetation affecting regenerative processes, nutrient and moisture cycles, and the whole hydrology of a region. (ii) the population increase, rural land use changes and resource depletion (iii) societal conditions, including the availability of productive resources, production flows from resources, and the resilience of the economy and society such as reduced diversity of agriculture influencing resilience of farming system (iv) the implication of the use-patterns of the resource base, which tend to accentuate the vicious circle of resource over-extraction. For instance, any negative change such as reduced resource productivity, slackened regenerative process that further compels people towards greater resource extraction and use of desperate measures (persistent felling of live trees, extraction in deep/steep slopes) are the important symptoms of the criticality of the situation.

This investigation into the urban physical expansion and the implication on the rural land use in Damaturu identifies the magnitude of severity in the land use changes,

environmental as well as ecological resources and human well being. The severity is considered in the spread and intensity of the consequences on the selected variables.

6.8.1 The Magnitude of Change on the Indices

Environmental changes are subject to a variety of indicators having multi-faceted consequences that sometimes undermine absolute contextual and empirical interpretations. Due to lack of measuring index for the consequences, the researcher used weighted-opinion assessment to analyze the perception and on that basis compute the severity index of the consequences on some selected variables such as loss of rural land use, loss of bio-diversity and indigenous species, depletion of the resources. These reveal the wide spread severity in terms of coverage and intensity (destruction) of the consequences.

6.8.2 The Spread Severity Index of the Consequence

The Severity assessment considered people's opinion on the spread, severity and reversibility of specific consequences. The dominant view of the respondents on the severity of the consequences relating to the extraction of local resources is that, resource merchants' attitude and methods of resource abstraction and the natural forces exacerbate environmental change. Respondents' opinions in this context are not only based on their opinions but also views that emerged from the data analysis. However, the weighted opinion assessment used to assess severity does not distinguish between the different types of changes in terms of their relative importance and potential role in precipitating other negative changes.

Spread severity of environmental changes as perceived by the settlements close to resource-sites also indicates that there are very high adversities. The magnitude and the intensity of the indices of the consequences are explained in terms of their effects on people, land use and ecological resource components. Thus, consequences on land use are reported by more than 93.0% of the respondents as being severe in table 6.1. Similar changes were reported on farmlands, tree-cover areas and water bodies, which portends that the situation is critical.

6.8.3 Simultaneous Occurrence (spread) of Indicators of Environmental Consequences Due to Urban Physical Expansion of Damaturu

In this study, the assessment strategies are classified into four categories: The first relates to the status of specific negative change such as mass removal of tree cover, shrubs and grass cover in the arid area, keeping in mind their severity, spread and irreversibility. The second relates to the assessment of the potential and actual consequences of a negative change on the biophysical resource-base and their systemic function such as decline of natural vegetation affecting regenerative processes, nutrients and the hydrological system. The third relates to the human environment that influences and reveals the societal condition including resource availability, exploitation and development activities that utilizes natural resources in the study area. It is observed that over-taxing of resources for economic development without environmental compensation reduces the resilience of the ecological and economic well-being. The fourth relates to the use-pattern of the resource-base, which tend to accentuate the vicious circle of resource degradation through unsustainable method and exacerbates degradation in the study area. Use pattern is said to be adverse where negative changes (reduced resource productivity, slackened regenerative process) compel people to adopt more desperate search and less sustainable resource extraction measures. For example, frequent looping of trees will further impoverish the unstable environmental resources and cause more negative changes.

In assessing the degree of the consequence of environmental change due to urban expansion, the data affirm that the decline in resource status without regenerative process of the land resources portends further decline, which significantly contributes to further deterioration of the societal well-being. The land use and land cover changes affect the future economic resource availability to respond to the increasing demand and this combines to further reduce the ecological and economic resilience in the adjoining rural communities. It is also observed that, adverse environmental changes accentuate the severity of negative changes. However, villagers viewed loss of farmlands, vegetation and roads degradations as the most critical environmental changes in the villages, because other consequences of rural land use changes are less pronounced in the villages.

6.8.4 Consequence of Waste Disposal in Borrow-pit

This highlights the consequences of some activities that are directly related to urban physical expansion. Observation during reconnaissance survey shows that there is improper disposal of waste in borrow-pits, which pollutes early storm water and makes it unsuitable for consumption by domestic animals. The villagers close to such places reported that, the animals that drink early storm waters from these borrow- pits become sick and some die. This is an adverse consequence on the socio-economic status of the proximate settlements.

6.8.5 Consequence on Indigenous Land Management Methods

The rural residents normatively comply with indigenous methods of rural land use management. However, the rapid population growth and the attendant statutory land acquisition that has taken precedence over the customary practice in government acquired lands have undermined the indigenous practices of land management. The implication is that the statutory land procedure did not establish a compatible relationship between the rural ecology, socio-economic activities and the emerging urban land uses. This explains why the urban land use is rapidly evolving without regards to rural ecology. For example, the abandoned borrow-pits that were not initially planned for waste disposal centres were converted to waste disposal centres wherever they are located. These have become feasible sites that initiate erosion during heavy downpours.

6.8.6 The Consequences of Urban Physical Expansion on the Surrounding Rural Land Uses

The process, characteristics and consequences of urban expansion on the surrounding land use changes were analyzed and the driving mechanisms behind the expansion were also investigated. The land use results show that from 1986 to 1999, the urban built-up area increased by 0.8% (398.6 to 2045.9ha) from 1999 to 2005, it increased by 4.03% (from 2045.9 to 2802.4ha), and from 2005 to 2009, it increased by 5.52%(from 2802.4 to 3078.3ha). It is the analysis and details on the expanse of urban physical expansion and the severity of the attendant implications that enables rural institutions to

apply appropriate policy instruments to reduce the severity of the consequences. The respondents lack this knowledge because of their low level of education and the value they placed on the natural resource and its sustainable use.

6.8.7 Consequences due to Physical Proximity

The settlements closer to Damaturu, major resource sites and roads reported severer consequences of physical expansion of Damaturu in terms of rural land use changes and resource exploitation that lead to environmental degradation than the settlements that are far from these sources. Similarly, data from resource merchants also reported higher level of resource reaping and consequences by settlements close to resource sites more than farther settlements. Therefore, physical proximity to resource sites and to Damaturu increases rate of resource harvest and severer consequences. Furthermore, 50% of the respondents (resource merchants) indicate that distance is affecting their rate of supply. The effects of increasing distance to natural resource sites inversely affect the quantity and severity of the consequences. Thus there is distance decay effect on the consequences as the resource sites or settlements become farther from Damaturu. The exposure to non-native resource merchants threatens the privacy of the rural communities, the over-exploitation of resources that leads to environmental degradation and loss of farmlands among others are the negative effects on socio-economic well-being that increase their vulnerability and reduce the security of the rural residents' livelihood.

The trend line for the urban physical expansion in the region internalizes four related human-induced factors (population growth and its resource demand, the institutional and economic establishments, government investment policies and weak urban growth control measures) which have contributed in varying proportions to the devastating environmental changes. These have increasingly forced the poor farmers to relocate to marginal portions of semi-arid land with lesser produce as they lack the resources, labour and technology to make land improvements. Meanwhile, societal management responses to these are dilatory, quite ineffective and also have potentials for future large-scale resource-collapse as well as degrading of the regional environment and economy.

Furthermore, the changing nature-society conditions have declined environmental recoverability as a result of the draw-down of the environmental resource base, possibly exacerbated the decline in the 'sustainable use' for a number of reasons (such as decline or weak political power of the region, decline in regional wealth, or change in terms of trade). The portending state of increasing environmental threats corroborates the respondents' perception concerning the current states of resource-use in the study area and the degree of confidence in the probable accuracy of our judgment.

6.8.8 Summary Results on Severity of Indices Analysis

Percentage of the Severity Index (PSI) = 62.5%. Referring to the rating classification of the indices, 50% to 75% is considered significantly severe. Mean severity index =2.16. This lies between adverse (2.0) and very adverse (3.0) weighted index classes. That is to say that the obtained value (2.16) is tending to 3 which is the maximum value (very severe). It implies that both the severity index and the mean severity indices are high.

CHAPTER SEVEN

7.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

The preceding chapters have presented a broad account of the pattern of expansion, the factors and the implications on rural land use. It also presents the driving forces and the perceptions associated with environmental changes in the study area. Specifically, the study examined the trend, the pattern, the driving forces, the consequences, the dimensions affected, the perception of the residents and their coping strategies. It finds that Damaturu has significantly expanded over the study period at the mean annual expansion rate of 28.0%. However, this rate of expansion varies between time-frames and physical areas as it was as high as 32% between 1986 and 1999; it came down to 7.4% and 2.45% between 1999 and 2005, and 2005 and 2009 respectively. Spatially, it expands faster in the eastern and southern parts that are settled by non-indigenes that establish more schools, hospitals and other economic activities than in the western part that is dominated by indigenes whose plots are usually reserved for their children and other family relations. The physical expansion is star-shaped extending farther along corridors of transport network, the nature of location of its housing estates leap-frog leaving swath of land between them and the town, the emerging junctions of the ring road provide new nuclei for fast development while the ring road is helping its concentric structure. The trend and pattern of physical urban expansion depicts varied temporal and physical expansions.

In terms of its driving forces, the analysis shows that the intensity of human-induced activities has significantly influenced the landscape pattern and the dynamic changes in the land use and land-cover types of the study area. The driving forces include government's jurisdictional policy that elevated the town to a state capital. This led to increase in population and demand for land to accommodate federal, state and local government infrastructure. The elevation and population increase also led to increased

investment in transport network, such as the ring road, which is significantly contributing to the transformation of the rural lands near and along the road into built-up areas. Another factor is the development of housing estates and administrative complexes, establishment of commercial facilities, institutions of academic and medical nature among others. Out of the 3078.3 hectares of land converted to urban land use, analysis of the updated land use map of 2010 revealed the contribution by each factor as follow: Federal development due to change in status contributed 3.07% (94.504ha); residential contributed 53.31% (1641.042ha), academic institutions contributed 19.67%(605.502ha), medical institutions 05.26%(161.918ha), economic facilities contributed 09.24% (284.443), transport networks contributed 2.39% (73.571ha), religious activities contributed 4.03% (124.05549ha) and other factors contributed 3.03% (93.27249ha). During this study period, it was discovered that many of the farmlands at the periphery of the urban land were being converted to urban built-up lands. In response to the food and fibre need of the increasing population, other rural lands were converted to farmlands while the farmland was being taken over by the urban land use.

The study also examined the consequences of the expansion and found that the development of Damaturu, as experienced in many other urban centres in developing countries, draws heavily on the surrounding natural resources and creates waste that ends up in the surrounding regions of the town. Large proportions of soil, sand, gravel mines, and fuel-wood were consumed as many of the tipper drivers go to excavate sand, gravel and filling soil on daily basis. From the data, some of these trucks go more than two times a day depending on the demand for it. Through this, urban population growth has caused an increasing rate of resource-extraction for development and depletes natural resources. Across the settlements, respondents identify that the hallmark of their well-being is having access to natural resources as the main source of their livelihood as this access reduces their vulnerability to destitution. About 95% of the respondents engage in resource-dependent activities such as rain-fed farming, animal husbandry and other menial work including the selling of water, fuel-wood and packing of sharp/plastering sand in depressed areas with bullock-powered trucks during rainy season. This they pack and sell for their sustenance. From the analysis, the rapid conversion of rural land use has destroyed environmental richness, depleted the natural resources and vegetation, and

through that has been negatively affecting their means of livelihood. Therefore, consistent monitoring and measurement of urban expansion and land use changes are not only to determine the type, amount, and location of land conversion, but are also crucial to formulation of environmental resource sustainability policies and updating of information for sustainable land use planning and management as well as control of other associated consequences of rapid urban expansion.

It was found that rural land use (shrubs and forest) have been fragmented, modified and converted to satisfy increasing space-demand for urban expansion. Consequently, the urban area becomes more extensive and encroaching on rural land use, and there is a seemingly strong competition between urban expansion and agriculture, which adversely affect the stability of other rural land uses and the core traditional means of livelihood.

Urban physical expansion causes loss of arable land, destroys habitat and impoverishes bio-diversity. It degrades the ecological resilience through sand and gravel mines, over-exploitation of forest and veld products arising from demand for fuel-wood and construction industry. These cause soil erosion and decline in soil productivity among others.

In terms of the status and activities of resource merchants, analysis show that people harvest natural resources to alleviate poverty. Data show that natural resources sustain about 90% of the ever-growing population of the rural unemployed households. However, such exploitation is not without cost, as the resource abstraction has become more intense; it caused changes that are adverse to the environment such as rural land use, resources and ecological impoverishment.

The town and settlements are surrounded by farmlands extending into the rural hinterland. However, the green environment with its associated natural resources is under the threat of rapid urban physical expansion. This threat manifests in fragmentation, modification, conversion and sometimes destruction of vital rural land use resources such as forest lands, shrubs, grass lands, farmlands, wildlife species and habitat, grazing lands, strip mines (quarries, sand and gravel pits) and other rural-based bio-resources. Therefore, it is clear that the rapid urban physical expansion of Damaturu is occurring at the expense of the natural resource environment around the town. Since majority of the rural residents depend on natural resources for their livelihood, the diminishing trend of the resources

due to rapid urban expansion, adversely affects their core source of livelihood. Investigations of the human and physical dynamics of the five of the rural land uses reveal that there have been significant changes. For example, between 1986 and 2009, human population increased by 112.2% (from 363,313 to 770,550); in the same period, bare land increased by 574.8% (from 435.1 to 2,936.2ha), built-up land increased by 672.3% (from 398.6 to 3,078.3ha) and farmland increased by 21.2% (from 24237 to 29379.9ha). On the other hand, tree-cover land decreased by 68.6% (from 8420 to 2642.9ha), shrubs and grass land decreased by 25.6% (from 17009.4 to 12647.5ha), while water decreased by 71.8% (from 256.1 to 72ha). The farmlands initially decreased rapidly, but later increased as more civil servants and support population engage in farming activities to augment their meager earnings. Also, bare surface increased persistently due to continuous conversion of rural land to urban and depletion of forest areas and increasing grazing intensity in the area.

A summary of findings on the severity of the consequences of the urban physical expansion on the rural land uses revealed a dynamic expansion characteristics such as outward, up-ward, road-led and sprawling expansion that have led to the loss of rural land use and affected the livelihood of more than 90% of the rural-based. Severity analysis shows that while it was easy to measure and quantify the emerging land use changes, it was difficult to measure and quantify severity of consequences on all the rural land uses and built settlements, and more difficult to measure the consequences (either direct or indirect) on human-beings. For example, one may agree that their core source of livelihood is being affected, but to what extent? Severity analysis was used to assess the degree of the severity and the result was described as being very adverse. Using the weighted opinion-assessment method to assess the perception of the respondents on the environmental changes and the consequence, more than 85% of the respondents perceived that the consequences were more negative than positive. Besides, the widespread of the consequences across the settlements as shown in the imageries indicate the simultaneous spread and the expanse of the destruction and intensity on ecological components across the settlements, which corroborate the opinions of the respondents.

The severity of the ecological resources destroyed is revealed in the estimated 42,030 tree-loss in the 3,078.3ha converted from natural environment to urban use within

the study period. Besides, the computation of the severity index of the consequences was 62.5%, which is severe. The Mean Severity Index (MSI) was 2.16 in the range of 0-3, where 3.0 represent the very severe values. This implies that the 2.16 MSI is tending to very severe condition.

A statistical test to assess the severity of consequences as distance changes over time reveals the severity of the implications of the urban physical expansion on the land use. Further relating the severity to distance, it shows that there is a significant inverse relationship between distance and severity of consequences as presented in the frequency table 6.1. Another test on proximity of settlements to resource sites and the consequences of resource extraction on such settlements yielded a P-value of .014, which is statistically significant. From the data supplied by the respondents in table 6.5, as the distance increases, the quantity supplied decreases. It implies that settlements closer to Damaturu and natural resource sites experience more severe consequences than those farther from these sources which confirms that there is distance decay effect.

7.1 Contribution to knowledge

Investigation into the urban physical expansion and its implication on rural land use in Damaturu reveals the pattern, the driving forces of change at work, leading to greater environmental degradation and less socio-economic well-being. On the whole, the overall well-being, except among indigenous groups, has continued to increase. This thesis has empirically shown that accurate analysis of human impact on the natural resources presented informed choices about positive and negative environmental changes. The implication is that since the area is dominantly agricultural where increasing environmental degradation causes wealth and well-being to decline, the bio-physical resource-base that is degrading rapidly will eventually discount all the positive benefits including the rapid transformation. Therefore, it is the responsibility of the state government to promote changes that will improve the socio-economic well-being of the native inhabitants while at the same time reducing the negative changes that degrade the environment and limit its human use.

7.2 Suggested areas for Further Research

This research concentrates on analyzing the implications of urban physical expansion on rural land use in Damaturu. As a framework to achieve this, it assessed how the city has been rapidly urbanizing, the forces driving the expansion, the consequences and impacts, how the residents perceive the urban expansion and its implication on rural land use among the vulnerable groups, the coping strategies and the planning policy implication of the consequential changes. There are related areas such as monitoring and evaluating the application of control measures, perception and effects on the most affected social groups and the policy strategy that addresses the impacts better among others.

7.3 Conclusion

Salient factors that have influenced the expansion of Damaturu comprise the elevation of its status to a state capital. This was found to be significantly responsible for the ensuing population growth and the high urban demand for land that converts rural land uses to accommodate emerging urban infrastructure and institutions. Another factor is that of availability of natural resources that constitute the foundation for livelihood option in the study area, these have been significantly over-taxed and this unsustainable use and management of the available natural building and ecological resources have affected rather than enhance food security and human well-being. Similarly, availability of the Jos/Kano-Maiduguri regional road, the Gashua-Biu road that traverse the town, and more recently the ring road also contributed to the linear, multi-nuclei and leap-frog expansions. Closely related is the state government's investment policy in economic and housing estates that are often located away from Damaturu town. The religious and ethnic sentiments against integration of non-indigenes have resulted to the non-natives dominating areas such as Sabon Pegi, New Jerusalem and Nyanyan among others, which develop faster than indigenous areas.

Another factor is the establishments of public and private tertiary institutions such as Bukar Aba University, the Federal Polytechnic, Secondary schools such as Yobe Academy, Royal School, Excel Academy, Yobe International Academy, Yobe Scholars and Leaders' Private secondary school among others, have facilitated the expansion process of Damaturu as they occupy space and influence rapid extraction of natural

resources for development and maintenance. Lack of good governance in terms of land laws, democratic dividends, planning agencies, weak enforcement of urban growth control measures among others, have contributed in different proportions to the expansion of Damaturu with significant consequences on the rural land uses and resources. Many of these constitute pull-factors for rural population.

The prevailing inequity in the distribution of basic resources between the urban rich and the rural poor has continued to widen the gap between the standards of living of the urban and the rural-communities from whose ecosystems natural resources are harvested for the development of the urban centres. The study on the urban physical expansion of Damaturu and its implication on rural land use in Damaturu, shows that if the rural poor from whose areas natural resources are being exploited with ecological consequences and whose daily grueling labour is just enough to feed them for a day are ignored in the distribution of basic resources, they will undermine the principles of sustainable development such as environmental resource conservation. They will ignorantly or deliberately cultivate or excavate any land, harvest any resource, cut down or haul any tree for fuel-wood, poach any animal if such fetches something to satisfy their basic necessities regardless of the long-term consequences.

Urban physical expansion and severe environmental degradation in Damaturu is found to be associated with poverty in the region. It is also characterized as inadequately managed because the existing planning agencies and instruments available have not effectively managed its growth and the adverse implications on the natural environment due to the conflict between economic growth and environmental protection. The absence of conservation-linked or environmentally-friendly resource development in Damaturu, whose socio-economic system relies heavily on its natural environment has directly degenerated the human-support system. It also caused profound reduction in human well-being and human relocations of farmers and shepherds, which has evolved spontaneous and unplanned settlements at the fringes of the town.

In view of the foregoing discussion, the state agencies that are charged with the responsibility of ensuring ordered development of Damaturu (survey, town planning) seem to have been outpaced by the rate of expansion. In response to this, the town planning department has to apply planning control measures such as development control,

urban growth boundary in a stricter manner than before to control the development trend. Besides, there is urgent need for a regional development plan for this rapidly urbanizing region and the state government should commission a planning firm to prepare a regional development plan of the Damaturu region to manage the region with a focus for linkages and synergies between economic, social and environmental sectors. These will regulate the rapid urban physical expansion, manage the consequences and propose regional environment-friendly resource abstraction methods to arrest the environmental degradation through resource abstraction. It is hoped that this approach will slow the rate of urban expansion and resource exploitation, manage the negative implications, stem the tide of environmental and ecological impoverishment, reduce the declining stocks of natural resources, as well as enhance the economic well-being of the rural residents.

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APPENDIX I

Department of Urban and Regional Planning

Faculty of the Social Sciences

University of Ibadan

IMPLICATIONS OF URBAN PHYSICAL EXPANSION ON RURAL LAND USE IN DAMATURU, YOBE STATE

Dear respondent,

This questionnaire is designed to assess the consequences of physical expansion on the rural land use in Damaturu, Yobe State. You are requested to supply answers to the questions below. The study is purely an academic exercise and the information will be used strictly for that purpose and confidentially too.

QUESTIONNAIRE TO THE HEADS OF HOUSEHOLD

Part A: Socio-economic variables

(1) Name of settlement unit ……..

(2) Gender (a) male (b) Female

(3) Age of respondent……..

(4) Religion ……

(5) Ethnicity…….

(6) Occupation (a) Farming (b) trading (c) civil servant (d) Artisan (e) Others (specify)……..

(7) Marital status: (a) married (b) unmarried (c) widower (d) divorced (e) Separated

(8) Educational qualification (a) Arabic (b) primary Cert. (c) SSCE/GCE (d) post secondary Cert.

(9) Number of years in this area (a) less than 5years (b) 6-10years (c) 11-15 (d) 16-20

(10) Is this your main source of family income? (a) Yes (b) No

(11) Is your occupation adequately sustaining your family? (a) Yes (b) No

(15) How many sacks of the following crops do you produce per farming season?

Description	1-3	3-5	5-7	7-10	>10
Millet					
Beans					
Guinea corn					
Ground nut					
maize					

(16) What is your annual income from farm produce?

(a) 10,000.00 - 20,000.00 (b) 21,000.00 - 40,000.00 (c) 41,000.00 - 60,000.00(d) 61,000.00 - 80,000.00 (e) 81,000.00 -100,000.00 (f) >100,000.00

17. Have you changed farm site in the last twenty years? (a) Yes (b) No

18. If yes what led to your change of farm site?

19. Does the change affect your farm size? (a) Yes (b) No

20. Were you producing more on your previous portion of farm? (a) Yes (b) No

21. Do you practice mixed farming? (a) Yes (b) No

22. Has urban expansion affected your livestock grazing? (a) Yes (b) No

23. Have you relocated settlement in the last twenty years? (a) Yes (b) No

24. If yes, was the change due to urban physical expansion forces? (a) Yes (b) No

25. How does this change impact on your means of livelihood? (a) very significant (b) significant (c) not significant (e) very not significant

26. What are your responses to this urban physical expansion in terms of livelihood?

(a) Relocation of farm sites (b) Intensive Agriculture (c) Land conservation.

Part B: Urban Physical Expansion of Damaturu

(27) Do you agree that Damaturu town is physically expanding? (a) Yes (b) No

(28) If yes, describe the rapidness of the expansion by your assessment (a) Not rapid (b) rapid (c) very rapid.

29.Tick the extent the following variables have influenced the urban physical expansion of Damaturu

Key variables		No influence	Fair influence	influence	Very much influence
Jurisdictional factors	Federal offices				
	State offices				
	Other Federal projects				
Socio-demographic	Population growth				
	Preference to single-family houses				
	Recreational land use activities				
	Religious land use activities				
Socio economics	Educational institutions				
	Health institutions				
	Commercial market, shopping mall				
	Ease in land acquisition				
	Increase in wages				
Investment policies	Residential estates				
	Transport network				
	Industrial layouts				
Proximity to building resources sites	Sand				
	Gravel				
	Chips				
	Timber				

(30) By your own assessment, tick the extent the physical expansion has affected the followings:

	V. not adverse	Not adverse	Adverse	V. adverse
Rural land use				
Rural open space				
Land cover				
Wild life habitat				
Farm lands				
Natural building resources				
Forest lands				
Bio-diversity richness				
Rural roads condition				
Environmental quality				

31. Rank the following variables in the order of their influence on the urban physical experience

Description of key variables	1st	2nd	3rd	4th
Jurisdictional factors				
Socio-demographic				
Socio economics				
Investment policies				
Proximity to building resources sites				

32. In what ways has the urban expansion affected you?.....

33. Assess the consequences of urban physical expansion on the following variables

Description of variables	Increasing	Decreasing
Rural land use		
Local building resources		
Firewood resource		
Biodiversity		
hardcore		
Greenery land cover		

34. Rank the following land use variables in terms of their being most disturbed by urban physical expansion

Description of land use variables	Ranking sequence
Tree cover land	
Bare	
Farm land	
Pasture/grass land	
Water bodies	
Building resource sites	

Part c: Natural Resource Sites

(35) Is there any natural resource site close to this settlement? (a) Yes (b) No

(36). If yes, what type of resource(s) are endowed close to this settlement? (a) Mineral resource (b) Building materials (c) vegetal resources (d) soil fertility (d)

(37). How far is the site from this settlement? (a) <5 km (b) 6-10 km (c) 11-15 km (d) >15 km

(38) Assess the consequence of urban spatial expansion on the following natural building resources?

Resource description	V. not good	Not good	fairly good	Good	V. good
Soil mines deposits					
Sand mines deposits					
Gravel mines					
Granite deposits					
Chips deposits					
Quarries					
Boulders/Stones					
Tall trees					
Land Surface quality					

Part D: Vegetation

(39) How adversely has the physical expansion of Damaturu affected the followings?

Resource	Very not adverse	Not adverse	fairly adverse	adverse	Very adverse
Natural landscape					
Land cover					
Grass land					
Trees					
Shrubs					
Bare lands					
Agric lands					
Soil fertility					
Soil Erosion					
Vegetation					
Environmental integrity					

Part E Consequences

(40). Assess the consequences of urban physical expansion activities on the following variables within the study area?

Variables	V. Adverse	Adverse	Fairly Adverse	Not adverse
Environmental variables				
Rural land use Conservation				
Ecological resilience				
Wildlife habitat capacity				
Soil fertility and resistance				
Agricultural land and produce				
Resistance to desertification				
Area under Forest				
Biodiversity				
Grassland				
Resource site				
Natural Resource Variables				
Trees				
Clay Soil deposit				
Laterite mining sites				
Sand resource sites				
Natural water bodies				
Gravel mining sites				
Granite quarries				
Socio-economic Variables				
Family Cohesion				
Health				
Source of livelihood				
Agricultural Produce				
Schooling Opportunities				
Income status				

Livestock husbandry				
Human Well-being				
Rural Development and Resource management				
Quality of development of adjoining rural areas				
Traditional resource management methods				
Indigenous Land management methods				
Rural Road Condition				

APPENDIX II

Department of Urban and Regional Planning

Faculty of the Social Sciences

University of Ibadan

QUESTIONNAIRE ON THE IMPLICATIONS OF URBAN PHYSICAL EXPANSION ON RURAL LAND USE IN DAMATURU, YOBE STATE

Dear respondent,

This questionnaire is designed to assess the consequences of urban expansion of Damaturu on its rural land uses. You are requested to supply answers to the questions below. The study is purely for academic exercise and the information will be used strictly for that purpose and confidentially too.

QUESTIONNAIRE TO RESOURCE MERCHANTS

Name of unit ……..……..

Part A: Socio-economic variables

(1) Gender (a) male (b) Female

(2) Age of respondent……..

(3) Religion ……

(4) Ethnicity…….

(5) Occupation (a) Farming (b) trading (c) civil servant (d) Artisan (e) Others (specify)……..

(6) Marital status: (a) married (b) unmarried (c) widower (d) divorced (e) Separated

(7) Educational qualification (a) Arabic (b) primary Cert. (c) SSCE/GCE (d) post secondary Cert.

(8) Number of years on this job (a) less than 5years (b) 6-10years (c) 11-15 (d) 16-20

(9) Is this your main source of family income? (a) Yes (b) No

(10) Is the job adequately sustaining your family? (a) Yes (b) No

(11) Estimate your income per day……

Part B: Natural resources availability, harvest and use variables

(12) What type of surface land resources do you supply? (a)Fuel wood (b) Building sand (c) gravel (d) others (specify)……..…….

(13) What type of transportation mode/ truck do you use in the supply of the resource? (a) Fuel powered truck (b) Animal powered truck (c) Man powered truck (d) Tipper vehicles.

(14) How far was the site of the resource when you started?

(15) How far is the resource now?

(16) Is the distance affecting the quantity you harvest every day? (a) Yes (b) No

(17) How many trucks were you supplying per day when you started? ……

(18) How many trips do you make per day?

(19) What determine the supply rate? (a) Urban demand (b) distance to the site (c) Road condition (d) cost of labour.

(20) What is the supply cost per truck of the resource? …….…….

(21) Does it take you more than one day to sell your supply? (a) Yes (b) No

(22) Are you satisfying the urban-demand for the resource? (a) Yes (b) No

(23) Have you abandoned any site since you started? (a) Yes (b) No

(24) Why did you abandon the site? (a) Extinction of the resource (b) government's ban (c) resistance from indigenes (d) bad road (e) others (specify) ……

(25) Do you treat sites before you abandon them? (a) No (b) Yes

(26) What has been the challenges limiting your performance? (a) Inadequate finance (b) government restrictions (c) Low market (d) community resistance (e) others (specify)……..…

(27) Are more people getting engaged in this job? (a) No (b) Yes

(28) What do you think is attracting people into the job? …….

(29) Do you agree that the resource will be exhausted in the next five years if this current rate of harvest continues? (a) No (b) yes

(30) How many live trees do you fell per week?.....

(31) Do you re-grow or allow for regeneration of the resources you harvest? (a) No (b) Yes

Part C: Effect on rural land uses

(32) How adversely do you think the harvest of the resource is affecting the followings?

Resource	Very not adverse	Not adverse	fairly adverse	adverse	Very adverse
Forest land use					
Rural open space					
Farm lands					
Grassland					
Wildlife habitat					
Biodiversity presence					
Land cover					
Natural building sites					
Grazing land use					
Rural road condition					

(33) What is the condition of the road to that site? (a) very not good (b) Not good (c) Fairly good (d) Good (e) Very good

(34) What are the other environmental problems associated with the method of harvest of the resource?.....…

(35) Do you agree that your trucks contribute to the bad condition of the road? (a) No (b) Yes

(36) Have you ever taken any counter measures to mitigate negative consequences? (a) Yes (b) No

Part D: Supervision and enforcement of environmental standards

(37) Do you know of any government agency supervising the extraction of the resource? (a) No (b) Yes

(38) Do you know of any agency that issue license to willing reapers? (a) No (b) Yes

(39)Are you aware of any law(s) regulating the harvest of this resource? (a) No (b) Yes

(40) Do you know of any penalty for contravening the law protecting the resource? (a) No (b) Yes

(41) Do you know of any arrest, seizure or fine for contravening the laws regulating the harvest of the resource? (a) No (b) Yes.

Part E: Management of the consequences

(42) Has your association done anything to reduce the consequence on the rural land use resource? (a) No (b) Yes

(43).What would you advise the union to do for the settlements close to the natural resource sites?

Part C: Natural building materials

(44) Assess the consequences of urban resource extraction the following natural building resources?

Resource description	V. not good	Not good	fairly good	Good	V. good
Soil mines deposits					
Sand mines deposits					
Gravel mines					
Granite deposits					
Chips deposits					
Quarries					
Boulders/Stones					
Tall trees					
Land Surface quality					

Average Prices of Local Building Resources (1986-2009)

45. Fill in the cost of the resource as applicable

Year	Sharp Sand (in tons)	Earth for backfilling	Local Gravel	Water per tanker
1986				
1999				
2005				
2009				

Part D: Vegetation

(46) How adversely does the resource extraction affect the followings?

Resource	Very not adverse	Not adverse	fairly adverse	adverse	Very adverse
Natural landscape					
Land cover					
Grass land					
Trees					
Shrubs					
Bare lands					
Soil fertility					
Soil Erosion					
Vegetation					
Environmental integrity					

Appendix iii

Correlations

		Damaturu expansion	Rural land use	Farm lands	Forest lands
Damaturu expansion	Pearson Correlation	1	.099(*)	-.116(*)	-.122(*)
	Sig. (2-tailed)		.046	.019	.014
	N	409	409	409	409
Rural land use	Pearson Correlation	.099(*)	1	-.031	.018
	Sig. (2-tailed)	.046		.531	.723
	N	409	409	409	409
Farm lands	Pearson Correlation	-.116(*)	-.031	1	.397(**)
	Sig. (2-tailed)	.019	.531		.000
	N	409	409	409	409
Forest lands	Pearson Correlation	-.122(*)	.018	.397(**)	1
	Sig. (2-tailed)	.014	.723	.000	
	N	409	409	409	409

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Correlations

		Distance of the site when started	No. of truck supply when started
Distance to the site when started	Pearson Correlation	1	.520(**)
	Sig. (2-tailed)		.000
	N	100	100
No. of truck supply when started	Pearson Correlation	.520(**)	1
	Sig. (2-tailed)	.000	
	N	100	100

** Correlation is significant at the 0.01 level (2-tailed).

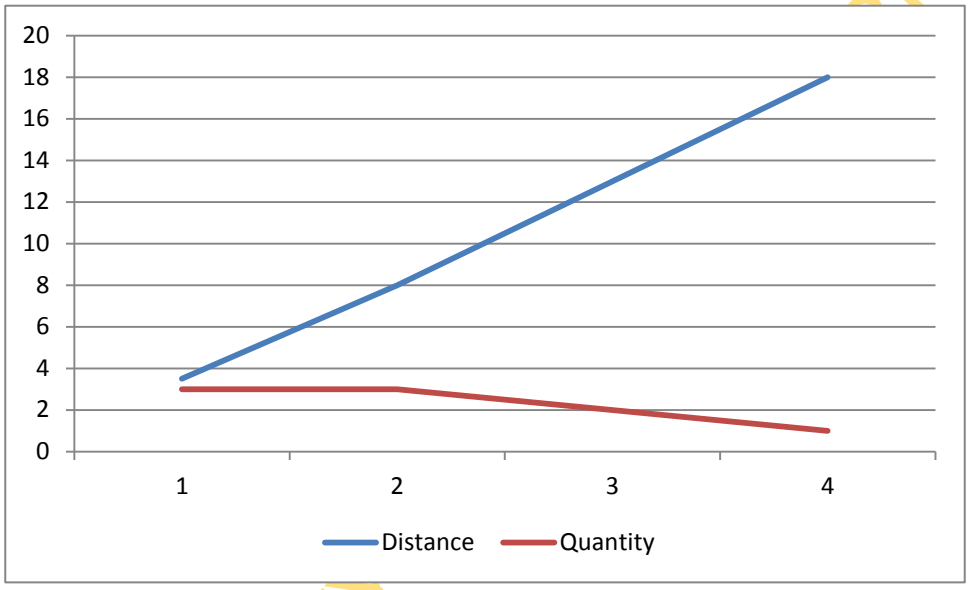
Correlations

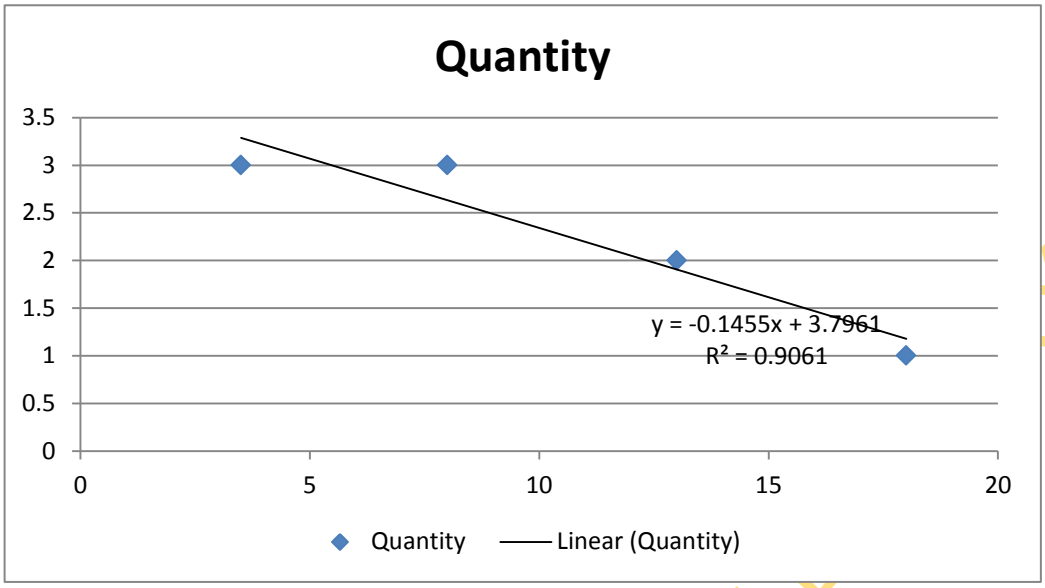
		Distance now	No. of trip per day
Distance to the site now	Pearson Correlation	1	.245(*)
	Sig. (2-tailed)		.014
	N	100	100
No. of trip per day	Pearson Correlation	.245(*)	1
	Sig. (2-tailed)	.014	
	N	100	100

* Correlation is significant at the 0.05 level (2-tailed).

APPENDIX IV

Distance Range	Average Distance	Quantity Supply
1-5km	3	3
6-10	8.5	3
11-15	13.5	2
16-20	18	1





APPENDIX V

The answers to question 35 of the questionnaire for the heads of households on the perception of the consequences was presented on a likert scale of 1-4 options that correspond with 0,1,2,3 values, while the severity index was calculated using Al Hammed and Alsalf equation (1996):

$$SI = \frac{3\sum_{I=0} aixi}{3\sum_{I=0} xi}$$

Where a_i = the index of a class; constant expressing the weight given to the class

xi= the frequency of the response

i=0,1,2 and 3 and described as below: where

X0, X1,X2,X3 are the frequencies of response corresponding to a_o= 0, a_1=1; a_2=2; a_3=3 respectively.

The rating classification was adapted and modified after Majid & McCaffer (1997)

$a_o = Not\ Adverse \quad (NA) \quad 0 \le SI < 25$

$a_1 = Fairly\ Adverse \quad (FA)\ 25 \le SI < 50$

$a_2 = Adverse \quad (A)\ 50 \le SI < 75$

$a_3 = Very\ Adverse \quad (VA)\ 75 \le SI < 100$

NR=No. of Response; PR= Percentage of Response

In order to assess the evaluation of respondents' perception of the severity of the consequences of urban expansion on each variable, the results of the responses were presented as below:

Variables		Very Adverse	Adverse	Fairly adverse	Not Adverse	Severity Index
Values		(3)	(2)	(1)	(0)	
Environmental Variables						
Rural land use Conservation	NR	294	105	8	2	2.7
	PR	71.9%	36.4%	1.9%	0.5%	
Ecological resilience	NR	249	149	8	3	2.6
	PR	60.9%	36.4%	1.9%	0.7%	
Wildlife habitat capacity	NR	230	140	23	16	2.4
	PR	56.2%	34.2%	5.6%	3.9%	

Soil fertility and resistance	NR	143	185	67	14	2.1
	PR	35%	45.2%	16.4%%	3.4%	
Agricultural land and produce	NR	244	144	17	4	2.5
	PR	59.7%	35.2%	4.2%	1.0%	
Resistance to desertification	NR	159	230	16	4	2.3
	PR	38.9%	56.2%	3.9%	1.0%	
Area under Forest	NR	187	174	46	2	2.3
	PR	45.7%	42.5%	11.2%	0.5%	
Biodiversity	NR	150	222	31	6	2.3
	PR	36.7%	54.3%	7.6%	1.5%	
Grassland	NR	269	115	21	4	2.6
	PR	65.8	28.1	5.1	1.0	
Resource site	NR	181	170	53	5	2.3
	PR	44.3%	41.6%	13.0%	1.2%	
Natural resource variables						
Tree-forests	NR	226	132	40	11	2.4
	PR	55.3%	32.3%	9.8%	2.7%	
Earth/Clay mines	NR	198	168	29	14	2.3
	PR	48.4%	48.4%	7.1%	3.4%	
Building resource sites	NR	122	124	139	24	1.5
	PR	29.8%	30.3%	34.0%	5.9%	
Laterite mining sites	NR	122	174	67	46	1.9
	PR	29.8%	42.5%	16.4%	11.2%	
Sand resource sites	NR	171	113	82	43	2.0
	PR	41.8%	27.6%	20.0%	10.5%	
Natural water bodies	NR	124	114	122	49	1.8
	PR	30.3%	27.9%	29.8%	12.0%	
Gravel mining sites	NR	96	172	80	61	1.7
	PR	23.5%	42.12%	19.6%	14.9%	
Socio-economic variables						
Family Cohesion	NR	85	101	158	65	1.5
	PR	20.8%	24.7%	38.6%	15.9%	

Health	NR	81	94	153	81	1.4
	PR	19.8%	23.0%	37.4%	19.8%	
Source of livelihood	NR	152	173	57	27	2.1
	PR	37.2%	42.3%	13.9%	6.6%	
Agricultural Produce	NR	238	105	51	15	2.4
	PR	58.2%	25.7%	12.5%	3.7%	
Schooling Opportunities	NR	131	195	53	30	2.0
	PR	32.0%	47.7%	13.0%	7.3%	
Income status	NR	270	77	47	15	2.5
	PR	66.0%	18.8%	11.5%	3.7%	
Livestock husbandry	NR	105	179	92	33	1.9
	PR	25.7%	43.8%	22.5%	8.1%	
Human Well-being	NR	211	96	61	41	2.2
	PR	51.6%	23.5%	14.9%	10.0%	
Rural Development and Resource Management Variables						
Quality of development of adjoining rural areas	NR	182	164	55	8	2.3
	PR	44.5%	40.1%	13.4%	2.0%	
Traditional resource management methods	NR	152	228	18	11	2.3
	PR	37.2%	55.7%	4.4%	2.7%	
Indigenous Land management method	NR	315	79	12	3	2.7
	PR	77.0%	19.3%	2.9%	0.7%	
Rural Road condition	NR	93	76	181	59	1.5
	PR	22.7	18.6	44.3	14.4%	

Source: Fieldwork 2011

The first group of variables is classified as environmental factors with MSI of 2.41. The second group classified as natural resource variables has a MSI of 2.20; the third group classified as socio-economic variables and their MSI is 2.00, while the fourth group of variables classified as development and management variables have a MSI of 2.20. The overall percentage of the Severity Index (PSI) is 62.5%. Looking at the rating classification of the indices, 50% to 75% is significantly severe. The computed Mean severity index is 2.16. This lies between adverse (2.0) and very adverse (3.0) weighted index classes. This implies that the value is tending to 3 which is the maximum value of range (very severe). In summary, the values of both the severity index and the mean severity indices are high.