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The Effects of Cutting Types and Length on Rooting of *Duranta Repens* in the Nursery

By Okunlola, A. Ibironke
The Federal University of Technology, Akure Ondo State, Nigeria

Abstract - An experiment was conducted at the Horticultural garden of the Federal College of Agriculture Akure Ondo State Nigeria to investigate the effects of the types of stem cuttings and stem cutting lengths on the rooting and growth of *Duranta repens* in the nursery. Stem cuttings of the plant were subjected to different treatments; stem cutting types (softwood, semi hardwood and hardwood) and lengths (10 cm and 20 cm). The experiment was conducted under normal nursery conditions to determine the types of stem cutting and stem cutting lengths best for the rooting of the plant. The experimental design was a 3 x 2 factorial in complete randomized design (CRD) with four replications. The results revealed that the type and stem cutting length had effect on the rooting of *D. repens*. Percentage rooting was higher for hardwood cuttings irrespective of the length of cutting. Hardwood cutting of 20 cm length however, gave the best rooting followed by the semi hardwood of same length. Softwood cutting of length 10 cm and 20 cm gave the poorest result.

Keywords : *cutting length, rooting, nursery, duranta repens, ornamentals.*

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The Effects of Cutting Types and Length on Rooting of *Duranta Repens* in the Nursery

Okunlola, A. Ibironke

Abstract - An experiment was conducted at the Horticultural garden of the Federal College of Agriculture Akure Ondo State Nigeria to investigate the effects of the types of stem cuttings and stem cutting lengths on the rooting and growth of *Duranta repens* in the nursery. Stem cuttings of the plant were subjected to different treatments; stem cutting types (softwood, semi hardwood and hardwood) and lengths (10 cm and 20 cm). The experiment was conducted under normal nursery conditions to determine the types of stem cutting and stem cutting lengths best for the rooting of the plant. The experimental design was a 3 x 2 factorial in complete randomized design (CRD) with four replications. The results revealed that the type and stem cutting length had effect on the rooting of *D. repens*. Percentage rooting was higher for hardwood cuttings irrespective of the length of cutting. Hardwood cutting of 20 cm length however, gave the best rooting followed by the semi hardwood of same length. Softwood cutting of length 10 cm and 20 cm gave the poorest result. It can therefore be deduced from the study that for nursery production of *D. repens* semi hardwood and hardwood of 20 cm will give the best rooting.

Keywords : cutting length, rooting, nursery, duranta repens, ornamentals.

I. Introduction

Ornamental plants are very essential in environmental beautification and management, they make public parks and houses more conducive for relaxation and enjoyment (Day and Loveys, 1998). They are grown for the display of aesthetic features including flowers, leaves, scent and overall foliage texture- fruit, stem and bark. They are a valuable tool for the harmonious and practical resolution of many physical site problems, and they provide durable aesthetic satisfaction (Armstrong, 2000). They offer a variety of noticeable effects: screening, cooling, enhancement of architectural lines, enframement of views, erosion management, sun and wind control, sound deadening, and horticultural focus (Hynes, 2002). It is generally accepted that most of perennial ornamental plants are multiplied and propagated by the use of vegetative propagation; cuttings, layering or grafting (Deng Xiong, 2000). The use of cuttings from stems, leaves, roots or terminal buds are considered the most commonly applied technique due to its practicability and simplicity especially in a developing country like Nigeria.

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Duranta repens (yellow bush) belongs to the family Verbanaceae, it is a spreading, large, fast-growing, multi-stemmed shrub which matures with a height 1 to 3m. The full cluster of fragrant, pale blue flowers followed by bunches of golden- orange berries are often found on the plant simultaneously which makes it very attractive (Rowezak, 2001). It is a popular ornamental used for accent plants and hedges in tropical and subtropical parts of the world because of its profuse display of flowers and fruits (Pipattanawong, 2008).

It is well known that *Duranta repens* can either be propagated through seeds or stem cuttings (Robbins and Evans, 2006). However propagation by stem cuttings is the most popular and extensively used method of vegetative propagation. Stem cuttings are classified based on their maturity as softwood, semi-hardwood and hardwood (Hartmann *et. al*, 2002). These cuttings are important because of the ease by which plants grow from them although, some are more difficult to root than others hence this study was conducted to examine the type and length of stem cuttings that is most suitable for propagating *Duranta repens* in the nursery.

II. Materials and Methods

The experiment was conducted at the Horticultural garden of the Federal College of Agriculture Akure Ondo State Nigeria April-July 2002. The state lies between 4^1 30^0 and 6^1 40^0 east of the Greenwich meridian and latitudes 50^1 45^0 and 8^0 north of the equator. It is located in the rainforest zone with two distinct seasons. The mean annual rainfall and number of rainy days in year 2002 that the study was conducted were 1495.4mm and 110 days respectively. The mean daily maximum and minimum temperatures of the area in the year were 29^0C and 21^0C and the mean monthly maximum and minimum relative humidity were 83% and 65% (the Federal University of Technology Akure Meteorological Station 2002).

The nursery was made of wood stands and covered with bamboos in 10 cm by 10 cm spaces. Top soil from the top 0-15cm depth and sand (plastering grade) were collected from the Horticultural Garden of the College. The top soil and sand were sieved and mixed manually in the ratio 1:1, the container (polythene bags of size 20 cm by 12 cm) were filled with the rooting media and lightly firmed down so that the surface is just

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one inch below the container's top edge. The physical and chemical analyses of the soil and sand were determined following routine procedure described by the Department of Crop, Soil and pest management, the Federal University of Technology Akure (Laboratory Manual, 1998) and the result presented in table 1.

Stem cuttings 10 and 20cm length each from the softwood (obtained from soft, succulent new growth of the plant that has some flexibility but does not break when bent sharply with a gradation of leaf size oldest leaves are mature while newest leaves are still small), semi-hard (taken from partially mature wood, the wood is reasonably firm and the leaves of mature size) and hardwood cuttings (taken from dormant mature stems, the wood is firm and does not bend easily) were obtained from healthy, normal stem tip growth; very early in the morning when the plant is fully turgid with a sharp thin-bladed pocket knife (the cutting tool was dipped in a mixture of one part bleach and nine part water to prevent transmitting diseases from infected plant parts to healthy ones) making the cut just below a leaf. The hardwood cuttings of same lengths 10 cm and 20 cm were taken farther back on the stems (all the cuttings had equal number of nodes). The top of each cutting were cut just above a leaf bud and the bottom cut just below another one with the top cut slanted and the bottom cut square. All the leaves on the lower half of the cuttings were removed to reduce transpiration; the cuttings were then inserted to about half its length in the rooting media maintaining the vertical orientation of the stem (ensuring that the cuttings are not upside down). The cuttings were spaced adequately to allow all the leaves receive sunlight and then watered daily after planting, except when it rained and kept free of emerging opportunistic weed seedlings by regular handpicking throughout the duration of the experiment.

The experiment was laid out in a complete randomized design (CRD) with four replications, the treatments were; cutting types (softwood, semihardwood and hardwood) and cutting length (10 cm and 20 cm).

Data collection started at three week after planting (WAP) and continued till 12 WAP when the experiment was terminated, the following parameters were measured: number of leaves, roots and sprouts (branches) were obtained by counting, length of sprouts were measured using meter rule. To measure the root length, the cuttings were uprooted by gentle digging and washed after taking the readings the cuttings were replanted in the container. The leaf area were measured using an automatic leaf area meter (Delta-T WinDIAS 3 Version 3.1v 2009 Delta-T Devices Ltd).

The data collected were subjected to analysis of variance (ANOVA).

III. Results and Discussion

Table 1 : Chemical properties of the growth media

Media type	P_H in H_2O 1:2	O/C (%)	O/M (%)	N (%)	P (mg/kg)	K^+	Na^+	Ca^{2+}	Mg^+
							(CMol/Kg)		
Sand	4.09	0.42	0.72	0.06	6.98	0.07	0.05	0.80	0.50
Topsoil	6.75	4.38	7.57	0.57	26.14	0.58	0.44	3.90	2.60
Sand +Topsoil	5.42	2.94	5.01	0.37	13.07	0.29	0.24	2.38	1.57

Table 2 : physical properties of sand and soil

Particle size %	Soil	Sand
Sand	78.0	93.0
Silt	12.0	6.0
Clay	10	1.0
Textural class	Sandy loam	Sand

Table 3 : Water capacity (%) and Percent air-porosity of the different media

Media type	Water holding capacity (%)	Percent air-porosity (%)
Sand	37.24	63.07
Topsoil	106.80	44.00
Sand+ Topsoil	147.06	45.04

Table 4 : Mean Percentage sprouting at 3 WAP

Type of cutting	Length	
	10cm	20cm
Softwood	16.7	29.2
Semi hardwood	16.7	33.3
Hardwood	33.3	33.3
Total	56.7	95.8

Table 5 : Mean number of leaves

Type of cutting	Length	
	10 cm	20 cm
S oftwood	9.5	13.0
Semi hardwood	12.8	19.7
Hardwood	13.3	25.8
Total	35.6	58.5

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Figure 1 : Mean number of sprouts due to cutting types and lengths of the woods

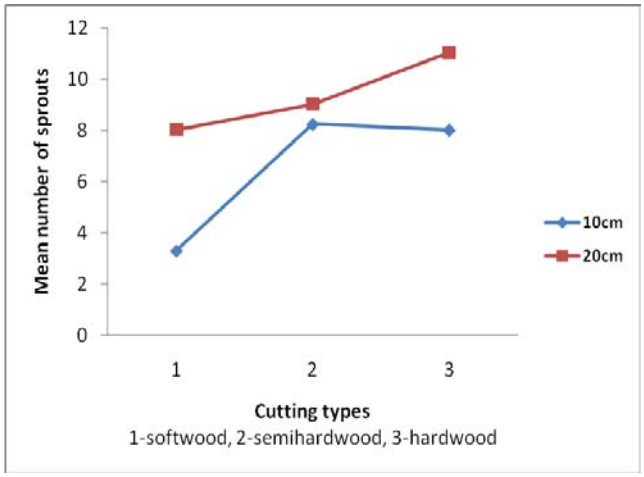
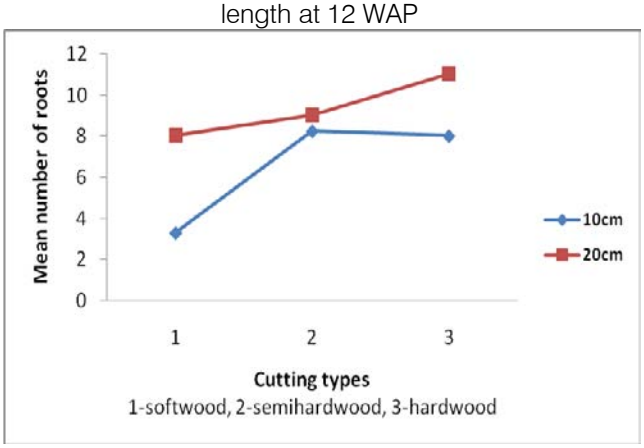


Figure 2 : Mean number of roots due to cutting type and length at 12 WAP



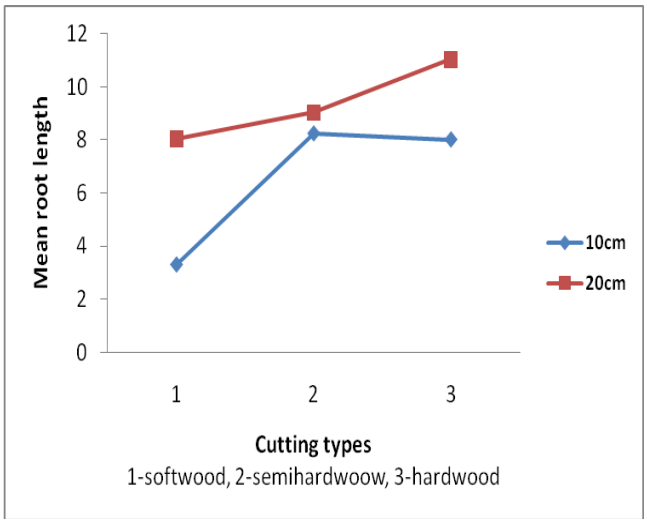


Figure 3 : Mean root length due to cutting type and length

Table 6 : Mean sprout length and leaf area due to cutting type and length of the wood

Type of cuttings	Sprout Length		Leaf Area (cm^2)	
	10cm	20cm	10cm	20cm
Softwood	6.3	12.5	4.7	5.6
Semi	5.8	13.5	3.4	8.8
Hardwood	4.8	13.0	6.6	10.6

The result from the study indicated that there were increases in the mean percent sprouting for all the cutting types (softwood, semi hard and hardwood cuttings at 20cm length) though the highest mean percentage sprouting was recorded in the semi hardwood and hardwood cuttings at 20 cm length. This support the findings of Khan et al. 2006 that the less mature a plant, generally the easier it is to root a cutting from it, also the less mature the growth stage of a plant for example the softwood the more easily it can lose water, dry out and die. In addition, Day and Loveys, 1998; Dole and Wilkins, 1999 also stated that the success of rooting of woody stem cuttings in the majority of ornamental plants depends on the physiological stage of the mother plant. Also rooting varies with the type of cutting, the species rooted and the environmental conditions.

The semi hard and hardwood cuttings of 10 cm and 20 cm length had higher number of leaves however, at 20 cm; the highest number of leaves was recorded for the hardwood cutting. The same trends was observed for the average sprout length at 12WAP the average sprout length at 20 cm were highest for all the stem cutting lengths.

The experiment was conducted during the rainy season which supports high humidity thereby reducing the heat load on the cuttings hence permitting the utilization of high light conditions to increase photosynthesis (Hartmann *et. al*, 1990; Acquaah, 2005). Leaves are the primary photosynthetic organ which captures sunlight for the process of photosynthesis towards the growth and subsequent development of the plant (Stancato et al. 2003). It is important to maintain high humidity levels while rooting vegetative stem cuttings in order to reduce water loss due to transpiration (Scianna, 2004). For average leaf area semi hardwood and hardwood cuttings at 20 cm performed better result from the study conducted by Singh, 1980 revealed that leaf area was found to be directly related to rooting.

The average numbers of roots were higher in the 20 cm length for all the stem cutting types. Result for the average root length showed that hardwood cuttings at 20 cm stem cutting length performed better than the softwood and semi hardwood however at 10cm the root length of the semi hardwood and hardwood cuttings were comparable. Root lengths for the 10 cm softwood cuttings were poor. Janick, 1986 reported that an

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important component of the capacity for a stem to root is the nutritional status of the plant. The vigorous rooting of the hardwood enabled the cuttings to absorb more nutrients and produce more leaves, Reuveni and Raviv, 1981; Karaguzel, 1997 also, the presence of leaves on cuttings exerts a strong stimulating influence on root initiation, leaves and buds are also known to be powerful auxin sources (Edmond et al, 1994).

IV. Conclusion

The result obtained from the study revealed that *D. repens* will not root easily when propagated with softwood cuttings. The semi hard and hardwood cuttings however showed good response at 20 cm length. It is therefore recommended that *D. repens* can be propagated using semi hard and hardwood cuttings of 20 cm stem cutting length.

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Traditional Knowledge and Environmental Conservation among Indigenous People in Ranau, Sabah

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Abstract - Traditional knowledge is a form of continuation of the inherited knowledge of a race from its forefathers. This traditional knowledge represents a holistic understanding of an indigenous society towards its day-to-day practices and environment, based on their life experiences, interacting with nature over a span of countless centuries. The bulk of this traditional knowle-dge has been adapted by means of traditional songs, stories, legends, dreams, and also other methods and living practices of the indigenous societies. At times, it is translated in the form of customs that are inherited from father to son or from mother to daughter. This knowl-edge is disseminated first-hand from one individual to another. Indigenous societies are citizens in free countries who are considered as natives, who have their ancestry from inhabitants who had been residing in a certain country or geographical region of an indepen-dent country, at the time of colonial conquest.

Keywords : *traditional knowledge, environment, conser-vation, indigenous, sabah.*

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Traditional Knowledge and Environmental Conservation among Indigenous People in Ranau, Sabah

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I. Introduction

Traditional knowledge is a form of continuation of the inherited knowledge of a race from its forefathers. This traditional knowledge represents a holistic understanding of an indigenous society towards its day-to-day practices and environment, based on their life experiences, interacting with nature over a span of countless centuries. The bulk of this traditional knowledge has been adapted by means of traditional songs, stories, legends, dreams, and also other methods and living practices of the indigenous societies. At times, it is translated in the form of customs that are inherited from father to son or from mother to daughter. This knowledge is disseminated first-hand from one individual to another. Indigenous societies are citizens in free countries who are considered as natives, who have their ancestry from inhabitants who had been residing in a certain country or geographical region of an independent country, at the time of colonial conquest [1]. Thus it Would be more accurate to say that indigenous communities are groups that have lived and settled in a certain area to the extent that they have forged their own racial identity, have rights (customary lands) in a certain area and possess a high level of traditional knowledge.

Indigenous people make up the largest population group in Sabah. However, when studying the Sabah population survey from the year 1891, it is shown that there is difficulty in ascertaining the races who are the permanent residents of Sabah. Even though this is the case, the term 'indigenous' has been defined with reference to the term 'native' or 'anak negeri'as found in Ordinance No. 12 1952-Interpretation (Definition of Native) which clarifies the meaning of the term 'native'. Based on this ordinance, indigenous people are grouped into three main groups; non-Muslim natives, natives who have embraced Islam from the first group and thirdly natives who are already Muslims [2]. The indigenous society in Sabah cannot be separated from the natural environment as far as their daily lives are concerned. This environmental factor has influenced many aspects that helped to form their traditional knowledge. For instance, indigenous people are often seen as interacting with environmental factors in evolving a certain form of traditional knowledge in farming. Agricultural activities carried out in hilly areas, as in the planting of hill padi for example, are designed to help safeguard the ecosystem of the agricultural land from pollution and erosion. To preserve the species of trees and reduce the incidence of soil erosion, indigenous farmers avoid cutting down trees in hilly areas. They also practise mixed farming through a system of crop rotation that enhances the fertility of the soil besides increasing their income [3]. In this regard, the traditional knowledge of the indigenous community, especially in farming and medicine, represents a form of knowledge that has been inherited from generation to generation by the indigenous society. It is hoped that an in-depth research into this aspect of traditional knowledge serves as a contribution to society at large, especially Malaysians. Therefore this paper will analyze the traditional knowledge aspect of the indigenous community in Sabah in two main areas, namely agriculture and medicine. This working paper is divided into six sections: introduction, literature review, research methodology, findings, suggestions and finally, conclusion.

II. Literature Review

The indigenous community in Sabah has for centuries developed a unique system encompassing social, economic, political, spiritual, and customs aspects among their community. This system has been safeguarded by the indigenous people to create peace, a stable way of life and also to preserve resources and their environment [4]. In Sabah, most of this traditional knowledge has been forgotten and lost because of inadequate understanding of its importance in conserving the environment and preserving the biodiversity of the local community. Regarding to Tuaran customs, agricultural customs hold an important place, and are included in the collection of laws relating to the customs of the Dusun tribe in Tuaran. These agricultural customs include land lease, wages, trespassing and

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livestock [5]. The flora and fauna in Sabah are obvious assets for the state. Although the number of species of wild plants in Sabah has not conclusively been determined, it is roughly estimated that there are more than 10,000 plant species in Sabah [6]. The terrain, soil, climate and variegated plant form have contributed to produce various agro-ecosystems for the indigenous people who are mostly farmers practicing traditional farming methods [7].

The bulk of the indigenous community are located in hinterland areas, due to the characteristics of the land, as they rely on the diversity of the flora from the jungle for food, medicine, oil, building materials and other daily needs. As for the indigenous people who live along the coastline and river mouths, the majority of them are fishermen and their income is derived from harvesting crops, jungle produce and by selling their catch of fish at the markets [8]. The Kadazandusun tribes mainly live in rural areas and involve themselves in farming especially padi cultivation, whereas those who live in the highlands mostly plant hill padi, sweet potato, maize, water melon, cucumber and tobacco for personal consumption. During the 19th Century in Penungah, the men would forage for jungle produce that was to be bartered for padi or sold to traders who conducted business at Sungai Penungah. In hilly places such as at the Crocker Range, Kudat and Bengkok, and at the valley areas such as at Sungai Sugut, Labuk, Kinabatangan and Segama, most of the inhabitants practised shifting agriculture and subsistence agriculture for their daily needs. Meanwhile, in the west coast of Sabah, in the interiors of Keningau, Tambunan, and Ranau, this tribe carried out farming and reared cattle, chicken and ducks [9].

Traditionally the Kadazandusun have dwelt at the fertile coastal plains along the west coast of Sabah (from Kudat in the north until the border of Sarawak in southern Sabah). The early settlements of Chinese migrants from China brought the Kadazandusun into contact with farming techniques such as the metal plough. The Kadazandusun are also well-known for their craftsmanship using natural materials such as cane, bamboo and wood to produce daily needed goods and also farming and hunting equipment. The men-folk are also skilled in building houses and this traditional knowledge has been handed down throughout the generations [10]. It can be seen through the customs of the Kadazandusun in the district of Putatan that farming was indeed important in their community. There are two parts that are found in the 'Dusun Customs' related to agriculture, namely 'Dusun Custom regarding Crops' and "Dusun Custom regarding rules of Farming'. Besides that, there are other sections that speak of 'Dusun Custom regarding Animals' [11]. The Dusun groups in Tuaran district are frontier farmers who are non-migratory [12]. The Dusun in Tuaran possess valuable padi-growing lands and own a large number of buffaloes and cattle. Compared to the other groups, the Dusun Lotud in Tuaran district are rich and prosperous. This is because they have large tracts of padi land. This proves that the Kadazandusun people are an indigenous society with extensive knowledge in the care of the environment in the hinterlands of Sabah. Furthermore, Kadazandusun is the largest indigenous ethnic community in the state and they are also known as Dusun tribes and live in separate areas and use different dialects but there is no communication problem among them, so the cultural traits that they share are based on a common inherited tradition [14].

The Dusun community has common social system denominators, such as oral history, social structure, heritage, belief system, farming, cultural materials, religion and practice of customs [15]. Prior to this, the Dusun community has generally been categorized as a closed society due to geographical factors. The Dusun community's regions, such as at Ranau, Kota Belud, Tambunan and Keningau are situated at remote areas that have a mountainous terrain and make it difficult to access by roads, let alone, bringing about other forms of development in those areas. For example, Kampung Himbaan Ranau was only connected by road in 1970 and electrical supply was available only in September 1991 [16]. This situation points towards a form of obstacle and dividing gap to the influence of external systems, or generally put, to the influences of globalization. Indeed national development has only been minimally enjoyed by the Dusun community. Seen from another angle, the divisive factor has caused traditional knowledge of the Dusun community at Ranau to be still maintained and practised due to the low incidence of external, disruptive factors that affect their traditional practices. As such, the Dusun have an exceptionally high level of knowledge with regards to traditional knowledge due to their interaction with the natural environment and the varied biodiversity around them for such a very long time.

The Kadazandusun community's traditional knowledge can be broken up into a few aspects such as agricultural and medicinal aspects. With regards to agriculture, some of the aspects are choosing of the farmland and observing the physical geographical features, among others, before developing a new farmland. For the Kadazandusun, Murut and Rungus in Sabah, there are taboos and certain rituals during the choosing and clearing of jungle, besides certain observances of the environment before opening up a certain piece of farmland. Their approach involves looking for certain signs that surround the area, such as birds, insects, animals, rocks, plants and also water elements. The signs that are taken into account include barking sounds made by a bird called 'lokiu kopio toki' or the detecting of certain animals such as foxes, bats, deer, mice, or reptiles such as iguana, snakes, and centipede, all of which indicate that the particular plot of

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land is not suitable for farming [17]. These signs are indicative of the presence of predators and prey and it will be highly risky and detrimental to the farmers if they were to open up that land for cultivation. Physical geographical signs too can be determining factors for suitability with regards to opening up of a certain piece of land [18]. For example, if there are large rocks and trees or presence of reddish-coloured water, then that area is not suitable for agriculture. Dreams are also a main determining factor. For instance, if there were to be a bad dream before the opening up of a certain piece of land, then they would have to move on to look for another farming area. Kadazandusun farmers will stop farming work for the day if their machetes (parang) were to break or be damaged suddenly or unexpectedly.

The indigenous community not only preserve their environmental system but they also benefit from the resources found in it by means of their traditional knowledge, especially for medicinal purposes. Because of the safeguarding of the ecosystem, the indigenous community has obtained benefits by means of the use of various plants, animal products and minerals that have served as medicine to them for thousands of years. Today, the contribution from this medicinal practice and knowledge is of great potential towards modern medicine as more than 40% of general pharmaceutical drugs are in fact derived, directly or indirectly, from plant and animal extracts. These include many life-saving drugs such as reserpine, atropine, quabin, vinblastine, vincristine and taxol [19]. According to World Health Organization (WHO) estimates, about 80% of citizens in developing countries rely on traditional medicine for healthcare and a large portion of this involves using plant extracts. In most places in Borneo, plant extracts continue to be used in its raw form to treat ailments, for example dissolved Atropabeladonna is used as antispasmodic, the root Rauvolfiaserpentina is used for high blood pressure and the extracts of somniferum tranquiliser and Papaver are used as pain killers [20].

Besides that, indigenous traditional knowledge, especially that of the Kadazandusun, has been responsible for the discovery of many jungle plant species that have great value medicinally. A total of 50 plant species that are commonly used by the Kadazandusun living around the Crocker Range have been identified and recorded as being extremely valuable. In scientific terms, some of the plants that are commonly used are Blumeabalsamifera for fever, Cassiaalata for skin diseases, Centella asiatica for abdominal pain, Tabacum Nicotiana as insect-repellant, Psidiumguajava for diarrhea, Phyllanthusniruri for malaria, Tinosporacrispa for high blood pressure and many more [21]. The Kadazandusun have in fact developed their own traditionnal medicine system which they obtained from nature and have categorized them before using them. For example, rusap tribau is used for non-critical illnesses and is normally prepared for colds, cough, diarrhea, minor wounds and skin diseases, while rusap taralom is a prescription that is made from more complex substances and used for life-threatening diseases including prolonged illnesses that cannot be diagnosed by even the village medicine man [22].

III. Research Methodology

This study made use of the qualitative approach as its method of research. In-depth interview sessions and participative observations were carried out in selected areas. Six respondents and two villages in Ranau district were chosen. Sampling method, namely purposive sampling, was conducted whereby respondents' criteria and location were determined to fulfil research objectives. Each village was represented by three respondents. The respondents consisted of the village headman and two villagers who were well-versed in traditional knowledge of the indigenous community in Ranau district. The two villages involved were situated in remote parts of the district and its residents were Kadazandusun natives.

The selected research area of Ranau is a hilly region. Among its features are the Crocker Range and Pinousuk Peak in the northern part, Ranau Valley in the east with the Trus Madi range and Labuk highlands in the south. The main waterway here is the Liwagu River. Briefly stated, Ranau district is an undulating area, made up of valley plains, sloping terrain and mountains in most areas. Having wet and cool climate facilitates agricultural activities in Ranau. Next, in terms of ethnicity, almost the whole of Ranau is populated and dominated by the Dusun community. About 350,000, or one third of its population, consists of the Dusun, who mostly live in Keningau and Ranau and have formed a dynamic culture in Sabah [23]. Two villages were selected as research areas, namely the villages of Bayag and Tiang Lama. These locations were selected as research locations based on a number of factors such as being located in the interior, being Kadazandusun settlements and due to traditional practices still being practised by the people here.

Bayag is a village located in the centre of Ranau district and is among one of the settlements situated in the interior part of this district. With an area of about 120 acres, the estimated population of Bayag village is about 102 residents with the majority being Dusun and of Christian faith. The chief occupation of villagers here is that of being farmers. The journey to Bayag takes approximately two hours by motor vehicle from Ranau town. Tiang Lama Village, meanwhile, is located in the southern Ranau district and is close to the border with Tambunan district. With an approximate area of 100 acres, the villagers in Tiang Lama are estimated to be 150 in number with the majority being Dusun Christians. Their principal occupations are also farming. The trip to

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Tiang Lama village takes about two and a half hours from Ranau town. As in Bayag village, the terrain in Tiang Lama Village is hilly and its forest area borders the Trus Madi gazetted forest reserve land, which occupies an area of approximately 10,000 hectares. A portion of the villagers here have migrated and opened up new villages in Ranau town due to the need for greater convenience and transport difficulties, especially due to the lack of a secondary school in Tiang Lama Village. Even so, the other portion of villagers still live and practise a traditional way of life at Tiang Lama village.

IV. Findings and Discussions

Throughout the duration of this study, there were several types of traditional knowledge that had been identified especially knowledge of agricultural products and medicine that fulfilled the requirement of this research literature. Based on initial findings, the major economic activity of indigenous settlers here was farming. However it was more of subsistence farming and not commercially orientated. Occasionally, the people here would take certain types of agricultural produce to Ranau town where these produce would be sent to tamu (market) and sold at low prices. The tamu at Ranau town normally is on Wednesdays and Saturdays. The villagers also carry out fishing in rivers, hunting and foraging for jungle produce.

V. Traditional Knowledge in Agriculture

There exist various forms of traditional practices that can be seen in this district. The traditional practices in farming that are still found include hill padi planting, growing fruits, Kasou (tapioca) and vegetables and all these crops make up the traditional food of the community in this village. Besides that the indigenous society also practises shifting cultivation for hill rice in order to maintain the fertility of the soil and this avoids having to depend on fertilizers. As the padi is normally planted on hill slopes, they plant other plants as cover crops such as kasou (sweet potato) and legumes. There are also certain prohibitions while carrying out farming such as observing dreams before the opening up of farmland and listening for omens from certain bird species before and while working on the farmland. The signs and messages in dreams are used to determine the suitability of a certain piece of land for cultivation. If there is a good dream the day before the farmland is about to be opened up, then this denotes that that place will be fertile and good for farming. Conversely, if there is a bad dream, then they would need to find an alternative site as it is believed that the place is not suited for cultivation. However, this belief is being increasingly forgotten and not being practised due to the factors of change in religious belief and also because of the fact that individuals who know about this phenomenon are becoming scarcer.

In order to focus this research for greater clarity, the researcher was more interested in exploring agricultural traditional knowledge that centred oncharacteristics of plants and their potentials. There are several types of indigenous agricultural products that have the potential to be developed commercially such as red rice, pangi fruit, and kederei. Red rice is well-known among all indigenous people in Sabah. The way it is prepared among the Dusun community is quite unique. Once cooked, it is wrapped using leaves of forest trees that give aroma to the rice. In addition, the water extracted from rice has medicinal values and it is extremely efficacious for women who have just given birth. Besides that, it also has other health uses such as to increase blood content in the body. The medicinal value of these leaves has been verified by local medical practitioners.

"*Pangi*" is used in the preservation process of fish and raw meat to make them last longer. It is unlike common salt. Pangi can only be used to preserve fish and raw meat and cannot be eaten when it is raw because its contents are poisonous. Pangi is small in size like that of a rubber seed. It can be processed and packaged for commercial purposes. Based on its application for the preservation of raw meat, further studies using modern technology can be carried out to assess the extent to which the use of Pangi can contribute to a form of new discovery in modern preservation methods. The potential of Pangi usage, if it can possibly be developed, can be tapped for commercial purposes for locally produced products. "Kederei" is leaf used as a substitute for betel leaves. However, kederei is only used as supplementary food to strengthen teeth. With further scientific studies, kederei has the potential to be a research sample because according to the observation of researchers, kederei is usually eaten by the elderly, and it has been found that their health was not affected by eating it, but to the contrary, they did not have any chronic diseases such as cancer. The people here consume kederei which is found in abundance in the nearby forests. They also sell kederei at the local market. Besides these three traditional products, the people here still possess many other traditional products which hold much potential.

VI. Traditional Knowledge in Medicine

The Dusun society also still practices traditional medicine such as the use of wonod or sukut liquid to treat several minor ailments. Wonod is a liquid found in several types of plants such as bamboo and vines found in the forest. The use of wonod as traditional medicine is very popular amongst the Kadazandusun tribes. It has been practically used through various means and taboos according to the experience of

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generations of ancestors. The method of taking this liquid also has some very unique ways and taboos. Wonod can only be taken at dawn before the sun rises. The extraction techniques of wonod from bamboo trees are practically described by respondents who still have knowledge of this traditional medicine. Those who still have knowledge in the methods of extraction usually consist of the elderly among the indigenous population here. When extracting wonod, it should be done by slicing the bamboo branch slightly until the needed fluid is obtained. A downward incision must be made for the wonod to flow and the liquid should be caught in a receptacle before it drips to the ground. Wonod is commonly used to cure stomach aches and eye diseases that affect children. The liquid should be drunk three times a day.

Apart from *wonod,* there are several other types of traditional medicinal products that are very useful and easy to obtain in the surrounding forests such as tawawo leaves used to cure itchy skin and fever. Tawawo leaves should be boiled and drunk to treat fever, while for itchy skin; the tawawo leaves must be crushed and placed on the affected area. Also, the crushed lagup leaves can be used for the treatment of purulent sores. Interestingly, at the natives' homes, we can see many traditional plants with medicinal values such as misai kucing and many more being grown. Besides traditional medicinal knowledge as stated above, this study has looked into other traditional methods used by these indigenous people, such as fishing activity in rivers. There was one method observed that reflected the traditional style of fishing activity in rivers i.e. the use of bamboo stems which are designed as a trap and placed in prepared waterways. The bamboo stems are placed in the middle of the waterway as fish traps.

VII. Threats to Traditional Knowledge and Environment

It was found that the types of traditional practices in this area were detected to have decreased from previous times. Nevertheless, there are still many types of traditional agricultural crops that are grown such as lesun, pepper and mundok (tapioca). In traditional medicine, there are still a few products or herbs that are being used, for example, herbs for fever, stomach aches and others. However, according to estimates by the respondents, biodiversity resources of the forest still remained at about 70 percent and had also been threatened by logging activities in the 90's. Rapid growth and development can damage many forest products that can be exploited and commercialized. For the purpose of conserving the environment and preserving natural biodiversity resources, the indigenous people here have adopted a system called the tagal system. Tagal is a Kadazan-dusun word which means 'prohibition'. This system is a traditional system that has been used by the Dusun community for a long time to protect and preserve an area from a variety of threats through certain agreed regulations, before an area undergoes tagal. The forest tagal system has been practised once again in Tiang Lama Village to protect the forests around it from being encroached and destroyed. This method is also practised for river care. The rivers here were once somewhat threatened by upstream logging activities. However, presently some nearby rivers have been protected by the traditional river care system (tagal system). Forest clearing for commercial activities and traditional development of agricultural sector were the major causes of siltation occurring in rivers in Sabah. The geological condition in Sabah is still young and rivers in Sabah are expected to go through natural erosion processes in the years to come. Other causes are sewarage water from municipal councils and sewage waste from the industrial sector.

VIII. Suggestions and Measures for Preservation of Traditional Knowledge

Several proposals have been identified to protect the importance of traditional knowledge, especially in the medical and agricultural aspects. Among them is the effort and cooperation from the state government to gazette a number of traditional villages of indigenous people as 'customary land'. This customary land includes the gazetting of several areas as areas for preservation of herbs and wild animal breeding in forests and preservation of aquatic life in rivers. The government too should review and plan in more detail each development that is going to be carried out such as large-scale plantation ventures, logging and forest clearing, and so forth. This includes taking into account the views and opinions of the indigenous population in the surrounding area. One measure that has been taken to maintain traditional knowledge and preserve nature was gathering older people (practitioners of traditional knowledge) to discuss their traditional knowledge. However, this discussion had only been held at the Kaamatan festival which was organized 3 years ago. Furthermore, the discussion that was carried out was not in-depth and this effort was no longer continued. This initial step had only been conducted at Bayag village. However, according to respondents at Tiang Lama Village, there had been no form of measures taken to maintain their traditional knowledge. Still, traditional knowledge is seen to be decreasingly preserved due to the indigenous settlers' migration activities that have influenced the life-style changes of the indigenous community.

Only a handful of villagers are serious in preserving this knowledge. The younger generation too

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is less sensitive to the importance and practice of many of the traditional knowledge acquired through conversation with the older generation. The risk of losing this knowledge will continue if the present generation ignores this knowledge and does not preserve it. Nevertheless, something interesting that was obtained from this study was the existence of a local tourism resort establishment that was newly developed in this area. It is called Widu resort, named after a river known as Widu River. Remarkably, this resort is conceptualised on the natural environment and cultural traditions of the local community. Although newly opened, this resort has attracted many visitors, especially students who wish to undertake various activities including forest and river activities. There are also activities that engage the local population whereby they are involved in cultural events and telling various cultural tales of the indigenous community here. Enterprises such as this resort is another step that can be applied in helping to maintain cultural traditions of the indigenous community in general and traditional knowledge will also to some extent are preserved. The respondent's suggestion was also for an undertaking of a form of cooperation and assistance from the State Government to maintain or document their traditional knowledge. Assistance, especially advice and the right way of doing things should be conveyed to the people, particularly the method to safely preserve traditional knowledge. Another suggestion is to not plant commercial crops like rubber by clearing the land or stripping the forest bare. Villagers are also reminded to not destroy the forest products containing medicinal values to avoid their extinction. To maintain the traditional knowledge of indigenous people here, steps needed to be taken are to preserve natural forests and encourage the villagers to preserve their knowledge, and document them. Efforts to maintain and preserve this traditional knowledge should be undertaken immediately and aggressively, starting now due to the fear of it being gradually lost as a result of the explosive influence of globalization. Efforts in the form of education, especially for the indigenous population and the younger generation towards the awareness of preserving the traditional knowledge must be inculcated.

IX. Conclusion

Most of the traditional knowledge in Bayag, Tiang Lama, and other villages, in Ranau district is still available and there are a few who still practice it, especially the elderly. There are a variety of agricultural and medicinal products that are very useful which are found around the Ranau district, and they need to be preserved. Some examples are kederei, pangi fruit, red rice that is used in agricultural products, while wonod, lagup, tawawo and others have uses in medicine. However, the risk of loss will definitely occur if preservation efforts are not carried out. Although many people here are ready to preserve their traditional knowledge through documentation, yet they do not know how to do so. There are several traditional villages located nearby that have valuable traditional products, but they are not preserved properly and only serve for common daily use. For researchers, it is important that these valuable traditional products are recorded in detail and systematically labeled. Efforts for patent rights must also be immediately undertaken so that their rights to the knowledge are assured. It is also recommended that these traditional practices be recorded live through video recording and graphics. Besides that, efforts to preserve this traditional knowledge require collaboration and support from State and Local governments. However awareness of preserving the importance of this traditional knowledge needs to be fostered among the indigenous community itself so that these efforts will be more effective.

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Sustainable Water Resources Management, Future Demands and Adaptation Strategies in Sudan

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Abstract - For the thirty-nine million, who live in Sudan, environmental pollution is a major concern; therefore industry, communities, local authorities and central government, to deal with pollution issues, should adopt an integrated approach. Most polluters pay little or no attention to the control and proper management of polluting effluents. This may be due to a lack of enforceable legislation and/or the fear of spending money on the treatment of their effluent prior to discharge. Furthermore, the imposed fines are generally low and therefore do not deter potential offenders. The present problems that are related to water and sanitation in Sudan are many and varied, and the disparity between water supply and demand is growing with time due to the rapid population growth and aridity. The situation of the sewerage system in the cities is extremely critical, and there are no sewerage systems in the rural areas.

Keywords : *sudan, water resources development, community water supply, effective water-supply management, environment.*

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Sustainable Water Resources Management, Future Demands and Adaptation Strategies in Sudan

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Abstract - For the thirty-nine million, who live in Sudan, environmental pollution is a major concern; therefore industry, communities, local authorities and central government, to deal with pollution issues, should adopt an integrated approach. Most polluters pay little or no attention to the control and proper management of polluting effluents. This may be due to a lack of enforceable legislation and/or the fear of spending money on the treatment of their effluent prior to discharge. Furthermore, the imposed fines are generally low and therefore do not deter potential offenders. The present problems that are related to water and sanitation in Sudan are many and varied, and the disparity between water supply and demand is growing with time due to the rapid population growth and aridity. The situation of the sewerage system in the cities is extremely critical, and there are no sewerage systems in the rural areas. There is an urgent need for substantial improvements and extensions to the sewerage systems treatment plants. The further development of water resources for agriculture and domestic use is one of the priorities to improve the agricultural yield of the country, and the domestic and industrial demands for water. This article discusses the overall problem and identifies possible solutions.

Keywords : Sudan, water resources development, community water supply, effective water-supply management, environment.

I. Introduction

In Sudan, with more than ten million people do not have adequate access to water supply, twenty million inhabitants are without access to sanitation, and a very low proportion of domestic sewage being treated. The investment, which is needed to fund the extension and improvement of these services, is substantial (Omer, 1995). Most governments in developing countries are ready to admit that they lack the financial resources for proper water and sanitation schemes. Moreover, historically, bilateral and multilateral funding accounts for less than 10% of total investment needed. Thus the need for private financing is imperative.

Many water utilities in developing countries need to work in earnest to improve the efficiency of operations. These improvements will not only lead to better services but also to enhanced net cash flows that can be re-invested to improve the quality of service. Staff productivity is another area where significant gains can be achieved. Investment and consumption subsidies have been predicated on the need to help the poor to have, access to basic services and to improve the environment. Failure of subsidies to reach intended objectives is due, in part, to lack of transparency in their allocation. A key element to successful private participation is the allocation of risks. How project risks are allocated and mitigated will determine the financial and operational performance and success of the project, under the basic principle that the risk should be allocated to the party, which is best able to bear it. Many developing countries (Sudan is not an exception) are encouraging the participation of the private-sector as a means to improve productivity in the provision of water and wastewaters services. Private-sector involvement is also needed to increase financial flows to expand the coverage and quality of services. Many successful private-sector interventions have been under taken. Private operators are not responsible for the financing of works, nonetheless they can bring significant productivity gains, which would allow the utility to allocate more resources to improve and extend services. Redressing productivity, subsidy and cross-subsidy issues before the private-sector is invited to participate, has proven to be less contentious. I have previously thought to encourage more private-sector involvement (Omer, 1995).

Sudan is geo-politically well located, bridging the Arab world to Africa. Its large size and extension from south to north provides for several agro-ecological zones with a variety of climatic conditions, rainfall, soils and vegetation. Water resources available to Sudan from the Nile system, together with groundwater resources, provide a potential for thirty years increase in the irrigated sub-sector. There are also opportunities for increased hydropower generation. The strategy of Sudan at the national level aims at the multi-purpose use of water resources to ensure water security for attaining food security, drinking-water security, fibre-security, hydro-energy security, industrial security, navigation, waste disposal and the security at the regional levels within an environmentally sustainable development context and in harmony with the promotion of basin-wide integrated development of the shared water resources (Noureddine, 1997). The government has continued to pay for the development and operation

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of water systems, but attempts are being sought to make the user communities pay water charges. In order to ensure the sustainability of water supplies, an adequate institutional and legal framework is needed. Funds must be generated (a) for production, (b) for environmental protection to ensure water quality, and (c) to ensure that water abstraction from groundwater remains below the annual groundwater recharge. At present, there are private-sector providers who do not have an enabling environment to offer the services adequately. There is a need for the government to have a mechanism to assist in the regulation and harmonisation of the private-sector providers. Privatisation is part of a solution to improve services delivery in water and sanitation sector. At present, there is a transitional situation characterised by: (i) A resistance to water charge; (ii) Insufficient suitable law/law enforcement; (iii) Insufficient capacities; and (iv) Inadequate interaction between actors.

In a country with a relatively sparsely populated, there are extreme pressures on water and waste systems, which can stunt the country's economic growth. However, Sudan has recognised the potential to alleviate some of these problems by promoting renewable water and utilising its vast and diverse climate, landscape, and resources, and by coupling its solutions for waste disposal with its solutions for water production. Thus, Sudan may stand at the forefront of the global renewable water community, and presents an example of how non-conventional water strategies may be implemented. In Sudan, more than ten million people do not have adequate access to water supply, twenty million inhabitants are without access to sanitation, and a very little domestic sewage is being treated. The investment needed to fund the extension and improvement of these services is great. Most governments in developing countries are ready to admit that they lack the financial resources for proper water and sanitation schemes. Moreover, historically, bilateral and multilateral funding accounts for less than 10% of total investment needed. Thus, the need for private financing is imperative. Water utilities in developing countries need to work in earnest to improve the efficiency of operations. These improvements would not only lead to better services but also to enhanced net cash flows that can be re-invested to improve the quality of service. Staff productivity is another area where significant gains can be achieved. Investment and consumption subsidies have been predicated on the need to (a) help the poor, which have not an access to basic services and (b) improve the environment.

Failure of subsidies to reach intended objectives is in part, from lack of transparency in their allocation. Subsidies are often indiscriminately assigned to support investment programmes that benefit more middle and high-income families that already receive acceptable service. Consumption subsidies often benefit upper-income domestic consumers much more than low-income ones. Many developing countries (Sudan is no exception) are encouraging the participation of the private-sector as a means to improve productivity in the provision of water and of wastewaters services. Private sector involvement is also needed to increase financial flows to expand the coverage and quality of services.

A key element to successful private participation is the allocation of risks. How project risks are allocated and mitigated determines the financial and operational performance and success of the project, under the basic principle that the risk should be allocated to the party, which is best able to bear it. Many successful private-sector interventions have been undertaken. Private operators are not responsible for the financing of works, nonetheless they can bring significant gains in productivity, which would allow the utility to allocate more resources to improve and extend services. Redressing productivity, subsidy and cross-subsidy issues before the private-sector is invited to participate, has proven to be less contentious. I have previously sought to encourage more private-sector involvement (Omer, 1995).

This study comprises a comprehensive review of water sources, the environment and sustainable development. It includes the renewable water resources, water conservation scenarios and other mitigation measures necessary to reduce climate change. This is still very much lacking particularly under developing countries conditions.

II. Water Resources

Sudan is rich in water (from the Nile system, rainfall and groundwater) and lands resources in Table 1. Surface water resources are estimated at 84 billion m^3 and the annual rainfall varies from almost nil in the arid hot north to more than 1600 mm in the tropical zone of the south. The total quantity of groundwater is estimated to be 260 billion m^3, but only 1% of this amount is being utilised. Water-resources assessment in Sudan is not an easy task because of uncertainty of parameters, numerous degrees of freedom of variables, lack of information and inaccurate measurements. However, according to seasonal water availability, Sudan could be globally divided into three zones: (a) areas with water availability throughout the year are the rainy regions (equatorial tropical zones); (b) areas with seasonal water availability; and (c) areas with water deficit throughout the year, which occupy more than half the area of Sudan.

The ground water quality is suitable for animal and human consumption as well as for agriculture and other uses. The potential renewable ground water suitable is estimated at 6×10^9 m^3.

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Table 1 : Land use, land-resource zones and water resources (Omer, 2002)

(a) Land use (millions of ha)

Geographical area (total Sudan area)	250.6
Land area	237.6
Cultivable area	8.4
Pastures	29.9
Forests and woodland	108.3
Uncultivable land	81.0
Area under crop (irrigated, rain-fed, mechanised, and rain-fed traditional)	10.0

(b) Land-resource zones

Zone	Area as % to total area of Sudan	Persons per km^2	Mean average rainfall range (mm)
Desert	44	2	0-200
QOS sands (dune)	10	11	200-800
Central clay plains	14	19	200-800
Southern clay plains	12	8	800-900
Ironstone plateau	12	7	800-1400
Hill area and others	8	16	Variable

(c) Water Resources

Water resource	Available number	Static water level (m)	Number
Haffirs	824	0-0	824
Slow sand filters	128	0-0	128
Open shallow wells	3000	0-10	3000
Boreholes deep wells	2259	0-25 26-50 51-75 76-100	1248 478 287 246

(d) Geological Formations

Basins	Amount of water recharged (10^6 m^3)	Water level below land (m)	Aquifer thickness (m)	Velocity (m/year)	Abstraction (10^6 m^3/year)
Sahara Nile	136	30-100	300-500	1-2.5	7.3
Sahara Nubian	20.6	10-50	300-500	0.8-1.5	1.5
Central Darfur	47.6	25-100	250-550	0.3-6.0	5.5
Nuhui	15.4	75-120	200-400	1.0-2.75	1.6
Sag El Na'am	13.5	50-1000	300-500	1.0-25.0	2.5
River Atbara	150	100-150	250-300	0.3-5.0	2.3
Sudd	341	10-25	200-400	0.1-1.8	1.8
Western Kordofan	15	50-70	300-500	0.1-0.3	1.7
Baggara	155	10-75	300-500	0.1-2.4	11.9
Blue Nile	70.9	10-50	250-500	0.1-2.5	10.2
The Alluvial	N.A	Shallow	N.A	N.A	N.A
Gedaref	41.7	50-75	200-500	0.1-2.0	1.2
Shagara	1.1	25-30	200-300	0.1-2.5	0.7

The most important research and development policies which have been adopted in different fields of water resources are: (i) the water resource; (ii) irrigation development; (iii) the re-use of drainage water and groundwater; (iv) preventive and canal maintenance; (v) aquatic weed control and river channel development, and (vi) protection plans. The physical and human resources base can provide for sustainable agriculture growth and food security for itself and for others in the region. Failure to do so in the past derives from several causes and constraints, which are manageable. These include misguided policies, poor infrastructure, low level of technology use, recurring droughts and political instability. Perhaps the biggest challenge is that of finding resources for capital improvements in the light of changing water-quality regulations and ageing systems (James, 1994).

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The desert environment is fragile and highly affected by human activities. Disturbances in the balanced ecosystems are apt to take place causing serious problems to the environment, and consequently, initiating geotechnical hazards. Urbanisation, climatic conditions, and geomorphic and geologic setting are usually the controlling factors influencing the types of these hazards. One of the potential geotechnical hazards that may occur under desert conditions is sand drifting and dune movement. The problem of sand drifting and dune migration is of special interest in Sudan as moving sand covers approximately one-third of the country. Because sand poses natural erosional-depositional hazards on the existing structures, such as roads and urbanised areas, it become necessary to study the behaviour of the sand forms in the different parts of the country.

Although deserts are known to be simply barren areas, they are scientifically defined in terms of water shortage or aridity, soil type, topography and vegetation. Anon, 1979 presented a map showing the distribution of deserts in the world. Accordingly to this map, most of the Middle Eastern countries lie within the semi-arid, arid, and hyper-arid desert zones, with an aridity index (ratio between annual precipitation and mean annual potential evapotranspiration) ranging between 0.03 and 0.02. Most of the geotechnical hazards are associated with desert environments. The desert environment, being a fragile ecosystem, needs to be treated with care. Intercommunications between different national and international agencies and education of the layman should help to keep the system balanced and reduce the resulting environmental hazards. In addition, any suggested remedial measures should be planned with nature and be engineered with natural materials.

III. Water and Sanitation Management

Community water supply and sanitation management is a new form of cooperation between support agencies in the water and sanitation sector and communities.

It involves a common search to identify problems with the local water supply and sanitation systems, to establish the possibilities for, and constraints on, management by communities, and to find possible solutions that may be tested. Some fundamental principles of community water and sanitation management are: (i) Increased management capacities are the basis for improved water and sanitation systems, and each community must develop its own specific management systems; and (ii) Communities own the process of water charge; facilitators and local researchers participate in the community's projects, not the other way around.

Through this approach, the support agency is no longer the provider of technical goods or solutions, but the facilitator of process to enhance the capacity of the community to manage its own water and sanitation systems. Constraints include:(i) A lack of funds or substantial delays in allocating funds for essential requirements such as operation and maintenance of irrigation and drainage projects; (ii) Deterioration in data-collection activities; (iii) A lack of appropriate and consistent policies for water development for both large- and small-scale projects; (iv) Serious delays in completing water projects after major investments such as dams and other hydraulic structures, and main secondary canals not being completed; (v) An absence or inadequacy of monitoring, evaluation, and feedback at both national and international levels; (vi) A lack of proper policies on cost recovery, and water pricing or, if policies exist, absence of their implementation; (vii) A shortage of professional and technical manpower, and training facilities; (viii) A lack of beneficiary participation in planning, implementation, and operation of projects; (ix) Inadequacy of knowledge, and absence of appropriate research to develop new technologies and approaches, and an absence of incentives to adopt them; (x) General institutional weaknesses and a lack of coordination between irrigation, agriculture, energy, healthy, environment, and planning; (xi) Inappropriate project development by donor agencies, e.g., irrigation development with drainage, supporting projects which should not have been supported; and (xii) A lack of donor coordination resulting in differing approaches and methodologies, and thus conflicting advice.

As developing nations strive to provide a safe and reliable drinking-water supply to their growing and increasingly urbanised population, is becoming more evident that new approaches to this problem will be needed. To meet this challenge, new methods of reclaiming and re-using water have been developed in cost-effective and environmentally sound ways (ODA, 1987; Seckler, 1992; and Salih, 1992).

Despite the constraints, over the last decade the rate of implementation of rural and peri-urban water supply and sanitation programmes has increased considerably, and many people are now being served more adequately. The following are Sudan experience in water supply and sanitation projects:

a) At community level

- Participatory approaches in planning, implementtation and monitoring.
- Establishment and training of water tap committees.
- Clear ownership of improved water supply and sanitation systems.
- Technology and service level selection by consumers.
- Sensitive timing of hygiene and sanitation education.

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- Establishment and training of reliable financial and maintenance management.

b) At district and national level

- Integrated multi-sectoral approach development.
- Training approach and material development for district and extension staff.
- Continuing support from integrated multi-sectoral extension team.
- Establishment of technical support system.
- Multi-sectoral advisory group including training and research institutions.
- Development and dissemination of relevant information for district and extension staff.

IV. Water Resource Management Systems

Water is a substance of paramount ecological, economical, and social importance. Interrelationships inherent in water use should encourage integrated water management. Water resources are to be better managed to:

1. Ensure more reliable water availability and efficient water use in the agricultural sector.
2. Mitigate flood damage.
3. Control water pollution.
4. Prevent development of soil salinity and water logging.
5. Reduce the spread of water-borne diseases.

The emerging water crisis, in terms of both water quantity and quality, requires new approaches and actions. Priority areas needing concerted action in various sectors are:

(a) Water use efficiency, (b) Flood control, (c) Management of scarce water resources, (d) Water quality management and provision of safe drinking water, and (e) Coordination and integration of various aspects of water management, and water management with other related resources and societal concern. The following are recommended:

- Community must be the focus of benefits accruing from restructures, legislature to protect community interest on the basis of equity and distribution, handover the assets to the community should be examined; and communities shall encourage the transfer the management of water schemes to a professional entity.
- The private-sector should be used to mobilise, and strengthen the technical and financial resources, from within and without the country to implement the services, with particular emphasis on utilisation of local resources.
- The government should provide the necessary financial resources to guide the process of community management of water supplies. The government to divert from provision of services and be a facilitator through setting up standards, specifications and rules to help harmonise the private-sector and establish a legal independent body by an act of parliament to monitor and control the providers. Governments to assist the poor communities who cannot afford service cost, and alleviate social-economic negative aspects of privatisation.
- The sector actors should create awareness to the community of the roles of the private-sector and government in the provision of water and sanitation services.
- Support agencies assist with the financial and technical support, the training facilities, coordination, development and dissemination of water projects, and then evaluation of projects.

The development of new, modern, and complete water-resources-information systems is one of the basic needs for the implementation of the water-resources- management system. The decision process in drought or flood conditions, and also in over-exploitation cases, can only be correct if based on a reliable information system. A complete and comprehensive database on water availability, users, water quality monitoring, current technologies (like geographical information systems), is certainly the way to produce an efficient framework for decision-making. Lack of information is one of the most critical points regarding the development and implementation of the new management system (FAO, 1999). The types of data related to flood management include:

- Topographic data (elevations, land use, soils, vegetation, and hydrography).
- Administrative data (political boundaries, and jurisdictional boundaries).
- Infrastructure data (roads, wells, utilities, bridges and culverts, hydraulic structure, properties, facilities) and imagery (satellite images and aerial photographs).
- Environmental data (threatened and endangered species, critical aquatic and wildlife habitat, archaeological sites, and water quality).
- Hydrometeorology data (stream flows, precipitation, temperature, wind, solar radiation, soil water, discharge rating curves, flood frequency, and flood plain delineation).
- Economic data (stage-damage relationships, insured values, and industries), and
- Emergency management data (emergency plans, census data, and organisational charts).

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V. The Policy Regime in Water Quality Management

Apart from effluent regulations, and sometimes, national water quality guidelines, a common observation is that few developing countries (Sudan is not an exception) include a water-quality-policy context. Whereas water supply is seen as a national issue, pollution is mainly felt at, and dealt with at, the local level.

With few exceptions, national governments have little information on the relative importance of various types of pollution (agriculture, municipal, industrial, animal husbandry, aquaculture), and therefore, have no notion of which is of greatest economic or public health significance.

Usually freshwater quality management is completely divorced from coastal management even through these are intimately linked. Consequently, it is difficult to develop a strategic water quality management plan or to efficiently focus domestic and donor funds on priority issues.

A national water-quality-policy should include the following water quality components:

- A policy framework that provides broad strategic and political directions for future water-quality management.
- A strategic action plan for water-quality management based on priorities that reflect an understanding of economic and social costs of impaired water.

This plan should include the following components:

- A mechanism for identifying national priorities for water-quality management that will guide domestic and donor investment.
- A plan for developing a focused and cost-effective data programme for water quality and related uses, as a basis for economic and social planning.
- A consideration of options for financial sustainability including donor support, public/private-sector partnerships, and regional self-support initiatives.
- A regulatory framework that includes a combination of appropriate water-quality objectives (appropriate to that country and not necessarily based on Western standards) and effluent controls. This includes both surface and groundwater.
- A methodology for public input into goals and priorities.
- A process for tasking specific agencies with implementation so that accountability is firmly established and inter-agency competition is eliminated.
- Specific mechanisms for providing drinking water monitoring capabilities, at the community level if necessary.
- National data standards that must realistically reflect national needs and capabilities. Nevertheless, the objective is to ensure reliable data from those organisations that provide information for national water management purposes and at the community level for drinking water monitoring.

The design criteria in any water-quality programme are to determine the management issues which water quality data are required. Generally, there are four categories of data objectives:

- Descriptive data that are typically used for government policy and planning, meeting international obligations, and for public information.
- Data specific to public health.
- Regulatory concerns, and
- Aquatic ecosystem health.

The last category is not normally included in many developing countries for reasons of cost and complexity. In most developing countries, countries with transitional economies, and some developed countries, the technology of monitoring has changed little since 1970s, yet some of the largest advances in monitoring in recent years involve technical innovation that serve to reduce costs and increase efficiency. Admittedly, not all of these are inexpensive; however when deployed appropriately, they may eliminate traditional monitoring, or reduce costs by increasing the efficiency of more traditional approaches to chemical monitoring. Types of innovation include: biological assessment, use of surrogates, use of enzymatic indicators, miniaturisation, automation, and simplification of laboratory analytical methods.

VI. Sustainable Developments

In the past decade, sustainability has increasingly become a key concept and ultimate global for socio-economic development in the modern world. Without a doubt, the sustainable development and management of natural resources fundamentally control the survival and welfare of human society. Water is an indispensable component and resource for life and essentially all human activities rely on water in a direct or in direct way. Yet supplying water of sufficient quantity and safe quality has seldom been an easy task. Although sustainability is still a loosely defined and evolving concept, researchers and policy-makers have made tremendous efforts to develop a working paradigm and measurement system for applying this concept in the exploitation, utilisation and management of various natural resources. In water resources arena, recent development has been synthesised and

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presented in two important documents published by (ASCE, 1998) and (UNESCO, 1999), which attempt to give a specific definition and a set of criteria for sustainable water resource systems. When considering the long-term future as well as the present, sustainability is concept and goal that can only be specified and implemented over a range of spatial scales, of which urban water supply is a local problem with great reliance on the characteristics and availability of regional water resources.

Table 2 : Water and Sustainable Environment

Technological criteria	Water and environment criteria	Social and economic criteria
Primary water saving in regional scale	Sustainability according to greenhouse gas pollutant emissions	Labour impact
Technical maturity, and reliability	Sustainable according to other pollutant emissions	Market maturity
Consistence of installation and maintenance requirements with local technical known-how	Land requirement	Compatibility with political, legislative and administrative situation
Continuity and predictability of performance	Sustainability according to other environmental impacts	Cost of saved primary water

Cleaner, leaner production processes- pursuing improvements and savings in waste minimisation, energy and water consumption, transport and distribution, as well as reduced emissions are needed. Tables (2-4) indicate water conservation, sustainable development and environment. With the debate on climate change, the preference for real measured data has been changed. The analyses of climate scenarios need an hourly weather data series that allows for realistic changes in various weather parameters. By adapting parameters in a proper way, data series can be generated for the site. Weather generators should be useful for:

- Calculation of energy consumption (no extreme conditions are required)
- Design purposes (extremes are essential), and
- Predicting the effect of climate change such as increasing annually average of temperature.

This results in the following requirements:

- Relevant climate variables should be generated (solar radiation: global, diffuse, direct solar direction, temperature, humidity, wind speed and direction) according to the statistics of the real climate.
- The average behaviour should be in accordance with the real climate.
- Extremes should occur in the generated series in the way it will happen in a real warm period. This means that the generated series should be long enough to assure these extremes, and series based on average values from nearby stations.

Table 3 : Classification of key variables defining facility sustainability

Criteria	Intra-system impacts	Extra-system impacts
Stakeholder satisfaction	Standard expectations met Relative importance of standard expectations	Covered by attending to extra-system resource base and ecosystem impacts
Resource base impacts	Change in intra-system resource bases Significance of change	Resource flow into/out of facility system Unit impact exerted by flow on source/sink system Significance of unit impact
Ecosystem impacts	Change in intra-system ecosystems Significance of change	Resource flows into/out of facility system Unit impact exerted by how on source/sink system Significance of unit impact

Growing concerns about social and environmental sustainability have led to increased interest in planning for the energy utility sector because of its large resource requirements and production of emissions. A number of conflicting trends combine to make the energy sector a major concern, even though a clear definition of how to measure progress toward sustainability is lacking. These trends include imminent competition in the electricity industry, global climate change, expected long-term growth in population and pressure to balance living standards (including per capital energy consumption).

Agriculture is largely subsistence with a wide range of food crops including: maize, sorghum, millet, root crops, banana, pulses, tea, and coffee. Because of the marked fluctuation between the flood discharge and the low season period in the Nile system, storage reservoirs in Sennar, Rosaries, Girba and Jebel Aulia were constructed to ensure the availability for water during the recession period.

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Table 4 : Positive impact of durability, adaptability and energy conservation on economic, social and environment systems

Economic system	Social system	Environmental system
Durability	Preservation of cultural values	Preservation of resources
Meeting changing needs of economic development	Meeting changing needs of individuals and society	Reuse, recycling and preservation of resources
Energy conservation and saving	Savings directed to meet other social needs	Preservation of resources, reduction of pollution and global warming

Table 5 : The basket of indicators for sustainable consumption and production

Economy-wide decoupling indicators
1. Greenhouse gas emissions
2. Air pollution
3. Water pollution (river water quality)
4. Commercial and industrial waste arisings and household waste not cycled
Resource use indicators
1. Material use
2. Water abstraction
3. Homes built on land not previously developed, and number of households
Decoupling indicators for specific sectors
1. Emissions from electricity generation
2. Motor vehicle kilometres and related emissions
3. Agricultural output, fertiliser use, methane emissions and farmland bird populations
4. Manufacturing output, energy consumption and related emissions
5. Household consumption, expenditure energy, water consumption and waste generated

Designing and implementing a sustainable energy sector will be a key element of defining and creating a sustainable society. In the electricity industry, the question of strategic planning for sustainability seems to conflict with the shorter time horizons associated with market forces as deregulation replaces vertical integration. Sustainable low-carbon energy scenarios for the new century emphasise the untapped potential of renewable resources. Rural areas can benefit from this transition. The increased availability of reliable and efficient energy services stimulates new development alternatives. It is concluded that renewable environmentally friendly energy must be encouraged, promoted, implemented, and demonstrated by full-scale plant especially for use in remote rural areas (Figure 1).

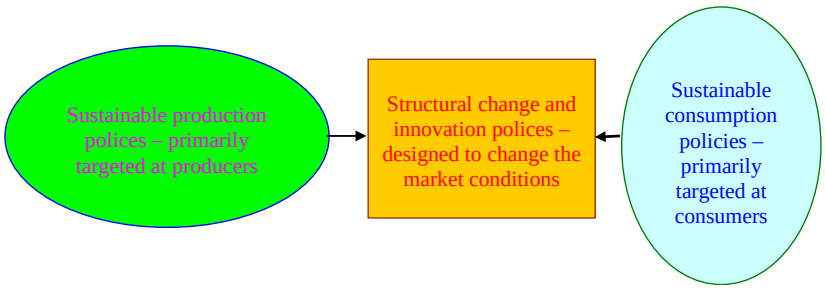

Figure 1 : Link between resources and productivity

This is the step in a long journey to encourage a progressive economy, which continues to provide us with high living standards, but at the same time helps reduce pollution, waste mountains, other environmental degradation, and environmental rationale for future policy-making and intervention to improve market mechanisms. This vision will be accomplished by:

- 'Decoupling' economic growth and environmental degradation. The basket of indicators illustrated shows the progress being made (Table 5). Decoupling air and water pollution from growth, making good headway with CO_2 emissions from energy, and transport. The environmental impact of our own individual behaviour is more closely linked to consumption expenditure than the economy as a whole.
- Focusing policy on the most important environmental impacts associated with the use of particular resources, rather than on the total level of all resource use.

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- Increasing the productivity of material and energy use that are economically efficient by encouraging patterns of supply and demand, which are more efficient in the use of natural resources. The aim is to promote innovation and competitiveness. Investment in areas like energy efficiency, water efficiency and waste minimisation.
- Encouraging and enabling active and informed individual and corporate consumers.

VII. Goals and Challenges

Sudan needs assistance in developing and implementing (a) river-basin management, (b) diffuse source pollution, (c) environmental restoration, and (d) urban storm drainage.

At present the international, bilateral donor agencies, and relevant United Nations bodies provide such assistance. The international associations constitute an additional, but as yet untapped, source of assistance. The solution, which should be seriously explored, is the forging of partnerships with bodies such as the World Bank and the appropriate United Nations agencies.

Advanced research and technology contribute to resolving water shortage and sanitation problems, and non-conventional reliable water supplies cannot be provided unless the environmental impacts are taken into consideration. Looking to the future, Sudan has a set the following priorities for water-resource research and development until the year 2020:

a) Increase overall water-use efficiency to the maximum limit. This could be achieved by (a) improving the irrigation system and assure its flexibility to cope with modern farm irrigation system, (b) developing the farm system, (c) drawing up a proper mechanism for water charges;

b) Modify the cropping pattern; for example (a) planning the different cropping pattern according to water quality, (b) gradually replacing sugar cane by sugar beet, (c) introducing genetic engineering and tissue culture to develop salt tolerance crops, and (d) reducing the area of clover (*Berseem*);

c) Re-use all the possible agricultural drainage water using proper technological means to deal with its quality, especially after implementing the irrigation development programme;

d) Plan properly the re-use of sewage effluent after drawing up guidelines for its use;

e) Research agreements of losses and suggest conservation projects;

f) The conjunctive use and management of reservoirs and groundwater sources in the Nile valley, giving special consideration to drought conditions;

g) Develop non-renewable groundwater resources in the deserts on a sustainable basis;

h) Water harvest rainfall in desert areas and make full use of torrential streams and flash floods;

i) Use new economical technology of seawater desalination;

j) Raise public awareness about water resource scarcity and government management plans;

k) Consider laws to match with the required development and existing scarcity;

l) Establishment of efficient operation, maintenance and repair procedures;

m) Community participation in operation and maintenance;

n) The extent to which initial government investment can or should be recovered from water uses;

o) Domestic potable water supply should reach at least 25 litres per day per person;

p) Water should be available for ten livestock units at 450 l/d;

q) Potable water must be available within two kilometres of individual residences.

The water quantity situation is highly variable in Sudan reflecting different levels of development and different needs for water quality programmes in Table 6.

The conventional paradigm of water quality monitoring is not suitable for the Sudan being too expensive, inefficient, and ineffective. Financial and sustainability issues include cost avoidance and cost reduction, local and accountability frameworks that encourage good business practices by senior programmme managers, the use of new cost-effective technologies for monitoring, and a variety of donor/public/private-sector linkages that focus on commercial benefits that permit the transfer of certain parts of water quality programmes to the private-sector.

From a visual investigation of the River Nile in Table 7, the major sources are industrial effluents, crude sewage from blocked, broken or overloaded sewers, sewage effluents, surface runoff, and solid wastes which have been dumped into the river.

Therefore remedial and improvement measures must be taken before the environment becomes further polluted and the natural resources are completely over-exploited (Omer, 2000).

The challenges facing and enhancing the ecology in the twenty-first century are as follows: (a) Drinking-water sources should be treated with chemicals; (b) Suitable toilet facilities should be provided along the main roads to minimise pollution; (c) Proper arrangements should be made for litter dumping and waste disposal; (d) Local people should be fully educated about environment matters and hygiene; (e) Previous damage should not be allowed to continue

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while planning for a balanced development in the future; (f) The concept of the ecosystem (involving education and interpretation of the natural environment) must be promoted.

Environmental pollution is a major problem facing all nations of the world. People have caused air pollution since they learned to how to use fire, but man-made air pollution (anthropogenic air pollution) has rapidly increased since industrialisation began.

Table 6 : Present water management of Sudan

Using of resources	Sources	Institutions	Pricing Principle	Price Details
Urban	Surface and groundwater	National Water Corporation (NWC)	Full cost recovery	Progressive rate with increasing uses. Rates lower in the north
Major rural villages	Mostly groundwater	Rural Water Corporation (RWC)	Stand pipe free, recovery of recurrent costs, charges for yard and house connections	Progressive rates but less comparative to urban cities
Rural villages	Groundwater	District Councils	As above	Not available
Livestock	Surface and groundwater	Rural Water Corporation (RWC)	All investments and recurrent costs	Regressive, no charges on relatively small use
Mines	Surface and groundwater	National Water Corporation (NWC)	Full cost recovery	Progressive rates
Wildlife	Mostly surface	Rural Water Corporation (RWC)	Full cost of boreholes	Regressive

Many volatile organic compounds and trace metals are emitted into the atmosphere by human activities. The pollutants emitted into the atmosphere do not remain confined to the area near the source of emission or to the local environment, and can be transported over long distances, and create regional and global environmental problems. The privatisation, and price liberalisation in energy fields has to some secured (but not fully). Availability and adequate energy supplies to the major productive sectors is needed. The result is that, the present situation of energy supplies is for better than ten years ago.

Table 7 : Wastes in the River Nile water

Materials	(%)
Paper, and wood	50.0
Ferrous residues	12.5
Glasses	11.0
Organic wastes	10.0
Plastics	5.0
Non-ferrous residues	1.5
Other	10.0

VIII. The Challenge of Overcoming the Country's Diversity

Sudan is a federal republic of 2.5 million km^2 located in the eastern Africa. The country is divided into 26 states and a federal district, in which the capital, Khartoum is located. Sudan is known as a country of plentiful water, with highest total renewable fresh water supply in the region. Table 8 shows some of the most significant regional diversities concerning water issues.

Adequate water management is essential to sustain development. Competing needs for this beneficial resource include municipal supply, industry, and agriculture, among others. The National Water Act of 1994 (Law No. 1155) defines the objectives, principles, and instruments of the National Water Resources Policy and the National Water Resources Management system. The law establishes the institutional arrangement under which the country's water policies are to be implemented. The National Water Resources Policy was proposed to achieve:

- Sustainability: to ensure that the present and future generations have an adequate availability of water with suitable quality.
- Integrated management: to ensure the integration among uses in order to guarantee continuing development.
- Security: to prevent and protect against critical events, due either to natural causes or inappropriate uses.

Table 8 : Main water resource issue in region

Region	Water resource issues
South	1. Abundant water resources 2. Localised scarcity of water and untapped water supplies 3. High hydropower potential 4. Water conflicts arising from immigration of Bagara Arabs (nomadic) from north to south 5. Water-borne diseases

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Central	6. International water conflicts (Upstream and downstream countries) 1. Water quality problems from untreated sewage and other pollution 2. Water-borne diseases 3. Potential use of rivers for navigation and recreational purposes 4. Intensive erosion and sedimentation from agriculture 5. High hydropower potential 6. Excessive use in large urban and industrialised areas 7. Frequent urban floods
North	1. Good water quality 2. Scarcity of water resources 3. Intensive erosion and sedimentation from agriculture 4. Frequent urban floods
Northeast	1. Scarcity of water resources 2. Water quality problems from untreated sewage 3. In mining areas, water quality problems from effluent
West	1. Scarcity of water resources 2. Water conflicts between nomadic and non-nomadic tribes 3. Water-borne diseases 4. Soil erosion and degradation caused by agriculture

To achieve such objectives, water management must be implemented according to the following principles:

- Water is a public good, and it is a finite resource that has economic value.
- The use of water required to meet people's basic needs shall have priority, especially in critical periods.
- Water management shall comprise and induce multiple uses.
- The river basins are the appropriate unit for water management, and water management shall decentralise, with the participation of government, stakeholders and society.

Table 9 : Capacity assessment for flood management: institutional factors

High capacity (plans, etc., in places)	• Basin-wide management plan has been drafted. • Natural mitigation strategy in place. • Basin-wide coordination and communications strategy instituted. • Trained emergency management staff coordinating at the regional level. • Effective regulatory policies that address floodplain occupancy. • Decentralised decision-making with a high degree of local autonomy.
Medium capacity (evidence of activity on- going)	• Evidence of an updated national response plan. • Bilateral response agreements. • Evidence of regional preparedness and response training. • Some trained emergency management staff at the local and/or national level. • Evidence of some regulatory policies designed to address floodplain occupancy. • Attempts to decentralise decision-making, moderate local discretion.
Low capacity (no formalisation in place nor apparently evolving)	• No existing flood response plan. • No evidence of mitigation-related activities. • Poor local-and national- level coordination and communications. • Little or no evidence of flood preparedness and response training. • No regulatory policies addressing floodplain occupancy. • Centralised decision-making, no evidence of local autonomy.

Water resources plans are developed to guide future decisions and are to be developed for each river basin and state, as well as the country. The objective is to coordinate efforts and establish guidelines and priorities for water allocation and water pricing. The priorities established for water allocation will be used in critical drought conditions. Water pricing is the single most controversial instrument of the law. The pricing system is also the most difficult step to implement. The pricing system recognises the economic value of water, as stated in the principles of the policy. The development of a new, modern, and complete water resources information system is one of the basic needs for the implementation of the water resources management system. The decision process in drought or flood conditions, and also in overexploitation cases, can only be correct if based on a reliable information system. A complete and comprehensive database on

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water availability, users, water quality monitoring, and current technologies (like geographical information systems), is certainly the way to produce an efficient framework for decision-making. Lack of information is one of the most critical points regarding the development and implementation of the new management system. The institutional framework provides the basis by which all actions are taken, and an assessment of its functional character helps determine the collaborative potential. The resulting criteria for measuring a given community's institutional capacity can be found in Table 9.

IX. Water Scarcity Impacts and Potential Conflicts

The failure of water resources to meet the basic requirements of society has a host of social, economic, environmental, and political impacts. Water scarcity is man-made phenomenon brought about by the increasing demands of the population for water. The imbalance in the population- water resources equation strains society and has an adverse impact on domestic hygiene, public health, and cost of domestic water, and could impart political problems as a serious as bringing down government. On the social side, water scarcity adversely impacts job opportunities, farm incomes, credibility and reliability of agricultural exports, and ability of the vulnerable to meet the cost of domestic water. Economically, the adverse impact is displayed in the loss of production of goods, especially agricultural goods, the loss of working hours because of the hardships society faces as a result of water scarcity. The impacts of water scarcity on regional stability are addressed with reference to water in the Middle East Peace Process, taking into account the serious impacts of conflicts and potential water war.

Conditions of scarcity propel an increase in competition among the different sectors of water use with results, invariably, at the expense of irrigated agriculture. Pure market forces create a gradient under which water flows from the poor to the rich. Tough decisions await politicians, and the consequences are expected to displease one or more parties, and please others. The scene of domestic politics becomes as fluid as water itself, with politicians shifting positions continuously in response to domestic pressures. The political fallout from water resources scarcity on the domestic scene is parallel to the impact the scarcity has on domestic households in terms of basic needs for drinking and food preparation, on domestic hygiene, and on public health. Other important factors have a delayed response to water scarcity, and these pertain to the integrity of the environment, and deterrence it imparts on development investment and economic credibility of the country. The cost of mitigating these problems and of the provision of services to the increased urbanisation could very well be beyond the ability of government to bear. The political consequences resulting from this will not be in favour of domestic stability, and social explosions can be anticipated. A bilateral agreement was reached between Egypt and the Sudan in 1959 by which the two countries share the Nile flow: 55.5 billion cubic meters to Egypt, 18.5 billion to Sudan, and 10 billion were allocated to evaporation. Hopes are high for achieving a more extensive participation by the other riparian parties in what could be a multilateral treaty on the Nile encompassing the other riparian states in addition to Egypt and Sudan. The above agreement is not complete; it lacks the entry of other legitimate riparian states, lacks water quality components, and tends to focus on quantity measures, and miss important management issues. It is to be noted that regional relations, including those among the riparian parties, are connected to the political, economic, and trade network of international relations. Water is not the only determinant factor in shaping the nature of bilateral, regional, or international relations. Water relations can be transformed into a positive sum game by which all parties can be made to win. One common gain to all is the environmental protection of the common watercourse or water body. Lack of cooperation and agreement will most likely lead to environmental neglect and water quality degradation, which is loss to all. International encouragement to attain cooperation can, therefore, be brought to bear on the regional parties, and efforts of international lending agencies can be called upon to pool with the regional and international efforts to achieve this objective. It has been stipulated by many that under conditions of scarcity, water conflicts can lead to hostile actions between riparian parties. Experience in the region indicates that water, in its own right, has not been the cause of any of the wars that have broken out in the region.

Today's advanced societies heavily depend on energy. The principal sources of energy and electricity generation today are solar, wind, biomass, hydropower, and fossil fuel. Energy from hydropower is short of meeting the current or future energy requirements, and the fossil fuel resources, being depleted with time, will eventually run out. For human civilisation to continue at its natural pace, new forms of affordable and clean energy will have to come on line. Failure of human civilisation to introduce new forms of energy will render that civilisation doomed, and the quality of life will deteriorate. If this unlikely scenario actually takes place, the requirements will decrease because the mechanism of making it available for use (pumping) diminishes.

The more likely scenario is more optimistic one, and it is that a new form of energy generation will be introduced in which case water desalination becomes affordable and its pumping from the coastal desalination plants become possible at reasonable cost.

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The way out of the looming water crisis rests, therefore, in the invention of new forms of energy generation that will make possible the reliance on desalination and in the recycling of wastewater for reuse in agricultural production and for environmental reasons. Integrated management of the three resources of water, energy, and the environment, will result in better results with a positive sum for society.

X. Common Language and Culture

A common language and similar culture simplify communication and reduce the potential for misunderstandings. In the Nile basin where several languages are spoken, an international language, English, is used with some success by multi-jurisdictional basin management authorities.

a) Primary Factors Promoting Data and Information Exchange

Data and information exchange is more probable when needs are compatible and when there is potential for mutual benefit from cooperation in Table 10. Where countries are working on developments that are beneficial to both countries as well as other riparians, there is little incentive to hide project impacts. This means that since data and information exchange is unlikely to lead to pressure from surrounding countries that might restrict developments, countries have less reason to restrict access to their data and information resources. It is important, therefore to be no perceived clash of interests in development plans and needs. An example of this might be in developing their part of the basin primarily for hydroelectric development, while the lower riparians are more interested in developing the irrigation potential of their portion of the basin. By constructing large storage dams in the upper part of the basin, the river Nile seasonal flow might be evened out, reducing flooding downstream while increasing irrigation water supplies and even making downstream run-of-the-river hydroelectric projects more profitable. Ecosystem effects would have to be considered.

Table 10 : Summary of the situation relating to data and information exchange in the Nile basin

River basin	Nile basin
Basin states or territories	Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda
Cooperative frameworks in place	Nine of the countries of basin are pursuing the development of a cooperative framework
Major languages spoken	More than 6 official languages and numerous unofficial languages
Major water issue facing the basin	Rapid population growth, environmental degradation, under development
External funding of cooperative basin initiatives	Extensive external funding of cooperative initiative
Range of GDP *per capita* of the basin	$550-$3000
Extent of data/information exchange	Information exchange through the cooperative framework being developed is beginning to occur

b) Sufficient Levels of Economic Development

Sufficient levels of economic development across a basin are needed to permit joint funding of cooperative processes, particularly data collection and dissemination. Although countries with differing levels and forms of economic development may, at times, have more complementary needs than countries with similarly structured economies, the overall level of economic development is still significant. A wealthier country in a river basin may be able to assist with the funding of data collection activities in the neighbouring country with much needed data and helping to build confidence between the two countries.

c) Increasing Water Resources Stress

As *per capita* water resources availability decreases as shown in Table 11, tensions between riparian nations may rise and make cooperation difficult. Stress may, therefore, reduce cooperation and data sharing rather than strife.

The historical background of the basin may have a lasting effect on current negotiations. Past conflicts can have a deleterious effect on the prospects for establishing cooperative practices, such as data sharing. Where there is a history of conflict between two nations, both nations may view the present situation primarily as competitive and focus on conflicting rather than common interests. Democracies may find it easier to negotiate cooperative arrangements with other democracies. Political differences can lead to legacies of mistrust developing between countries.

Table 11 : Diverse water challenge (WRI, 2002)

Country	Egypt	Sudan
Per capita annual water resources 2000 (m^3)	34	1187
Per capita annual withdrawal (m^3)	921	666
Per capita annual withdrawal for agriculture (m^3)	86	94

XI. Discussions

a) Water Stress in Sudan

Water stress refers to economic, social, or environmental problems caused by unmet water needs. Lack of supply is often caused by contamination, drought, or a disruption in distribution. In an extreme example, when Sudan split four years ago between the rebel-led west and government-ruled north, the conflict led to unpaid water bills, which precipitated a dangerous

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health threat in the region, increasing the risk of water-born diseases such as cholera. Some analysts believe the disruption of distribution was a political ploy to put pressure on the rebel-led west.

While water stress occurs throughout the world, no region has been more afflicted than sub-Saharan Africa. The crisis in Darfur stems in part from disputes over water: The conflict that led to the crisis arose from tensions between nomadic farming groups who were competing for water and grazing land-both increasingly scarce due to the expanding Sahara Desert. As Mark Giordano of the International Water Management Institute in Colombo Sri Lanka says, "Most water extracted for development in sub-Saharan Africa-drinking water, livestock watering, and irrigation- is at least in some sense 'transboundary'". Because water sources are often cross-border, conflict emerges.

Improving water and sanitation programmes is crucial to spurring growth and sustaining economic development. Because it takes time to develop these programmes, a paradox emerges: poor economies are unable to develop because of water stress, and economic instability prohibits the development of programmes to abate water stress. Developments in water storage could have prevented that drought from significantly affecting Sudan's economy. Hydropower can also spark economic development. Accordingly, some transboundary water agreements also play a clear role in fostering development, for example, by facilitating investment in hydropower and irrigation.

b) The Role of Agriculture in Water Stress

Agricultural development has the potential to improve African economies but requires extensive water supplies. These statics from the Water Systems Analysis Group at the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire reveal the urgent need for sustainable agricultural development:

- About 64 percent of Africans rely on water that is limited and highly variable;
- Croplands inhabit the driest regions of Africa where some 40 percent of the irrigated land is unsustainable;
- Roughly 25 percent of Africa's population suffers from water stress;
- Nearly 13 percent of the population in Africa experiences drought-related stress once each generation.

Another aspect of water-related stress is the relationship between water, soil, and agriculture. Improved access to quality water is a long-term goal that requires more than humanitarian funds.

- Because sub-Saharan Africa is subject to more extreme climate variability than other regions, it needs improved water storage capacity. Some experts say that large dam projects would create a more sustainable reserve of water resources to combat the burden of climate fluctuations, but other disagrees, stating the harmful environmental impact of large dams.
- Many experts say more water treaties are needed. The transboundary water agreements have cultivated international cooperation and reduced the "probability of conflict and its intensity".
- Better donor emphasis on water development is needed. Small-scale agricultural improvements also offer a solution to water stress, including the harvest of water in shallow wells, drip irrigation for crops, the use of pumps, and other technological innovations.

Farmers can access green water through drip irrigation systems that slowly and consistently deliver water to plant's root system, supplemental irrigation (supplementary to natural rainfall rather than the primary source of moisture during periods of drought) and rainwater harvesting (the collection of rainwater for crops, which reduces reliance on irrigation). Crops can grow poorly even during periods of rainfall, and most farms in Africa suffer from nitrogen and phosphorus depletion in soil.

One way to assuage water stress in terms of food scarcity is to increase water-holding capacity with organic fertilisers that would increase availability and efficacy of green water.

c) Water Supply Problems in the Butana Region - Central Sudan with Special Emphasis on Jebel Qeili Area

The Butana region of central Sudan is famous for its animal wealth and extensive pastures. Yet scarcity of water resources in the area especially during the dry seasons handicaps the proper utilisation of these pastures. The area is occupied by non-water-bearing basement rocks and the only source of water is from direct run-off.

Thus large numbers of small-size water reservoirs, "haffirs", were constructed, but these are inadequate to provide enough water for the growing human and animal population. An all-year lake is here proposed to be constructed utilising the ring-structure the Jebel Qeili igneous complex, central Butana. This lake is expected to solve the present water problem and meet the future demand of central Butana at the present rate of human and animal growth (Omer, 2001).

d) Southern Sudan

World Vision began its work in Sudan in 1972 through a partnership with the African Committee for Rehabilitation of the Southern Sudan (ACROSS) to provide emergency relief aid to war-effected families. Efforts included the reconstruction of the Rumbek community hospital and surrounding buildings, the provision of medicine and supplies, and education in preventative health care.

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Other projects during this period focused on training health and social workers in general medical aid and child welfare and instruction in water development, agriculture, handcrafts, and literacy (Omer, 2004). The 1980s brought constant turmoil to the Sudanese people as the civil war raged on and severe drought parched the country. In 1983, approximately 1,500 refugees entered Sudan daily from violence-torn neighbouring countries, straining the already limited food supply. World Vision, through the ACROSS Refugee Settlement Project, responded by distributing blankets, grain, cooking oil, medical kits, and shelter to more than 50,000 people. Supplemental feeding for children also was provided.

Numerous development projects were initiated during this time that assisted communities in improved crop production, animal husbandry, health care, clean water collection, infrastructure repair, and literacy. In 1989, World Vision became a founding member of Operation Lifeline Sudan (OLS), a partnership of non-governmental organisations (NGOs) and the United Nations (UN) agencies designated to coordinate the southern relief efforts.

During the 1990s World Vision conducted operations in all major regions of southern Sudan. Project objectives included primary health care, water provision, agriculture, local grain purchase, enterprise development, and emergency relief efforts. World Vision focused on an integrated work approach that involved peace and advocacy, gender development, church support, and environment and natural resource initiatives. Some specific projects included:

- The Kapoeta Medical Supplies Project provided health and educational assistance to more than 200,000 people to help reduce incidences of disease and suffering.
- The Agriculture/Livestock Rehabilitation Project assisted the aforementioned families with food, seed, vaccinations, and agricultural consults.
- The South Sudan Relief/Church Support Project coordinated a pastors' conference for 150 pastors and religious leaders from the Western Equatoria province.
- The South Sudan Relief and Rehabilitation Project, a 10-year programme, provided 450,000 Sudanese with agriculture and economic development, food and water, health care, enterprise development opportunities, and emergency relief.

e) Beja People's Problems

The Beja, a semi-nomadic group of people, who live in rebel-held areas of eastern Sudan, need a huge amount of humanitarian assistance, a representative from the International Rescue Committee (IRC). Although Beja can be found throughout northeast Africa, tens of thousands are currently trapped in an area of eastern Sudan near the Eritrean border, held by Sudanese rebels since the late 1990s. Only two NGOs, both based in Eritrea, are able to access the 15,000 sq km area at the moment, one of which is the IRC. The organisation estimates the Beja population in the area to be between 45,000 and 186,000 people (Omer, 2008).

Although it did rain in the area in 2004, a shortage of water had also posed serious problems. "Fresh drinking water is incredibly hard to come by. All the settlements have just focused around dry river beds, in which people dig hand-dug wells". Locusts would eat the foliage that usually sustains the Beja's goats and camels-upon which the Beja utterly depend for survival. A few immature locust swarms have formed in northeast Sudan near the Red Sea and the border of Egypt, the UN Food and Agriculture Organisation said in March 2004. Moreover, Beja grazing areas have been severely restricted by a front line between rebel forces and Khartoum government soldiers, the second to be opened by southern rebels during Sudan's 21-year-old civil war.

Sudan is an example that projects the environmental plight of Africa, south of the Sahara-drought and desertification, floods, deforestation, loss of biodiversity, tribal and ethnic conflict and poverty are only too common. As a result, interest and commitment to environmental impact assessment practices have become mandatory by donors when executing new development projects. The ecological zones of Sudan in 1998 as:

- Deserts: cover almost 30% of the northern parts. Annual precipitation is less than 50 mm; soils are sandy. Sparse vegetation grows on seasonal 'Wadis' and the banks of the Nile.
- Semi deserts: cover above 20% south of the desert belt. Rainfall ranges from 50 to 300 mm. It is speckled with few Acacia trees and thorny bushes and zerophytes.
- Low rainfall woodland Savannah: covers about 27% of the area of Sudan with rainfall less than 900 mm, with a nine-month dry period. Annual grasses are dominant. Heavy clay soils lie on the east of the Nile and the west is sandy. Most of the 36 million feddans of rain-fed agriculture and the 4 million irrigated lands fall within this heavily populated belt.
- High rainfall woodland Savannah: 13% of the area with rainfall more than 900 mm and with broad-leafed trees in the southern parts of Sudan.
- Swamps: are probably the largest in the world and cover about l0% and fall in three main areas around the tributaries of the White Nile.
- Highlands: are less than 0.3% of the areas of Sudan and are scattered along the Red Sea coast, the south and the west of the country.
- The Red Sea Coast-Marine ecosystem, mangrove swamps, coral reefs and associated fauna.

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Environmental problems include:

- Horizontal expansion in rain-fed and irrigated agriculture;
- The complete absence of the environmental dimensions in policies, strategies, plans and programmes of management of resources;
- Development is random and environmental evaluation does exist before or after execution of projects;
- The economy and society, in spite of the century-long attempts at 'modernisation' are still dominated by subsistence way of living;
- The economy is still affected seriously by the yearly, seasonal and geographical variability of rainfall for crop and livestock production;
- Dependence on imported seeds and agricultural chemicals has increased cost of production;
- Loss of land productivity and marketing policies decreased cash surplus;
- The civil war in the south has grave economic and social costs;
- Population distribution and rural-urban migration due to desertification and civil strife has led to deterioration of natural resources, indigenous knowledge and loss of local culture and dignity;
- Problems of poor sanitation, limited industrial pollution and food hygiene have become more complex;
- The energy crisis is aggravating desertification and affecting climate charge;
- Vast water resources are badly managed;
- Environmental education has only been recently incorporated in school curricula; and
- Laws and legislation concerning the environment are not effective and law enforcement measures are not integrated.

f) Western Sudan

El Fasher, Darfur region, Sudan, 24 August 2005 – Torrential rains have caused severe flooding in this city of 400,000 people and in nearby Abu Shook, a camp for people forced to flee their homes as a result of the ongoing Darfur conflict (Figures 2-3). The floods have destroyed hundreds of homes and have made El Fasher's water supply largely unsafe (WHO, 2006).

UNICEF is mounting a concerted effort to restore basic services to those affected by the flood, and to prevent the outbreak of disease. Since the flood, UNICEF has assisted with the following:

- Reinstalling pipes in Abu Shook and restoring the water supply by linking boreholes with pumps.
- Testing the water quality each day. No bacterial contamination has been found.
- Rebuilding 156 latrines and 88 bath stations.
- Renting five tankers to deliver more water.
- Repairing damaged schools and child-friendly spaces.
- Providing daily door-to-door hygiene-promotion trainings.
- Distributing jerry cans, soap, tarps, and mosquito nets.



Figure 2 : For some people water collection is a daily need



Figure 3 : A typical donkey-drawn water tank used by water vendors

XII. Conclusion

A booming economy, high population, land-locked location, vast area, remote separated and poorly accessible rural areas, large reserves of oil, excellent sunshine, large mining sector and cattle farming on a large-scale, are factors which are most influential to the total water scene in Sudan. It is expected that the pace of implementation of water infrastructure will increase and the quality of work will improve in addition to building the capacity of the private and district staff in contracting procedures. The financial accountability is also easier and more transparent. The communities should be fully utilised in any attempts to promote the local management of water supply and sanitation

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systems. There is little notion of 'service, invoice and move on'. As a result, there are major problems looming with sustainability of completed projects. A charge in water and sanitation sector approach from supply-driven approach to demand-responsive approach calls for full community participation. The community should be defined in terms of their primary role as user/clients. Private-sector services are necessary because there are gaps, which exist as a result of the government not being able to provide water services due to limited financial resources and increase in population. The factors affecting the eco-environmental changes are complex, interrelated, and interactive. The deterioration problems of water and sanitation have attracted some attention in recent years. There is an urgent need to study possible rehabilitation measures to ensure a sustainable and excellent water quality and improved sanitation. Water resources plans are developed to guide future decisions and are to be developed for each river basin and state, as well as for the country. The overall objective is to coordinate efforts and establish guidelines and priorities for water allocation and water pricing. The priorities established for water allocation would be used in critical drought conditions. The water quality classification of water bodies by different classes of use is the basis for truly integrating the quality and quality of water management. Water pricing is the single most controversial instrument of the law. The pricing system recognises the economic value of water, as stated in the principles of the policy, but is also the most difficult step to implement. It is expected that the pace of implementation will increase and the quality of work will improve in addition to building the capacity of the private and district staff in contracting procedures. The financial accountability is also easier and more transparent. The communities should be fully utilised in any attempts to promote the local management of water supply and sanitation systems. A charge in water and sanitation sector approach from supply-driven approach to demand-responsive approach calls for full community participation. The community should be defined in terms of their primary role as user/clients. Private-sector services are necessary because there are gaps, which exist as a result of the government not being able to provide water services due to limited financial resources and increase in population. There is little notion of 'service, invoice and move on'. As a result, there are major problems looming with sustainability of completed projects. The factors affecting the eco-environmental changes are complex. There are interrelated and interact. The deterioration problems of water and sanitation have attracted some attention in recent years. There is an urgent need to study possible rehabilitation measures to ensure a sustainable and excellent water quality and improved sanitation.

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Private Sector Participation Model in Waste Management for Developing Countries: Framework from Lagos Study in Nigeria

By Odewumi, S. G.
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Abstract - This study is presenting an empirical justification for the inclusion of private sector participation in municipal solid waste management. It is derived from a study of waste management in metropolitan Lagos. Primary data were obtained through interviews and ten questionnaires with the various stakeholders and secondary data were collated from the archives of relevant agencies, especially Lagos Waste Management Authority (LAWMA) websites, Digital libraries and earlier studies. The study reveals that the private sector which comprises of the highway managers and the private sector participant (PSP) collected more than 70% of the waste volume even in the experimental stage. This is a pointer to the potential of this sector as a strong ally and a more efficient one at that.

Keywords : *municipal waste management, private sector partnership, lawma, lagos.*

GJHSS-B Classification : *FOR Code : 710702p*



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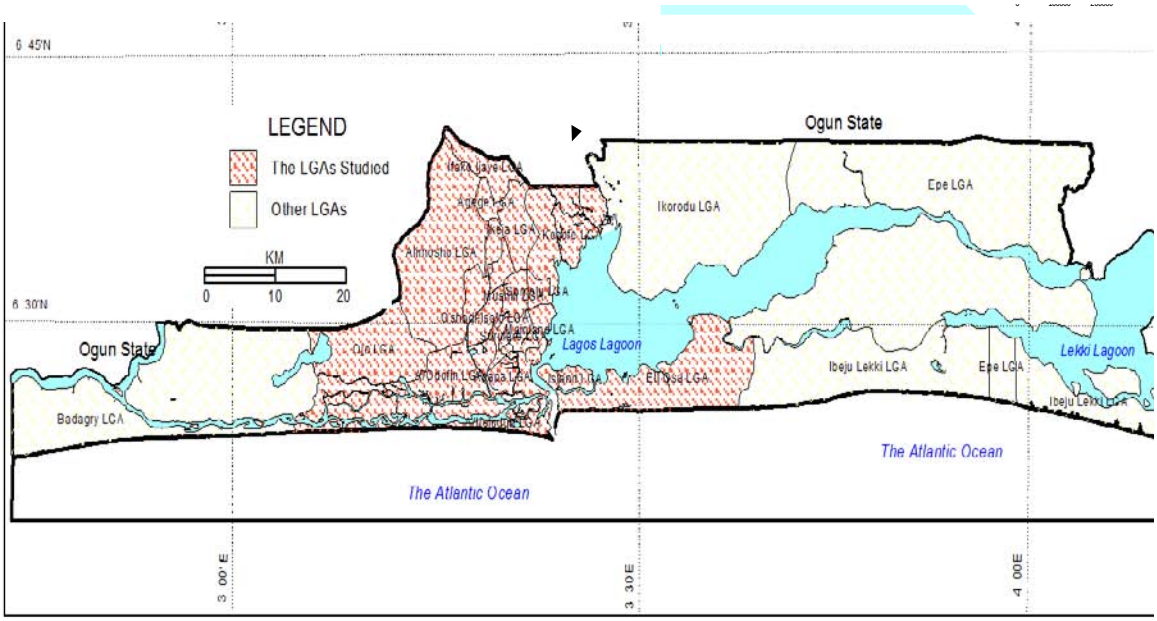
Keywords : municipal waste management, private sector partnership, lawma, lagos.

I. Problem Defined

The fact that successive Governments in Nigeria have had to contend at one time or the other with the problem of huge mountains of un-cleared solid waste in the cities is a clear indication that an appropriate solution is yet to be proffered (Adeniji and Kunle, 1996) Saka, 1995; Odumosu, 1995 and Oloke-susi, 1994). Since the populace cannot be stopped from generating waste, the fundamental issue therefore is how to manage, the waste being generated so that it will not constitute health hazard and also meet the aesthetic demand of a decent society (Onibokun, Adedipe and Sridhar, 2000). The search for the appropriate manag-ement techniques has been long and frustrating (Filani and Abumere, 1986; Faniran, 1994). Various modalities have been adopted like the shifting of the managing authority from the state to the local government, to independent management boards and then back to the state (Odewumi, 2002). Currently the approach being experimented upon is the Private Sector Participation (PSP), which, essentially is the involvement of private businessmen in the waste removal. This study is expected to offer suggestions that could assist in making the experiment successful.

II. Aim of Study

It is therefore part of the objectives of this study to examine the existing strategies, propose the inclusion of private sector participation and offer suggestions for mode of operations.



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III. Area of Study

Metropolitan Lagos is the spatial limit of this inquiry (Map 1). The area is located between longitudes 6^0-7^0 east of the Greenwich meridian and between latitude 3^0-5^0 North of the Equator. It has an approximate size of 3,577 square kilometres, shares boundaries with Ogun state in the north, in the west with Republic of Benin, Ondo state on its eastern boundary while the long coastline of about 180 kilometres of Atlantic Ocean constitutes its Southern boundary. The area is a mega-city with high population density and consequently high volume of waste generation.

IV. Factors for High Volume of Waste Generation in the Area of Study

In order to derive a framework for sustainable management, it will be helpful to understand the factors that coalesce to make waste generation so high and the removal so difficult compared with areas of similar size, role, location and stage of development.

The first major factor is the rapid rate of urbanisation. It is the most urbanised and most populous state in Nigeria. Besides the rapid rate of urbanisation, there is a very high percentage of transiting population who come and go out of the metropolis daily to trade, seek employment, transact government business, contact embassies, receive education, visit relatives, receive goods and family at the ports- sea and air- socialise or holiday etc. The sources are both from the country's hinterland as well as the West African sub region. According to LAWMA (1992, p.50) the figure in this category cannot be less than 398,000 people daily. These sets of people contribute in no small measure, to mountains of refuse in the state. Theirs is even more difficult to manage since the facilities do not exist to handle the wastes that are daily generated by this crowd.

As for the resident population there are over 400,000 properties in the city from within each of these properties wastes are daily generated, which should be collected to avoid any backlog. This was obtained during the property enumeration project undertaken as part of the World Bank projects for improved waste management services in the city. It was stated that the state has the highest number of industries in Nigeria. It is estimated that the area generates over 50% of the total industrial/commercial waste in the country. Presently, the Waste Management Authority services only 1,159 industries/commercial premises, which constitute less than 10% of the actual number of industries/companies in Lagos. There are more than 229 markets in the metropolis, all of which are points of high waste generation.

Another factor is lack of and/or improper planning. Most parts of metropolis are developed without a master plan. This led to poor/insufficient/ inadequate road network, poor road condition, and non-provision of space for waste collection operations. Presently, the trucks of the Waste Management Authority cannot gain access into 40% (LAWMA, 1995 p.30) of the inner parts of the city because the roads are too narrow, blocked and at times, are not linked with each other. Many roads are in various stages of disrepair.

Lack of proper drains makes most roads un-motorable during the raining season. Many people have also built shops, markets and houses on the truck paths that waste disposal vehicles therefore find it difficult gaining access to most houses/streets to pick up waste. Poor road network in most cases leads to a situation in which trucks spend more than five (5) hours in traffic hold-up during the day for a journey that might not ordinarily have exceeded one hour. This reduces the spate of work in waste collection.

Topographical factor has significant input. Lagos is located below sea level. Most times, when it rains, most areas are not accessible as flood takes over roads/streets and dump sites within the municipalities. The situation is even worse at the landfill sites, as they are not accessible during the raining season because they become waterlogged. During such periods, rate of refuse collection and disposal drops to about 10%-20% (LAWMA, 1995, p.31) of normal rate and the metropolis becomes littered.

Since most manufactured goods and foods are packaged, the fact that Lagos has the largest volume of importation, manufacture and consumption leads to high rate of waste generation in packages that are more than the rest of the country put together. This has significantly increased tonnage of waste collected daily. These wastes are in plastics, papers, nylons, metals etc of canned food, bottled water, domestic and industrial items.

Due to her large population large volume of agricultural products from the hinterland are brought to Lagos. This explains why at any given day there are over 20 trailers discharging food items packaged in high waste generating materials in various Lagos markets e.g. Ketu, Ikosi, Alaba etc. Also over 70% of livestock brought from the Northern part of the country and those imported into Nigeria from neighbouring countries like Niger Republic and Cameroon find their way into Lagos for sale and consumption. At least 30 – 60% of such agricultural goods end-up as waste to be collected and disposed.

V. Methodology: Archival Data Collection

The sources of data include secondary and primary, The secondary sources are LAWMA Planning Research and Statistics Dept, Consultants Reports: LAVALIN and Resource Consults, Reports of

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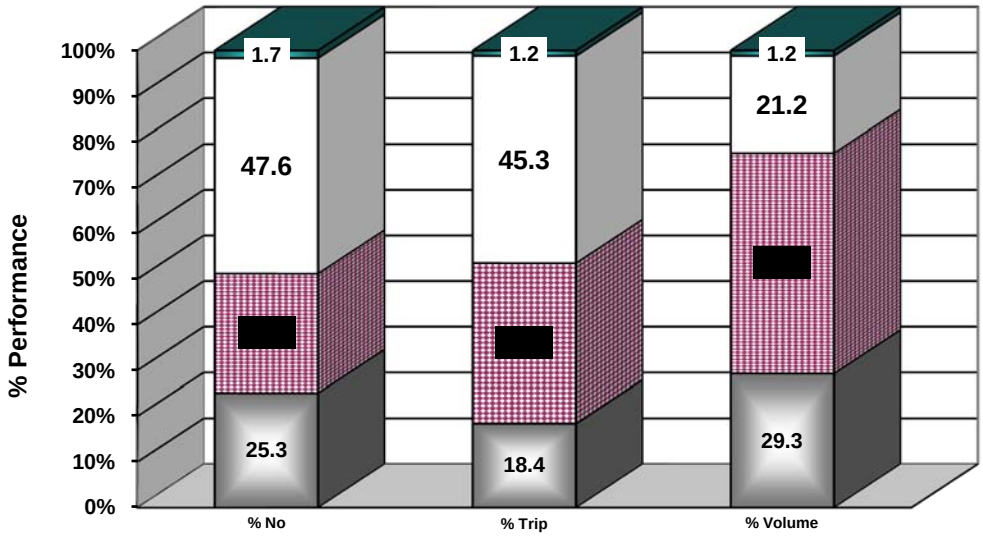
Commission of Inquiry, Academic journals and past research works, Task Force Reports while the fieldwork entail questionnaires, interviews, observations and measurements. Others are websites and Digital Libraries like Solid Waste Technology and Management: www.widener.edu/solid.waste, Recyclers World: http://www.recycle.net/recycle/index.htm/World Environmental Library 1.1, United Nations University Press: www.unu.edu.

VI. Findings and Analysis

The relevant institutions for analysis are The Highway Managers operating on major federal and state roads; LAWMA working on industrial and public spaces' Private Sector Operators focusing on domestic waste, the Cart Pushers and the scavengers operating from domestic front dumpsites. Highway Managers and PSP are the experiments in the involvement of private sector in waste collection.

The Relative Performances of the Waste Transportation Agencies



OTHERS	1.7	1.2	1.2
PSP	47.6	45.3	21.2
H MAN.	26.4	35.1	48.2
LAWMA	25.3	18.4	29.3

The study derived the daily basic waste collection parameters of the relevant waste collection agencies. The parameters are the number of vehicles available, their trip frequency, the capacity or the size of the vehicles. The major highlights are that in terms of the absolute number of vehicles PSP has the highest average of 97 on the road per day and this constitutes forty-eight percent of the total number of waste vehicles on the road in the study area. But a closer look at their vehicles reveals that 57% of this stock belongs to the small 5tonnes category. The second agency having the second largest number is the Highway Managers with an average of 55 vehicles on the road per day that amount to 26.4% for all. LAWMA came close in the third position with 52, which makes 25.3% of the stock of all the agencies. The least, as in all other respects, is the group classified as others.

On the relative number of trips, the most frequent again is the PSP with a frequency rate of 148 trips per day making 45.3%. The 5ton vehicle makes 90 trips out of this number. The Highway Managers came second with a daily trip frequency of 115. The utility vehicle of the Highway Manager is the 15ton, which made 84 out of the total trip of the agency thereby controlling 73% of the operational movements of the Highway Managers. The vehicle of the second choice is the 30ton making 24 (20.7%) trips daily. LAWMA came third with average daily trip frequency of 60, taking 18.4% of the share of all the trips made. The vehicle of choice for LAWMA is the twenty and thirty tons (Dino, Mammoth and DAF Trailers); 93% of its trips were made by the 20ton vehicle type.

The effect of the type of vehicle is reflected in the total volume of waste transported by the different agencies. While the PSP was leads in the number and trips made, the size of the vehicle of choice is very small such that the Highway Managers with less number of vehicles and trips collects the largest volume of waste daily. They are collecting 2,043 tonnes daily, which accounts for almost 50% of the waste being transported in metropolitan Lagos. LAWMA comes second with daily transportation of 1,243 tonnes of waste, which is about 30% of the total waste moved to the landfill sites. PSP collects 900 tons (20%) while the others were collect only about 1%. The waste transporters in order of capacity and delivery is first, the Highway Managers,

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second is LAWMA followed by the Private Sector Participant. There are some others but their input is marginal.

The findings on the relative performances of the different types of vehicles in the waste collectors' fleet show that the Vehicles of choice for the waste carriers in the study area are the 15, 20 and five tonnes size. The vehicle taking the biggest share is the 15ton size; it accounts for 31% of the total waste removals. Close to this is the 20ton size collecting 30%. In the order of weight transported, the other types of vehicles' share are 30ton, (19.4%) 5ton, (10.9%) 10ton, (4.8%) and 7ton (2.2%). The rest are collecting less than 1% each. The total daily waste collection capacity of all the waste collection agencies in metropolitan Lagos is 4,237 tonnes.

VII. Waste Generation and Collection Differentials

The average per capita waste generation in the area is estimated to be 0.53 kg. The 1991 Census put Lagos population at 5.68 million; the United State's Bureau of Census estimated the figure to 11.314 million. The United Nations projected the figure to be 12 million. From this the daily waste generation in the metropolis will be 12million x 0.53 = 6,360 tonnes.

Given the estimated collection capacity of 4,237 tonnes for all the agencies, the expected left over will be 6,360 – 4,237 = 2, 123. This will be the waste that ends up in unofficial dumpsites dotting the metropolitan landscape. Sometimes the PSP operators dump their collections in many of these places. The Cart pushers, due to their non- recognition have adopted these as the normal dumpsites. Majority of the households, in the city do not see any need for engaging a private collector who will be charging them fees what they believe they themselves can dump in the nearest swamp, open space, Lagoons, the Atlantic, Creeks, roadsides and road junction.

VIII. Conclusion and Recommendations

Given that the private sector which comprises of the highway managers and the PSP collected more than 70% of the waste volume even in the experimental stage is a pointer to the potential of this sector as a strong ally and a more efficient one at that. The LAWMA which is the government agency could only collect less than 30%. It is therefore suggested here that the solution to the problem of waste disposal in urban centres of the country-and equally likely in other cities of developing countries-is the involvement of the private sector participant. However the following suggestions should be noted on the part of the relevant supervising government agency. There should be appropriate legal framework and enforcement to address fee collection for the private operators. There should be adequate provision of basic infrastructure like the landfill site and transfer loading station. Public enlightenment campaign is required to carry the populace along on such concomitant issues like payment modalities, sorting and the general policy thrust of government. It is important to grant the scavengers and cart pushers official recognition and create a niche for them in the scheme. And there should be continuous monitoring and evaluation to accommodate the changes that will necessary occurs overtime.

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Landsat ETM-7 for Lineament Mapping using Automatic Extraction Technique in the SW part of Taiz area, Yemen

By Anwar Abdullah, Shawki Nassr & Abdoh Ghaleeb
Taiz University, Taiz, Yemen

Abstract - The application of remote sensing technology may cover many fields of studies, especially in structure geology, and mineral exploration, where the remote sensing is a useful for lineaments and structure features extractions. Landsat ETM-7 satellite data were used and band -5 was found as the most suitable band in automatic delineation. The automatic lineament extraction process was carried out with LINE module of PCI Geomatica V9.1 based on automatic detection algorithms (canny algorithms). The comparison of the autom-atic lineament extraction and the published fault maps of the area in terms of total length, number of lineaments and directions. The number and the total length of the lineaments using automatic method were found to be more than the number and the total length of the faults in the fault map. The directional analysis of the automatic lineament map was done with the reference of fault map of the area and the structure features measured in the field.

GJHSS-B Classification : FOR Code : 291099, 291003



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Landsat ETM-7 for Lineament Mapping using Automatic Extraction Technique in the SW part of Taiz area, Yemen

Anwar Abdullah [α], Shawki Nassr [σ] & Abdoh Ghaleeb [ρ]

Abstract - The application of remote sensing technology may cover many fields of studies, especially in structure geology, and mineral exploration, where the remote sensing is a useful for lineaments and structure features extractions. Landsat ETM-7 satellite data were used and band -5 was found as the most suitable band in automatic delineation. The automatic lineament extraction process was carried out with LINE module of PCI Geomatica V9.1 based on automatic detection algorithms (canny algorithms). The comparison of the automatic lineament extraction and the published fault maps of the area in terms of total length, number of lineaments and directions. The number and the total length of the lineaments using automatic method were found to be more than the number and the total length of the faults in the fault map. The directional analysis of the automatic lineament map was done with the reference of fault map of the area and the structure features measured in the field. The results show extremely major trends in NE-SW. The pattern of the lineaments extracted from Landsat data suggests that some faults belonging to the Fault Zones were properly identified using this technique in the study area.

I. Introduction

In recent years, remote-sensing has been increasingly used for obtaining geoscientific data for both regional and small scales of investigations. Landsat Enhanced Thematic Mapper plus (ETM+) data in digital format were preferred data due to the availability of seven bands ranging from visible to mid-infrared with 30 m spatial resolution, and one thermal band with 60 m spatial resolution, this permitted a large spectrum of band combinations, useful in visual interpretation of different features. Studies of linear geologic features (lineaments) of both local and regional significance have been progressing rapidly. Lineaments have long attarcted the interest of field geologists with remote sensing satellite imagery that the character and extent of these features have been realized, and lineament analysis of remotely sensed data, either by visual or automatic interpretation, is a valuable source of information for studying the structural setting. A lineament is any extensive linear surface on a planet, as a fault line or fracture line. The term "lineament" is one of the most commonly used terms in geology. Hobbs [1] first used the term lineament to define a "significant line of landscape within basement rocks. O'Leary et al. [2] described the term lineament as a mappable simple or composite linear feature of a surface whose parts are aligned in a rectilinear or slightly curvilinear relationship and which differ from the pattern of adjacent features and presumeeably reflects some sub-surface phenomenon. The purpose of this study was to test the automated lineament extraction method for detecting the lineaments over the study area, and to investigate the ability of this method in giving real results compared to the fault map.

Figure 1, shows the study area is located in the western part of Taiz state and extend between Jabal Habashi and Turbah Mawaset. It includes the highest mountains, about 2800m above the sea level.

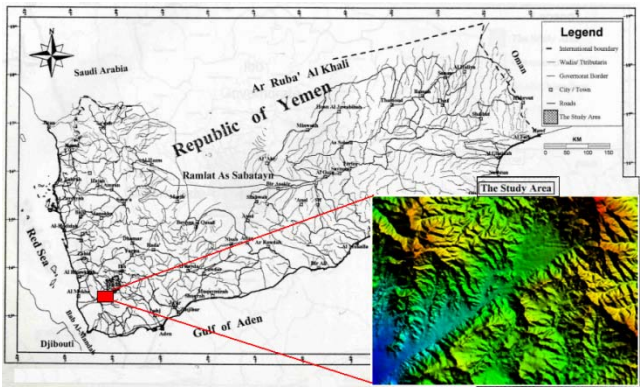

Figure 1 : Location of the study area

According to GSY [3] classification, the rocks in the study area divided into three groups as follows:

1. Proterozoic sediments (Paragneiss meta-sediments)
2. Mesozoic sediments (Cretaceous sandstones beds)
3. Cenozoic rocks (Tertiary Granitoid intrusives and volcanic rocks)
4. Recent sediments (Quaternary alluvium sediments)

The structural map of the study area (Figure 2) was digitized from geological sheet map of Taiz with scale 1:250,000.

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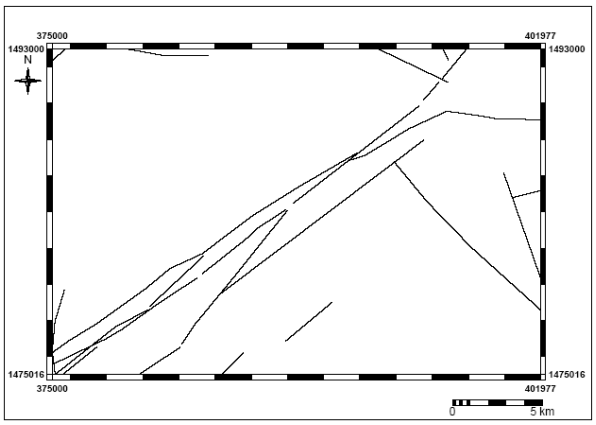

Figure 2 : Fault map of the study area

II. Materials and Methods

There are several techniques that were developed for determine the linear features and geomorphologic characteristics of the terrain. According to this paper the automatic lineament delineation was based on decision of the most appropriate band for edge enhancement, followed by edge sharpening enhancement technique which gives the best result of lineaments that are not delineated by human eyes, and apply LINE module of PCI Geomatica V9.1 for recognized lineaments. Landsat ETM-7 satellite data were used and the first step was to select the band that should be used for lineament extraction (Süzen and Toprak [4]; Madani [5]). Visual inspection of the individual bands was carried out, based on the ability to identify features, and band 5 (1.55 - 1.75 μm) (SWIR) was selected and it was stretched linearly to output range 0 to 255 (Figure 3). The second step was to select the filter type. For this purpose, different types of filters are tested. Edge sharpening filter was the best which convolved over band 5. Edge sharpening enhancements make the shapes and details for analyses (Richards [6]). Edge sharpening was applied using PCI Geomatic software package. And finally the final image of the study area was used for automatic lineament extraction. According to Abdullah, A et al. [7], the lineament extraction algorithm of PCI Geomatica software consists of edge detection, thresholding and curve extraction steps. These steps were carried out over band 5 image under the default parameters of the software as follows:

RADI = Radius of filter in pixels, GTHR = Threshold for edge gradient, LTHR = Threshold for curve length, FTHR = Threshold for line fitting error, ATHR = Threshold for angular difference, and DTHR= Threshold for linking distance (PCI Geomatica [8]).

According to the six parameter above. Several lineament maps were generated using different threshold values. The most suitable threshold values were selected (below) considering these lineaments as fault lines. General properties of faults were taken into consideration such as the length, curvature, segmentation, separation and so on in order to determine the threshold values. The parameters in this application are selected as follows:

•RADI=12, •GTHR=80, •LTHR=30, •FTHR=10, •ATHR=30, •DTHR=15.

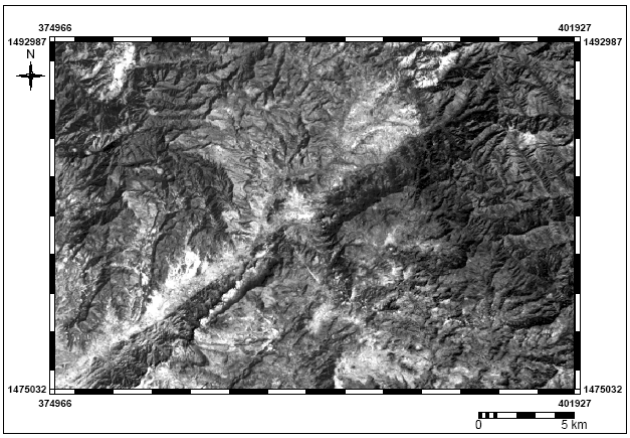

Figure 3 : Band 5 of Landsat ETM-7 after contrast enhancement

III. Results and Discussion

Lineament maps are generated using different values. The most suitable values were selected as mentioned in the above section considering these lineaments as fault lines (Figure 4). In order to test the ability of this method to extract the lineaments. The results obtained from automatic lineament detection need to be checked (Abdullah, A et al. [9]). For this purpose, the fault map of the study area was used in this work.

As seen in Table 1, it was noticed that the automatic lineament map has the higher lineaments number compared with the fault map. The highest score of the lines number was recorded in the automatic lineament map as 362 and whereas the lowest score of the lines number was recorded in fault map as 25.

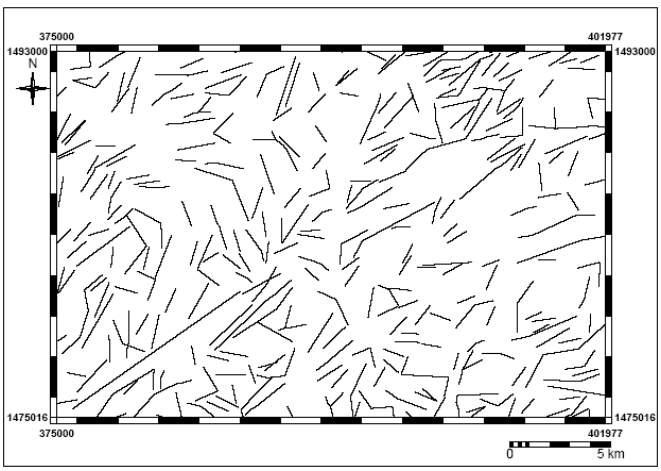

Figure 4 : Automatic lineament map over the study area

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Table 1: Basic statistics of the automatic lineaments map and fault map

Variables	Fault map	Automatic lineaments map
No. lineaments	25	362
Max. length (Km)	21.345	17.05
Min. length (Km)	0. 711	0.855
Total length (Km)	154.590	539.815
Avg. length (Km)	6	1
Std. length (Km)	4	0.8

The total length of lineaments was (539) km for automatic map, and (154) km for fault map. And the average length of lineaments was (1) km for automatic map and (6) km for fault map. The total length of lineaments was 539 km which was the highest value. The maximum length of lineaments was (17) km for automatic map, and (21) km for fault map. And the minimum length of lineaments was (0.855) km for automatic map, and (0. 711) km for fault map.

The number and the total length of the lineaments using automatic method were more than the number and the total length of the faults in the fault map. This result was possibly due to the fact that the automatic lineament extraction method approach does not discriminate man made features during the analysis, as well as the automated lineament extraction method was worked successfully over the hilly area (topography might be the main reason for this problem which was eliminated in the data bands and easy to extract by using automatic method). This leads to increases the total number and length of the lineaments.

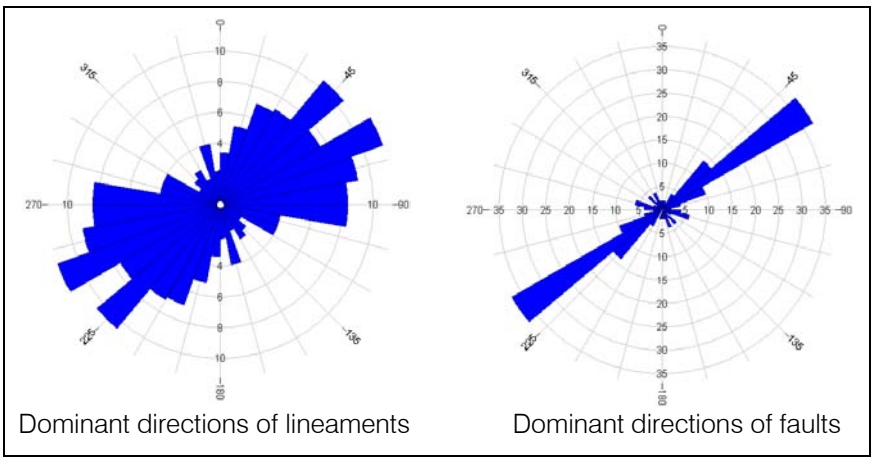
The most important factor for this was that the lineaments in an automated one were shorter in length so that a few of them could be combined to form one long lineament.

The orientations of lineaments and faults lines were created by using rose diagrams (Figure 5) and the results mostly showed great similarities. The main trends observed in the structural truth map (fault map), field features and the lineament map could be recognized in these diagrams, showing strongly major trend in NE-SW, and the subdominant directions were in E-W, NW-SE and N-S. All these lineaments directions were coincide with the major faults directions.

Generally, the pattern of the lineament maps extracted from Landsat ETM-7 data suggests that some faults belonging to the some areas were properly identified in the study area. Lineaments in other parts especially in the central and southern sections display a typical pattern of the faults such.

There were some of lineament lines in the lineament map could not matched any fault line in the output map of the fault map, also there were some fault lines in the fault map could not matched any lineament lines in the lineament map. This means the algorithm of the automated lineament extraction method does not work successfully to identify all the linear features existing in the area, and it needs some mathematical enhancements and applying it with different satellite images, different resolutions, and different geological environments. Anyhow, this technique may be still a good technique in the moment but, expert knowledge is always required to evaluate the extracted lineaments.

Automated methods require an inordinate amount of computer processing of the image and adequate algorithms for lineament identification which at the present time are still being develop and would still not produce an accurate map devoid of cultural effects. This means that the machine method still requires some interaction to eliminate cultural effect.



Dominant directions of lineaments Dominant directions of faults

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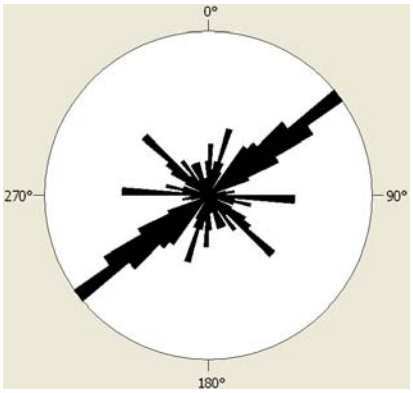

Dominant directions of features measured in the field

Figure 5 : The dominant directions of lineaments, faults and field features

IV. Conclusions

Landsat (ETM-7) imagery has higher spatial resolution (30 m) was providing us a powerful for lineament study and analysis especially in the semi arid area. The image enhancement was one of the useful tools to improve the interpretability or perception of information in images for human viewers, or to provide better input for automated image processing techniques, one of those enhancements is edge sharpening enhancement technique for enhancing the edges in an image. Automatic lineament delineation was developed for minimizing the power and saving time. Whereas, non-geological and artificial lineaments may be added to the final lineament map due to the nature of algorithms used. Automatic methods needs advance mathematical algorithms and proved this enhancement by applying it with different satellite images, different resolutions, and different geological environments to improve this technique.

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29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

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Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.



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An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.



- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
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This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

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- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

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The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.



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Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
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The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

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- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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