Vegetation Change as an Indication of Climate Change: The Case of Butana, Sudan

A.D. Awad Ibrahim Abdel Rahman El-hafian

Faculty of Geographical and Enviromental sciences - Khartoum university Sduan

المستخلص:

يبرز البحث حساسية النبات نحو التغيرات المناخية كأحد مكونات أي نظام بيئي. اعتمادا على هذه الحقيقة يتجه البحث نحو توضيح العلاقة التشريحية، من جهة، والعلاقة الإيكولوجية بين التغير البيولوجي (النباتي) و التغير المناخي، من جهة أخرى. و قد تم اختيار منطقة البطانة في وسط السودان كمسرح لاختبار هذه العلاقة. و يهدف البحث إلى وضع نموذج متكامل للعلاقة بين التغير النباتي (الإيكولوجي) و التغير المناخي. وقد تم اختيار هذه المنطقة تحديدا حيث تظهر مبررات الدراسة بوضوح؛ فهي منطقة ذات أهمية اقتصادية في السودان من حيث احتضانها لأكبر مرعى طبيعي و معه ثروة حيوانية ذات وزني اقتصادي هام، كما إنها منطقة ذات تباين مناخي واضح بين أجزائها المختلفة، إضافة إلى موقعها الوَسَطي في السودان. كل ذلك مما يؤهلها لاختبار فرضيات البحث. و يعتمد البحث بدرجة أساسية على المعلومات التي جمعت من مصادرها الأولية من خلال البحث الميداني حيث تم اخذ العينات النباتية و عينات التربة، من اجل تحليلها بطرق و أساليب شتى، منها المختبري ومنها الإحصائي، وغيرهما، إضافة إلى جمع المعلومات المتاحة من محطات الرصد المناخي المتوفرة في المنطقة. كما أن المعلومات من مصادر الدرجة الثانية، مثل الخرائط و الصور الجوية و التقارير الحكومية الرسمية؛ و مصادر الدرجة الثالثة من كتب منشورة و غيرها، تمثل مصادر مكملة لما تم تجميعه من معلومات من المصرين المذكورين أعلاه. و يتوقع أن يتوصل البحث إلى نتائج هامة حول اعتبار التغير النباتي مؤشرا للتغير المناخي، و ذلك وفق المحددات و العلاقات و العوامل التالية التالي:

1. العلاقة بين التساقط المطري و عاكسية سطح الأرض (الألبيدو)، و التي فيها يلعب النبات دورا هاما، إن لم يكن أساسيا.
2. العلاقة بين رطوبة التربة والتساقط المطري، من جهة، ثم العلاقة بين انجراف التربة و كل من رطوبة التربة والغطاء النباتي، من جهة أخرى.

3. العلاقة –أو المؤشر النباتي لتغير خطوط المطر المتساوي.

Soudao region

وعلى ذلك، يتبع البحث منهجا بيئيا (إيكولوجيا) تحليليا لتتبع و تحليل العلاقة بين التغير النباتي و التغير المناخي في منطقة الدراسة. وتتبع ترفع من قدره هذا المنهج التحليلي عدة أساليب بحثية :

أ. أسلوب التحليل الإحصائي.

ب. أسلوب التتبع الزمني لرصد التغير الزمني (التاريخي) لكل من الغطاء النباتي والمناخ في منطقة الدراسة.

ج. سلوب الرصد المكاني بغرض معرفة التباين المكاني بين درجات التغير النباتي و المناخي، وذلك مما يجعل تحليل مشكلة البحث أكثر عمقا.

Vegetation Change as an Indication of Climate Change: The Case of Butana, Sudan

Key words: Climate Change- Floristic Composition- Albedo– SoilMoisture- Isohyets.

Synopsis:

As climate changes, the natural vegetation must also change, and vise versa. Climate is always shifting and this is not, therefore, a new process: What is new is that much of the earth is now a garden, with its vegetation controlled not only by natural processes but by the design or accident impact of humanity. On the other hand, plant is a crucial component of any ecological system. Butana is chosen as a research area to test the research hypothesis and to accomplish the research rationale, due to its both geographical location, and physical and economic eminence. Based on this, the paper aims at finding and assessing the relationship between shrubbery changes and climate change in Butana area, Sudan. Such a relationship will be modeled in a form of paradigm for different purposes.

The research is approached by an ecological contemplation. Such an approach necessitates that both temporal (timely) and spatial. It pursues an analytical method that relies mainly on primary data collected from its original sources. Such sources are supplied by other secondary and tertiary sources. Secondary sources

include official reports and statistics, maps, satellite imagery and air photos; while tertiary sources refer mainly to both published books and research. Climatic data are collected from metrological stations in the research area, as well as from other official anon-official reports. This is beside that plant and soil sampled information are collected through fieldwork survey, and are all scrutinized in different ways.

The Research has reached some outstanding results pertaining to the following in the context of the shrubbery changes as an indication of climate change:

♦ The association between albedo and rainfall is crucial in understanding the relationship between vegetation changes and climate change.

♦ The association between soil moisture and rainfall, on one hands, and between soil erosion and both plant cover and soil moisture, on the other, is essential in understanding the relationship between shrubbery changes and climate change.

♦ There is a connection between vegetation aspects changes and isohyets changes.

Introduction:

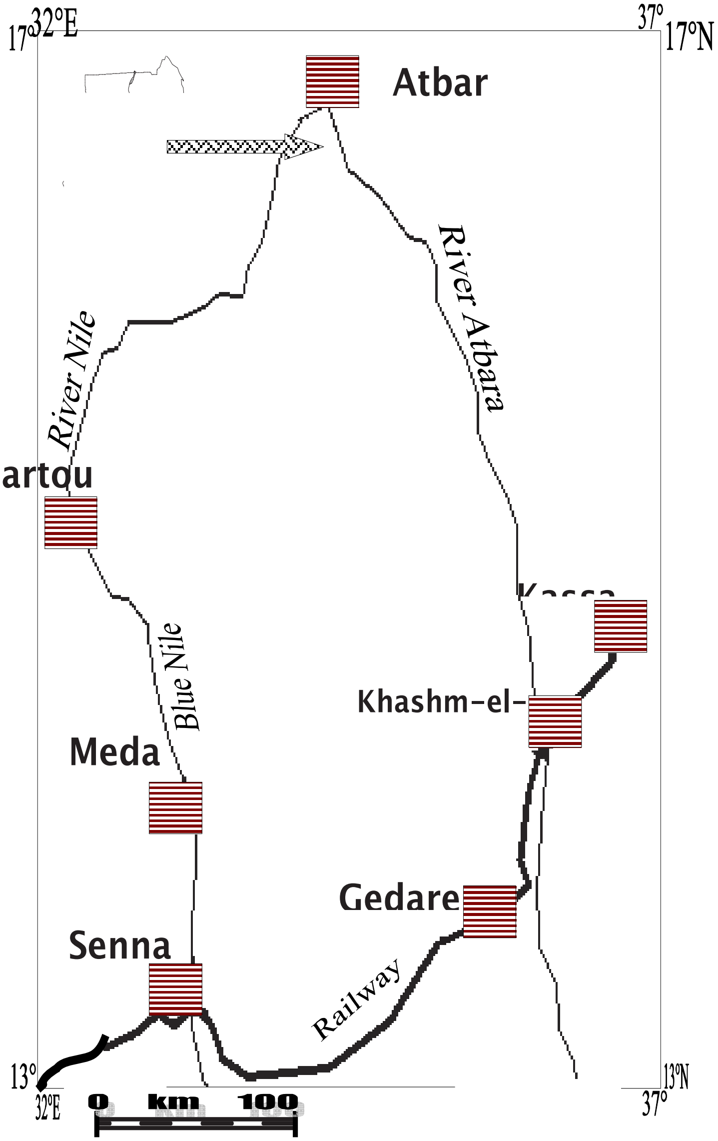
Generally speaking, climate change means, due to the researcher viewpoint, is that change which is due to man activity, and which means quantitative and qualitative modification of climate components, i.e. rainfall, temperature, air pressure and wind systems and air humidity. Symptoms of such a change include:

- short winter,
- long summer,
- desertification,
- wind storms,
- polar glaciers melt, forest fires, and
- repeated climatic phenomena.

The research area, i.e. Butana, is a savanna semi arid region that is quite liable to climatic variation. It is located between 13°35´N and 15°35´N latitudes; and 33°20´E and 36°E longitudes. It is bound by the Blue Nile, on the west, and Atbara River, on the east, and railway line on the south (Fig. 1). Climatologically, the area is classified as a semi-arid region on the basis of Thornswaite formula. It is part of the Sahelian zone, that extends between latitudes 12°N and 16°N, and which is typified by a savanna climate prototype.

As nomadism is the dominant type of economy, human pressure on natural vegetation is though as a main cause of fauna degradation in Butana (Gordon, 2000). "*Although grazing is primarily an issue arising from the pressure of introduction of new species to the land, overgrazing also has the potential to completely remove ground cover*" (Alredaisy, 2011, p. 184). In other areas, human influence signifies a decrease in biomass of vegetation as a result of collecting wood for fuel and other domestic uses. Accordingly, bush land appears to be expanding with the same trend at the expense of richer ecosystems. Several researchers (Ayoub, 1999) blamed agricultural intensification for resulting in the loss of natural grassland and ecosystems, as well as in substantial losses in biodiversity. Then, anthropogenic impacts are mainly to be blamed for the damage and destruction of the natural habitat in the research area.

Fig.(1): The Research area :



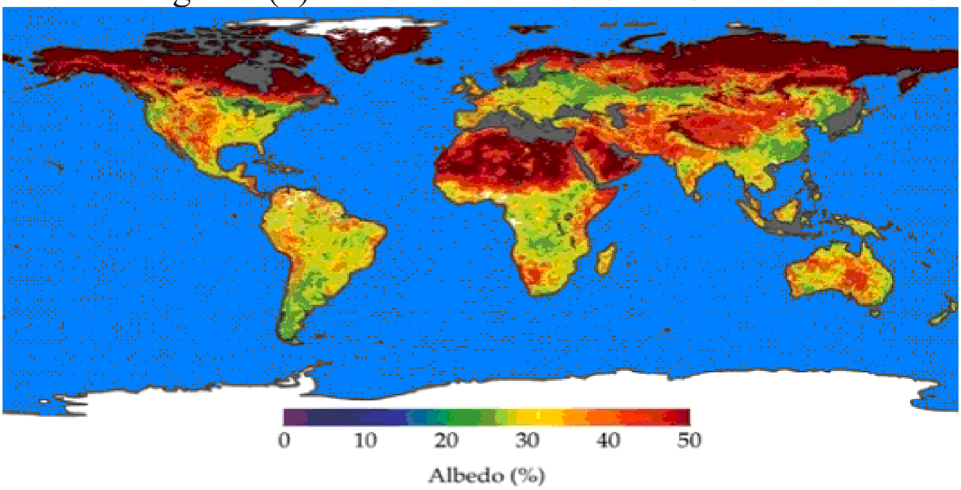
The dominant Vegetation type is acacia trees, shrubs and ephemeral grasses. It is composed mostly of the *mimosaceane* family. It is a vegetation type that is adapted to the type of climate that is dominant over the region. Also, such a type of vegetation is expansively varied spatially according to soil type, rainfall amount and human effects. Human effect is evident knowing that Butana area is one of the main nomadic areas in Sudan, relying solely on natural pasture. The last few decades trend has been inclination towards commercialization of nomadic economy. Animal is now raised as a capital wealth, rather than for social prestige, as it used to be. This is enhanced by inducing capitalist agriculture in the vicinity of the nomadic economy, as in the Gezira, Rahad, and Khashm-el-Girba irrigation schemes. This is in addition of the growing urban centers within and by the environs of the area. However, some speaks about growing landlordism among tenants of these schemes (Arifi, 1978). Such a transformation surely relied on the price to be paid by the Butana ecosystem. Alredaisy and Zubair (2011) point to the fact that the ecosystem carrying capacity, in the research area, was adequate to support natural vegetation up to the year 1900, when human exploitation of vegetation balanced its natural growth. It seems that such a misbalance started since then reaching its maximum by early 1970s. Although Most of the literature discussion focuses on deterioration due to both human pressure and climate change, yet, rainfall variability, by that time was the engine that has been driving such an ecological disequilibrium. This is why vegetation Change is considered as a salient indication of Climate Change in the research area.

Generally, vegetation change happens due to one or both of two reasons: either failure of adaptation or extinction. Regarding the first reason, and as the savanna is the ecoregion of the acacia type of vegetation, generally adaptation depends on rainfall amount, temperature, topography and soil type. Actually, all these adaptation factors are intermingled. This means that change of either of them is reflected on the others. In Butana, ephemeral grasses and short-lived shrubs, together with acacias are dominant. They are truly adapted to both astronomical and physical locations of the Butana region. Usually, this vegetation grows within the range of 200-600 mm amount of rainfall, with different means and procedures of adaptations. They have tailored to climatic changes, especially rainfall variability and change. Indicators and vectors of such an adaptation lies on small, spiny leaves, with waxy, and other, strata to help them reducing evapotranspiration and excess sun heat. Other means of adaptation include contorted trunks, to reduce water loss, and intense and extensive root system to obtain and soak up as much water from soil as possible. Then the mode and strategy of adaptation are a good and salient indicator of the relationship between Vegetation Change and climate Change in Butana area.

Albedo

Rainfall amount in any area is bound by all astronomical, geographical and geomorphologic locations. But in all these cases, earth albedo in the area, as determined mostly by land cover, is a crucial factor that determines both incidence and intensity of rainfall. The term albedo (Latin for white) is commonly used to apply to the overall average reflection coefficient of an object. An ideal white body has an albedo of 100% and an ideal black body has an albedo of 0%. The albedo of a body or surface is the ratio of reflected radiation to incident radiation. This ratio depends on many factors. In general, the earth's surface reflects only a small part of incident radiation. But plants can vary their reflectivity: For example, the albedo of the Earth is 0.39 (Kaufmann and this affects the equilibrium temperature of the Earth. Also, as the vegetation of the planet changes, so does the albedo. When it is said that albedo is determined by land cover, this pertains mostly to the type of vegetation and ecosystem. The unrefined connection between rainfall incidence and albedo is manifested in that the higher the albedo of the area, the lower the amount of rainfall is expected. Usually the albedo of an area indicates higher temperature in the troposphere. Such a high temperature retards vapour condensation in the atmosphere, which, in turn, retards cloud formation and precipitation. As dim surface tends to absorb heat, it then controls albedo; and vise versa for lighter surface. Then, in the case of dim surface, e.g. forests, it is expected to have more precipitation than in light surface, e.g., deserts. The analogy here is that the more vegetation covering the earth surface, the more precipitation to be expected, and vise versa: As heavy rainfall causes dense vegetation, also denser vegetation is a crucial factor of heavier rainfall.

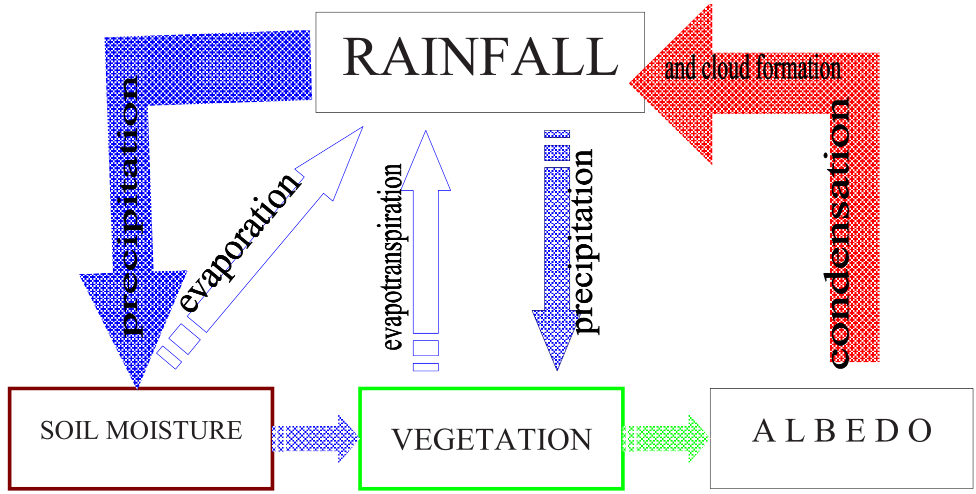
Fig. (2): The Albedo of the world



Soil moisture is a very good indication of plant cover density in any area.

It is understood that, generally, rainfall is a result of sun's energy transferred to ocean surface water to be evaporated and enter the atmosphere as a gas, i.e. water vapour. When it loses this energy, it falls to earth surface in a form of precipitation. Added to ocean source of water vapour is the evapotranspiration from the biomass. This last source plays a crucial role in the hydrological cycle enhancing fresh water being perpetual on the earth planet through precipitation. It is intended here to raise the role of Vegetation in this cycle. Actually, an intermingled quadruple relationship to be analyzed in this regard: rainfall, soil moisture, vegetation and albedo (Fig.3).

Fig. 3: A Quadruple Relationship among Rainfall, . Soil Moisture, Vegetation and Albedo



OURCE: The Research Theoretical Setting.

SOURCE: The Research Theoretical Setting.

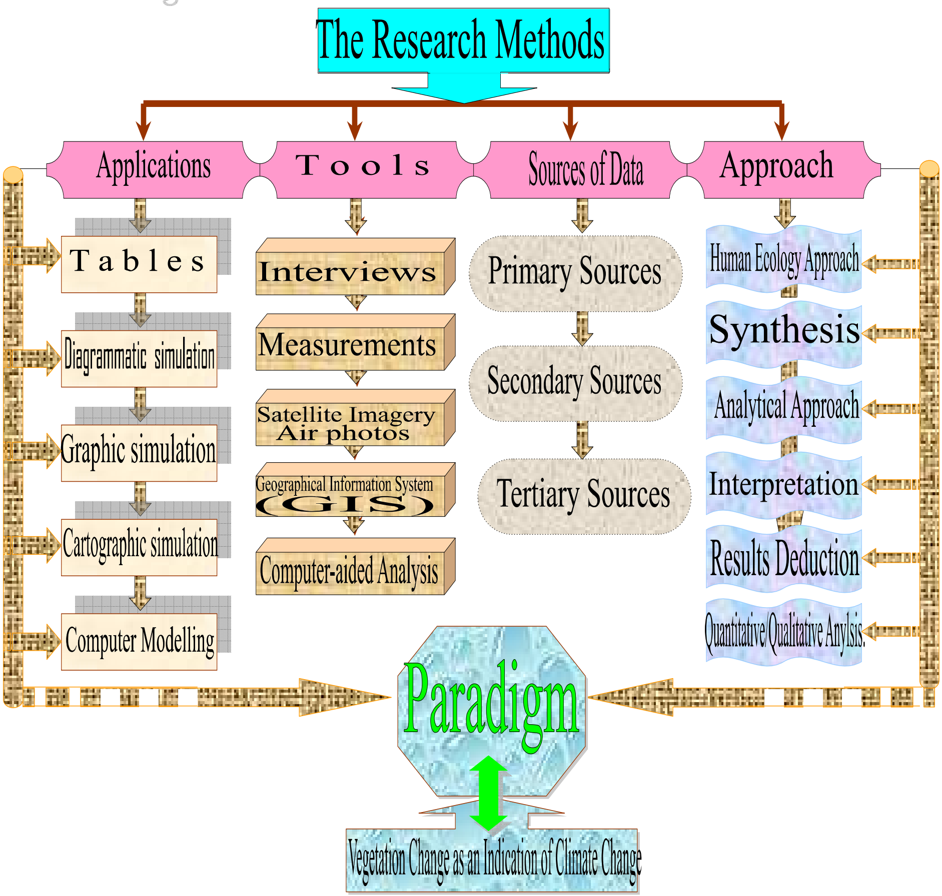
Such a relationship is manifested, within the framework of the research problem, in that rainfall, a main element of the climate, is controlled, at least partially, by vegetation cover. Such a control is understood from the viewpoint that albedo is controlled by the vegetation cover of the area through controlling earth surface reflectivity, while albedo controls vapour condensation and, consequently, cloud formation, through controlling upper troposphere temperature.

Methods and Data Sources:

A generalized framework of the research methodology is outlined in Fig. (4): A regional, analytical approach has been followed in the analysis of the collected data. Both the topic and area of the research nictitates an intensive fieldwork to collect the appropriate data. After Clarke (1954), Hills (1966), and Walton (1979), the researcher has to classify, in the first instance, the vegetation cover into different classes: succulent perennials, non-succulent perennials, and evergreen. In the second instance, the research area has to be classified into sub-regions, i.e. zones, mainly, in correspondence with the isohyets, together with other geographical and ecological features (Fig.5). Also, all the plant density, frequency, abundance and coverage are counted up and construed for the sake of assessing change. At the same time, climatic data, especially rainfall data, are analyzed and interpreted. Both botanical and climatic data are put into synthesis to attain the main goal of the research: Vegetation Change as an Indication of Climate Change. This necessitates that the plant condition, to be surveyed also. Accordingly, field observation involves deducting symptoms of certain soil components deficiency, or otherwise superfluous, syndrome on plant. As such, main fieldwork job has been to:

- measure macronutrients from air and water to plant.
- assess micronutrients from soil to plant.
- deduce symptoms of certain soil components deficiency, or otherwise superfluous, syndrome on plant.
- quantify and assess plant productivity per land unit.

Fig. 4: The General Research Methods



PRIMARY SOURCES: Basic Field/lab work data.

SECONDARY SOURCES: Reports, Maps, RS, Air photography ...etc.

TERTIARY SOURCES: Published Books.

Accordingly, the research main foci would be:

1. Plant change by zone through time.
2. Climate change, as indicated by rainfall amount change.
3. The effect of climate change on plant change and vise versa.

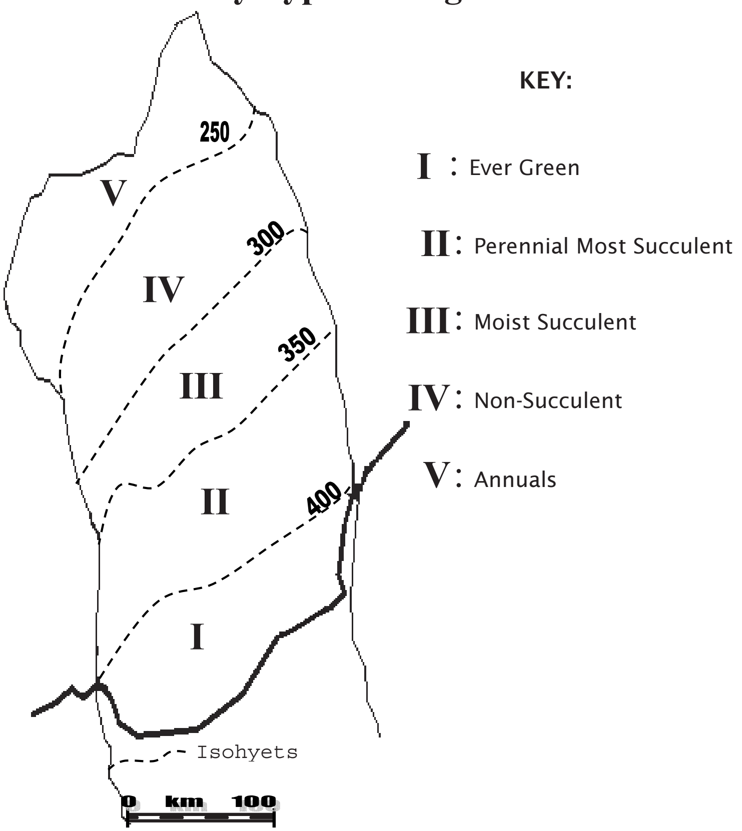
Other factors that enhance the process of plant and vegetation change in the area.

Analysis:

Rainfall effect on vegetation is threefold: type, density and diversity. In case of type, it is well known that the more the amount of rain the less dominant is the acacia of tree, and vise versa. In the case of density, the more the amount of rainfall, the more dense is vegetation cover, and vise versa. Also, rainfall affects natural diversity in the sense that the more amount of rainfall the more diverse is the plant cover, and vise versa.

On the other hand, vegetation cover affects rainfall incidence and amount, as elaborated above. Such a bilateral relationship is the theoretical setting on which the discussion is built.

Fig. 5: Dominance of Vegetation in the Research area Zones by Type During Wet Years



Source: Fieldwork data. and others

Table (1): Sample of The Most Dominant Type of Vegetation in Each Zone as in Fig.4:

Zone	Type 1: Ever Green	Type 2: Succulent	Type 3: Annuals	Type 4:Grass
I	Samur: *A. tortillis*	*Sunut: A. nilotica*	Haraz: *A.albida*	Bous: *D. glaucum*
II	Taleh *A.seyal*	Haraz:*A. albeda*	Hashab: *A. seyal*	SanaMecca: *C. senna*
III	*Sarah: M.crassifolia*	Laaot:*A. nobica*	Sydir: *Z.S. Christi*	Gao: *Aristida spp.*
IV	Ushar: *C. procera*	*Higlig:B. aegyptiaca*	Tundub: *C. deciduas*	Huskaniet: C. catharticus
V	--	--	Ushar: *C.procera*	Draisa: *T. terrestris*

Source: Fieldwork Data, and Others.

Table (2): Type of vegetation in each zone by Size (% From Sample) as in Fig.4

Zone	Type 1: Ever Green	Type 2: Succulent	Type 3: Annuals	Type 4:Grass
I	29.3	29.8	12.8	28.1
II	16.2	34.5	21.7	27.6
III	15.7	28.6	18.2	37.5
IV	11.6	27.1	21.7	39.6
V	--	--	32.4	67.6
500	72.8	120	106.8	200.4

Source: Fieldwork Data, and Others.

Table (3): Type of vegetation in each zone by Size (% From Sample) as in Fig.4

Zone	Type 1: Ever Green	Type 2: Succulent	Type 3: Annuals	Type 4:Grass
I	29.3	29.8	12.8	28.1
II	16.2	34.5	21.7	27.6
III	15.7	28.6	18.2	37.5
IV	11.6	27.1	21.7	39.6
V	--	--	32.4	67.6
500	72.8	120	106.8	200.4

Source: Fieldwork Data, and Others.

Results:

The attribute of each vegetation type is subtracted from its natural ecosystem, part of which is rainfall amount. Dominant vegetation type in each zone of the research area (Table 1) clearly proves this fact. It is to say that:

1. In zone I, which is the most wet zone, composition of natural vegetation is as follows:

•Succulent is the most dominant type of vegetation (29.8 %), followed by Ever Green trees (29.3 %).

•Annuals are the least dominant type of vegetation (12.8 %), followed by Grasses (28.1 %).

2. Such a composition goes in an opposite sequence in other zones. This is a clear evidence of some relationship between rainfall amount (being wet zone) and vegetation.

3. Annuals are the most dominant type of tree in all zones, although at different percentages.

4. Both ever green and succulent types of tree are now absent in two zones. Evidence proves existence in some earlier

times. Plant extinction or climate change could be a reason for non-existence in these two zones.

5. Grass is the most dominant type of vegetation in the whole research area , pointing to high ecological vulnerability.

When correlating these facts with isohyets, it is clear that there is a positive correlation: the higher the density of vegetation cover the higher the amount of rainfall in a zone.

Discussion:

To start the discussion, it is worth mentioning that the UN Convection to Combat Desertification-UNCCD, 1992, defined desertification as "*Degradation of land in arid, semi-arid and dry sub-humid areas. Desertification occurs in arid, semi-arid and dry sub-humid areas, where the soils are especially fragile, **vegetation is sparse** and the **climate** particularly unforgiving*".

Such a connection between land degradation and both climate and vegetation notifies the research main theme: *vegetation change as an indication of climate chang*e. Then, effect of plant on climate could be understood through the following:

- Controlling Co_2
- managing Albedo
- boosting or otherwise, diminishing pollution
- Humidity (water vapour in the troposphere).

As such, vegetation cover change restrains or, otherwise, reduces rainfall amount in the area through controlling albedo, both at the levels of micro and macro climates. At this juncture, it is better to view this point at the level of the whole research area stemming from spatial reduction of rainfall at local levels. I.e. *in-situ*. Both UNEP and WMO (2004)view the climate change indicators as follows:

- Higher temperature, waves of higher temperature and more hot days.
- More dry days during summer –rainy season- and conquest droughts.
- Severe drought incidences.
- More summer storms and floods, especially under Nino effect.
- Besides, rainfall change in the research area is noticed through rainfall variability, as shown in Fig. (6):

Fig.6: Change Of Rainfall Regime In The Research area During Two Periods: 1920-1970/ 1971-2010

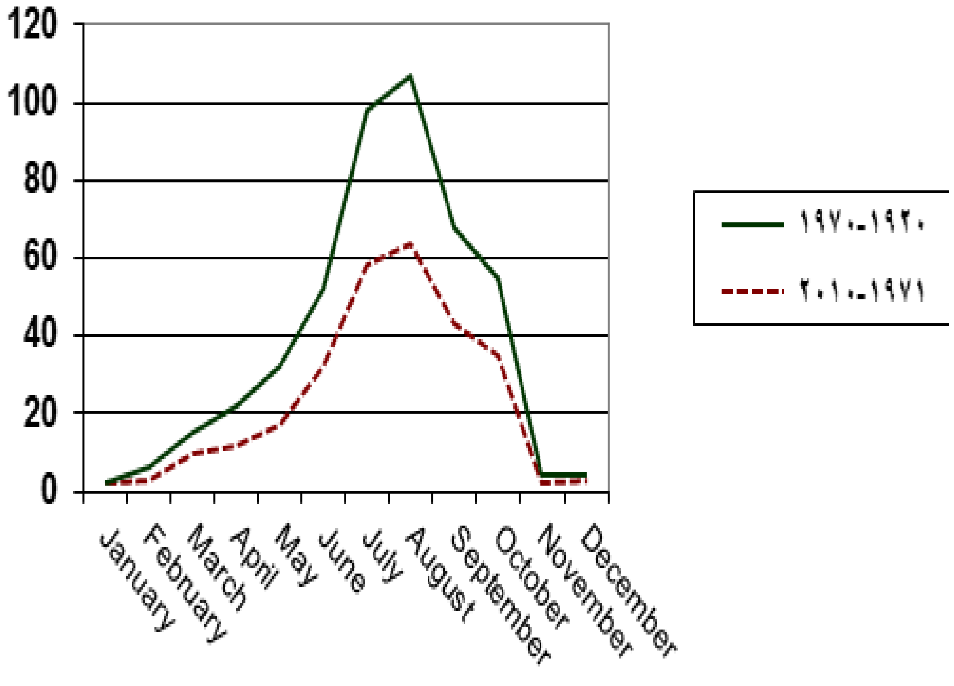
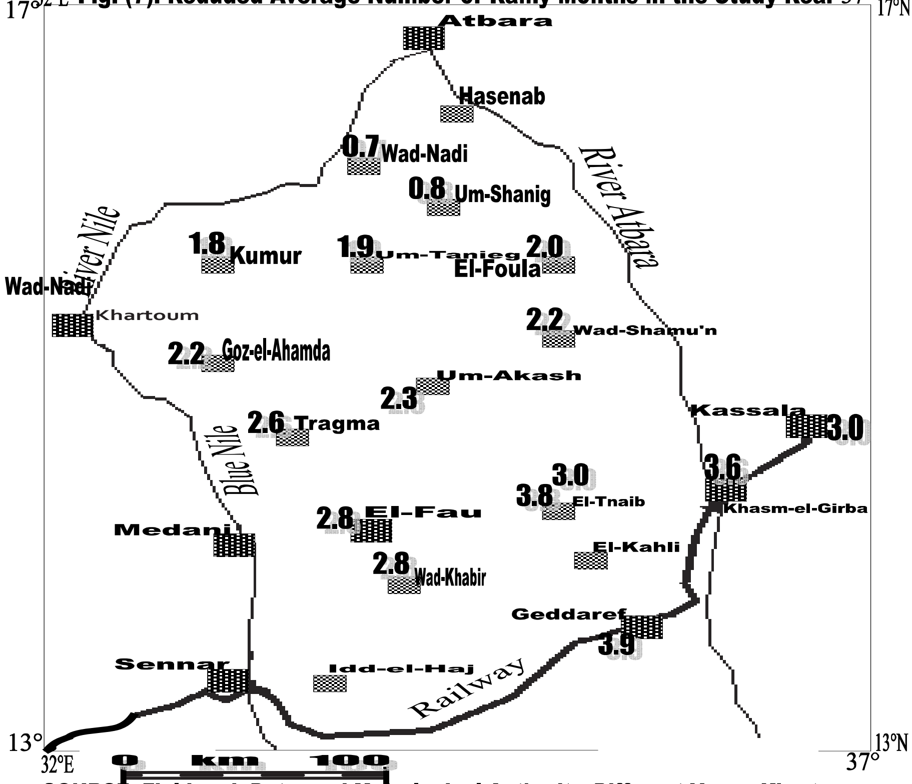


Fig. (7): Reduded Average Number of Rainy Months in the Study Rea:



SOURCE: Fieldwork Data, and Metrological Authority, Different Years, Khartoum.

SOURCE: Fieldwork Data, and Metrological Authority, Different Years, Khartoum.

It is worth mentioning that the main causes of Vegetation Change are:

1- Natural vegetation distinction due to man mal-use, such as overgrazing. The main consequence is soil decline, which means more natural vegetation deterioration.

2- Wood cutting and deforestation. The repercussion of this action is twofold: First, increase of albedo, which means less rainfall. Second, increase of wind speed leading to soil decline due mainly to erosion.

3- Over-cultivation that leads to macro and micro climate changes which, in turn, disturbs the ecosystem of the area due to which natural vegetation is first to be negatively affected.

4- Some natural factors, such as the water surface runoff alteration, due to hydrological change, which in turn, affect both soil moisture and aquifer recharge. The result is natural vegetation deterioration.

5- Regional climate change as a result of some changes at the vicinity of the research area .

All these factors lead to a salient change in the whole natural ecosystem of the research area . Indicators of such a change are:

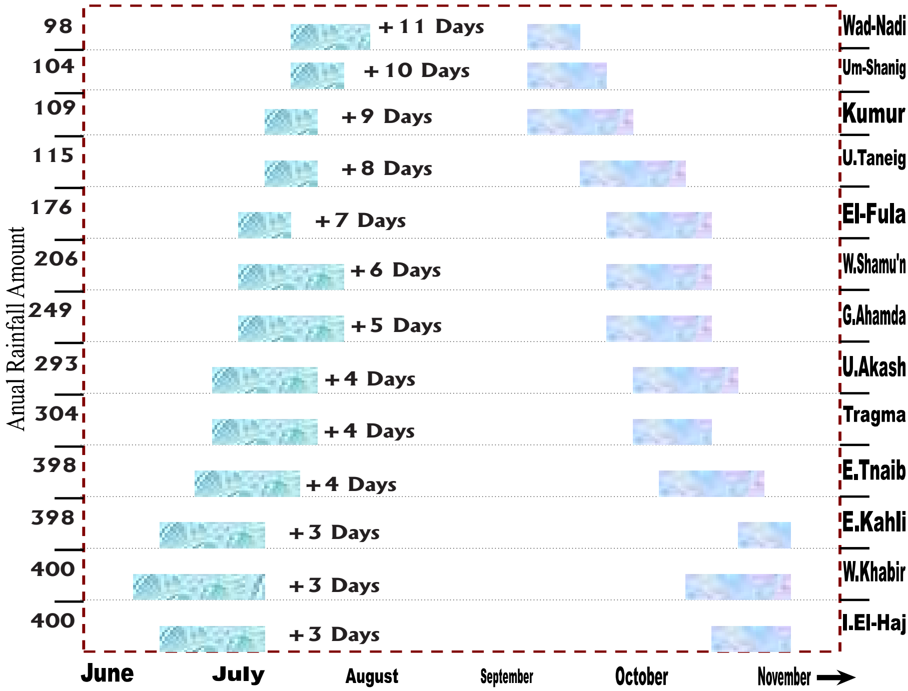
1. **Rainfall Regime alteration:** This is evident through:

a-**Less Rainy Days in the area**: This is an initial evidence of Rainfall Regime alteration in the area. Fig. (7) illustrates this through informing average rainy months in some main centers.

The Average number of rainy months (duration of the rainy season), as shown in Fig.7, indicates between 1.45% and 1.6% reduction, due to change pertained to Vegetation Change in the research area .

b- **Alteration of Rainy Season Commencement and End:** Any Negative alteration in either commencement of end of the rainy season in any area, has risky consequences in the whole ecosystem. Hulme and Tosdevin (1989, p.183) justified that by "... *rainfall reliability in mid-to-late season has decreased* ...". Then, such an alternation of the rainy season has risky consequences in the whole ecosystem of the area, part of which is the natural vegetation cover, which in turn has its negative effect on the rainfall regime. Fig. (8) illustrates such an alternation:

Fig. (8) Alteration of Rainy Season Commencement and End:



Source: Local Metrological Stations in the Study area.

c-Reduced Rainfall Amount: The change in annual amount of rainfall that to less precipitation in one main indicator of climate change in the research area . More than that, it found that the amount of precipitation per one storm is reduced by 75% in some cases, according to (Gyungsoo, 2011, p. 19). This is also an indication of reduced annual rainfall amount in the research area . Table (), below, informs a projected change in some surveyed villages in the research area .

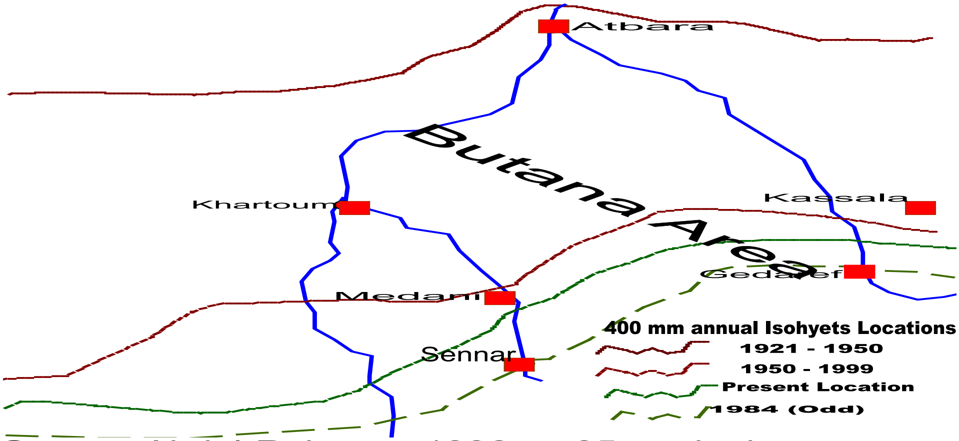
Table (4): A Projected Rainfall Change in Some Surveyed Villages.

Village (Station)	1920-1970 (mm)	1971-2010 (mm)	**Change (mm)**	**Change (%)**
Wad-Nadi	191	98	93	48.7
Um-Shanig	175	104	71	40.6
Kumur	178	109	69	38.6
Umm Tanieg	159	115	44	27.7
El-Fula	229	176	53	23.1
W.Shamu'n	260	206	54	20.8
G.Ahamda	294	249	45	15.3
Um-Akash	335	293	42	12.5
Tragma	321	304	17	05.3
E.Tnaib	413	398	15	03.6
Idd-el-Kahli	411	398	13	03.2
Wad-Khabir	424	400	24	05.7
Idd-el-Haj	416	400	16	03.9
Average	292.8	250.0	42.8	19.2

Source: Local Metrological Stations in the Research area , and Other Sources.

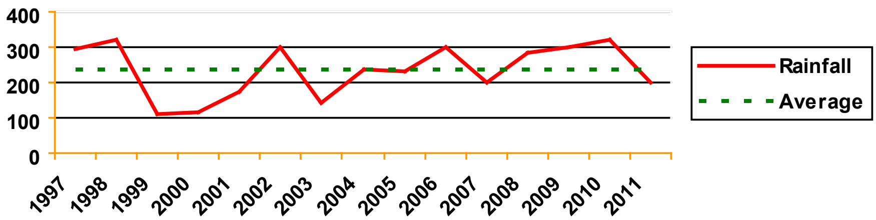
Also, Fig. (9) shows the 400 mm annual isohyets changing position in the research area through different Sudan climatic epochs. Such a change also indicates less amount of precipitation, which also points to climate change in the research area . This is clear by the creeping position to south, which means less amount of rainfall in the areas north of this isohyet line.

Fig. (9):The 400 mm Annual Isohyets Changing Position:



Source: Abdel-Rahman, 1996, p. 95, and other sources.

d- **Rainfall Variability:** It a phenomenon that tells non-stable climatic conditions. Climatic non-stability is always a pointer to climatic change, according to (Oduro-afriyi, 1989, p. 189). The, it also could be taken as an evidence of climatic change in the research area . However, Fig.(10) illustrates this rainfall variability in the research area .



2- Daily and Monthly Average Temperature Increase:

No doubt that a temperature change is associated with change in all other climatic element in any area. (Nisbet, 1991, p 47). Also, on the other hand, temperature change in any area is highly associated with change in the vegetation cover. During the fieldwork, it is found that temperature change in the research area is twofold: First: The average temperature Change: Second: Temperature Range change: Both minimum and maximum have been changed. It is found that this change increasing towards northern part of the research area . Average temperature increase is calculated to be between 0.3°c in the vicinity of Um-Shanig village and about 0.04°c in Wad-Khabir village. Temperature increase in the area is also supported by Mohamed, Alredaisy and Zubair (2011) study. On the other hand, temperature range has increased by between 2°c in the north and 1.2°c in the south. Such changes in the temperature indicate a climate change in the research area . It is a change that moves stealthily from northern towards southern parts of the research area being enhanced by Vegetation Change, as a main factor.

3- Wind Speed Increase: Several climatic and ecological studies (Jacobeit, 1988; Hulme and Tosdevin, 1989; and Mohamed, Alredaisy and Zubair (2011) confirm Wind Speed Increase in the research area . Such an increase is quite probable under the effect plant cover change both in density and type. Analyzed collected meteorological data provide evidence that the average wind speed was 4,4 m/second in may –the driest month- during the period 1921-1970. This average has increased to 6.1 m/second during the period 1971-2010 , i.e. by(38.6%). It is important to put in mind that wind blows in may from north to south and it is mostly dry. This is to say that ecological negative effects are quite probable. However, increasing speed of northerly wind has the following indicators:

1. The increasing speed of this wind means a decreasing natural plant cover either in area and density, especially trees and shrubbery, which could have reduced this wind speed.

2. This wind blows from a desert area. It able, with the help of its load of sand particles, to:

a- Enhance soil erosion, adding more pressure on the already fragile ecosystem, even making the area vulnerable to desertification.

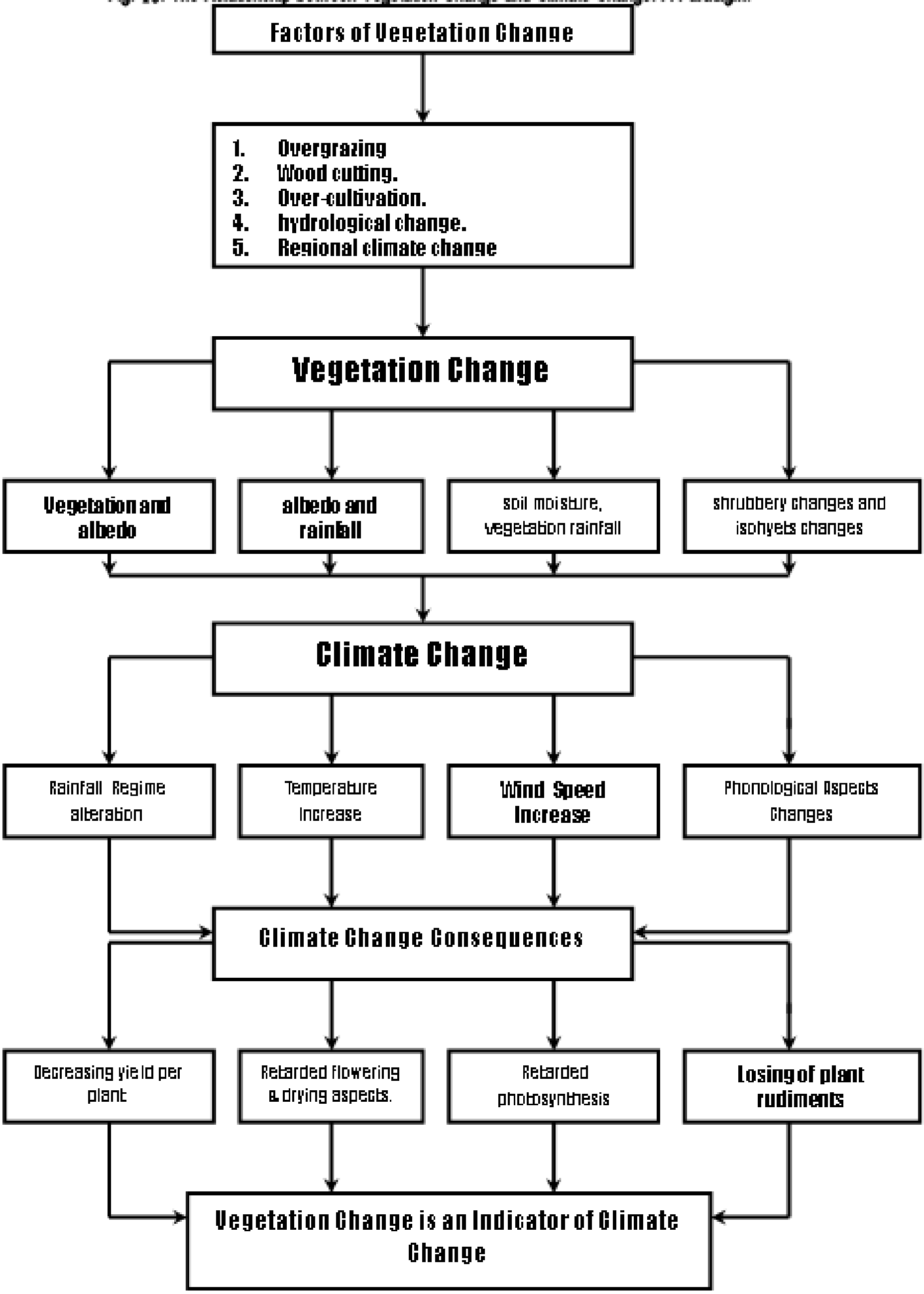
b- and creating, as a consequence, a sort of vicious circle where plant cover deteriorates leading to more wind speed that deteriorates the ecosystem … and so on.

4- Changes of Plant Phonological Aspects: Temperature increase has the following negative phonological or agronomical effects (Benson and Clay, 1994, p.27):

1. Length high temperature (>35°c) per day leads to seeds shrinkage or contraction. This means a decreasing yield per plant.
2. Retarded flowering and enhancing drying aspects of plant foliage.
3. retarding normal photosynthesis and chlorophyll making process.
4. Losing of plant rudiment.
5. The indirect negative effect through a deteriorating soil Pedological aspects, and invasion of exotic species.

The dilemma of all these changes has led to what could be an ecosystem vicious circle in the research area . It is illustrated in the following paradigm (Fig. 10):

Fig. 10: The Relationship between Vegetation Change and Climate Change: A Paradigm:



Such a relationship between Vegetation Change and Climate Change could also be manifested in Table (5) below:

Table (5): The Relationship between Vegetation Change and Climate Change Consequences.

Vegetation Change Aspects	Consequents Climate Change	Repercussions
Reduced Plant cover	Affected Albedo	Soil Erosion
Ever green Retreat.	Rainfall Regime Alteration	Lost Top Soil
Meager Floristic Composition.	Lower Rainfall Amount	Loose Soil
Annuals type supremacy	Rainfall Variability	Declined Land Natural Qualities
Succulent type supremacy	Isohyets Shift	Deteriorated Land C. Capacity
Shift of Ecological Zone.	Lower Soil Moisture	Declined Ecosystem
Impeded Phonological Aspects	Higher Temperature	Agro-ecological Zone Shift
Retarded normal photosynthesis	Higher wind Speed	Desertification Aspects

N.B: Not to compare information in one row Simultaneously.

The outcome of all that illustrated in the Table is some sort of a vicious circle where mutual negative effects between vegetation change and climate change. This means that there is a theoretical positive correlation between density of plant cover and permanence of climate in the research area. This is to say that unchanged natural vegetation cover mean unchanged climatic elements, i.e., temperature, rainfall, wind speed, and others.

Conclusions:

The example cited by the researcher as of the research area is to prove some close relationship between natural plant cover, whether in density, Floristic Composition or type, on one hand, and climate permanence, on the other, is evident. Butana area is one of the most ecologically fragile regions of Sudan. Then, it is mostly appropriate to apply the thesis of this research. Also, the topic of the research worth studying, due to its high importance. Both the problems of increasing Co_2 in the earth's atmosphere and global warming are two hot issues among academicians and researchers of the world, although with various viewpoints and with different approaches of undertaking. However, plant cover, especially terrestrial natural vegetation, is common among all these different view points.

This research, is not an exception regarding its topic. But what makes it a pioneer study is that it reverses others' viewpoints in dealing with the effect of vegetation change on climate change, and not vise versa. Also, the coincidence between researched area and the topic of the research and the synthetical approach followed in the interpretation of the collected data are two standpoints that make it an unsullied topic. This is plus some salient results as an outcome of this research:

1. Mutual negative effects between vegetation change and climate change. Changing vegetation cover leads to climate change and vise versa.
2. There is a triple close relationship among vegetation cover, albedo and precipitation. Such a bond clarifies the correlation between vegetation, i.e., natural plant cover, and rainfall in an area. Also, other relationships are important: A relationship between soil moisture and rainfall and between soil erosion and both plant cover and soil moisture. Based on this crucial fact, the research has progressed analyzing its problem.

3. egetation change in the study area is a proved fact. Causes of this change are various, and they are both natural and human:

- Vegetation distinction due to man mal-use.
- Wood cutting and deforestation.
- Over-cultivation that leads to macro and micro climate changes which, in turn, disturbs the ecosystem of the area due to which natural vegetation is first to be negatively affected.
- Some natural factors, such as the water surface runoff alteration, due to hydrological change.
- Regional climate change

4.Climate change in the research area is proved and measured through some of its elements change, such as:

- Less Rainy Days in the area.
- Rainfall Regime alteration.
- Alteration of Rainy Season Commencement and End.
- Reduced Rainfall Amount.
- Rainfall Variability.
- Daily and Monthly Average Temperature Increase.
- Wind Speed Increase

5.As such, vegetation cover change indicating climate change is viewed in the context that it restrains or, otherwise, reduces rainfall amount in the area through controlling albedo, both at the levels of micro and macro climates. At this juncture, it is better to view this point at the level of the whole research area stemming from spatial reduction of rainfall at local levels. I.e. *in-situ*; and alteration of both average temperature and wind speed. All rainfall, temperature and wind are main climatic elements that obviously testimony climate change in any area.

6.Climate change, as indicated by vegetation change, is not just a phenomenon that is research worth, but, rather, it is a serious hazard that should attract the attention of both researchers and decision-makers in any country.

References:

(A) References in Arabic:

1. عـوض إبراهيـم عبـد الرحمـن (1995): **التنميـة الريفيـة والأسـس البيئيـة للزراعـة في السـودان**، دار جامعـة الخرطـوم للنـشر، الخرطـوم.
2. عـوض إبراهيـم عبـد الرحمـن (2001): **الإنسـان و بيئتـه: أثـر الإنسـان عـلى أغلفـة البيئـة الأربـع: الغـلاف الجـوي و الغـلاف المـائي و الغـلاف الصخـري و الغـلاف الحيـوي**، دار جامعـة الخرطـوم للنـشر، الخرطـوم.
3. ليسـتر بـراون و إدوارد وولـف (1989): «إيقـاف تدهـور أفريقيـا» في: حسـين عبـد الفتـاح (مترجـم): **أبعـاد علاقـة النمـو بمنظومـات اسـتيفاء الحيـاة، معهـد مراقبـة العـالم** (World Watch Institute)- مركـز الكتـاب الأردني، عـمان.
4. مصلحة الأرصاد الجوي- السودان (سنوات مختلفة): **التقرير السنوي لمصلحة الأرصاد الجوي**، الخرطوم.

(B) References in Non-Arabic:

- Abdel-Rahman, 1996
- rifi, S.A. (1978): Development Strategy for Arid Zone of Western Sudan, Department of Geography, Khartoum University, Khartoum.
- Ayoub, T.A (1999): Land Degradation, Rainfall Variability and Food Production in the Sahelian Zone of Sudan, UN Environmental Programme, Nairobi.
- Benson and Clay, (1994): "*The Impact of Drought on Sub-Saharan African Economies*" in: IDS Bulletin, No. 25, pp.24-32.
- Clarke, L.G. (1954): Elements of Ecology, John Wiley and Sons, London.
- Donald, V.G. (2008): Impacts of Climate Change on British Columbia's Biodiversity, FORREX Series, ISBN 978-1-894822-49-7.
- Gordon, I.J. (2000): *Plant-Animals Interactions in Complex Plant Communities: From Mechanism to Modeling, CAB International*" in G. Lamaire et al (edits): Grassland Eco-physiology and Grazing Ecology, pp.191-207.
- **Gyungsoo, C. (2011):** "*The Impacts of Climate Change*

on Potential Natural Vegetation Distribution” **in Journal of Forest Resources, No. 16.**, pp. 53-69.

- Hills, E.S. (1966): Arid Lands Geographical Approach, Methuen and Co, Ltd. London.
- Hulme and Tosdevin (1989):”*The Tropical Easterly Jet and the Sudan Rainfall Review*” in: The Theoretical and Applied Climatology*, No.39, pp.179*-188.
- Hulme, M. (1990):The Changing Rainfall Resources of Sudan, Trans-Institute British Geographer, Series 15(1), pp. 21-34.
- Jacobeit, 1988
- Joaquin, G.C. and Gabriel, M.M. (2000): *Effects of Soil Erosion on the Floristic Composition of Acacia Communities on Marl in Northeast Spain*, Journal of Acacia Science, No. 11(3), pp. 329-36.
- Metrology Offices in Butana Area (Different Years): Different Climate Elements Records 1921-2010.
- Mohamed, Alredaisy and Zubair (2011): *Vegetation Dynamic in Semi-Arid Butana Plain, Sudan,* Journal of Geography and Regional Planning, www.academicjournals.org/JGRP.
- Nicholson, S.E. (1978): *Climate Variation in the Sahel and Other African Regions During the Past Five Centuries*, Journal of Environment, No. 1, pp. 3-34.
- Nisbet, E.G. (1991): Leaving Eden: To Protect and Manage the Earth, Cambridge University Press, Cambridge.
- Obeid, M.S. (1970): “*Ecological Study of the Vegetation of the Sudan, The Effect of the Simulated Rainfall Distribution at Isohyets on the Regeneration of the Acacia Senegal on Clay and Sandy Soil*”: in: Journal of Applied Ecology, No. 8, pp.203-09.
- Oduro-afriyi, K (1989): “*On the Mean Monthly Equiva-*

lent potential Temperature and Rainfall in West Africa" in: The Theoretical and Applied Climatology, *No.39, pp.189*-95.

- Pflaumbaum, H (1994): Rangeland Carrying Capacity in the Butana, Animal Research and Development Institute of Scientific Cooperation, Berlin.
- Ravindranah, N.H. and Sukumar, R. (1996): "*Impacts of Climate Change on Forest Cover in India*": in Commonwealth Foreign Review, No. 75(1), pp. 76-9.
- Richard, D.A. James, K.D. and Daniel, G.M (1999): "*Grassland Vegetation Changes and Nocturnal Global Warming*": in Journal of Science, No. 8-283(5399), pp. 229-31.
- UN Convection to Combat Desertification-UNCCD, 1992, WMO (2004): Africa Environment Outlook: Past Present and Future Perspectives, UN Environment Programme, Nairobi.
- Walton, K. (1979): Arid Lands, London Press.