

**EFFECTS OF URBAN GROWTH ON THE INTENSIFICATION OF UNGWAN  
DANYARO GULLY EROSION, SAMARU, ZARIA, NIGERIA**

**BY**

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,  
AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FUFILLMENT FOR THE  
AWARD OF MASTER OF SCIENCE (M. Sc.) DEGREE IN GEOGRAPHY**

**DEPARTMENT OF GEOGRAPHY,  
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**November, 2015**

## **DECLARATION**

I hereby declare that the work in this dissertation entitled ‘Assessment of the Effects of Urban Growth in the Intensification of Ungwan Danyaro. Gully Erosion, Samaru, Zaria’ has been carried by me in the Department of Geography under the supervision of Prof. E. O. Iguisi and Prof. L. B. Bello. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any institution.

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## **CERTIFICATION**

This thesis entitled: ‘Assessment of the Effects of Urban Growth in the Intensification of Ungwan Danyaro. Gully Erosion, Samaru, Zaria by Morenike Adeyinka meets the regulations governing the award of the degree of Masters of Science of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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## **DEDICATION**

I dedicate this dissertation to God Almighty, the sustainer of my life. Secondly to my mother Mrs. D. O. Adeyinka Somolu for denying all pleasures of life to ensure that I am what I am; and also to my Sweetheart Mr. Olugbenga Olatunde.

## ACKNOWLEDGEMENT

I wish to express my sincere and profound gratitude to Almighty God for the gift of life, opportunity to study and his provision, protection and his faithfulness throughout the cause of this work. Similarly, I express my profound gratitude to my team of Supervisors: Prof. E. O. Iguisi and Prof. A. L. Bello for their indelible assistance, constructive criticism guidance and close supervision of the work.

Secondly, my appreciation goes to all the staff of Geography department for their guide in one way or the other. To mention a few, Dr. I.J. Musa, the Head of Department of Geography, Ahmadu Bello University, Zaria. Dr. R.O.Yusuf, the Post Graduate coordinator for his concern, Dr. Yusuf Obadaki for putting me through the statistical techniques, the Librarians Mr. Ezekiel Bamaiyi and Mallam A.L. Yakubu for providing me with text books and other relevant materials related to the thesis work. Also, Mrs. Arigbede , and Mr. A. Jubril my course-mate.

Thirdly, I earnestly thank Mr. Emmanuel Bako, the GIS expert, and Mr. Ani I. Godwin (computer expert and typist) for the assistance rendered to me in analyzing my work. Special thanks go to my husband Mr. Olatunde Gbenga for his Love, moral support and encouragement. I sincerely appreciate my mother Mrs. Deborah Somolu, my siblings; Mrs. Aliu, Aunty Bola, Brother Adeola, Abiodun, Matthew and Samuel and my brother-in-law Mr. Olamilekan.

Finally, my sincere appreciation goes to my father and mother in the lord, Pastor, J.E. and Pastor Mrs. C. Akpami, Pastor S. Oyewole and Evangelist N. Patrick for their prayers.

Thanks to the principal, Mr Felix Ojo and all the staff of Baptist High school, S/G, Zaria, who have encourage me in one way or the other. May God bless you all. Amen

## ABSTRACTS

The study examines the effects of urban growth on the intensification of Ungwan Dayaro gully erosion in samara, Zaria. This was done with a view to map and describes urban expansion; to characterize gully growth in relation to human activities and to establish relationship between urban growth and the gully development. Topographical map of 1973 of scale 1:25,000 and Landsat images of 1980, 1996 and Google images of 2000 and 2015 were used to map the extent of urban growth and gully development. Arc 9.2 software was used to digitize the topographic maps of the decadian years, a Digital Elevation Model (DEM) was created and the elevation values was used to derive a cross section of nine selected gullies. Overlaying operation was carried out in order to establish the incremental growth in depth and width of the gullies and spatial growth of the study area. The result showed that the gullies differ one from another in depth and width; 1980 gullies were the shallowest while 2015 gullies were the deepest. The gullies also exhibited both “U” and V – shape. There was accelerated increase in the growth rate of the settlements from 1980 to 2015. The growth rate was 14% in 1996, 40.9% in 2000 and 45.1% in 2015. The Product Moment Correlation co-efficient of 0.991 indicates that Urban growth have a significant influence on gully development in the study area. Urban growth due to increasing population and human activities such as agriculture, deforestation, construction, grazing and sand mining were identified as factors that have enhanced the development of gullies and this in turn has led to the destruction of building foundation and communication route and formation of bad land in the area. Enlightenment and awareness of erosion control should include land use habit of the people in the agricultural practice and care of vegetation. Stabilizing of gully is recommended in the area to reduce the impact or the force of rain drop. This will restrict the widening of incipient gullies. A holistic rehabilitation programmer of monitoring the

gully affected area to reclaim devastated land as well as to ensure a safe environment is also recommended.

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## **CHAPTER ONE**

### **INTRODUCTION**

#### **1.1 BACKGROUND TO THE STUDY**

Urban growth or urbanization is the increase overtime in population of cities in relation to the region rural population. In spatial terms, urbanization means increased spatial /or density of settlement and or business and other activities in the area .The process could occur as cultural expansion of the existing population or migration into the area. Urbanization has intense effect on the ecology of a region and it economy (Microsoft Encarta, 2007).

Rapid pace of urbanization is a global phenomenon in most of the developing countries. The urban population in these countries has grown by 40% between 1900 and 1975. Estimation suggested that 60% of the world's population will be living in urban areas by the year 2015 (Adesina *et al*, 1999). Urbanization is among the most evident aspects of human impact on the earth system. The process of urbanization produces radical changes in the nature of the surface and atmospheric properties of a region, because the natural vegetation is replaced by non-evaporating and non-transpiring surfaces such as metal, asphalt and concrete. Also water holding capacity of the soil decreases and runoff rate increases which in turn leads to soil erosion (Aswathy and Sindhu, 2013). So it is necessary to determine the effect of urbanization on gully erosion of an area.

Gully erosion is the removal of soil along drainage lines by surface flow. Once started, gully will continue to grow headward or by slumping off the side walls. Unless serious steps which may be costly are taken to stabilize the phenomenon, repair works done in the early stages of newly formed gullies are easier and mo/re economical than letting the problem go unchecked, for too long. Large gullies are difficult and costly to repair (Bruce, 2005).

Gully development is a severe form of soil erosion and could be a natural geologic process, but it is greatly accelerated by anthropogenic factors such as urbanization, deforestation, overgrazing of cattle and poor agricultural practices (Microsoft Encarta, 2007).

When first formed, most gullies are quite narrow and have vertical side wall, increased pore pressure from groundwater, moving toward the gully, coupled with some under cutting of the side walls cause deep rotational slumps along the sidewalls if enough water is flowing through the gully to carry away the slumped material, additional slumping can occur. This causes the gully to widen. Widening also occur when upper portion of gully wall separate and topple into the gully (Bettis, 2008).

Erosion problems arise mainly from natural causes but their extent and severity are increasingly being attributed to man's ignorance and unintentional action (Enabor and Sagua, 1998). Gully erosion could start unnoticed, especially when it takes place slowly. The results are remarkable in terms of loss of land, properties and lives.

In the United State of America, the Western Iowa with an area of 28,000 square kilometers, encompassing about thirteen and portions of nine counties have severe gully erosion problems. Estimate indicates that 2,000 to 4,000 hectares of potential cropland are lost or removed from production annually as a result of gully growth in this region. Large amount of time and money are spent on maintaining ditches and stream channels which become choked with sediment eroded from gullies. Bridge failures resulting from gully widening are also a common and costly problem for counties in Western Iowa Numerous other problems directly or indirectly associated

with growth of gullies plague residents of this region. Several scholars have identified agricultural practices as the cause of Western Iowa's gully problems. Specifically, they cited increases in runoff from land clearing, overgrazing and stream channelization have led to the preponderance of gully erosion in the region. Numerous Federal, state and county agencies spend millions of dollars annually to control existing gullies and promote land management practice which reduces runoff in an attempt to alleviate the gully problems (Bettis, 2008).

The geologic record contained in Western Iowa valley shows that major gully is not new to the area; several episodes, some more widespread than that which affect the area today occurred prior to Euro-American settlement and the spread of modern agriculture. Gully is part of natural process of landscape evolution in Western Iowa. However modern gully which causes great concern may also be difficult to separate from natural geologic process. Land use change accompanying the spread of agricultural and urbanization have aggravated and possibly accelerated the growth and expansion of gullies in Western Iowa today (Bettis, 2008).

In many part of the world particularly in the Third World, urban sprawl often leads to a dramatic increase of peak runoff, runoff coefficients and a concomitant reduction of runoff concentration times. This leads to rapid development of large gully channels (urban gullies), endangering the bearing function of soils and causing damage to infrastructure and private property. Likewise, improper drainage of rural roads in tropical environments often results in the rapid development of large gully channels turning the often unpaved roads into road gullies (Asimba, 2009).

In many parts of Africa from Lesotho to Morocco, gully has become serious problems causing large scale destruction of communities and farmlands. One important example in southeastern Nigeria, is the Udi Cuesta and the adjacent Akwa upland area. These gullies have been identified as a classic example of accelerated erosion due to vegetation clearance coupled with violent rainstorm (Colin, 1981). According to Colin, (1981), a number of gullies in south eastern Nigerian are caused by overflow of concrete rain water gutters at the side of highways leading to erosion particularly at the point where the gutter and road meet. In Zaria environs, the phenomenon of gully erosion is also widespread. It occurred in different drainage basin of the Saye, Kubanni, Shika, and Yashi and manged into the Galma systems.

## **1.2 THE RESEARCH PROBLEM**

Historical and socio cultural factors gave Zaria the advantage of becoming an urban center with influx of people from rural hinterland and from neighboring states (Davis, 1970). Gradually, Zaria urban environment grew to incorporate Birnin Zazzau and the bigger suburbs/ settlements of Wusasa, Tudun Wada, Sabon Gari, Samaru and Shika. Zaria Master Plan prepared by the department of Urban and Regional Planning, Ahmadu Bello University, Zaria, carved out the university district, which has fussed smaller compounds / extension such as Hayin Dogo, Ungwan Danyaro into one township (Chafa, 2008). The sprawling settlement and sub-urban development for tenement housing and conversion to uncontrollable urban fringe area lead to intensification of gully development. Ungwan Danyaro in Samaru is a typical examples of area in which gully erosion has led to the change of visible and useful land to badland topography. A casual field observation of the area shows that gullies in some places run into several meters, particularly, those along the rail line and between JAWOM Church-God's Time Secondary

School and those draining through part of the south-western hill-side slopes of the study area. Field observation also shows that housing pattern, layout and use of corrugated iron sheet for roofing encouraged high runoff during raining season over poor land management practices in the area. Hence, many building foundation walls have shown cracks, caused by effect of gully; especially those of God's Time Secondary School.

Gully erosion is badly affecting Ungwan Danyaro in Samaru area and not much work has been done to study extent to which urban growth and associated human activities have intensified gullies in the area. Previous studies of Unwan Danyaro gully focused mainly on the effect of erosion in Hayin Dogo, Samaru (Chafa, 2008). In that study, the methods used in data collection include field observation, questionnaire administration and interview. No field measurement and gully mapping were carried out in order to know the extent to which gullies have grown. Other studies on gully in Zaria area centered on soil properties and gully forms such as Ologe (1971; 1972), Bello (1973), Sheyin (1989), Ojia (1998), Ojo (2000), and Duniya (2006).

A review of previous studies on gully initiation and development in Zaria shows that no one has considered the relationship between urban growth and gully development, particularly in the Ungwan Danyaro area. This is the gap that this study intends to fill.

### **1.3 AIM AND OBJECTIVES**

Aim of this study was to show the extent to which urban growth has contributed to the growth of the Ungwan Danyaro gullies in Samaru Township. This aim was achieved through the following objectives: were to;

- i. map and describe urban expansion in the study area.
- ii. characterize gully growth in relation to human activities
- iii. establish relationship between settlement growth and gully growth.

#### **1.4 HYPOTHESIS**

There is no significant relationship between settlement growth and gully development. In Ungwan Dayaro in Samaru ,Zaria.

#### **1.5 SCOPE OF THE STUDY**

This study is intended to cover Latitude  $11^{\circ} 9'30''\text{N}$  and  $11^{\circ} 9'50''\text{N}$  and Longitude  $7^{\circ} 39'30''\text{E}$  and  $7^{\circ} 40'50''\text{E}$ , located in Zaria, northern part of Kaduna state of Nigeria. Settlement that was considered was Ungwan Danyaro /. This study mapped and described urban expansion in the study area, characterized gully growth in relation to human activities and established relationship between settlement growth and gully development. It also covered 1980 to 2015.

#### **1.6 JUSTIFICATION**

Gully erosion is a great environmental issue in the recent decades, resulting in land degradation and lowering of agricultural productivity and promoting serious land degradation, (Ogbonna, 2009). In Ungwan Danyaro, the impact of gully erosion has been unimaginable, causing destruction of communication routes, building foundation and bad land topography proliferates

due to urbanization. Urbanization involves expansion of urban related area, and conversion of natural physical landscape to more economical land use. Due to urbanization water holding capacity of the soil decreases which led to soil erosion and consequently gully erosion .It is therefore necessary to assess and to manage areas that are vulnerable to gully erosion in order to mitigate any damage associated with it.

In developing a sustainable remediation procedure, an assessment of gully through spatial mapping the area affected by gully formation is necessary. Using Geographic Information System GIS as the basic analysis tool for gully erosion mapping presents an effective platform for spatial and database management .GIS based multi-temporal land use data provide a historical vehicle for determining and evaluating long time change in land use due to urbanization. The collection of remotely sensed data facilitates the synoptic analyses of Earth-system function, patterning and change at local, regional, and global scale over time; remote sensing and GIS data also provide an important link between intensive, localized ecological research and regional and international conservation and management of biological diversity (Ifatimehin, 2007).

## **1.7 ORGANIZATION OF THE STUDY**

The study was organized into six chapters beginning with *chapter one* that introduced the study and presented the statement of research problem, aim and objectives. *Chapter two* focuses on the theoretical framework and literature review while *chapter three* deals with study area. The methodology, gully mapping and the analytical tools used are presented in *chapter four*. The

results obtained are discussed in *chapter five* while the summary, conclusion and recommendations are presented in *chapter six*.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter explains the relevant literature reviewed in terms of conceptual frame work on urbanization and gully erosion, formation of gully, historical gully erosion, causes of gully erosion, effects of gully erosion, control of gully erosion and techniques for measuring gully growth

#### **2.2 CONCEPTUAL FRAME WORK OF THE STUDY**

##### **2.2.1 Urbanization**

Urbanization refers to the process by which rural areas became urbanized as a result of economic development and industrialization. Demographically, the term urbanization denotes the redistribution of populations from rural to urban settlement over time. However, it is important to acknowledge that the criteria for defining what urban is may vary from country to country. The fundamental difference between urban and rural is that urban populations live in larger denser and more heterogeneous cities as opposed to small, more sparse and less differentiated rural places (Peng,Chen, and Cheng, 2009).

Many `towns and cities in Africa are experiencing continuous urbanization. More towns and cities are booming with change in the land use along the highways and in the immediate vicinity of the city .This dispersed development outside of compact urban and village and village centers along highways and in rural countryside are defined as urban encroachment (Theobald, 2001). Urbanization is a form of metropolitan growth that is a response to bewildering set of economic, social, and political forces and to the physical geography of an area. Some of the causes of urban

encroachment include population growth, economy pattern of infrastructure initiatives like the construction of roads and the emergence of infrastructure that serves as growth point. The direct implication of such urban growth and encroachment is the change in land use and land cover of the region.

The process of urbanization is fairly contributed by population growth, migration and infrastructure initiatives resulting in the growth of villages into towns, towns into cities and cities into metropolis. However, in such a phenomenon for ecologically feasible development, planning requires an understanding of growth dynamics .Nevertheless, in most cases there are lot inadequacies to ascertain the nature of uncontrolled progression of urban encroachment. Encroachment is considered to be an unplanned outgrowth of urban centers along the periphery of the cities. Due to lack of prior planning, these outgrowths are devoid of basic amenities like water, electricity and sanitation. Provision of certain infrastructural facilities like new roads and highways help in fuelling such encroachment, that ultimately result in inefficient and drastic change in land use affecting the ecosystem.

### **2.2.2 Urbanization Theories**

Theories on urbanization have been around for a long time that they have blended into and intersect with theories that also pertain to cities, industrialization, and more recently, globalizations. At the risk of being subjective and circumvent, four theories were introduces and discussed which provide both earlier and recent explanations for why and how urbanization occurs. First, there is what may be labeled the theory on self-generated or endogenous urbanization. This theory suggests that urbanization requires two separate prerequisites-the

generation of surplus product that sustain people in non agricultural communities to be socially viable and stable (Peng, Chen, Cheng, 2009). From a long temporal perspective, these changes took place simultaneously in the Neolithic period when the first cities emerged in the Middle East. A much later period in which these two preconditions interacted strongly was the late eighteenth century when the rise of industrial capitalism led to the emergence of urban societies in Great Britain, North-West Europe and North America (Peng, Chen Cheng, 2009).

In a demographic sense, this theory focuses on the rural-urban population shift as the foundation of urbanization but it identifies industrialization as the basic driver behind the movement of rural population to urban areas for factory jobs. The historical evidence undoubtedly bears this out. Before the industrial Revolution in Great Britain, no society could be described as urban or urbanized (Peng, Chen, Cheng, 2009). All countries, primarily in the West, that began to industrialize rapidly after Great Britain became highly urbanized by the mid-twentieth century, which was followed by the accelerated industrialization and then urbanization in the rest of the world through the last century and into the present (Peng, Chen and Cheng, 2009).

The second theory on urbanization actually emerged from a broader theoretical school known as the modernization theory that became prevalent and influential from the 1950s through the 1970s. While overlapping with the first theory in the timing of development, modernization theory had a wider set of assumption and scope of influence (So, 1990). Looking at urbanization through the lens of modernization, first, the present state of urbanization in a given society is set by its initial state at the onset of modernization. Secondly, technology is fundamentally more important than a society's social organization in shaping urbanization. Finally, the path and pattern of urbanization within and between developed and developing countries are most likely

to converge through cultural diffusion, despite breeding inevitable social disequilibria (Kasarda and Crenshaw, 1991).

The intellectual underpinning of modernization view on urbanization in developing countries could be traced to an even earlier theoretical paradigm, namely, human ecology. While developed to describe the structure and evolution of American city, primarily Chicago in the 1920s-1930s by Robert Park and others, human ecology is based on strong assumptions about the interactive role of population dynamics, market competition, material technology (e. g., transport infrastructure), and the built environment in making and remaking urban life (Orum and Chen,2003). These assumptions became the predictive elements in how modernization theory would view subsequent developing-urbanization as being driven by industrialization, technological progress, information penetration and cultural diffusion. This optimistic prospective view was very developmental in heralding the more positive outcomes of accelerated urbanization in the developing world, but only to be challenged by more depressing reality of economic and spatial inequalities, as well as other social problems from urbanization in poor countries (Smith, 1996).

As modernization theory fails to account for both the conditions and consequences of urbanization in developing countries, it opened the door to a compelling theoretical alternative; the dependency/world-system perspective on urbanization. As detailed by Peng, Chen and Cheng (2009), dependency/world-system theory links changes in the roles and organizations of economies of developing countries to the growth and extension of capitalism world system. From this world system perspective, urbanization can be seen as an internal location response to global economy. First, dependency theorist assume that a uniquely capitalist development pattern exists, asserting that capitalism is a unique form of social organization. Second, capitalism

requires a certain social structure, which is characterized by unequal exchange, uneven development, individual social inequality, core-periphery hierarchies, and dominance structure. Finally, dependency theory models social organization, technology and population dynamics as endogenous factors in development and urbanization that are constrained by exogenous forces (Timberlake, 1987). The spread of capitalism to and its entrenchment in the developing world is the most recent stage in the development of capitalism as a world economic system. It is a result of changes in the ways in which wealth is accumulated and the evolution of the world system of nations. Dependency theory also suggests that underdevelopment is a result of the plunder and exploitation of peripheral economies by economic and political groups in the core areas (Peng, Chen and Cheng, 2009).

View from the dependency/world-system perspective, urbanization in developing countries, to the extent it occurs and at what speed, is a major spatial outcome of global capitalism and its own spatial organization. This is an inherently uneven process leading to geographic disparities between urban and rural areas and between cities, particularly if taking into account the unequal condition at the start of urbanization. Empirical studies, whether explicit from this theoretical perspective or not, have borne out the serious undesirable consequences of rapid urbanization in developing countries as rural-urban imbalance, lopsided city hierarchy, housing segregation, and income inequality both within and across nation (Chen and Parish, 1996); (Findley, 1993); (Smith and London, 1990). Besides challenging directly the basic assumptions and predictions of modernization theory for urbanization, the dependency/world-system theory goes a long way in accentuating the external and often negative impact of the capitalist global economy on domestic urbanization in the developing countries. This powerful insight from the 1970s laid the ground

work for a more systematic global perspective on urbanization, especially on the rise of networked world or global cities in the 1990s and beyond.

As the debate between modernization and dependency/world-system theories on urbanization continued from the 1970s into the 1980s, world-wide urbanization itself began to take on the striking feature of a growing number of megacities becoming functionally influential and structurally linked. This prompted geographer John Friedmann to advance a research agenda for world cities in the early-mid 1980s (Friedmann, 1986), suggesting that world cities are a small number of massive urban region at the apex of the global urban hierarchy that exercise worldwide control over production and market expansion. With their global control directly reflected in the structure of their production sector and employment, world cities also are major sites for the concentration and accumulation of international capital. The new focus on world cities marked a theoretical extension from the world-system perspective by highlighting the study of individual or a network of cities for the understanding broader urbanization trends and tendencies.

The globalization of urbanization theories did not stop there, Sassen (1991), brought definitive touch to the study of global city through a sharp conceptualization and a systematic comparison three such cities. According to Sassen, global cities function as; highly concentrated command points in the organization of the world economy; key locations for finance and specialized services, which have replace manufacturing as the leading industries; innovative sites of production in these leading industries; and markets powerful ways of the state in creating and sustaining rapid urbanization (Chen, 2009). One major weakness of the global city perspective may be that its theorizing and analysis are based primarily on a few dominant and heavily studied cities in Western industrialized countries (Orum and Chen, 2003).

## **2.3 MODELS AND GULLY EROSION**

Models capable of predicting size, location, timing, frequency and intensity are needed to more accurately effects of environmental change on soil losses due to gully erosion. For more development of an acute model, more detail monitoring, experimenting, and modeling of the development and infilling of both ephemeral gullies and bank gullies in a variety of environments to better stimulate gully sub processes needs to occur. There is also a need to predict gully cross-sectional size and shape and soil loss rate due to gully erosion (Harmon and Doe, 2001). Many models are available today to estimate soil losses

### **2.3.1 Water Erosion Prediction Project**

The Water Erosion Prediction Project (WEPP) model is a process-based, distributed parameter, continuous stimulation, erosion prediction model. It is applicable to sheet and rill erosion based on the simulation of the hydrologic and erosion processes on small watersheds (National Soil Erosion Research Laboratory). It was developed by United States Department of Agriculture's Agricultural Research Service for use on personal computers .The model requires specific climate, topography, soil and management inputs. WEPP attempts to mimic the natural processes that affect soil erosion, updates soil and crop condition daily, (National Soil Erosion Research Laboratory). It include conceptual components such as rainfall, freeze, furrow, runoff, drainage, soils, crop growth, residual management and composition, tillage, rill erosion, channel deposition and sediment delivery to predict and calculate estimates of soil detachment and deposition (National Soil Erosion Research Laboratory). WEPP can provide various type of out puts,

including water balance, soil detachment, deposition, and sediment delivery and vegetation growth.

Development have been made to not only run multiple simulations to see the effects of land use changes ,but also allow users to run a watershed simulation using digital elevation data from Geographic Information System (GIS) (National Soil Erosion Research Laboratory). However, WEPP does not predict gully erosion, erosion processes in continuously flowing stream bank sloughing, tillage erosion or mass wasting.

### **2.3.2 Revised Universal Soil Loss Equation**

The Revised Universal Soil Equation (RUSLE) is an empirical formula which is widely used to predict soil in sheet and rill erosion. It uses soil characteristic and land use factor (Dress2003). RUSLE may be used as a framework for considering the principal factors affecting sheet and rill erosion: climate (R), soil characteristics (K), topography (LS), and land use and management (C and P). Except for climate these factors suggested areas where changes in management can influence soil loss from water erosion. It is important to note that that the RUSLE predict soil loss not sediment delivery to receive water (Dress 2003).

The current model, RUSLE, is an advanced software model that makes its computation on a daily time step rather than half the month time step. It also uses a full mathematical integration procedure rather than the previously used approximate procedure.

## Revised Universal Soil Loss Equation (RUSLE)

$$A = R * K * LS * C * P$$

A = estimated average annual soil loss (tons/acre/year)

R = rainfall/runoff factor, quantifying the effect of raindrop impact and the amount and rate of runoff associated with the rain, base on long term rain fall record

K= soil erodibility factor based on the combination effects of soil properties influencing erosion rates

LS= slope length factor a combination of slope gradient and continuous extent

C= cover and management factor, incorporating influence of crop sequence, residue management and tillage

P= practice factor, incorporating influence of conservation practices such as contouring and terraces

### 2.3.3 Sequential Aerial Photographs

In New Zealand, gullies are common due to combination of bedrock susceptible to erosion.

Mountainous topography, extreme rainfall event s, and drastic land use change. Most gully system in this region are termed fluvio-mass movement, due to the major role that mass movement plays in sediment production and gully enlargement (Parkner *et al*, 2006). Here, sequential aerial photographs were interpreted to measure and analyze temporal changes for long time span with higher temporal resolution. The area of the gullies and complexity affected gully incision and mass movement erosion was measured for each time slice after digitizing in Arc GIS. Gully erosion is considered a threshold phenomenon because it occurred only when a threshold in terms of rainfall, topography and use is suppressed. The air photographs were interpreted to determine land use and land cover (Parkner *et al*, 2006). Rainfall data was

collected close to the study area at their highest temporal resolution, while a history of major storms record was also used. Studies with low time resolution showed the same pattern of overall gully complex development with expansion and stabilization. The threshold line developed for gully initiation allows for the prediction of which catchments will develop gullies and gully complexes (Parkner *et al*, 2006). However, this could not be used in other areas where mass movement does not play as significant role as it does in New Zealand. Sequential aerial photographs would be useful within the United States to study the migration of gully heads, but could not be used to estimate total erosion because it put less emphasis on erosion occurring along the channel side slope

#### **2.3.4 Photogrammetry and Ground Control Points**

Another method uses images taken from a blimp or kite allows for the gully systems to be surface modeled and monitored, while gully growth and soil loss are measured using geographic information system (GIS) and digital photogrammetric analysis. At all gully sites, ground control points (GCPs) were installed to help provide more accurate modeling and monitoring (Marzloff and Poesen 2009). These are located at points that are clearly identifiable places in the image because it has to be possible to derive location and elevation of the map. Automatic digital elevation model (DEM) generation in digital photogrammetry systems uses image matching and DEM interpolation. A hybrid method of automatic and interactive feature extraction was used to elimination false matches and produce problem such as shadowing (Marzloff and Poesen, 2009). Assessment of errors associated with DEM accuracy was done by examination of the bundle block adjustment results and by visual inspection of the concordance of the surface with the 3D dataset of GSPs. The change of gully area and volume were determined by differencing the raster

files with a simple subtraction operation in the GIS and the separating areas of loss and gain. Total gully volume was then calculated using the Arc GIS cut/fill operation. Small format aerial photogrammetry can be considered as an important tool for the monitoring of gully erosion sites (Marzolff and Poesen, 2009). Gully extent, volume and change can be derived with accuracy and detail that correspond to the magnitude and geomorphic characteristics of gully erosion processes. However, problem such as the sidewall erosion being omitted can distort the morphology and volumetric measurements, which cannot be solved without a combination of aerial and terrestrial imagery.

Many studies have been conducted to gain a better understanding of the location, formation and migration of gullies (Wells *et al*, 2009); (Casali *et al*,2000); (Smith,1993); (Foster,1986); (Hanson *et al*, 1997); (Parkner *et al*,2006); (Wang *et al*, 2003); (Gatto,2001) and how to best model these erosional features, (Gordon *et al*, 2007); (Marzolff and Poesen, 2009); (Thurrow ,1999); (Betts *et al*,2003). The majority of these studies focus on either natural (Parkner *et al*, 2006); (Marzolff and Poesen, 2009); (Thurrow, 1991); (Betts *et al*, 2003) or agriculture (Smith 1993,); (Gatto, 2001); (Mostaghimi *et al*, 1997) landscapes with no work on the specific problem of urban growth and gully development. The overall goal of this study is to determine the effect of urban growth in the intensification of gully erosion in Ungwan Danyaro in Samaru, Zaria. This information will determine the factors that intensify the growth of gully and establish relationship between urban growth and gully development.

## **2.4 GULLY FORMATION DUE TO SOIL EROSION**

When a plot of land is first cleared of forest and ploughed for cultivation, little erosion will occur following the action of rain splash to break down soil aggregates and seal soil pores to encourage surface wash and run off. Following this, overland flow begins to remove the soil in rather uniform thin layer, a process termed sheet erosion. Because of seasonal cultivation, the effects of sheet erosion could often not be notice until the upper horizon of the soil (A and B horizons) are removed or greatly thinned. Where slopes are exceptionally steep and runoff from storms is exceptionally heavy, sheet erosion progress into a more intense activity of that of rill or riling. If these rills are not destroyed by soil tillage, they may soon begin to integrate into still larger channels, termed gullies. Gully erosion creates deep channels that cannot be erased by cultivation, (Bettis, 2008).

Gully erosion; a severe form of soil erosion is a natural geologic process that can be greatly accelerated by human activities such as urbanization, deforestation, overgrazing of cattle and poor agricultural practices. Erosion attacks the moisture – bearing ability of soil and adds deposits to water ways. These destructive processes continue at an increased rate on every continent, as over population and industrialization tax the remaining soil (Microsoft Encarta 2007).

## **2.5 HISTORICAL GULLY EROSION**

Gullies are one of few morphological evidences of past soil erosion periods reflecting impacts of environmental changes (land use, extreme rain events) in the landscape. In fact, gullies are ideal geomorphic features to unravel human-environment interactions induced by particular socio-

economic condition in historical times. Therefore, detailed studies of historical gullies are crucial, not only to reconstruct the past but also to learn from it, (Poesen and Valentin, 2003).

Moreover, there is ample physical evidence of major historical gully erosion phases in various part of the world. Some of these have been studied in detail and have revealed strong increases in gully erosion as a consequence of a particular land use changes (sometimes in combination with extreme rain events) induced by socio-economic change, such as the conversion of forest to cropland (starting already in prehistoric and Roman periods, e.g. in Belgium, Germany, Poland), overgrazing in mountain areas as a subsequence of transhumance (e.g. France, Spain ), conversion of Mediterranean shrub land to cropland (e.g. for wheat and almond production) or to improve pasture, expansion of maize cultivation in cropland in the European loess belt, or the application of soil and water conservation measures on hill slopes resulting in an increased gully channel incision due to reduced sediment input from the hill slopes ( e.g. in Ethiopia), (Poesen and Valentin , 2003). Other studies have also documented the complete stabilization of gully systems as a consequence of forestation (e.g. in Belgium, France, Poland, China, USA).

However, there still many of these “old” gully systems which have not yet been analyzed in details, nor have they been dated. There is a particular need to combine detail field observations and process-base knowledge of contemporary gulling and dating techniques to reconstruct condition leading to gully incision, development and infilling. Most studies deal with gully development, very few with condition leading to channel infilling. Yet this process is equally important to better understand gully dynamics, (Poesen and Valentin, 2003).

## **2.6 CAUSES OF GULLY EROSION**

The rate and magnitude of gully erosion is controlled by both physical (natural) and human factors, such physical factors include climate. The most important aspect of climate that affects gully erosion is rainfall. Gully erosion occurs when rainwater is channeled across unprotected land and washes away the soil along the drainage lines. Under natural condition runoff is moderated by vegetation which generally holds the soil together, protecting it from excessive runoff and direct rainfall impact. Excessive clearing, inappropriate land use and compaction of the soil caused by grazing often leave the soil exposed and unable to absorb excess water. Surface runoff then increases and concentrates in drainage lines, allowing gully erosion to develop in susceptible areas (Microsoft Encarta, 2007).

Moreover, a decrease of soil resistance to erosion which can be caused by elimination of vegetal cover, breakdown of soil structure due to poor tillage and cropping practices, is its credibility and it is affected by soil characteristic such as the texture, infiltration potential, the amount of organic matter and its stability (Wall, et al 2003). Previous works of Sheyin (1989) has shown that high sand to silt/clay ratio as a textural characteristic is likely to encourage gully erosion in the region due to the prevalent soil type classified as the tropical ferruginous soil. These soils are rather deep, sandy near the surface but more clayey in the subsoil. Its structure is normally weak, fine blocky and highly prone to capping under the influence of rain. Leo and Gardiner (1982) showed that due to the high sand fraction found in the soils, once the silt/clay material of the top horizon is cut open, gulling by fast basal sapping and head scarp retreat enhances development of gulling. Kowal and Kassam (1978) observed that the soil displays weak aggregation thereby

when exposed to rain; it quickly leads to the formation of surface capping. Slope steepness is of more importance in gully development. Ofomata (1965) showed that gullies are well developed on scarp slopes inclined at more than 25, while Ologe (1972) showed that more gullies are aligned on the steep stream bank all over the Sudan Sahel zones. However, slopes inclination appears to be subordinate to factors of vegetal cover, soil erodibility and rainfall erosivity. However steep the slopes may be if these factors are unfavorable, gullies will not develop as in the case on the cultivated hill slope in Ekiti area of Western Nigeria (Jege 2005). But where factors are favourable, relatively gentle slopes such as on the dip slope of the Nsukka-Okigwe Cueta with a general slope less than 6 may be severely gullied.

Consequently vegetal cover is very important. Areas under effective vegetal cover especially forest with thick litter layer, are characterized more by infiltration and sub-surface drainage than by surface runoff. Bare surface encourage runoff which can cause sheet or gully erosion. This sparse vegetal cover is partly responsible for gulling all over the country. (Ologe, 1972).Also, local hydrological characteristic may be important in development of gullies. For instance, flow regime of most rivers in the Sudan Savanna correlate with rainfall pattern; as about 75% of the stream flow in almost all the rivers is derived from storm run-off. Such intense floods of short duration normally erode the bank using large quantities of elastic materials delivered from valley slopes undermining the channel banks followed by collapse and subsidence that often lead to incipient gully development. Such gullies are particularly well developed where rivers are deeply incised (Ologe, 1972). Thus, gullies in most Northern Nigeria are initiated on river bank and progress headwards on valley sides. Examples of such gullies are in Shika, Saye, and Kubani basins in Zaria area, and Kampe basin in Kwara State.

Human factors include urbanization, a process which involves housing development and laying of water pipes and cables for communication. Such land use encourages uncoordinated and substandard development with little or no regards for the provision of drainage infrastructure as observed in the study area. Moreover, heavy population pressure on available land and the consequence of over cultivation, over grazing, and the poor cultivation methods, often involving heap making on steep slopes and alignment of ridge orthogonally to the slope contour. All these can cause gulling in various ways. For instance, the ridge channel runoff water across the slope facilitates erosion. More importantly the frequent exposure of the soil leads to desiccation and the impoverishment of the soil shown by Ebisemiju (1979). High intensity land used on the red arenaceous soil on the cuesta slopes in south eastern Nigeria reduces the soil permeability which leads to increase in runoff and erosion. Gullies in Kano, Awka, and Zaria and on Jos Plateau have been partially attributed to this factor.

A part from over cultivation, engineering work involving construction and excavation of artificial drainage channels can also lead to gulling. Ofomata (1965) showed, that diversion channel excavated at Ugwuoba in Anambra State initiated a gully observed to be 0.5-1.0m deep at the head, 0.5 wide, 6.0m long and 0.8 to 1.5m deep at the exit.

## **2.7 EFFECTS OF GULLY EROSION**

Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences and buildings, (Bruce, 2005). An example is found in the eastern part of Nigeria where gullies have destroyed land resource, swallowed up farmland, destroyed road, and separated communities (Duniya, 2006). Such effects are observed within the study area where the gently rolling terrains have been scarred by deep gullies. Soil eroded from the gullied area can cause siltation of fence lines, waterways, road, culverts, dams, and reservoirs. Suspended sediment which may have attached nutrients and pesticides, can adversely affect water quality. These fine colloidal fractions clog ground water aquifers, pollute water courses and affect aquatic life

.Past researchers reveal that the Agwu-Nanka gully complex alone accounts for a physical loss of over nine hundred and thirty (930) hectares of agricultural land (Ofomata, 1964; 1981 and Grove, 1951a), while about 7.5% of Oko village was occupied by gullies (Grove, 1951b). Chukwuedozie and Arinze, (2011) documented that gully erosion menace has over the years been responsible for increase losses of houses and land of people, thereby displacing affected inhabitant. Also, it has led to loss of lives of people and livestock, as well as destruction of farms on which the majority of the population depend for survival.

## **2.8 CONTROL OF GULLY EROSION (PREVENTION MEASURES)**

Controlling gully erosion can be difficult and costly. It may be justified on better quality soil where there is a reasonable chance of success or where a road or building is threatened by an

advancing gully. However, controlling gullies over large areas of poor soil may be impracticable. For this reasons prevention is far better than control.

Regular monitoring is essential to detect early stage of gully formation. A range of measures to prevent the development of gullies is described below.

### **Property Development**

- Manage catchments to ensure run-off is not increased.
- Assess the land's capability to ensure it is suitable for the proposed use.
- Locate and construct roads, fences and laneways so that they cause minimal concentration and diversion of runoff.

### **Grazing Management**

- Maintain adequate pasture cover by better stock management.
- Fence off and exclude stock from land vulnerable to gully erosion.
- Locate watering points, stock yards, shade areas and gates away from gull-prone areas.
- Level poorly maintained banks or create gaps in the banks to safely disperse the run-off.

### **Cropping Management**

- Control erosion on sloping, cultivated land by stubble retention and the construction and maintenance of contour banks and water ways.
- Construct waterways to appropriate specification and stabilize and maintain them.
- Ensure that contour bank discharge into water ways at safe locations and speed.

- Spread flood flows on cultivated flood plains and avoid practices that concentrate flood flow.

### **Urban Development and Management**

- Avoid the development of bare, compacted area that may occur in school grounds or other heavily trafficked areas.
- Avoid developing steep sites and drainage lines.
- Minimize soil disturbance, stock pile and re-spread topsoil and re-vegetate affected areas.
- Construct flood detention system below run-off area
- Harvest rain water off house roofs for domestic use and gradual discharge through drainage channels.

### **2.9 TECHNIQUES FOR MEASURING GULLY GROWTH.**

In the past, comprehensive analysis of gullies has often been neglected by the scientific community. For example, a review by Casali *et al* (2009), shows that less than 10% of soil erosion studies around the world address gullies directly. However, in order to develop strategies to control, prevent and rehabilitate gullies, the spatial extent of the problem has to be established and monitored (Le Roux *et al*, 2007); (Kakembo *et al*, 2009). Geographic Information Systems (GIS) and Remote Sensing (RS) technologies have been frequently used to assess soil erosion features. The recent study mapped gullies by means of manual digitizing with SPOT 5 imagery on the background (Mararakanye and Le Roux, 2011). Although higher accuracy is achieved by

manual digitizing, it is extremely laborious and time consuming with lots of subjectivity during gully interpretations.

The advancement in remote sensing technology in terms of high spatial resolution satellite imagery and Geographic Object Based Image Analysis (GEOBIA) (Blaschke, 2010), offers a potential to map gullies with less effort, time and at an acceptable level of accuracy. Previous studies have shown that supervised classification technique such as Maximum Likelihood Classification (MLC) algorithm could not express water erosion features at an acceptable level of accuracy due to the spectral similarities with other non erosion features (Solaimani and Hadiani, 2008); (Pirie, 2009); (Torkashvand and Alipour, 2009). However, the use of object based gullies extraction techniques proved more effective than conventional supervised and unsupervised classification techniques. Taruvinga (2008) used the Support Vector Machine (SVM) to extract gullies in KwaZulu Natal (South Africa) tertiary catchment and the accuracy of results was considered acceptable. According to Lillesand *et al*, (2008) the advantages of using object oriented classification is that it uses both spectral and spatial patterns when classifying the image. Bergsma *et al* (1982) considers aerial photography as the most valuable tool in gully erosion mapping. Satellite images offer interesting possibilities to investigate gully erosion, provided that gullies affect areas wide enough to be covered by the resolution of the images (Giordano and Marchisio, 1991). In this respect, multi-spectral remote sensing techniques, and videography (Palacio and López 1994), have been applied to map the extension of gully erosion phenomena (Martínez-Casasnovas *et al*, 1996).

Most recently, large and medium scale multi-temporal aerial photographs and videographic techniques have been used for gully growth monitoring and to compute gully retreat rates, (Brooks *et al*, 1991); (Palacio and López, 1994). Other authors have also investigated the application of photogrammetric techniques, using multi-temporal aerial photographs, to map the volumetric changes occurring in gullies and from that, to calculate amount of eroded materials and the rate of gully erosion (Thomas *et al*, 1986). In this respect, Thomas *et al*, (1986) pointed out the possible benefits of using multi-temporal digital elevation models to compute gully erosion rates.

## **CHAPTER THREE**

### **STUDY AREA**

#### **3.1 INTRODUCTION**

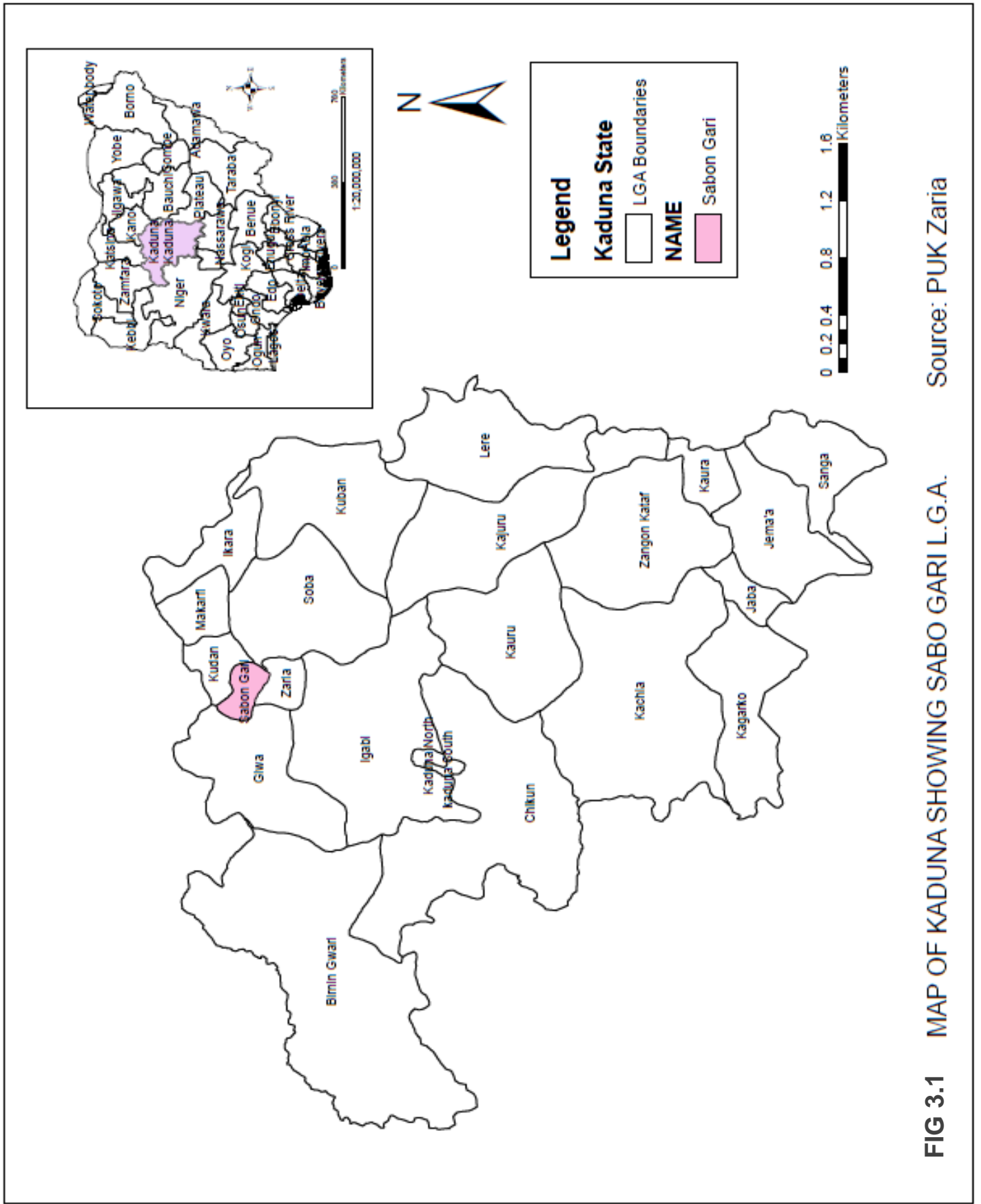
This chapter describes the study area comprising its location, climate, vegetation, soil, geology, geomorphology, relief, drainage, and land use changes.

#### **3.2 LOCATION**

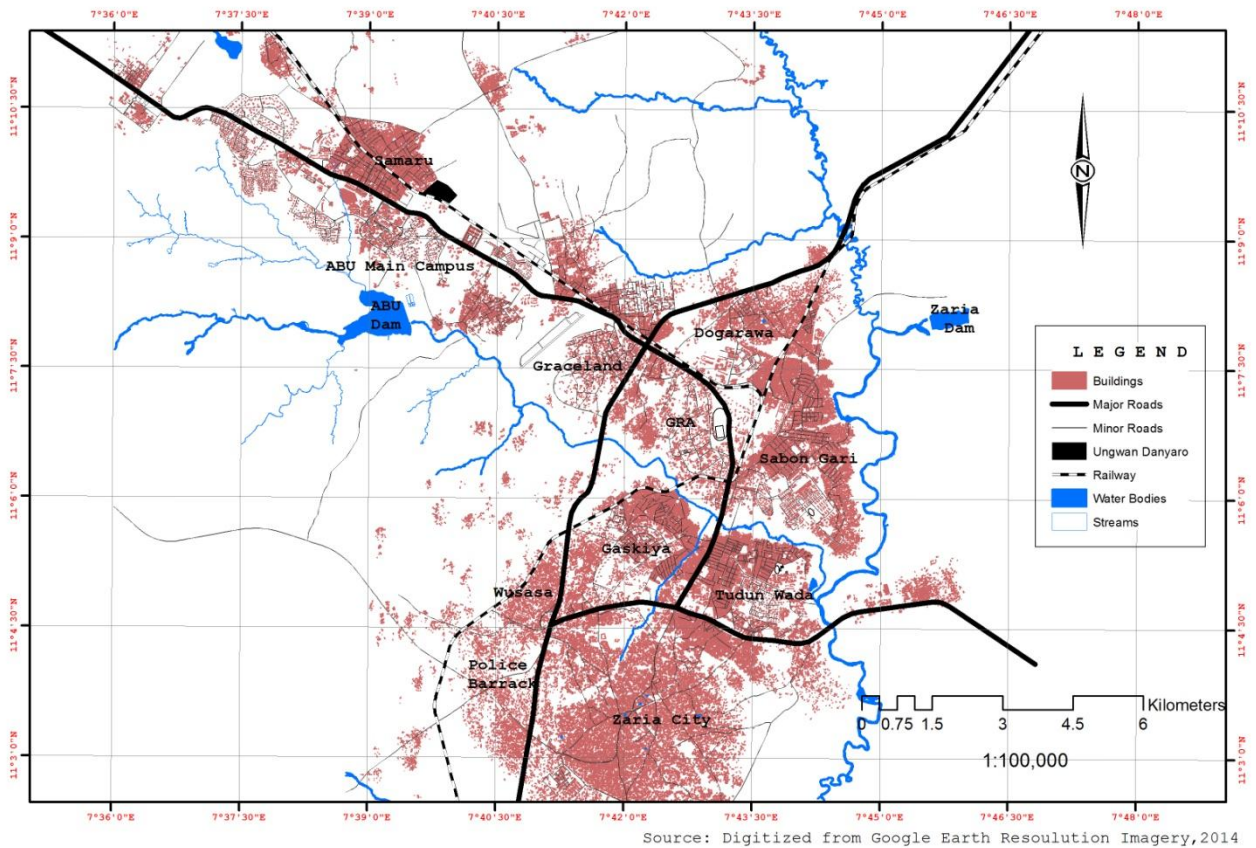
Samaru is part of Zaria area. It is situated within latitude  $11^{\circ} 3'N$  and latitude  $11^{\circ} 30'N$  and longitudes  $7^{\circ} 31'E$  and  $7^{\circ} 40'E$ . From the coast, it is about 640km north and lies within the political state called Kaduna. Samaru is under Sabon-Gari L.G.A and it is bounded to the north by Basawa military cantonment, to the south by Ahmadu Bello University main campus to the east by Federal College of Chemical and Leather Technology (CHELTECH) and Industrial Development Centre (IDC), and to the west by ABU formerly called College of Agriculture (Mortimore, 1970), (Fig 3.1 and fig3.2 ).

#### **3.3 CLIMATE**

The climate of Zaria is generally described as tropical wet and dry. It is also known as tropical continental climate with distinct wet and dry seasons. These seasons are controlled by the movement of the Inter-Tropical Discontinuity (ITD) line which in turn is dictated by the movement and dominance of the air mass (Tropical Continental air mass (cT) and Tropical Maritime air mass (mT) with alternating weather conditions of dry and rainy seasons respectively throughout the entire region.



**FIG 3.1** MAP OF KADUNA SHOWING SABO GARI L.G.A. Source: PUK Zaria



Source: Digitized from Google Earth Resolution Imagery, 2014

Figure 3.2: Map of the Urban Zaria Showing Ungwan Danyaro

Rainfall starts effectively from the month of May and ends in October. The beginning of rainy season is often marked by high intensity thunderstorm produced by the Tropical Easterly wind. Rain intensity decreases progressively as the rainy season becomes well established. It ranges from about 25mm/hr to 125mm/hr (Kowal and Knabe 1972). Zaria has only one maximum (peak) of rainfall and this occur in August with long term mean rainfall of 1110mm. The seasonality in rainfall is caused by the Tropical Maritime Air mass (mT) over the study area. When the cTs prevail, dry season dominates the study area while the rainy season is ushered into the study area by the incursion of the mT.

Temperatures in the area are high throughout the year. Mean monthly temperature is about 27°C. Daily maximum temperature can be as high as 40°C in the month of April and May and daily minimum temperature can be as low as 15°C in January. The atmospheric humidity is generally low in this area with its lowest in the dry season at 15% and its highest is the wet season above 60% for most of the time in the day. Evaporation is higher in the dry season and lower in the wet season. The average evaporation for the year is 121.9% (Kowal and Knabe, 1972).

### **3.4 VEGETATION**

The vegetation cover of study area is originally tropical savanna grassland. It is characterized by tall grass communities and short widely dispersed trees which are deciduous in character, shedding their leaves annually during the dry season in order to conserve water. The dominant tree species include *isoberlina doka*, *acacia bridelia*, *vitrex doniana* .

Grasses and shrubs occur in tussocks and predominant family is the *androgeneae*. At present it is only in a few places that this typical savanna vegetation can be found. In this study area, very little of this natural vegetation can be seen. A prolonged period of bush burning, overgrazing, cultivation and tree harvesting for cooking purposes has considerably degraded the vegetation cover to open grassland, bare surface and scattered scrubs. The grass communities sprout shortly after onset of rainy season, blossom and become luxuriant; almost completely covering the ground surface towards the latter part of the rainy season. In the dry season however, the grass communities wither and turn rustic brown.

### 3.5 SOILS

The soils in the study area are part of the tropical ferruginous soils, which are commonly called Ferrasols, developed on crystalline Basement Complex rocks. The soils are characterized by low organic matter content (about 1%), low cation exchange capacity and sandy clay texture (Iguisi 1996).

Klinkenberg, (1970) identified some general characteristic of the soils in the area. The lower part of the profile are usually derived in sites from the underlying weathered rock particularly the gneisses, granites and metasediment (Schist and Quartzite) while the upper parts are composed of mixture of the same material, alluvial and Aeolian drifts. Soil pattern of the study area has been described by Klinkenberg, (1970), pp 56-47, according to the geological units identified by Wright and McCurry (1970) as:

- 1. ‘Fadama’ (seasonal wet and dry) Soils:** The soils are generally classified as hydromorphic which occur in the bottoms of extensive wide valley systems. The soil are mostly dark grey clay with poor to very poor drainage, most of which have been formed in alluvial material. They occur widely in the Galma, Shika and Kubanni.
- 2. Soils Developed on Metasediment (Schists and Quartzite):** As a result of the widespread occurrence of elongated ridge in the west, soils are shallow and stony in the inter-fluve crests. However, on the middle and lower slopes, soil profiles are deeper, reddish-grey in color, exhibit signs of clay accumulation and hard iron concretion may be found.
- 3. Soils Developed on Granites:** The soils close to the granitic outcrops appear deep and consist of weathered materials and do not yet show much soil profile development. They contain many un-weathered fragments of quartz and Feldspar. Further away from the hills

very deep red clay soils occur. On the lower slopes are poorly drained area, the soils are mottled and generally grey in color. They also contain fragments of quartz and feldspar.

- 4. Lateritic Iron Pan:** There are two types of lateritic iron in the area; the older and younger. The older occurs at an elevation of about 700m and is generally very hard and vesicular in appearance. The pan is underlain by thick layer of clayey material which is strongly mottled in red, yellow, grey and pink which gradually gives way to weathered rock at depth. However, the younger latteric pans are topographically lower and may be found out cropping along river channels banks.

Most of the soils contain 30-40% of clay at a reasonable depth and thus allows for good moisture retention. The soils are inherently poor and cannot therefore sustain intense agriculture for long periods without the use of fertilizers. Many of the soil form a surface cap under the impact of heavy rain (Lawes, 1964) and the surface so formed has low infiltration rate. This may result to rapid runoffs and create the danger of accelerated erosion.

Kowal and Kassam (1978); Atolagbe (1970) and Jaiyeoba (1986) observed that organic matter and nitrogen contents of the soils are very low and this is attributed to sparse vegetation resulting from frequent bush burning, overgrazing, continuous cultivation and rapid oxidative decomposition of organic matter of the soil. The soils are normally heavy and hard to work. Drainage seems poor in spite of the sandy nature of the surface soil.

### **3.6 GEOLOGY**

The plain on which Zaria is situated are part of the vast gently undulating plain scenery which extends almost unbroken from Sokoto to Lake Chad and beyond and from south of Kaduna to the Tiguaddi scarp near Agades. Such plains are characteristic of Africa as a whole. Wright and McCurry (1970) described Zaria plain as dissected portion of the Zaria-Kano plain attaining elevations ranging from 550m – 740m above sea level. Department of Agricultural and Land Resources (FDARL, 1990) describe it as an undifferentiated Basement Complex. The Basement complex rocks have been described by Russ (1977) as composed of high grade meta-sediments of mainly quartzite and schist. The area is underlain by undifferentiated older alluvium and younger laterites with the bed rock exposed in some places.

### **3.7 GEOMORPHOLOGY, RELIEF AND DRAINAGE**

The Zaria plain is generally undulating varying in altitude from 550m to 740m above sea level and is surrounded by isolated rocky hills such as the Kufena hills rising to 820m and the Tukur Tukur hills 797m. These hills together with plain have being carved by geomorphic processes to give rise to distinctive inselberg - pediment landscape that characterizes the Zaria region. The valley bottoms are incised into plains and continued erosion processes have formed distinctive micro-landforms including degraded bluffs, erosional scarps and stripped micro-pediment (Thorp, 1973). Deep chemical weathering has created a substratum of residues which was subsequently modified by several cycles of erosion. The deeply weathered plains are being stripped of their regolith and under prevailing land use, often lead to gully development.

The major drainage system in Zaria is River Galma, a major tributary of River Kaduna. Supplied with runoff and seepage from a drainage basin 6902sq km in area, the Galma carries water throughout the year unlike many of its tributaries which dry up during January to June. The drainage patterns are commonly dendritic, reflecting absence of structural control over drainage lines on the deeply weathered plains. The channel pattern of drainage basins is of two types namely: those with large number of un-branched first order tributaries with high stream frequencies and drainage densities. The Awai, Marmara and Kuban to the east of Zaria are examples. Valley bottoms contain wide marshy flood plain often with intricately developed river meanders.

### **3.8 LAND USE**

Zaria evolved from a rural to urban community because of increasing population. This has given way to more extensive and intensive urban development. The presence of educational institution and industries serve as pull factors to the region. The occupations of rural communities include framing and rearing of cattle. Duniya, (2006) and Davis, (1970) reported that Zaria has been increasing rapidly in population. The implication of this general increase in population is that the old traditional agricultural practices summed up as bush fallow cultivation is becoming unsuitable for the region. This has led to intensive cultivation in the small agricultural area, especially in the urban fringes, in order to produce food for the increasing population, also the increasing population and search for cultivable land and firewood felling is converting the savannah woodland fast into degraded, over-grazed area.

### **3.9 HUMAN ACTIVITIES**

Human activities carried out in the study area include:

1. Agriculture; monoculture is the cultivation of the same type of crop year after year on the same plot of land. This type of agriculture is being practiced in Ungwan-Danyaro. The result is those single crops exhaust both humus and major nutrient and lead to loss of soil structure, hence erosion sets in.
2. Mining, particularly open cast excavation of clay and sand which require clearing of vegetation of an area. This method of mining has destroyed vast area of vegetation and land and thereby initiating soil erosion.

Ungwan-Danyaro is a practical example where the area is disturbed by gully erosion as a result of mining and construction activities taking place in the area.

## **CHAPTER FOUR**

### **METHODOLOGY**

#### **4.1 INTRODUCTION**

In this chapter the type of data collected, the mapping procedure and the statistical methods used in analyzing the relationship that exist between urban growth and gully development are described.

#### **4.2 RECONNAISSANCE SURVEY**

A reconnaissance survey of Ungwan Danyaro gullies in Samaru area was undertaken was undertaking with the aim of having a firsthand knowledge of the extent of urban growth and gully development

#### **4.3 TYPES AND SOURCES OF DATA**

The types of data used for the description of gully development are depth, width, and cross profile while the types of data used for the descriptions of urban growth are area occupied by the settlement and the population of the settlement of each decade (from 1980 to 2015). Topographic map of scale 1:25,000 was obtained from Department of Urban and Regional Planning, Ahmadu Bello University, Zaria. Land sat imageries of 1980, 1996 and Google imageries of 2000 and 2015 were downloaded from Google Map site. These data were used to establish the relationship between urban growth and gully development in the study area.

## **4.4 DATA ANALYSIS**

### **4.4.1 Mapping Procedure**

Land sat imageries of 1980, 1996 and Google imagery of 2000, and 2015 of Ungwan Danyaro were used to establish change over the catchment area. Topographical map of 1973 of scale 1:25,000 was used for delineation of the study area and of the contour lines. These were used to map the extent of urban growth and gully development for the different decades.

Arc GIS 9.2 software was used to digitize the topographic map of the decadian years in order to create a Digital elevation model (DEM) for these years. Landsat imageries of 1980, 1996 and Google imageries of 2000 and 2015 were digitized using Arc GIS 9.2 software to produce the base map for the different decades in order to establish spatial extent of the study area for the different decades. A cross section of nine selected gullies in the study area was derived using surfer 9.0. This was overlaid against each decade in order to establish the incremental growth in depth and width. The same was done for the spatial coverage in order to establish the incremental spatial growth of the study area, suffer 9.0 was used for map presentation of the selected gullies for the different decade over the period of 40 years. Elevation values were used to derive the cross profile of each year, in order to establish the incremental growth in depth and width of the selected gullies.

Data obtained from gullies depth, width measured at each sampling point of recent year 2015 was compared with the depth and width of the gullies of the initial year (1980) and subsequent decades. The extent to which urban growth has led to change in the landscape in term of gully

growth of the study area was assessed by deducing from the relationship between urban growth and incremental growth in depth and width of the gullies.

The statistical technique of Product – Moment Correlation coefficient was used to establish relationship between urban growth and gully development.

#### **4.4.2 Sampling techniques**

Nine sample points (A B C D E F H J K) were purposely selected especially where the gullies are more pronounced. This is done in order to show the trend of the gulling processes in the study area. Following the mapping procedure the data generated were stratified into gully morphometric data and settlement growth data. Simple tool such as percentage was used to describe the result and the relationship between the data.

Firstly area occupied by settlements for each decade was calculated using square method and subsequently comparing the result.

$$\text{Area} = (y + \frac{x}{2}) \times (\text{map scale})^2 \text{-----Equation 1}$$

Where y = no of complete square

x = no of incomplete square

**Source: Areola *et al*, (2004)**

The comparison of the area of the settlements for different decades was used in calculating the percentage growth of settlement between the decades.

A table was developed showing the area in kilometer square and the percentage growth of settlement against the decades that is (1980 to 2015).

To determine the percentage growth of settlement, the trend of growth was calculated by dividing the difference observed in the expansion of settlement between the decades by the sum of differences multiply by 100.

$$(Trend)percentage\ growth = \frac{observed\ difference}{sum\ of\ difference} \times \frac{100}{1} \text{ ----- Equation 2}$$

Overlay operation was used to identify the location and magnitude of difference.

Secondly land consumption rate and land absorption coefficient were calculated in order to establish incremental spatial growth of the study area.

The land consumption rate is a measure of compactness, which indicates a progressive spatial expansion of a settlement while land absorption coefficient is a measure of change in consumption of new land by each next increase in population. The formulas are given below;

$$L.C.R. = \frac{A}{P} \text{ ----- equation 3}$$

A = areal extent of settlement

P = population

$$L.A.R = \frac{A_2 - A_1}{P_2 - P_1} \text{ ----- Equation 4}$$

A<sub>1</sub> and A<sub>2</sub> = areal extent (in km<sup>2</sup>) for the early and later years

P<sub>1</sub> and P<sub>2</sub> = population figure for the early and the later years respectively (Yeates and Garner, 1976).

The population projection of Samaru area was obtained from district office Tax record in Sabon Gari Zaria. (Table 4.1) The formulae that was used to project the population is presented below.

The recommended national population commission (NPC) 3.2% annual growth rate was used.

$$TP = PV(1 + r)^n \text{ ----- equation 5}$$

Where PV = Present population

r = rate of growth

n = number of years being projected

The population of the area is shown in table 3.1 below

**Table 4.1: Samaru area population figures**

Year	Total population	Source
1963	4,147	1963 Census data
1970	6,000	Projected population
1975	20,000	Projected population
1980	23,411	Projected population
1986	40,000	Projected population
1991	82,250	1991 census data
1996	96,279	Projected population
2000	105,560	Projected population
2006	124,582	2006 census data
2015	165,414	Projected population

Source; District Office Tax Record Sabon-Gari, Zaria.

In order to establish a relationship between settlement growth and gully growth, the product-moment Correlation Coefficient was calculated. The formular is giving as

$$r = \frac{\sum xy/n - \bar{x}\bar{y}}{S_x S_y} \text{ ----- equation 6}$$

$r$  = the Product moment Correlation Coefficient.

$x$  and  $y$  = the value of two variables i.e.

$x$  = the area of settlement of each decade

$y$  = the total sum of width of gullies of each decade

$n$  = four decades

$\bar{x}$   $\bar{y}$  = means of the two variables

$S_x$  and  $S_y$  = the sample standard deviation of the two variables

$$S_x = \sqrt{\frac{\sum x^2}{n} - \bar{x}^2}$$

$$S_y = \sqrt{\frac{\sum y^2}{n} - \bar{y}^2}$$

**Source: Gayen, (1951).**

## CHAPTER FIVE

### RESULT AND DISCUSSION

#### 5.1 INTRODUCTION

This chapter presents the results and discussion of the study on the relationship between urban growth and incremental growth in gully in term of depth and width over the decadian periods based on the objectives of the study.

#### 5.2 URBAN EXPANSION

Area occupied by settlements and the percentage growth for each year (i.e. from 1980 to 2015) were calculated and summarized in table 5.1.

**Table 5.1: The extent of settlement growth**

Year	Area of settlement (km <sup>2</sup> )	Percentage growth (%)
1980	2.8	-
1996	25.6	14
2000	91.9	40.9
2015	165.1	45.1

Source Author's field survey 2015

Table 5.1 summarizes the incremental growth in settlement area of Ungwan Danyaro in Samaru area of Zaria. The table shows that there is progressive expansion of settlement area from 1980 to 2015. Area occupied by settlement was 2.8km<sup>2</sup> in 1980, 25.6km<sup>2</sup> in 1996, 91.9km<sup>2</sup> in 2000 and 165.1km<sup>2</sup> in 2015.

Moreover there is accelerated increase in the growth rate of the settlements from 1980 to 2015. The growth rate was 14% in 1996, 40.9% in 2000 and 45.1% in 2015. This is attributed to a continuous clearing of land due to population and settlement growth (Fig 5.1 to 5.4).

The progressive expansion of settlement is indicated by land consumption rate and absorption coefficient in table 5.2 below.

**Table 5.2: Land Consumption rate and absorption coefficient**

Year	Land consumption rate	Land absorption coefficient	Periods
1980	0.00012		
1996	0.00027	0.00031	1980/1996
2000	0.00087	0.0071	1996/2000
2015	0.00099	0.0012	2000/2015

Land consumption rate which is the progressive expansion of built up areas have indicates great increase between the periods of 1980 to 2015. It increased from 0.012% in 1980 to 0.027% in 1996, 0.087% in 2000 and 0.099% in 2015. The land absorption coefficient which is a measure of change in consumption of new land by each unit increase in the area population has also shown increase in the rate from 1980 to 2000. As shown by Table 5.2 the land absorption coefficient rate increases from 0.031% in 1980/1996 to 0.71% in 1996/2000, but decreases to 0.12% in 2000/2015. Factor that might be responsible for these rate include among others high population density of Samaru area. This is due to the influx of laborers who came from village around the study area and other part of the country to seek for job.

The conversion of Nigerian College of Art, Science and Technology into Ahmadu Bello University in 1962 encouraged more people into Samaru as it was the first university in northern Nigeria. The opening of Industrial Training Centre, the building of research centers as well as government housing estate followed this change. The linkage of Samaru to the rest of Zaria by tarred roads, along the Zaria – Sokoto road in 1953 exposed the village to many more migrant far and near. So did the Zaria – Kaura Namoda railway line expose Samaru to many more migrant from far and near.

The population of Samaru has been increasing steadily and since then very few people migrate out of Samaru and these are farmers who move out to find farmland and grazing land. Other factors for the rapid population growth of Samaru includes, the influx of people seeking for job in the University which itself has created multiplier effect in the establishment of other development sectors such as banks, petrol stations, shops super market.

## **5.3 CHARACTERIZATION OF GULLY GROWTH**

### **5.3.1 Cross Section View of Gully Site**

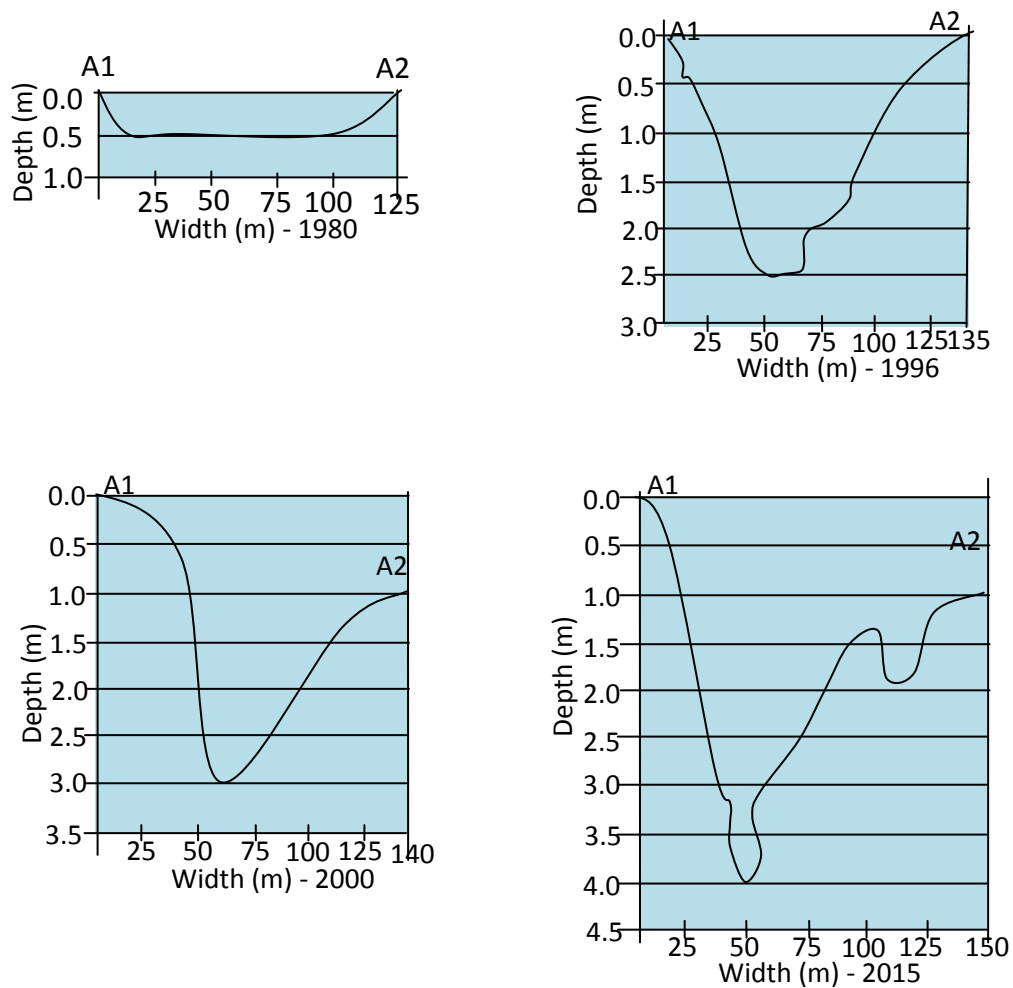
Nine sample points (A, B, C, D, E, F, H, I, J) were taken in order to determine the depth and width of the gullies at these various points. The values for the cross sections are summarized in the table 5.3.

**Table 5.3: Depth and Width profile of gullies**

Cross Profile Point	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2	H1	H2	J1	J2	K1	K2
	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)
<b>1980</b>	0.5	125	1.5	150	2.0	180	2.5	150	2.5	200	3.5	175	2.5	215	2.5	190	1.5	100
<b>1996</b>	2.5	135	4.0	200	3.0	200	3.0	175	3.0	220	6.5	210	7.0	225	3.0	200	2.0	135
<b>2000</b>	3.0	140	6.0	215	4.5	210	6.0	200	6.0	230	8.0	225	8.5	240	4.5	210	7.0	200
<b>2015</b>	4.0	150	8.0	225	5.0	225	10.5	225	9.5	245	11.5	245	9.0	250	7.5	250	10.5	225

*Source: Author's Field Survey 2015*

As evident from the table at point A<sub>1</sub>A<sub>2</sub> from 1980 to 2015, the gully depth ranged from 0.5m to 4m with the shallowest gully in 1980 and the deepest in 2015. The width ranged from 125m to 150m. Based on the slope characteristic as revealed by the DEM (fig. 5.1) coupled with field observation, the gully in 1980 and 1996 can be regarded as relatively gentle slope while that of 2000 and 2015 had steep slope. Both the headscarp and the gully side wall are actively eroded. This is attributed to the direct influence of urban development by building as seen in plate I below.

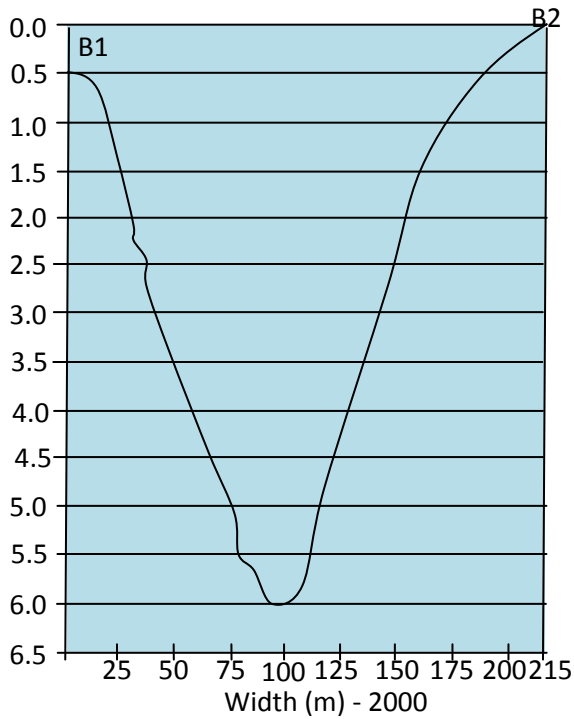
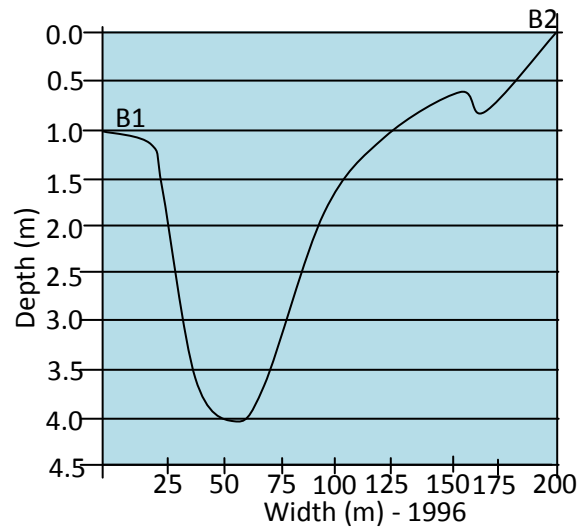
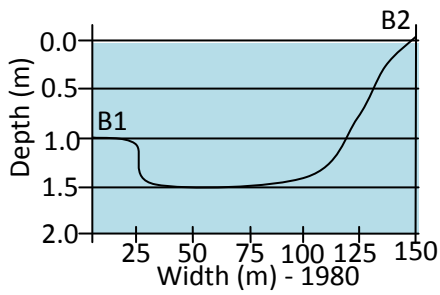


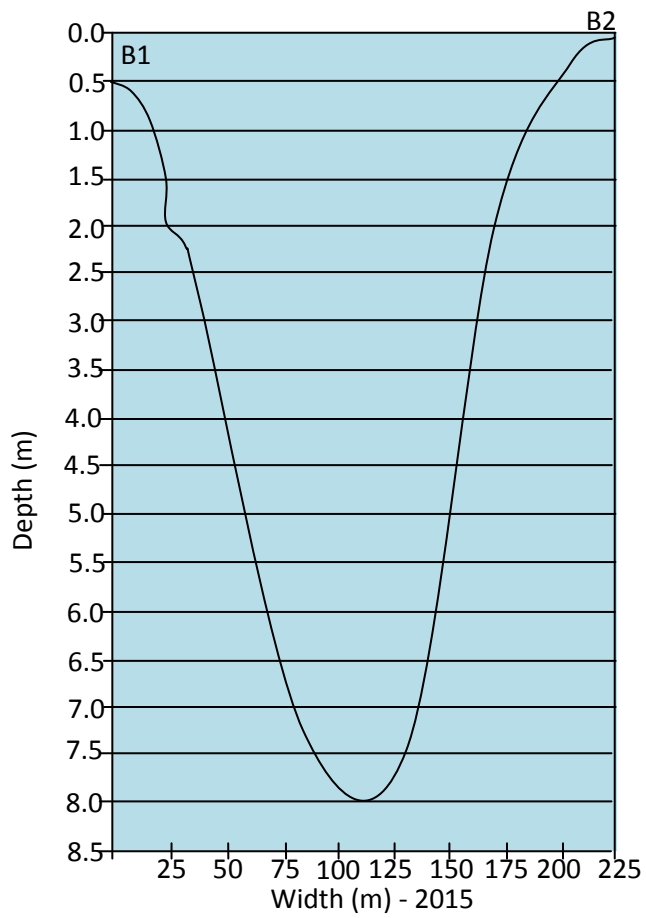
**Fig. 5.1: Point A<sub>1</sub>A<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate I: Buildings under the threats of gully erosion**

At point B<sub>1</sub>B<sub>2</sub> from 1980 to 2015 the gully depth ranged from 1.5m to 8m. The shallowest gully is observed at 1980 while the deepest at 2015. The width also ranged from 150m to 225m and the widest gully is observed at 2015. The gully assumed U-shaped with gentle slope in 1980 from 1996 to 2015 it changed its shape to V –shape with steep slopes. (Fig 5.2), this implies that the erosion process in the gully is more vertical than lateral. The widening and the deepening of the gully had affected the building foundation of God’s Time Secondary thereby causing the building to collapse as observed in plate II.



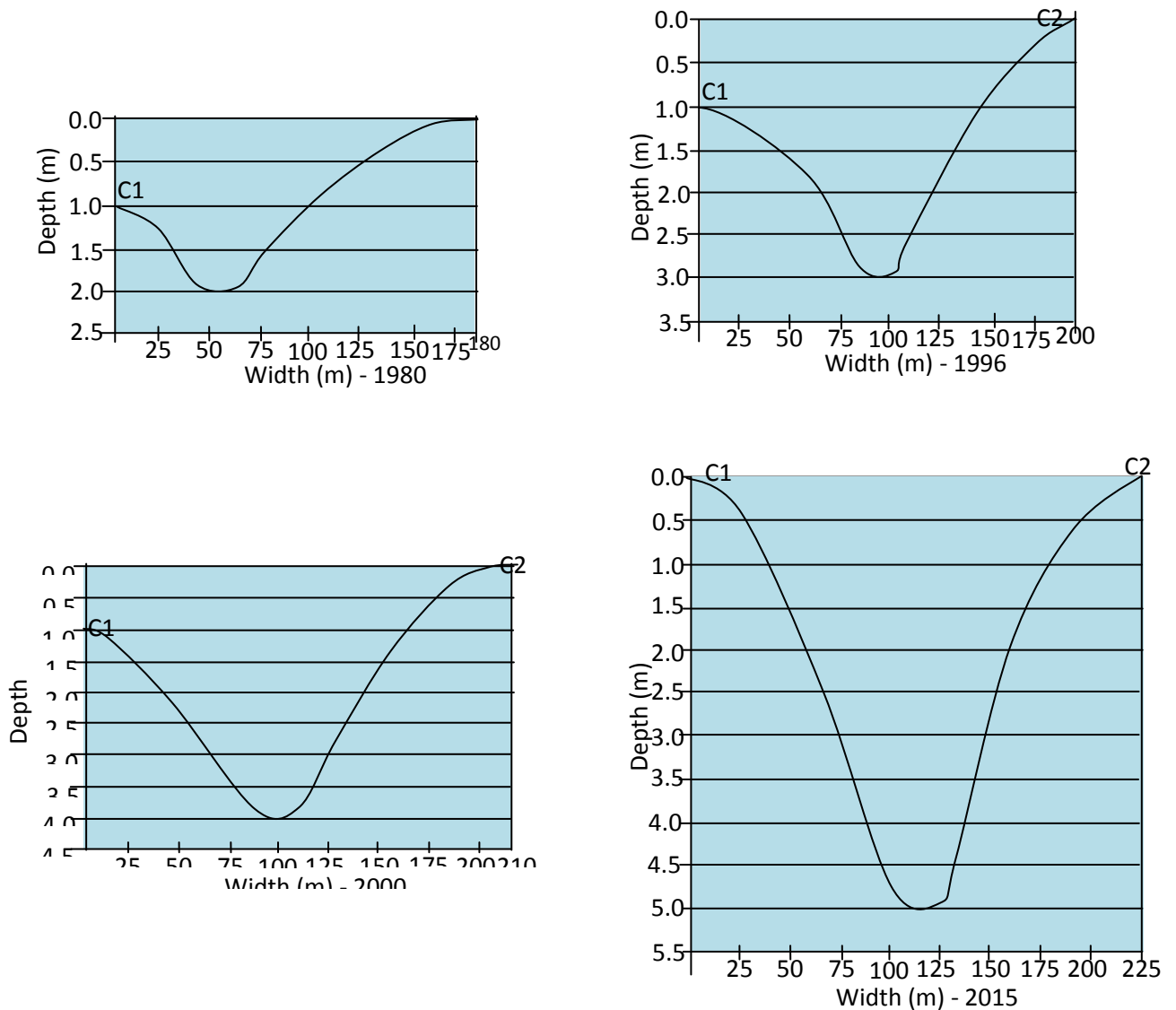


**Fig. 5.2: Point B<sub>1</sub>B<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate II: God's Time Secondary School buildings collapsed as a result of Gully erosion.**

At point C<sub>1</sub>C<sub>2</sub>, from 1980 to 2015, the gully depth varied from 2m to 5m the shallowest gully was observed in 1980, while the deepest in 2015. The width also varied from 180m to 225m. The shallowest gully is observed at 1980. The gully in 1980 and 1996 had U-shape with gentle slope (fig 5.3). From 2000 to 2015 the gully assumed V – shape with steep slope and convex slope. There is an expansion of settlement close to the gully site, (Plate III).

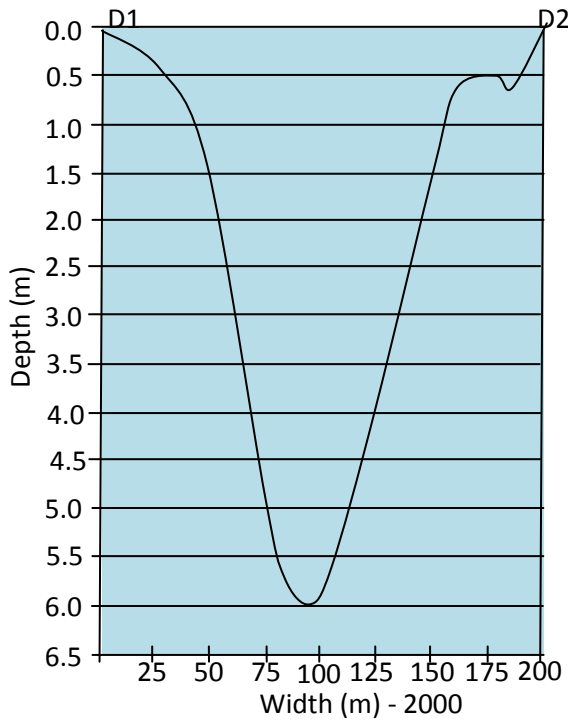
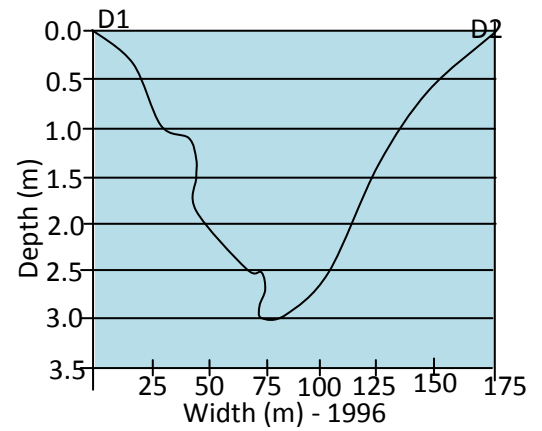
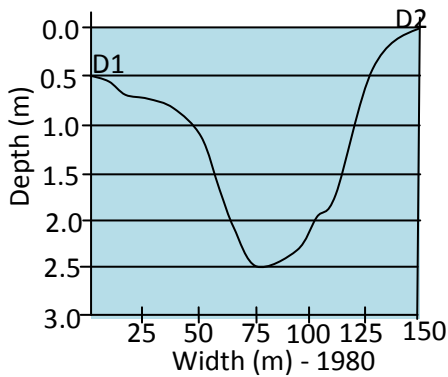


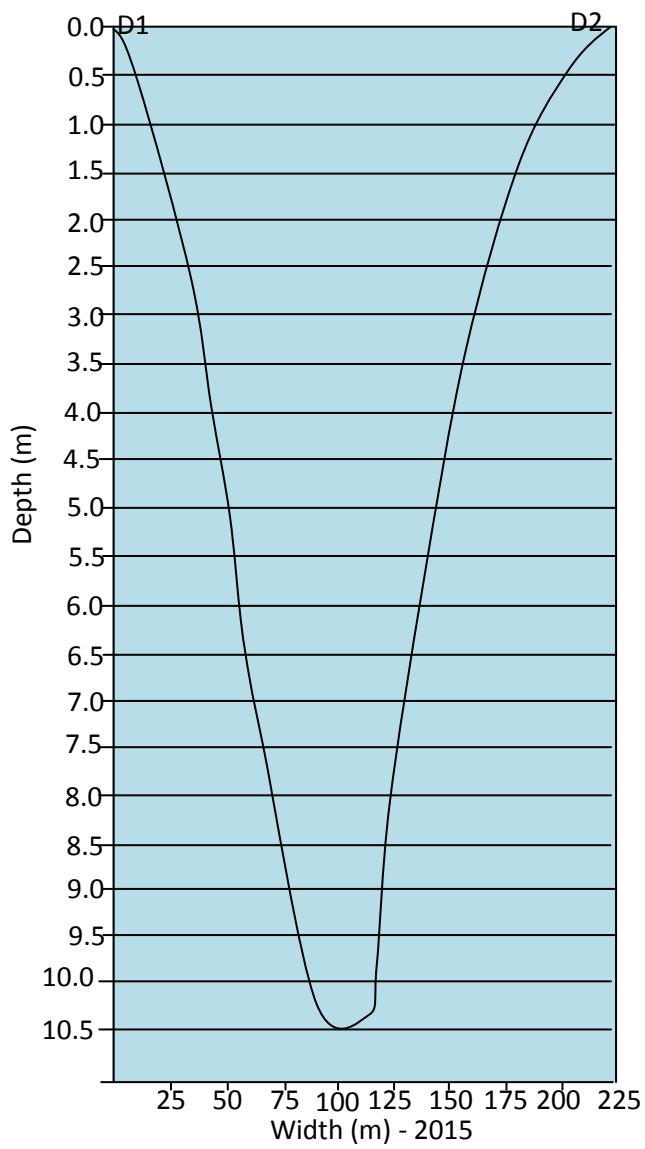
**Fig. 5.3: Point C<sub>1</sub>C<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate III: an expansion of buildings close to Gully erosion site.**

At point D<sub>1</sub>D<sub>2</sub> from 1980 to 2015, the gully depth varied from 2.5m to 10.5m. The gully in 1980 exhibits a shallowest depth while that of 2015 shows the deepest depth. The width varied from 150m to 225m with the widest gully at 2015 (Fig 5.4). This is due to the fact that the volume and the speed of runoff generated from the settlement as a result of poor or lack of drainage increased at each successive year thus, the runoff move swiftly, eroding the floor and the sides of the gully thereby increasing the depth and the width of the gully as seen in Plate IV.



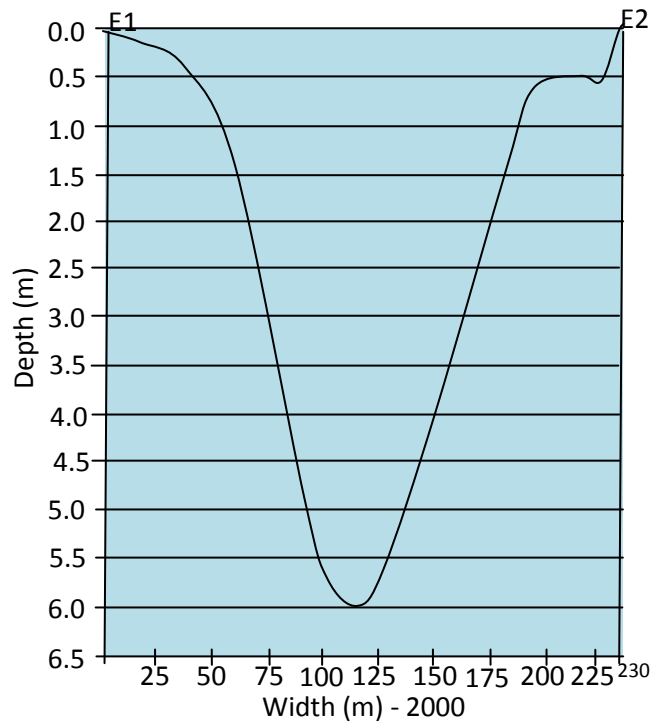
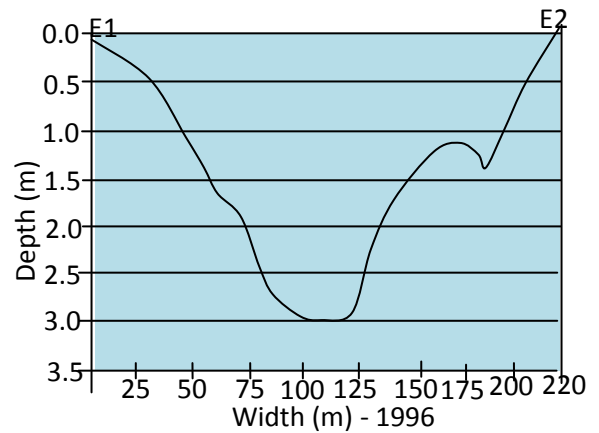
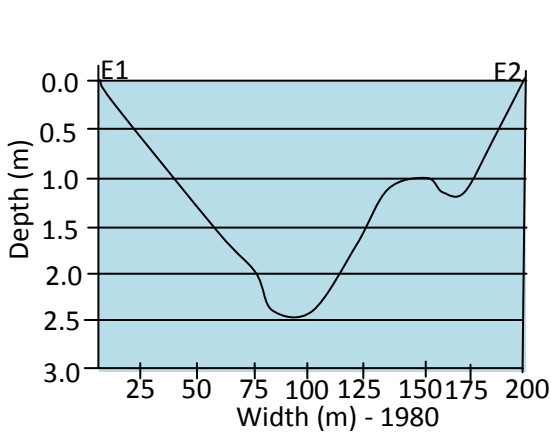


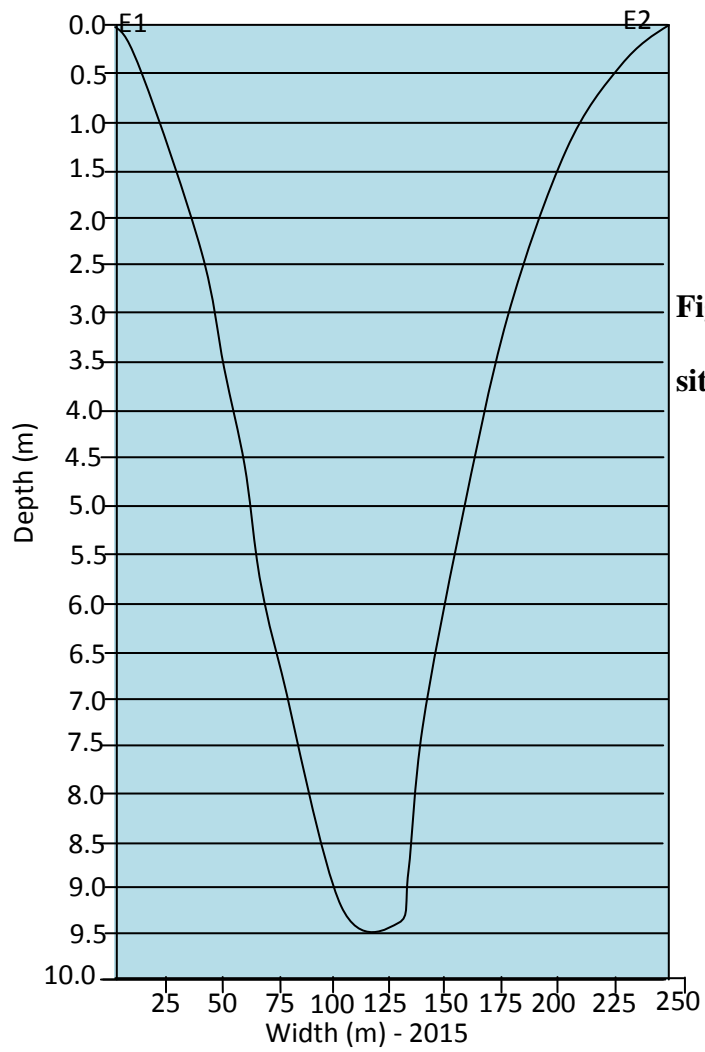
**Fig. 5.4: Point D<sub>1</sub>D<sub>2</sub> cross profile of gully site  
(1980 – 2015)**



**Plate IV: Expansion of gully side towards residential area at Ungwan Danyaro due to lack of drainage.**

At point E<sub>1</sub>E<sub>2</sub> from 1980 to 2015, gully depth ranged from 2.5m to 9.5m. The gully width varied from 200m to 245m. The shallowest and the narrowest gully was observed in 1980 while the deepest and widest is observed in 2015. Fig 5.5, the gully in 1980 and 1996 assumed U – shape with concave – convex slope while that 2000 and 2015 assumed – V – shape with steep slopes, (Plate V).



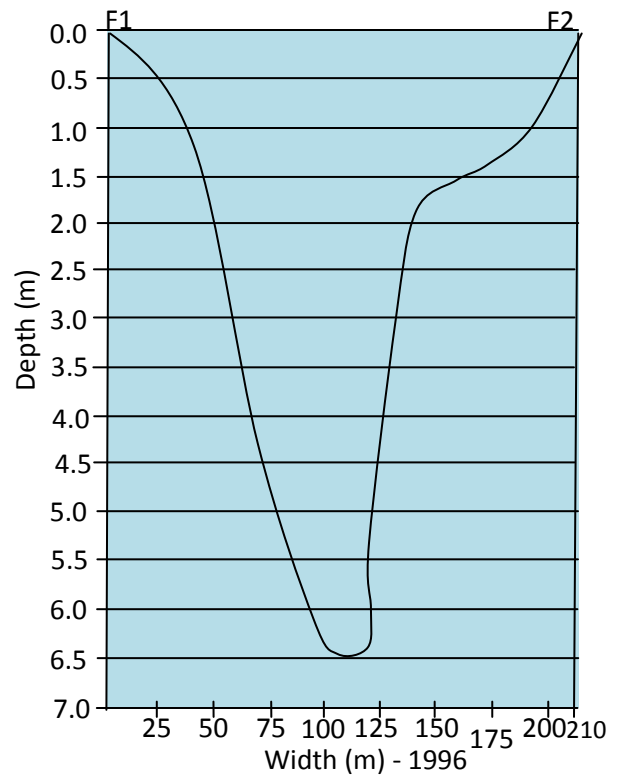
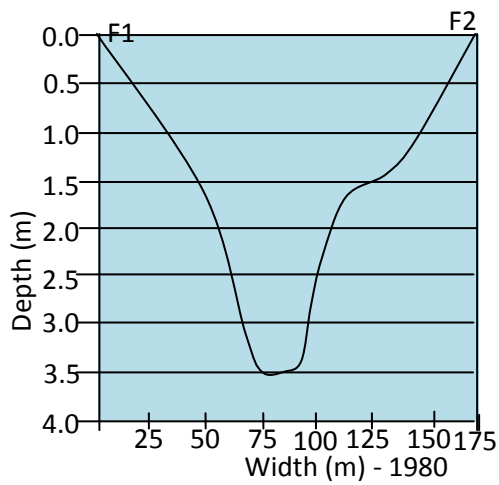


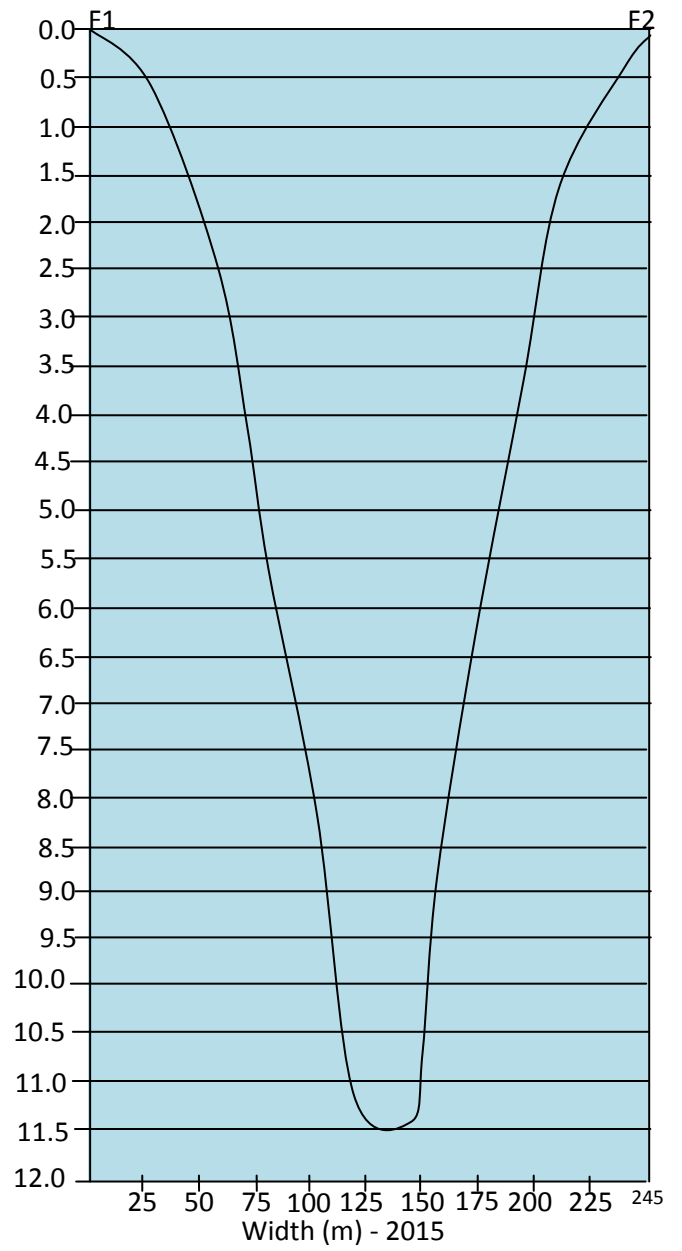
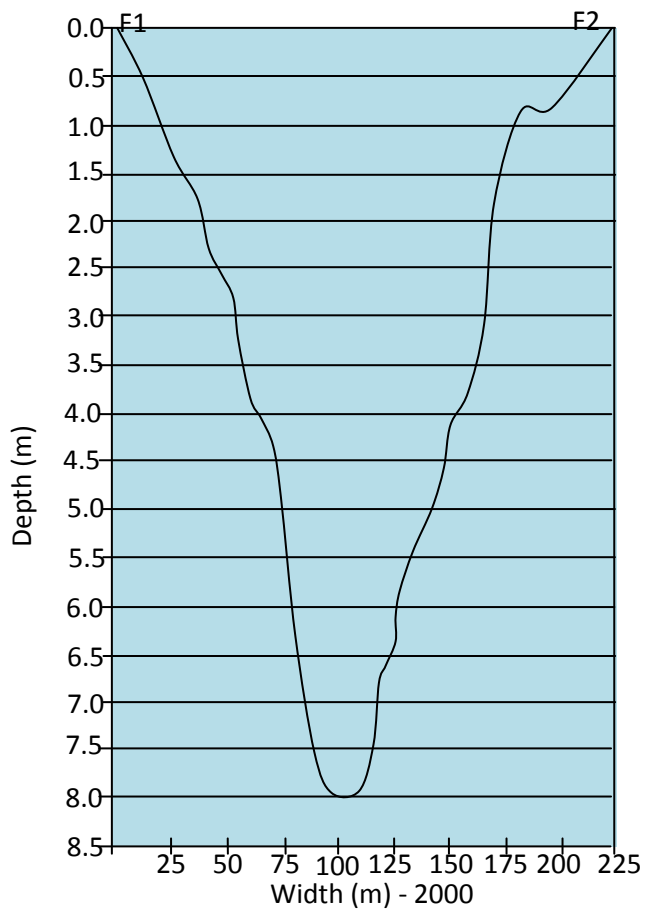
**Fig. 5.5: Point E<sub>1</sub>E<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate V: The expansion of gully**

At point F<sub>1</sub>F<sub>2</sub> from 1980 to 2015 gully depth varied from 3.5m to 11.5m. The width also varied from 175m to 245m. The gully in 2015 exhibited the deepest and widest valley (Fig 5.6), compare to the gullies in the other points and decades (table5.3). This is attributed to the inclination of the land which cause the erosion processes (i.e. the lateral and vertical erosion) to be more active eroding the side and the floor of the gully as a result of the speeding and the force of the running water from the upland from point A<sub>1</sub>A<sub>2</sub> down to F<sub>1</sub>F<sub>2</sub>, as shown in plate VI.



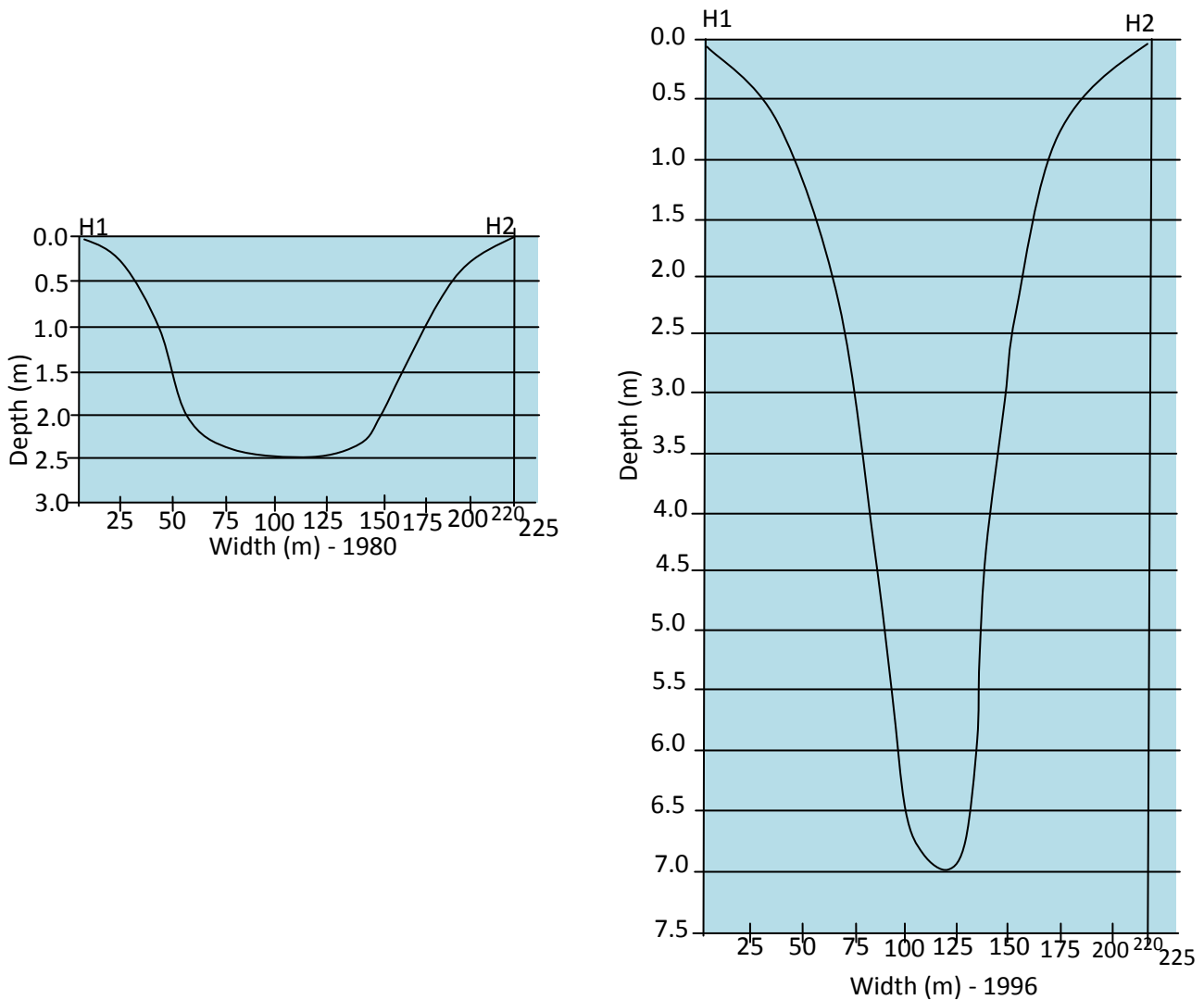


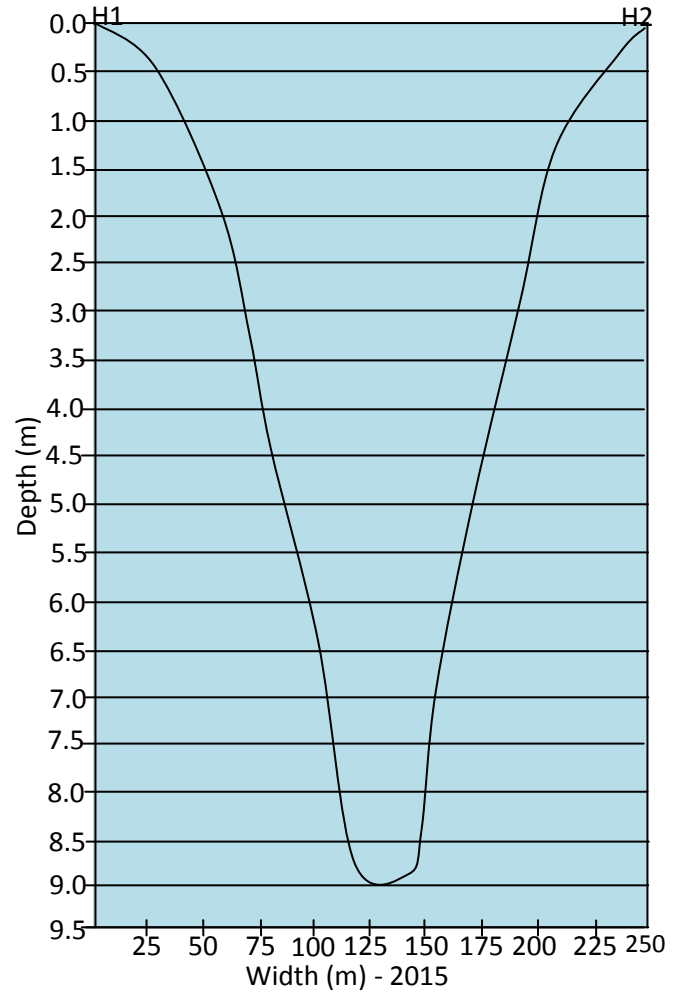
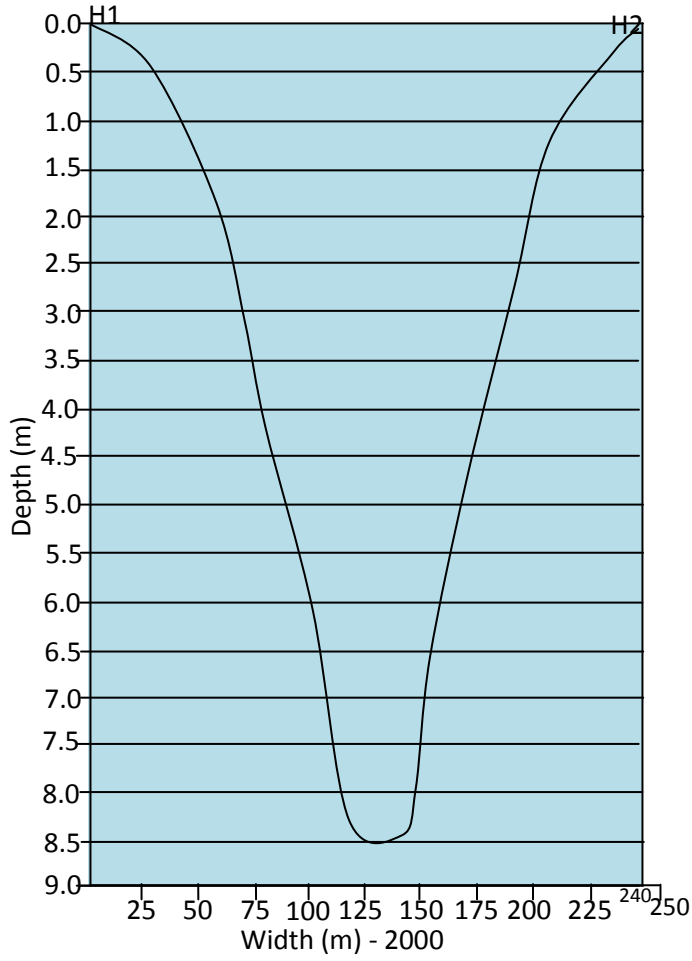
**Fig 5.6: Point F<sub>1</sub>F<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate VI: Gully advancing towards building foundation**

At point H<sub>1</sub>H<sub>2</sub>, from 1980 to 2015 the gully depth ranged from 2.5m to 9m (fig5.7). The shallowest gully is observed at 1980 while the deepest at 2015. The gully width varied from 220m to 250m. The gully in 1980 assumed u-shape while that of 1996, 2000 and 2015 exhibited v-shape with convex slope. In the floor of gully in 2015 are deposition of sediment and refuse transported by runoff from the upland of Ungwan Danyaro down to the lowland as observed in plate VII.



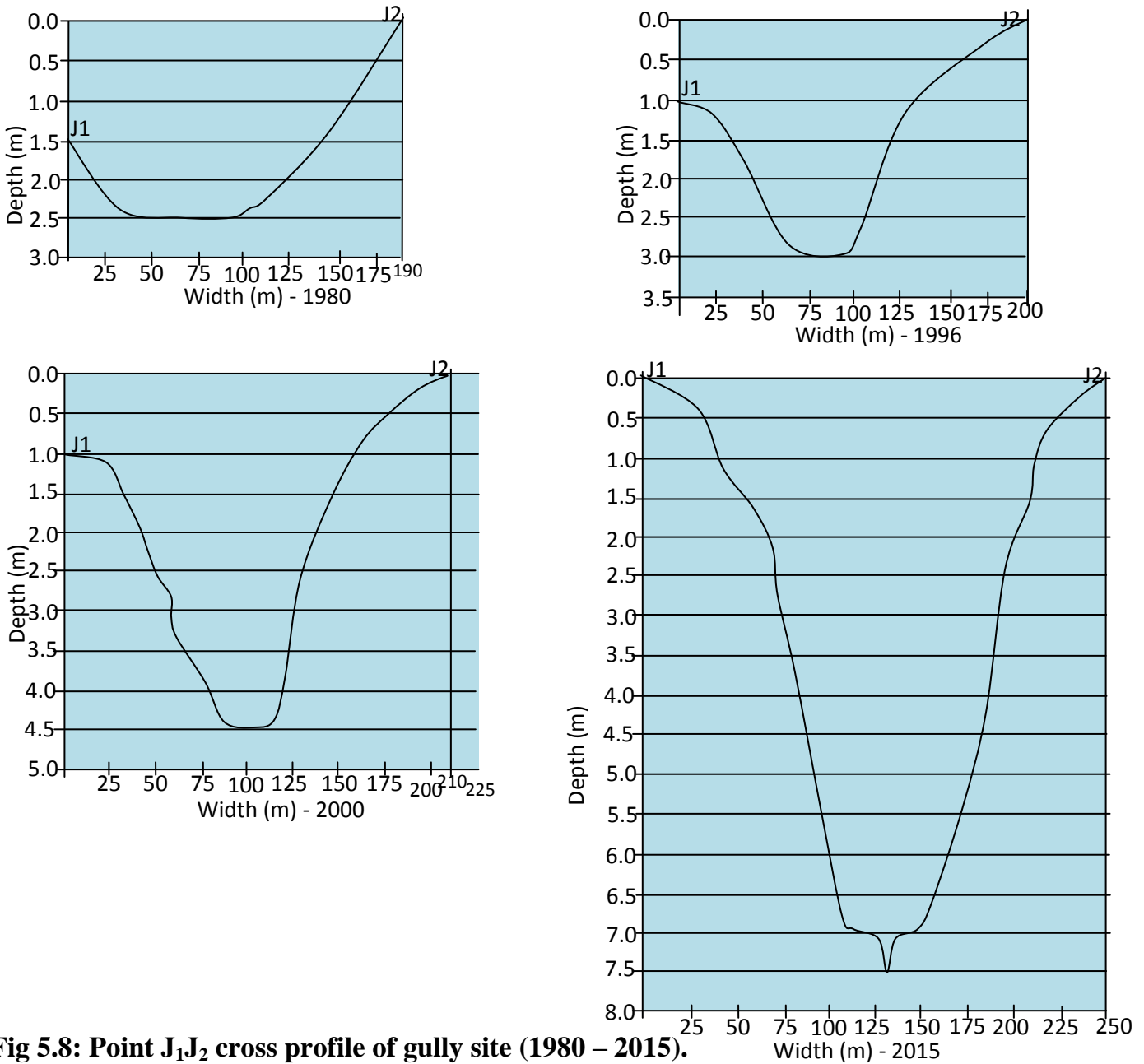


**Fig 5.7: Point H<sub>1</sub>H<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate VII: Filling of gully with refuse.**

At point J<sub>1</sub>J<sub>2</sub> from 1980 to 2015 gully depth varied 2.5m to 7.5m the shallowest gully is observed at 1980 while the deepest at 2015. The gully width ranged from 190m to 250m. The gully in 1980 assume U – shape with gentle slope on inside and steep slope at the other side, from 1996 to 2015 the gully changed its shape and assumed V – shape with convex slope. An overview of the gullies is shown in plate in plate VIII.

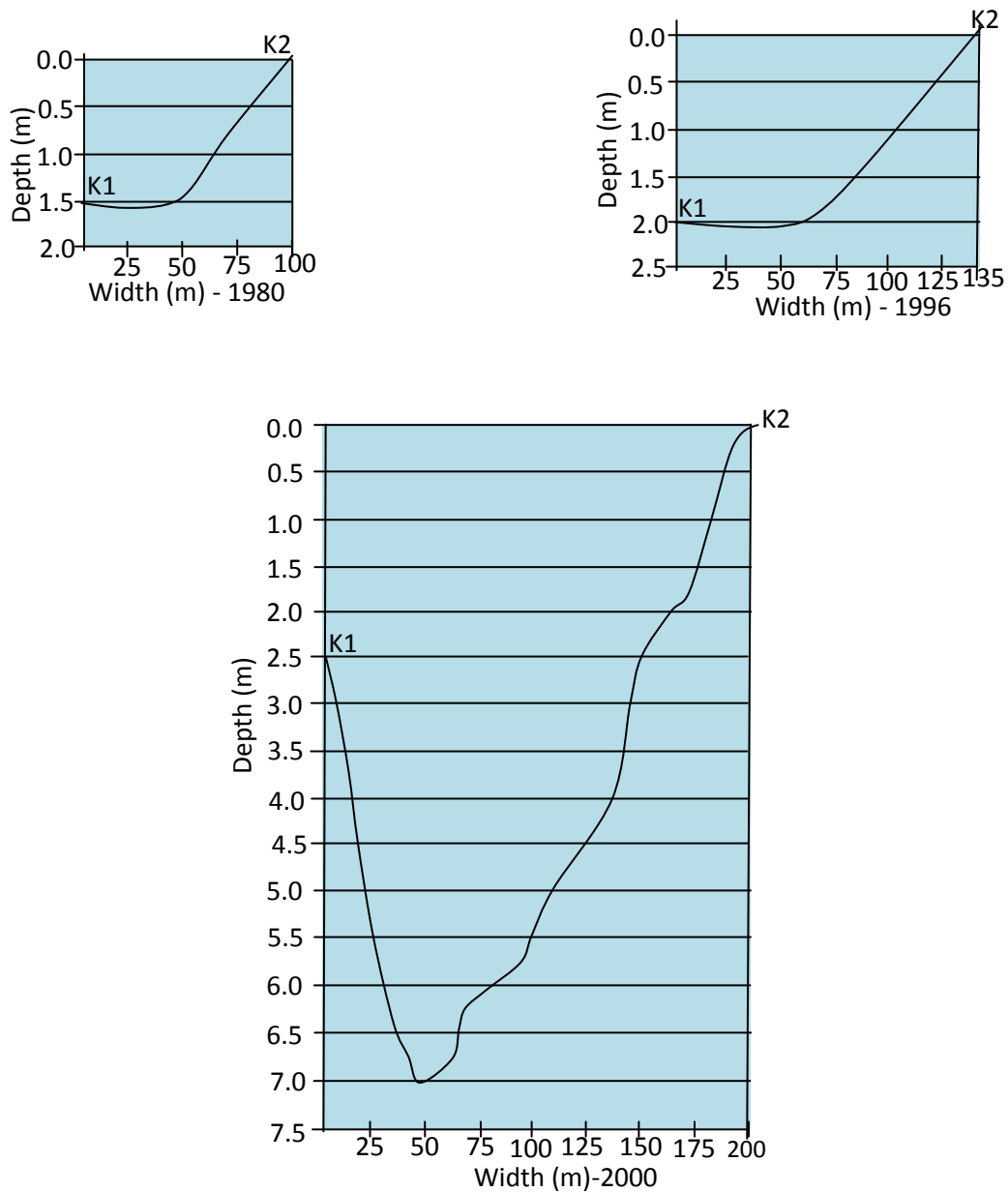


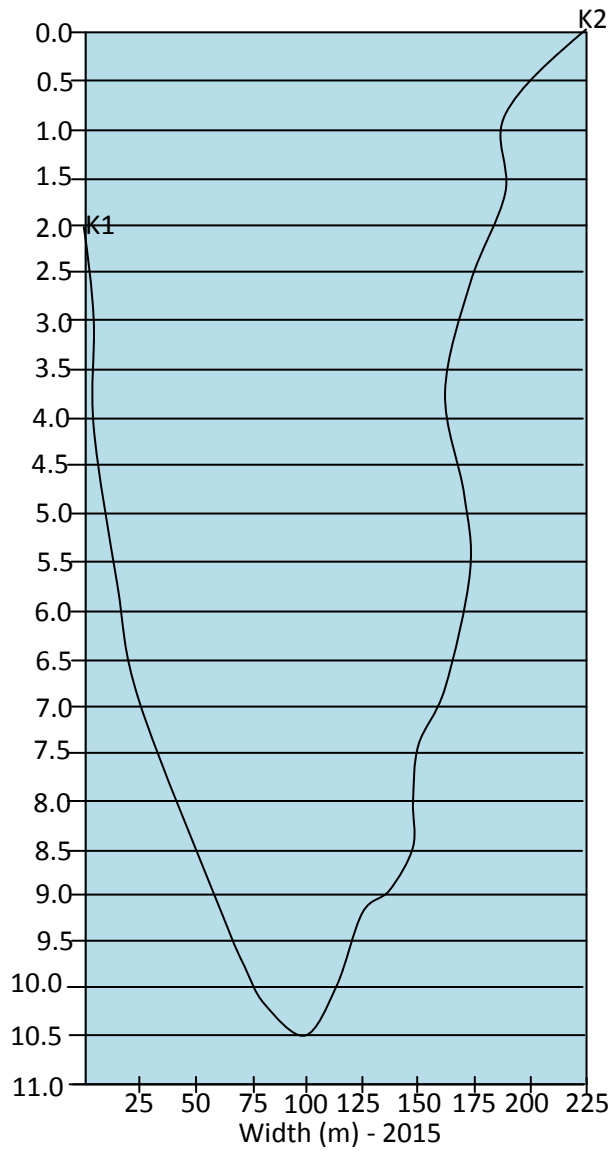
**Fig 5.8: Point J<sub>1</sub>J<sub>2</sub> cross profile of gully site (1980 – 2015).**



**Plate VIII: An overview of severe gully erosion at Ungwan Danyaro.**

At point  $K_1K_2$  from 1980 to 2015 gully depth varied from 1.5m to 10.5m. The gully in 1980 exhibited the shallowest depth while the gully in 2015 shows deepest depth. The gully width varied from 100m to 225m. The gully took a U – shape with steep slope in 2000 and 2015. Quarrying activity was observed to be taking place at this point and this has resulted to formation of badland as shown in plate IX.





**Fig 5.9: Point K<sub>1</sub>K<sub>2</sub> cross profile of gully Site (1980 – 2010).**



**Plate IX: Bad land as a result of sand mining for molding blocks.**

## **5.4 CHARACRISTICS OF GULLY DEVELOPMENT**

From the physical assessment of gullies supported by the measured cross – profile, two types of gully shape were identified, V – shaped and U – shaped. Apart from 1980 and 1996 gullies that had the highest number of U- shape gullies with gentle slopes at different sample points, 2000 and 2015 had the highest number of V –shaped gullies with steep slope (fig5.1 to fig 5.4). However some gullies exhibited irregular profile consequent on rock out crops on their floor along the profile. As shown in fig. (5.6, 5.7, and 5.9). Field observation also show that headscarps and gully sidewalls in 2015 were still actively eroding in many parts especially in the area under direct influence of urban development by buildings.

Apart from the geometry of gullies, land cover and land use in the area were pointer to their condition and stability or otherwise. Some areas exhibit shrubby vegetation, the vegetal cover was sparse and during the rainy season, the ground remains dry with cluster of leaves with few low trees and grazing still were allowed. Field observation shows that earth clay (laterite) and sand mining activities particularly in the floor of some large gullies were occurring. Such mining activities and passage of heavy trucks along gully sidewalls or trench are known to have encouraged and aggravated gully erosion and this has resulted to development of bad land in the study area.

### **5.4.1 Morphological Features Identified**

Field observation shows that head wall of the Ungwan Danyaro gully was marked by a vertical scarp, separating ungullied portion of the valley floor from the gully below. Water flows over sheadwall during runoff and falls into a plunge pool at the base of headwall. The water then

erodes the base and side of the pool under-cutting the headwall. Continuous erosion will eventually encroach into the road and rail and destroy them. Moreover, because of its location close to settlement of Ungwan Danyaro, it is expected that there will be increased storm runoff generated from rooftops.

#### **5.4.2 Gully Side Wall**

Ungwan Danyaro gullies have vertical – walls that are rilled and undercut especially where the lateritic capping were present. Field observation shows that some undercutting of sidewalls cause deep rotational slump along the sidewall, resulting in widening of the gullies. The gully also exhibits the sign of soil excavation in some areas.

#### **5.4.3 Gully Floors**

Ungwan Danyaro gully has a well defined channel which meanders through the entire gully system. Materials found on the gully floor were mostly washed into it from the upper profile either through slumping, sliding or man's deliberate activity. Most of the ferromagnesium compounds, clay and sand have been washed away leaving a conglomeration of iron concretion. Plung pools were also visible where there is a deep vertical drop from the sidewalls or in the headscarp area.

## 5.5 RELATIONSHIP BETWEEN SETTLEMENT GROWTH AND GULLY DEVELOPMENT

In order to determine the relationship between settlement growth and gully growth, the product – moment correlation coefficient ( $r$ ) was calculated, (Table 5.4). A value of 0.991 was derived which indicates that a very strong positive correlation exists between urban growth and gully development.

**Table 5.5 Correlation between settlement growth and gully growth**

Settlement growth of the Four decades (km <sup>2</sup> ) $X$	Sum of depth of the Gullies of four decades (m) $y$
2.8	19
25.6	34
91.6	53.5
165.1	75.5

The critical value of  $r$  at 0.05 significance level with 2 degrees of freedom is 0.900 for a one – tailed test ( $H_1 : p > 0$ ). A value of  $r$  greater than or equal to 0.900 is sufficient to enable the null hypothesis to be rejected in favour of a directional alternative hypothesis at the 0.05 significant levels. Hence, there is a significant relationship between settlement growth and gully growth.

The plan form of the gully in fig 5.10b and 5.11b shows that the gullies in 1980 and 1996 at each sample point had gentle slopes. This is indicated by widely spaced contour lines. The shallowest gullies are observed in 1980 followed by 1996 at each sample point (A, B, C, D, E, H, J, K ) as shown in fig 5.10b and fig 5.11b respectively.

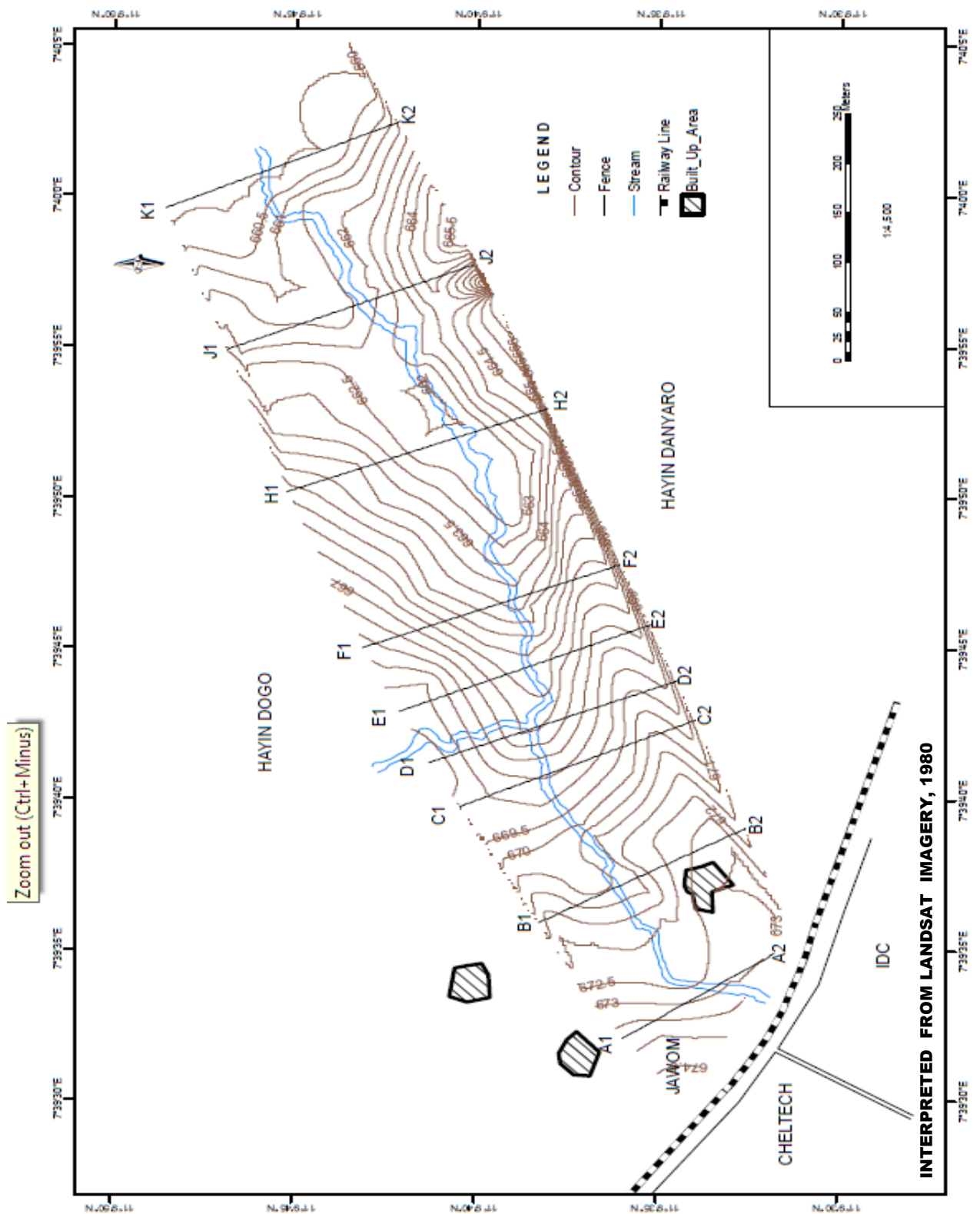
Moreover the settlement of Ungwan Danyaro were occupying a small area of land in these decades (i.e. 1980 and 1996), the building were very scanty and dispersed. In 1980 the built up area was  $2.6\text{km}^2$  and in 1996 it was  $25.6\text{km}^2$ . This is as a result of rapid increase in the population of Samaru. The presence of educational institution serves as a pull factor. The plan form of the gullies in 2000 and 2015 at each sample point had steeper slope than that of 1980 and 1996. This is indicated by closely packed contour lines as shown in fig 5.12b and 5.13b. The deepest gullies were observed in 2015 at each sample point (i.e. from  $A_1A_2$  to  $K_1K_2$ ). It is also observed that at these decades (2000 and 2015), the area occupied by the settlement of Ungwan Danyaro had rapidly increased. This is attributed to the continuous increases in population. As people keep on trooping into Samaru, more houses were built. In 2000 the built up area increased to  $91.6\text{km}^2$  and in 2015 it increased to  $165.1\text{km}^2$  as indicated in fig 5.12b and fig 5.13b respectively.

It is observed that a direct relationship exist between gully growth and the growth of settlement of Ungwan Danyaro. As settlement increase in terms of land area from 1980 to 2015, there is also increase in the growth of gullies at each sample point in term of depth and width from 1980 to 2015 as shown in fig 5.10b to 5.13b. The 1980 and 1996 land sat imageries, S the 2000 and 2015 Google imageries and digital elevation model of 1980, 1996, 2000 and 2015 were shown in fig 5.10a, 5.10c, 5.11a, 5.11c, 5.12a, 5.12c, 5.13a, and 5.13c respectively.

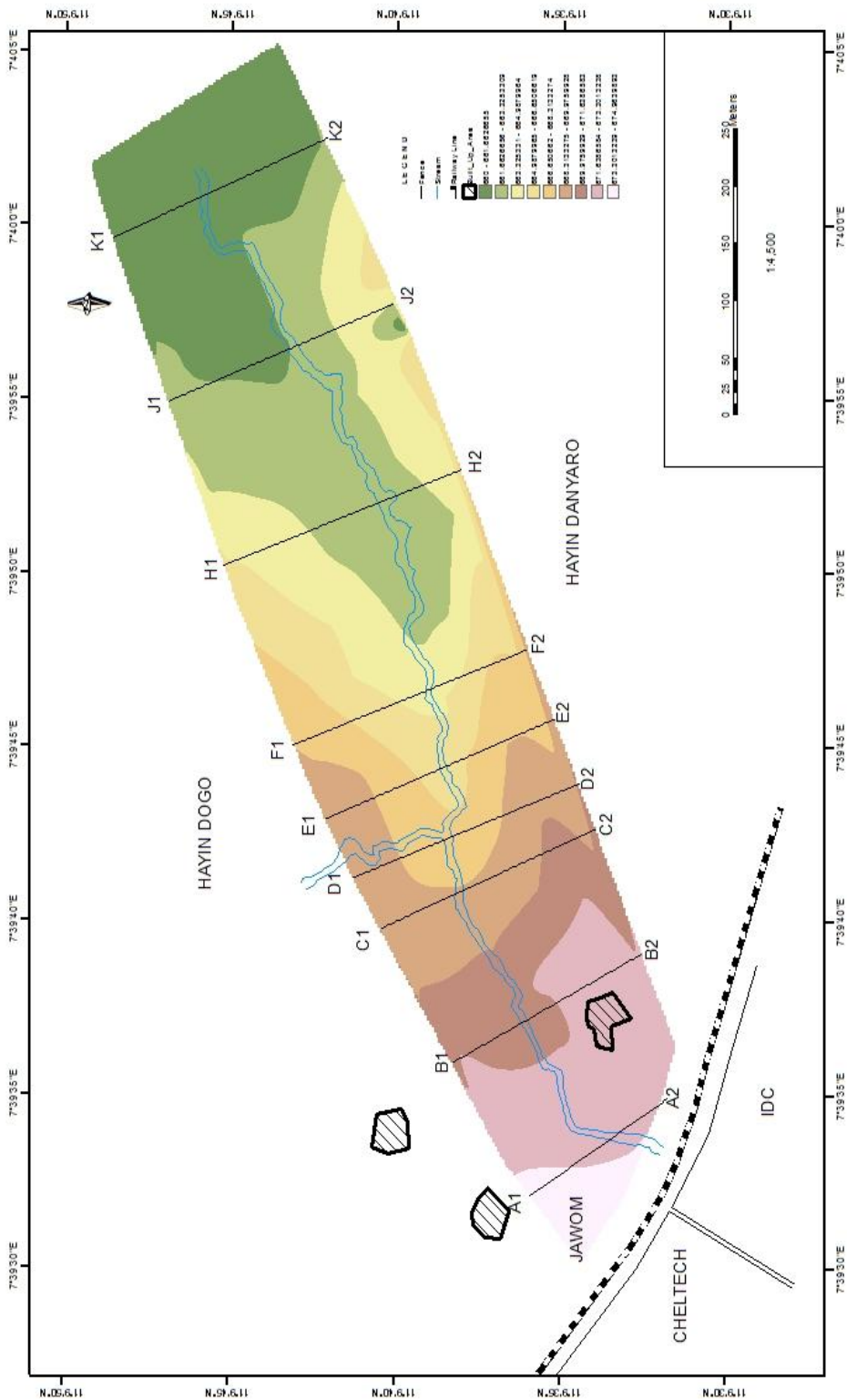


Source: Landsat Imagery, 1980

Figure 5.10 a: Landsat Imagery of Ungwan Danyaro 1980



**FIG.5.10 b POINT OF CROSS SECTION GULLY (EROSION (1980))**



**FIG.5.10 c DIGITAL ELEVATION MODEL (1980)**

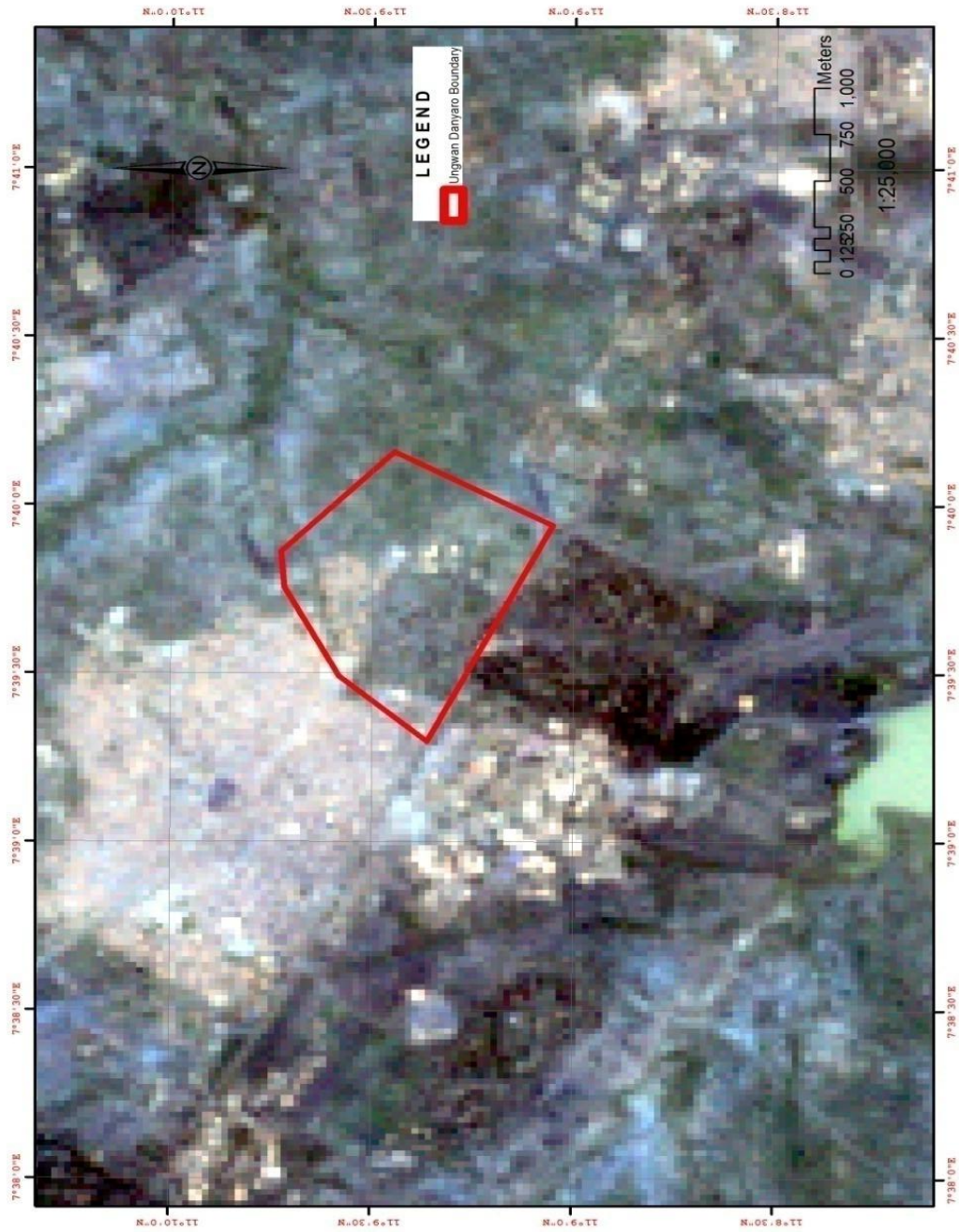
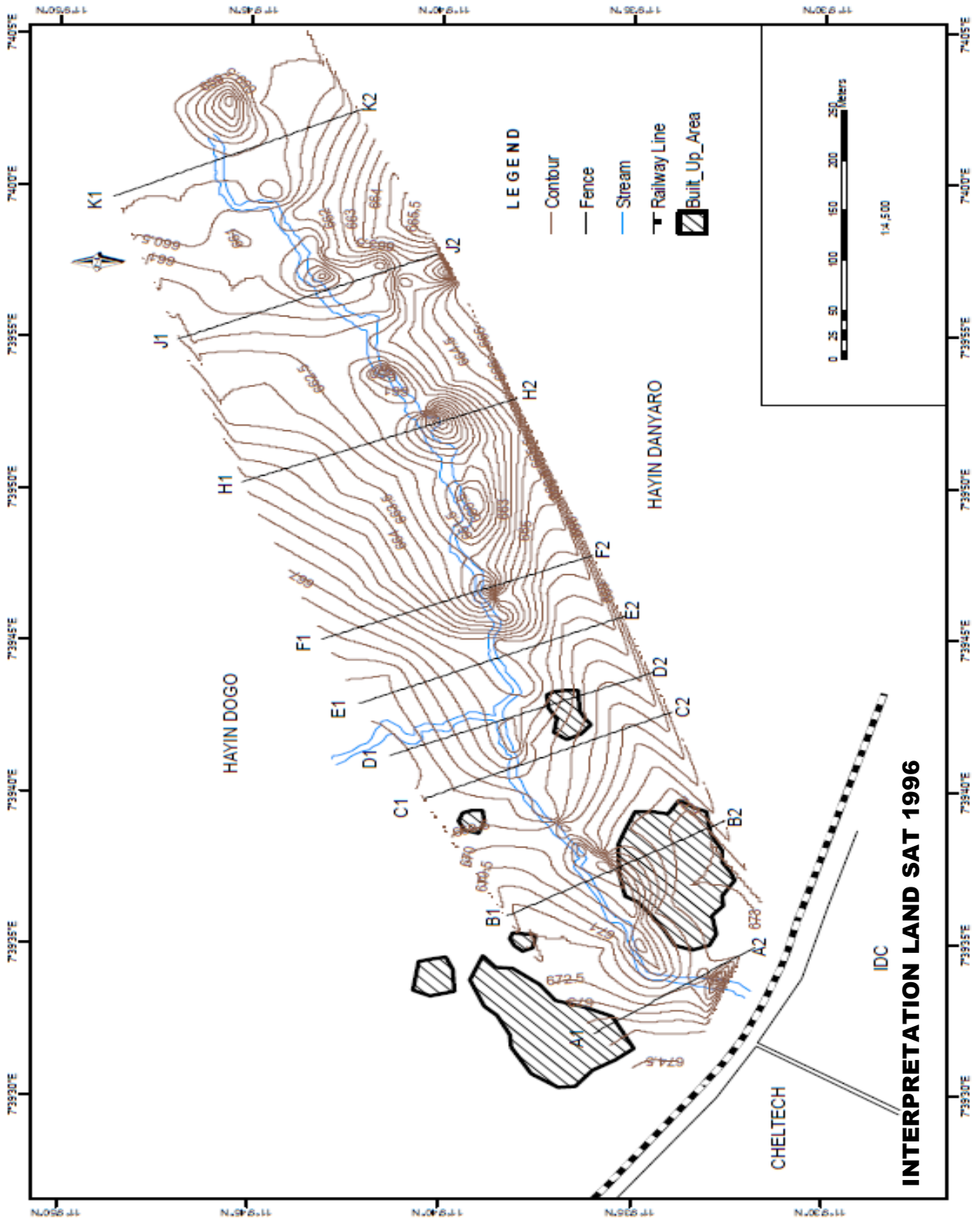
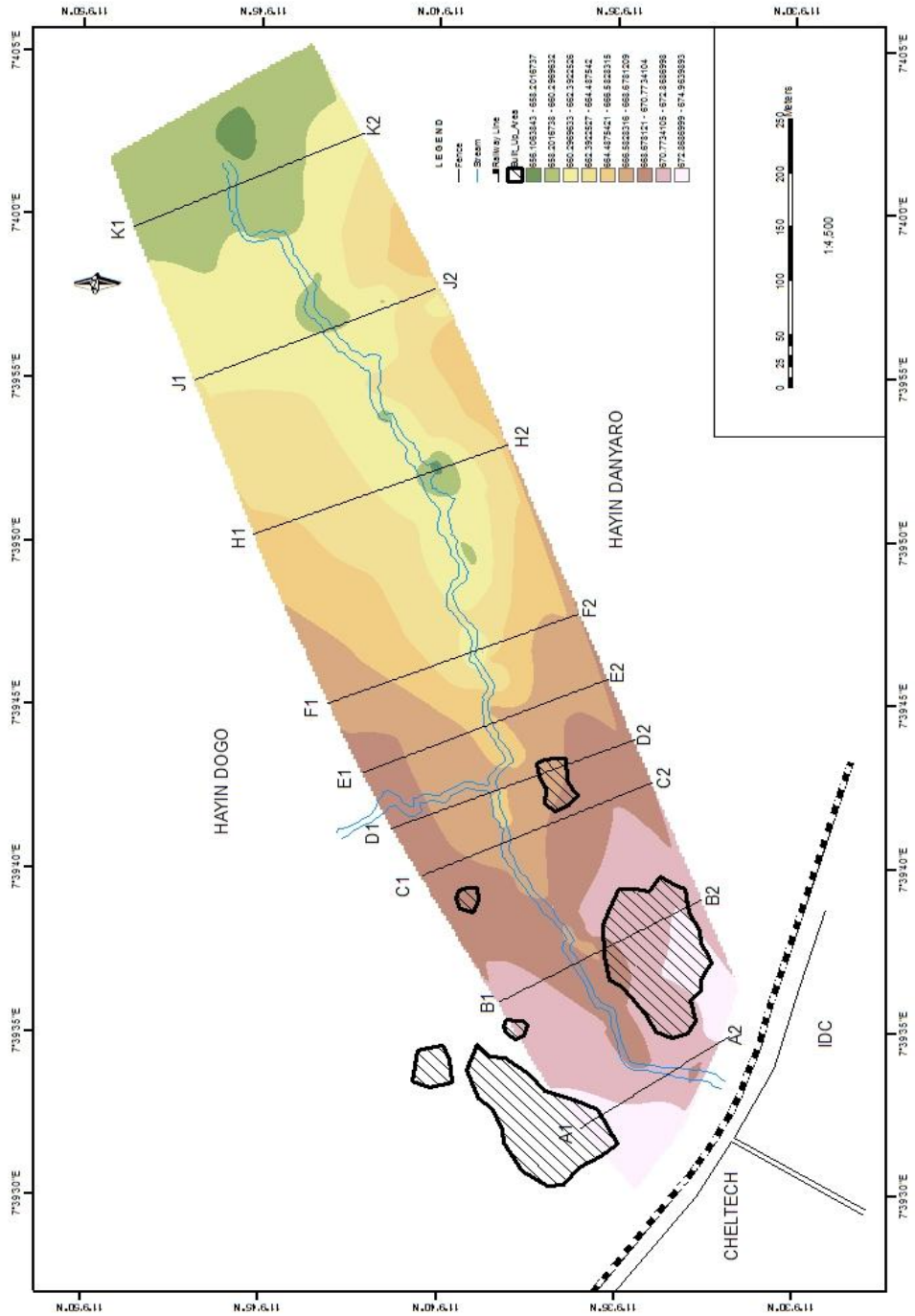
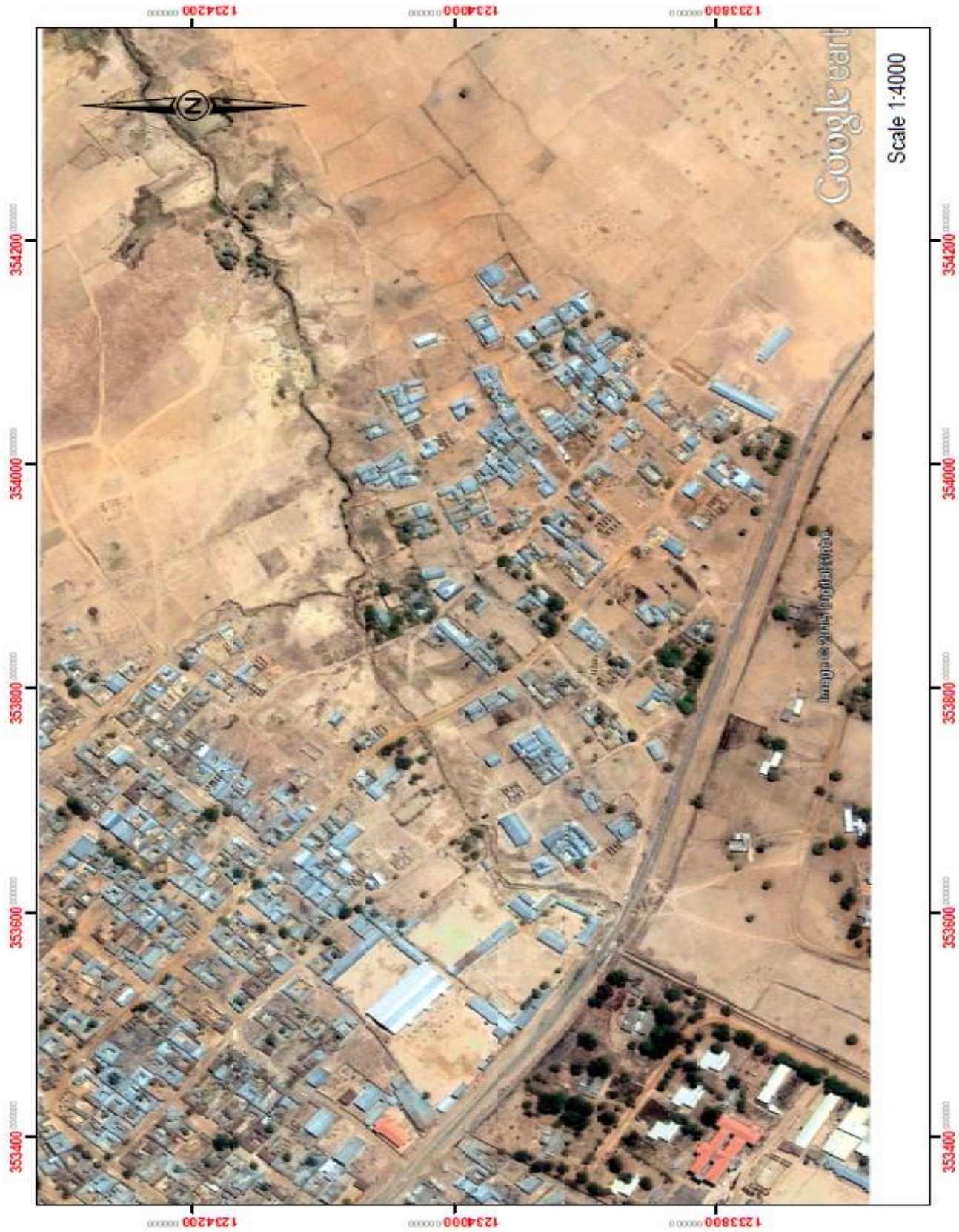


Figure 5.11 a: Landsat Imagery of Ungwan Danyaro 1996

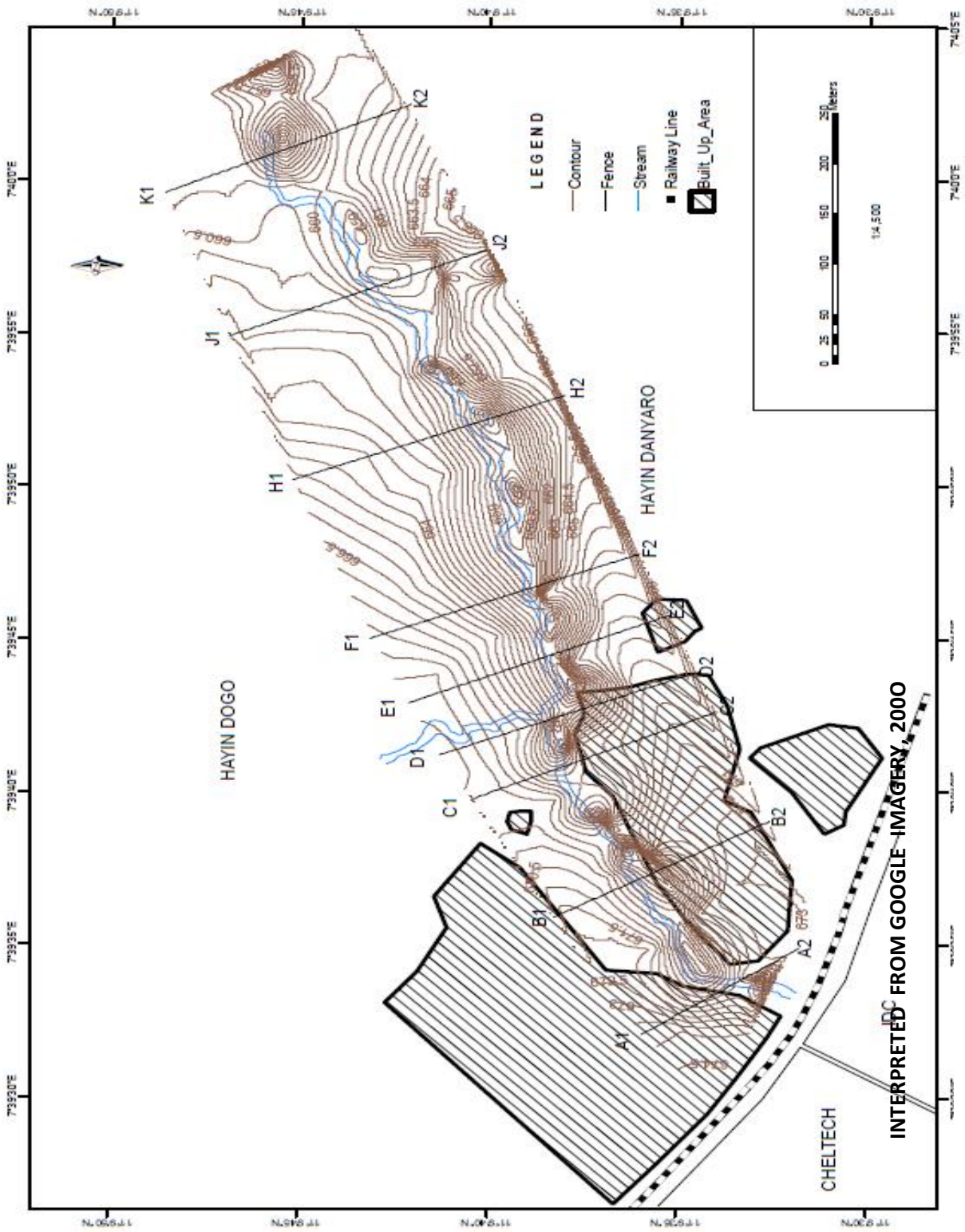




**FIG.5.11c DIGITAL ELEVATION MODEL (1996)**



Source: Google Imagery, 2000 **FIG. 5.12(a):** Satellite Imagery of Hayin Danyaro, 2000



**FIG. 5.12(b) POINT OF CROSS SECTION GULLY EROSION (2000)**

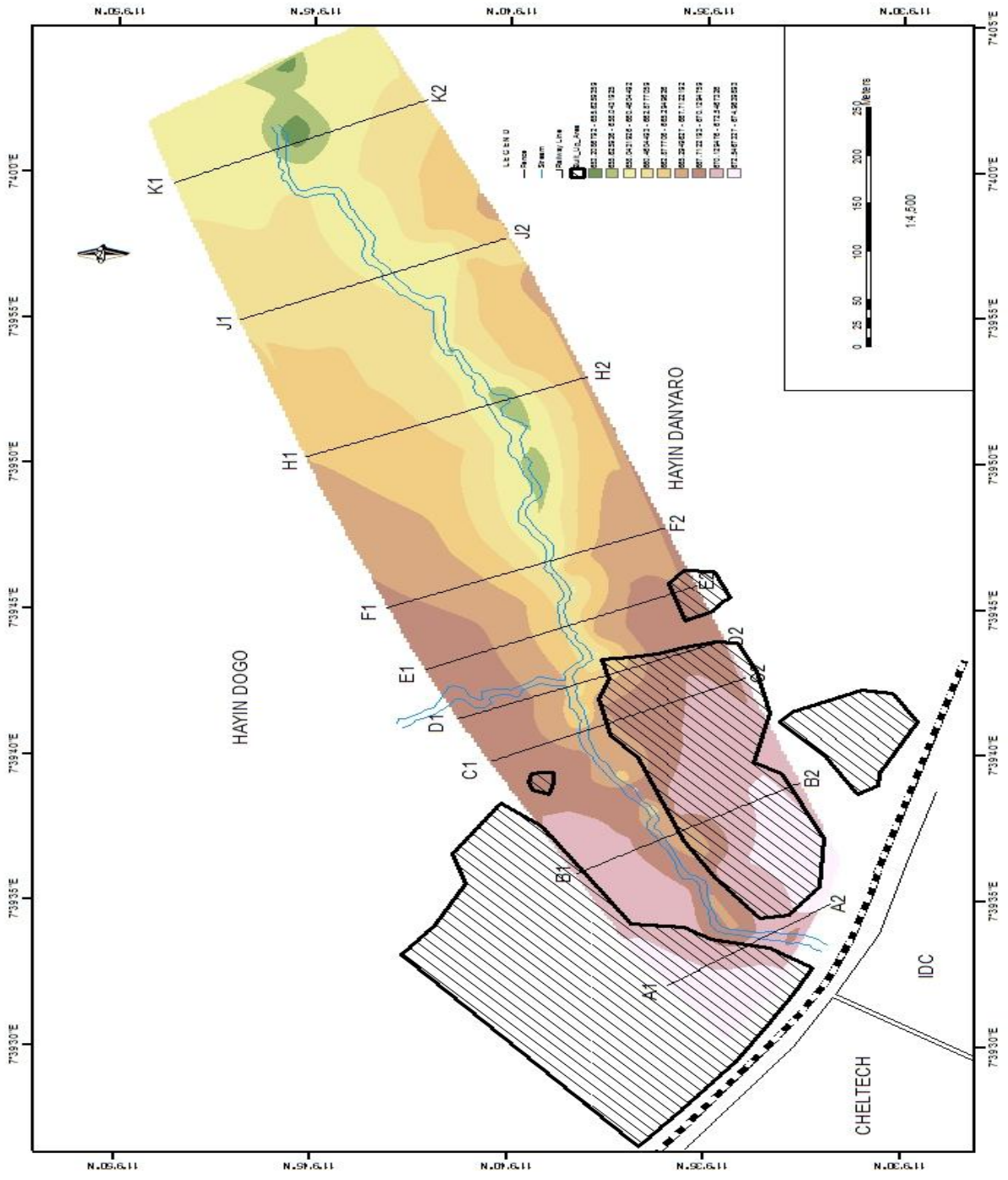
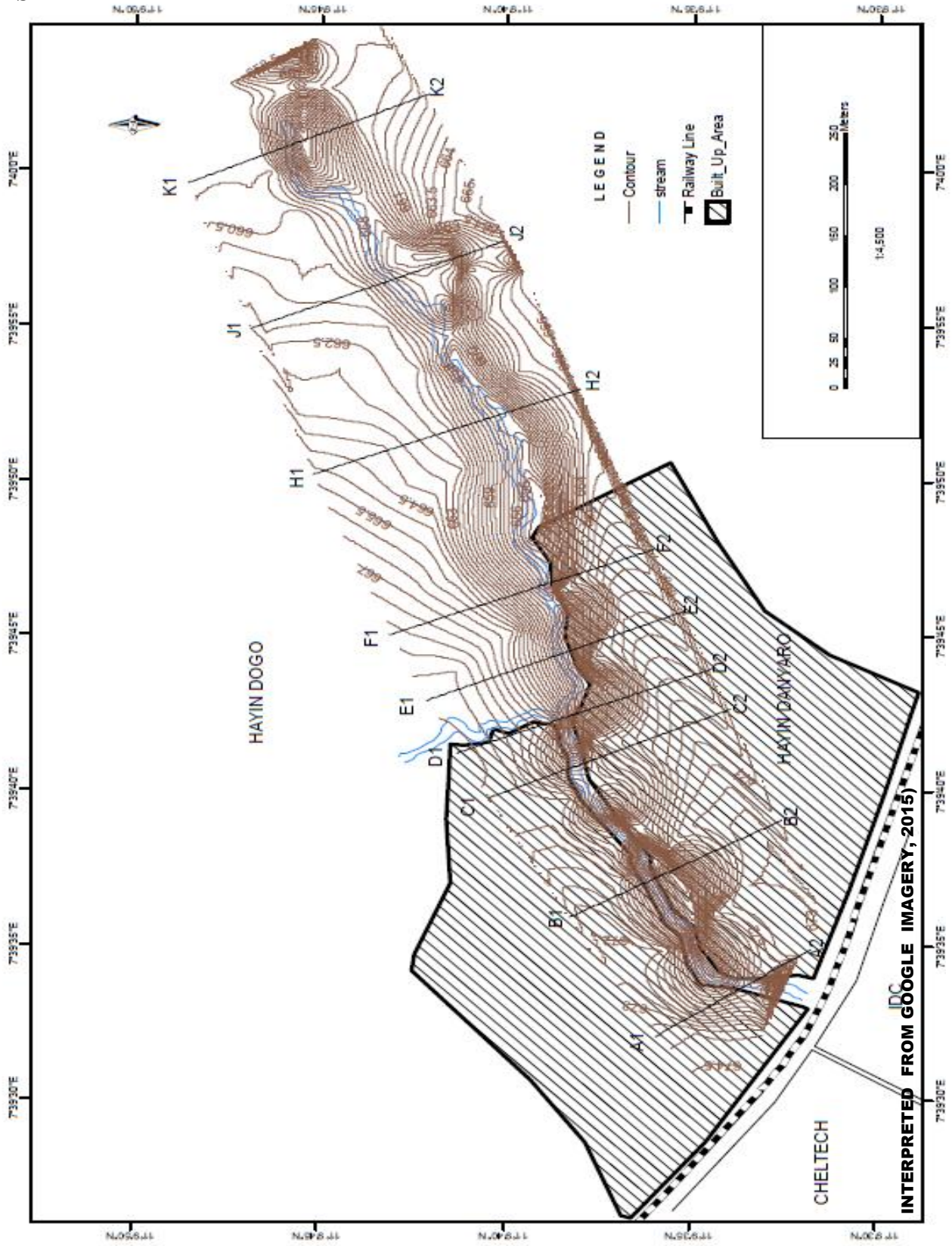


FIG. 5.12 (c) DIGITAL ELEVATION MODEL 2000



Source: Google Imagery, 2015  
**FIG. 5.13(a):** Satellite Imagery of Hayin Danyaro, 2015

S



**FIG. 5.13(b): POINT OF CROSS SECTION GULLY(2015)**



## **5.6. CAUSES AND EFFECTS OF GULLY EROSION IN THE STUDY AREA**

### **5.6.1 Causes of gully erosion**

The occurrence of gully erosion in the study area was both a result of anthropogenic factors and as well as physical factors. The influence of man here was the heavy population pressure on the land, over cultivation, over grazing, sand mining etc. These brought about exposure of soil because the vegetation covering it was removed, thus making the soil susceptible to erosion and consequently resulted in the development of gully. Apart from these reasons construction of rail track and road across the gully head with gutter underneath also contributed to the development of the gully. This was because it increased discharge and turbulence of runoff into the gully.

Physical factors like climate (rainfall), vegetation cover, soil and topography (slope), have worked together simultaneously to activate the process of gully already laid down by man's influence. The topography of land determines velocity at which surface runoff will flow; which in turn, determine erosivity of the runoff. Longer steeper slopes (especially those without adequate vegetative cover) were more susceptible to very high rate of erosion during heavy rains than shorter, less steep slopes. Steeper terrain was also more prone to mud slides, landslides and other forms of gravitational erosion processes (Whisenant, 2008); (Blanco, *et al*, 2010); (Wainwright and Brazier, 2011). The intensity of precipitation (rainfall) contributes to detachment of soil particles of the gully site. The large volume of water resulting from high rainfall intensity brought about the breaking up of soil particles and subsequently enlarged the gully.

Ofomata (1965) critically examined human component in soil erosion. Here he analyzed management as a factor responsible for soil erosion. According to him, if the soil is placed in a

state of disequilibrium, then the soil is susceptible to erosion. The burning of grass and trees combined with grazing of animals were various activities which lead to exposing the soil to accelerated erosion and deterioration depending on the existence other favorable conditions. Agbade and Ajagbe (2004) emphasized that human activities contributed immensely to Nigeria's soil problems. They attributed the causes of soil erosion in Okittunu Sango area of Ibadan city to bad land management and unheeded town planning regulation, which readily explain the construction of building in natural water path, bad environmental sanitation, lack of vegetation cover that could act favorably against wind and water erosion, lack of enlightenment on the part of inhabitant of the areas

### **5.6.2 Effects of Gully Erosion**

While erosion is a natural process, human activities have increased by 10 – 40 times the rate at which erosion is occurring globally. Excessive (or accelerated) erosion causes both “on-site and off-site” problems. On-site impacts include decreased in agricultural productivity and (on natural land scapes) ecological collapse, because of loss of nutrient in upper soil layer. In some cases, it eventually results in desertification. Off-site effects include sedimentation of water ways and eutrophication of water bodies, as well as sediment related damage to roads and house, (Blanco and Lal 2010). It was observed that sparse vegetation cover due to loss of soil nutrient characterizes the gully site (plate V, VII, SIX and XII) lowering water table and cause reduction in available arable lands as badland topography proliferates. The same phenomenon was observed by Ofomata (1965) of the 75,488km<sup>2</sup> eastern Nigeria, area of accelerated erosion cover 15.450km, 750km<sup>2</sup> by incipience gully erosion and 465km<sup>2</sup> by active and advanced gully erosion. In all, area of 16,608km<sup>2</sup> of this part of the country was affected by severe forms of

accelerated erosion and rendered completely useless for arable agriculture. The effect of soil erosion on man's environment cannot be overemphasized. Some of these include sliding, slumping, formation of badland as observed in the study area (plate IX and XII), destruction of communication routes (plate VII and XI), building foundation (Plate II, III, IV, VI and X) and the aesthetic appeal of the landscape. Soil erosion also affect the physical process of infiltration surface runoff and water holding capacity of the soil with pronounced effect on agricultural land and farming process (Faniran and Ojo,1978).

Many researchers have made tremendous contribution to the study of both consequences and assessment of physical damage done by soil erosion. Morgan (1974) stated that effects of soil erosion are felt not only in the area where top soil is removed by water and wind, the top soil and the bedrock exposed and the land entrenched by gullies but also in areas down valley where the ground is covered with sand and silt deposit. This brings about deduced productivity and increased expenditure on fertilizers to maintain cropping and grazing land.

Although, a lot of work has been done on gully erosion, there are few literatures which have attempted to access fully the role of urban growth in the intensification of gully erosion and to examine the interrelationship that exist between them.

The decrease in density of plant covers of this site due to overgrazing and clearing of land for cultivation has consequently exposed the soil to erosion. The inclination of this land equally favored the development of gully coupled with other factors stated above.

## 5.7 URBANIZATION

Samaru area found its origin in 1922 when the Institute of Agricultural Research (IAR) was established and since then the population has been growing continuously. Consequently, the population grew from 576 in 1944 to 20,000 in 1975 and today it is about 124,000.

The continuous growth of Samaru sub settlement (Ungwan Danyaro) can be traced to the establishment of tertiary institutions such as Ahmadu Bello University, Federal Institute of Leather Research (CHELTECH), school of Aviation, Sokoto road, Banks, and a host of others that have stimulated population growth and the construction of houses.

In Ungwan Danyaro, built up includes area of intensive use with much of the land covered by structures i.e. residential, commercial, religious, grave yards, educational (private schools). Results show that the built up land has increased from 2.8km<sup>2</sup> in 1980 to 1656km<sup>2</sup> in 2015. This increase in built up area was attributed to increasing demand of land from growing population.

Urbanization has major effects on erosion processes, first by denuding the land of vegetative cover, altering drainages pattern and compacting the soil during construction and next by covering the land in impermeable layer of asphalt or concrete that increases the amount of surface runoff and increases surface wind speed. Much of the sediment carried in runoff from urban areas (especially roads) is highly contaminated with fuel, oil and other chemicals (Ramdhir, 2007). This increased runoff, in addition to eroding and degrading the land that it flows over, also causes major disruption to surrounding watershed by altering the volume and rate of water that flows through them, and filling them with chemically polluted sedimentation.

The increased flow of water through local water ways also caused a large increase in the rate of bank erosion (James, 1995).



**Plate X:** Dumping of refuse to fill up gully



**Plate XI: Gully erosion threatens the main road at Ungwan Danyaro.**



**Plate XII: Bad land topography proliferation**

## CHAPTER SIX

### SUMMARY, CONCLUSION, RECOMMENDATION AND SUGGEST FOR FUTHER STUDIES

#### 6.1 SUMMARY

This study focused on assessment of the effects of urban growth in the intensification of Ungwan Danyaro gully erosion in Samaru area. In order to map the status of urban growth for the different decades in the study area, topography map of 1973 of scale 1:25,000 and land sat satellite imageries 1980, 1996 and Google imageries of 2000 and 2015 were used. The imageries were digitized using Arc GIS 9.2 software to produce base map for the different decades in order to establish spatial extent of the study area. Digital elevation model (DEM) was created by digitalizing topographic map of the decadian years using Arc GIS 9.2 software. The elevation values and Surfer 9.0 were used to derive cross profile of the selected nine gullies. These were overlaid against each decade in order to establish incremental growth in depth and width of the gully and of the spatial growth of settlement of the study area for the different decades over the period of 40 years. The shallowest gullies were observed in 1980 followed by 1996 while the deepest gullies were observed in 2015 followed 2000. There was accelerated increase in the growth of settlement from 1996 to 2015. The growth rate was 14% in 1996, 40.9% 2000 and 45.1% in 2015. To establish a relationship between urban growth and gully development, statistical techniques of Product Moment Correlation coefficient was calculated. A value of 0.991 indicates that a very strong positive correlation exists between urban growth and Gully growth.

## **6.2 CONCLUSION**

The results obtained in this study so far show that a strong positive relationship exist between Urban growth and Gully development, hence the menace of gully erosion in Ungwan Danyaro has an anthropogenic impacts. Agriculture, deforestation, grazing, sand mining ,construction and urban sprawling (resulting from population increase) were amongst the most significant human activities in regard to their effects on stimulating gully erosion in the area. Field observation and the result of the measurement of gully morphology (i.e. length and width) reported on Ungwan Danyaro indicate an area devastated by severe gully erosion. In order to reduce / minimize the menace of this erosion, urgent remedies are necessary to arrest further loss of arable land, building and other properties, transportation and communication links.

## **6.3 RECOMMENDATIONS**

In the context of the above, the following recommendations are made:

1. Due to the unplanned nature of Samaru, agencies such as development agencies should be established, geographer and urban planners should be involved in the planning of Samaru; most especially, the study area (Ungwan Danyaro).
2. Runoff should be diverted from the gully head, into natural water ways or vegetated water causes or onto rock outcrops and stable areas which are not susceptible to erosion.
3. Gullies should be stabilized by the use of appropriate structural and vegetative measures in head, floor and sides of gullies. Temporary physical structural measures such as woven – wire, brushwood, loose stone and sandbag, gabion and check dams can be used to dissipate the energy of runoff and to stabilize the gully. Check dam should be constructed across

gully bed to stop channel / bed erosion. By reducing the original gradient of gully channel, check dams diminish the velocity of water flow of runoff and the erosive power of runoff.

4. The use of vegetative material in gully control offers an inexpensive and permanent protection. Vegetation will protect the gully floor and banks from scouring. Grasses on the gully floor slows down velocity of runoff and causes deposition of sediment which forms an ideal environment for new vegetative growth. Vegetation can be established in the gully by natural recovery or use of planting material.
5. Fencing the gullied area is highly desirable. Stocks are attracted to the gullied area especially if they include shed trees. These areas are then subject to heavy grazing and compaction.
6. All existing gullies should be reclaimed by lateritic filling. Filling should be attempted after the water flow that caused the gully has been controlled or diverted above the gully head. Otherwise, fill placed in the gully is likely to be undermined and washed away. The common practice of filling gullies with refuse, logs, rock, branches, twigs and other materials does very little to solve the problem. In most cases, it makes the gully worse particularly if the placement and the anchorage of this material are not done properly, therefore people should be encouraged to dump their refuse in the incinerator rather than in the gully.
7. Public enlightenment campaigns to educate the people in the study area on what they should do to control erosion and their action that may lead to development of gully erosion. The people should be educated on the danger of deforestation.

#### **6.4 SUGGESTION FOR FURTHER STUDY**

Research should be carried out on the assessment of changes that takes place within the gully system. Attempt should be made to separate the human induced factors responsible for gully development from climatologically induced change in the study area.

Lastly, imageries of high spatial resolution ( $\leq 1\text{m}$ ) such as quick bird ikonos should be made available for research organization or institution for regular monitoring of environment (rural and urban).

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