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of Science Frontier Research: H

Environment & Earth Science

Tip of East Coast

Magnetic Data Interpretation

Highlights

Status of Remnant Forest

Assessing the Floristic Diversity

Discovering Thoughts, Inventing Future

VOLUME 18 ISSUE 1 VERSION 1.0

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Airborne Magnetic Data Interpretation to Delineate the Subsurface Structure of Qena-Quseir Shear Zone Area, Eastern Desert, Egypt

By Elkhadragy A. A., Ali M. S. Abdelaziz, Abdelmohsen G. N. Gharieb & Ahmed A. El-Husseiny
Zagazig University

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I. Introduction

The present study area (Fig.1) is located at the central part of the Eastern Desert of Egypt (covering an area of 9460 Km^2). This area is mainly covered by basement rocks. However, there are parts covered by sedimentary rocks ranging in age from Upper Cretaceous to Quaternary.

For better understanding of the subsurface structural features; magnetic method could be used as a good tool for delineation of the basement surface, and better definition of the geometry of complex bodies. Magnetic data can be analyzed in a number of ways, with enhanced techniques and imaging making it an increasingly valuable tool.

The basic geophysical concept behind this is that the magnetic method reflects spatial variations in the magnetic field of the Earth. These variations are related to the distribution of structures, magnetic susceptibilities, and/or remnant magnetization. Sedimentary rocks, in general, have low magnetic properties compared with igneous and metamorphic rocks that tend to have a much greater magnetic content. Thus, many aeromagnetic surveys are useful for mapping basement and igneous intrusions.

In this work, high resolution magnetic data have been aided with all available geological information to produce multiple attribute maps in order to reveal the complex structural setting of the area under study.

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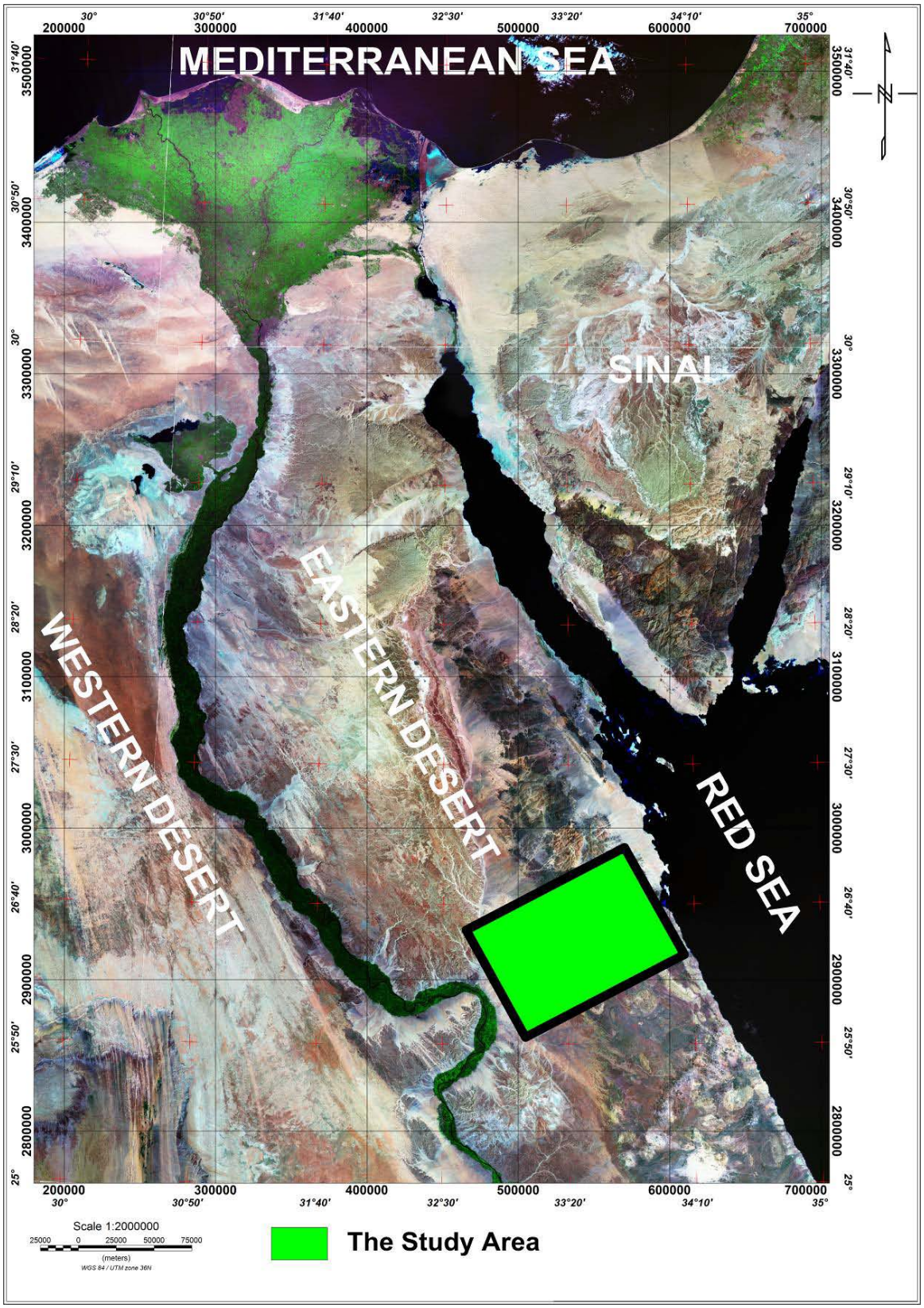

Figure 1: Satellite image showing location of the present study area

II. Geological Background

Based on the geologic map of Egypt (Elramly, 1972), Stern and Hedge, 1985, identified three distinct basement domains in the Eastern Desert; these are the North, Central, and South Eastern Deserts. These areas were divided by two fault zones, and are abbreviated NED, CED, and SED. The present study area located at the transfer zone between NED and CED (Qena-Quseir shear zone). There is a much higher concentration of granitic rocks in the NED and SED than in the CED. The CED exposes, by far, the greatest concentration of rocks with strong oceanic affinities, such as ophiolites and Banded Iron Formation (BIF) (Sultan et al., 1988). The area is covered at the western side by sedimentary rocks ranging in age from upper Cretaceous to Quaternary (Fig. 2).

The rock units exposed in the study area could be arranged into four main groups; from older to younger units (Schandelmeier et al., 1983 & 1987; Greiling et al., 1988):

1) Pre-Pan-African rocks (gneisses and migmatites).
2) Pan-African ophiolites and island-arc assemblage (serpentinites, metagabbros, metavolcanics and metavolcaniclastics).
3) Cordilleran-stage associations (different types of granites).
4) Quaternary sediments

The Eastern Desert of Egypt lies within the fold and thrust belt of the Pan-African continental margin orogeny (El- Gaby, 1983). It consists of relatively thin and imprecated thrust sheets overlying an attenuated Early Proterozoic continental margin.

Greiling, 1988 believe that the Pan African belt was created by compression from an easterly direction, while Shackleton et al. 1980, Ries et al. 1983, and Habeib et al. 1985) consider that the direction of tectonic transport was towards the NNW.

According to the constructed structural map (Conoco and EGPC, 1987), the fracture lineaments including faults have four main trend sets; NW - SE, NE – SW, ENE – WSW and E-W.

In the interior of the African–Nubian Shield, steep vertical movements are accepted for the Precambrian rocks and the Phanerozoic rocks. These faults are often regenerated with quite steep graben borders intersecting the uplift in the Miocene age, in connection with the variations and oscillations in the vertical pattern of faulted areas on the plunges of old massifs, (Schurmann, 1974).

The orientation of the Late Paleozoic to Mesozoic large-scale undulations indicates that the reason for the SE–NW compression in the rotation tendency of Africa start in Carboniferous and culminate in Tertiary regions of Africa separated from Asia (Schurmann, 1974).

Being of epi-Hercynian age, they are generally filled with Triassic and Jurassic series. They are often thick, containing such volcanics such as andesite, basalt, and related tuff. Unlike the aulacogens of ancient platforms, scientists have suggested calling these depressions taphrogenes. The second stage in the young platforms is characterized by the generation of gentle uplifts, similar to shields, and by extensive and long-developing depressions looking like synclines and pericratonic down-warps of ancient platforms. The depressions were initiated in the Jurassic time and then developed during the Cretaceous, Paleogene, and Neogene times; some of them are subsiding at present.

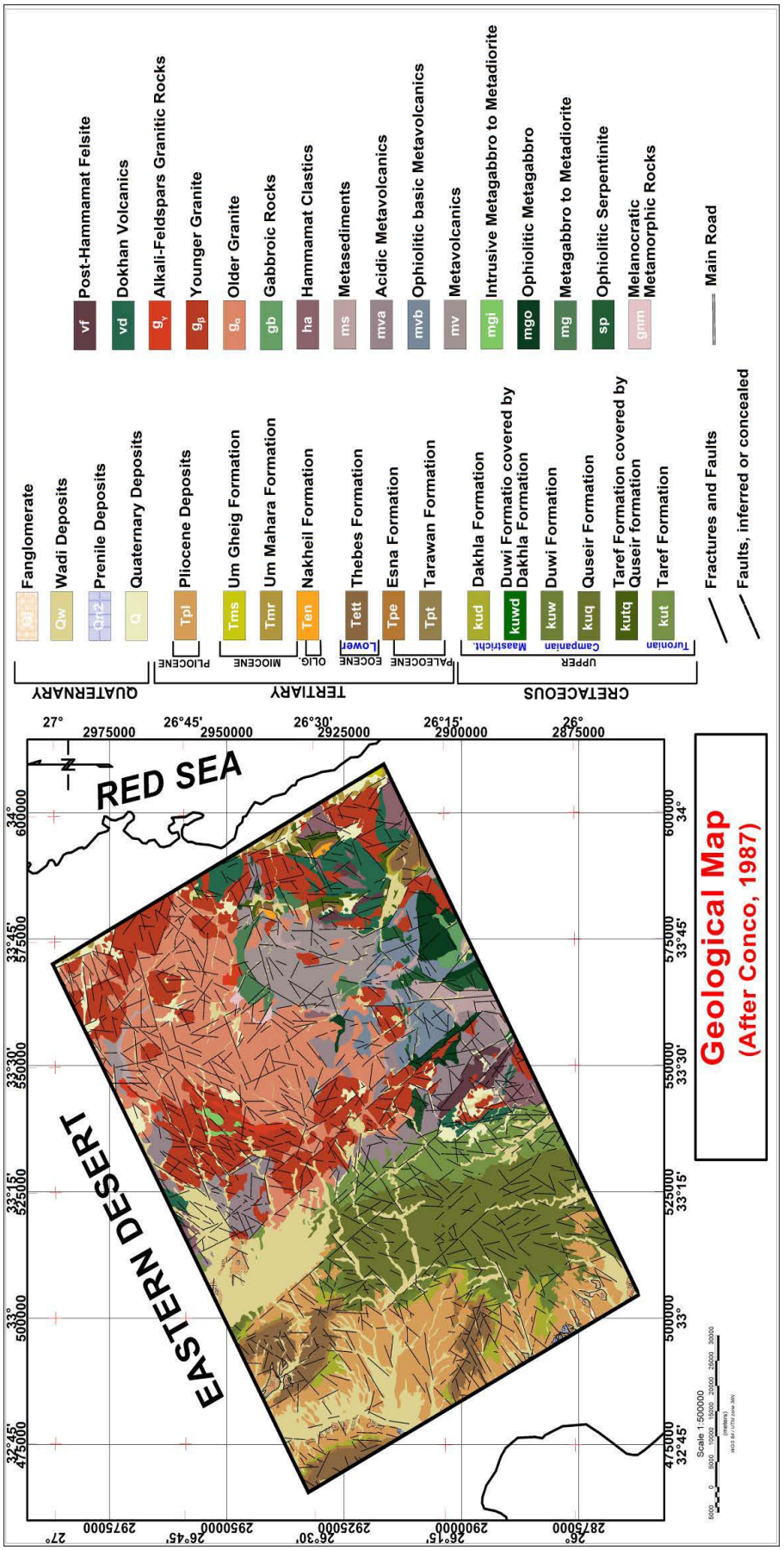

Figure (2): Geologic Map of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt, (After Conco, 1987)

III. Aeromagnetic Data

In 17th December, 1984, Aero-Service Division, Western Geophysical Company of America conducted high resolution magnetic survey covering an area of 9460 km^2 over Qena-Quseir shear zone area, Central Eastern Desert, Egypt (Fig. 1). The data were acquired along flight-lines oriented in NE-SW direction using 1.5 Km line spacing and along tie-lines oriented in NW-SE direction using 10000 m line spacing. Nominal flying elevation was 120m above ground surface (Aeroservice Report, 1984) (Fig. 3).

The Aero-Service aircraft, registration number N80DS, twin-engine Cessna-Titan, type 404 was used for the data acquisition. A 35 mm path-recovery camera was used to record the ground track of the aircraft. The airborne magnetometer used during the survey was a Varian V-85 proton free-precession magnetometer, with a sensitivity of 0.1 nT. The magnetometer was placed in a fiberglass tail stinger in the aircraft. The base station magnetometer was a Varian VIW 2321 G4, single cell Cesium Vapour (Aero-Service Report, 1984). The important advantages of the proton magnetometer are that it measures the absolute magnetic field of the earth.

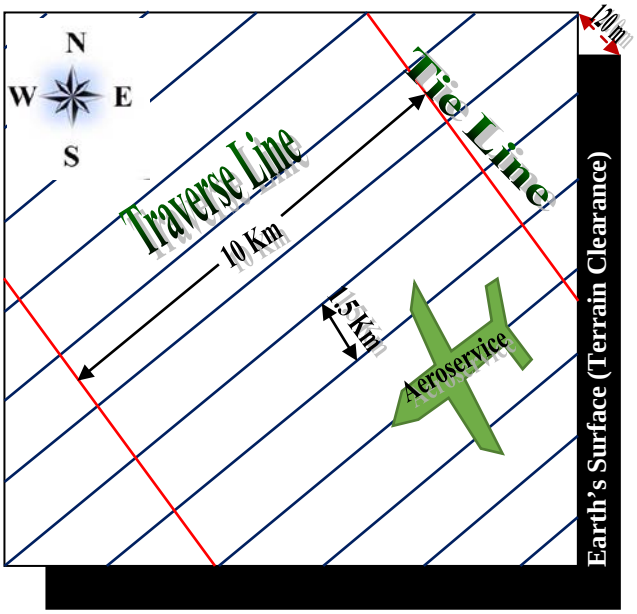

Figure 3: Flight Path Specifications of the Study Area (After Aeroservice, 1984)

IV. Interpretation

The total aeromagnetic map was reduced to the north magnetic pole of the earth by applying spectral analysis technique to overcome the Di-Polarity problem. The reduced to pole (RTP) magnetic map (Fig. 4) was separated into two magnetic components named the regional and residual magnetic components (Figs. 5&6). The RTP regional magnetic-component map (Fig. 5) resembles –to a small extent- the aerial RTP magnetic map. This similarity is shown in the major anomalies, which reflect the magnetic response of the basement rocks, which exposed in the study area. This similarity also means that the sedimentary cover in the western part of the study area possesses low or negligible magnetization. Therefore, the deep-seated structures play the major and important role in defining the general tectonic framework of the area under consideration. The RTP residual magnetic-component map (Fig. 6) shows to a much lesser extent the same general features as the aerial RTP magnetic and regional magnetic-component maps. Nevertheless, it can demonstrate more about the magnetic-rock types, their contacts and their over-all relationships including faulting, folding, etc., particularly at the near-surface shallow level. The estimated mean depths of both the regional and residual magnetic sources were found to be 1000 and 200 m respectively.

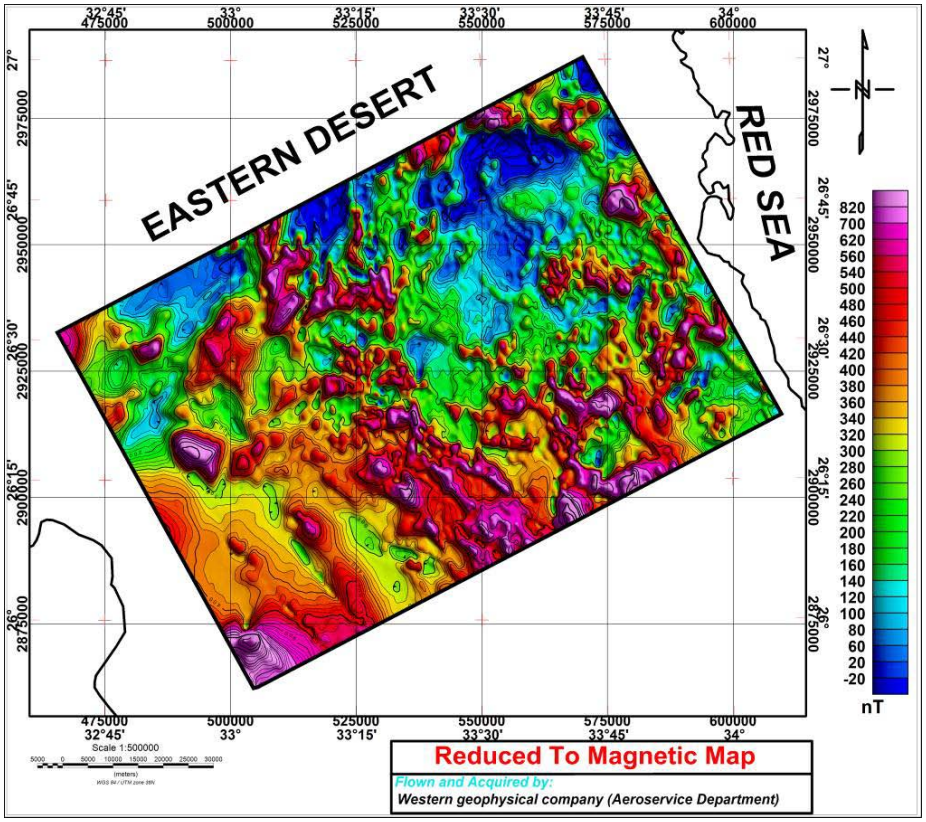

Figure 4: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Aerial Total Intensity Magnetic Field of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

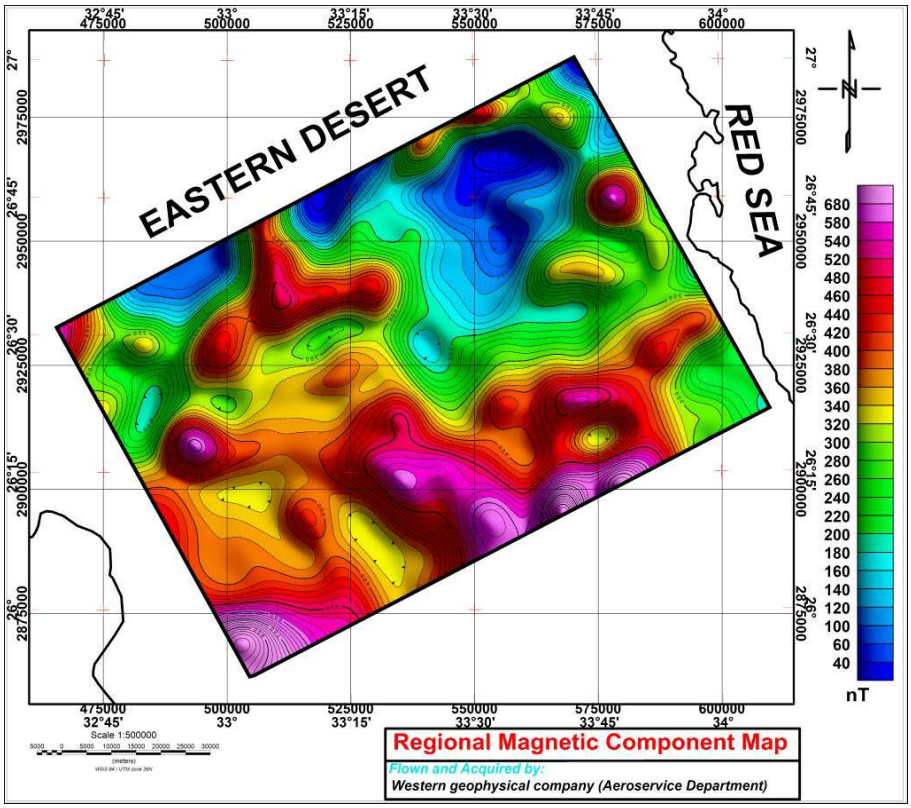

Figure 5: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Regional Magnetic Component of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

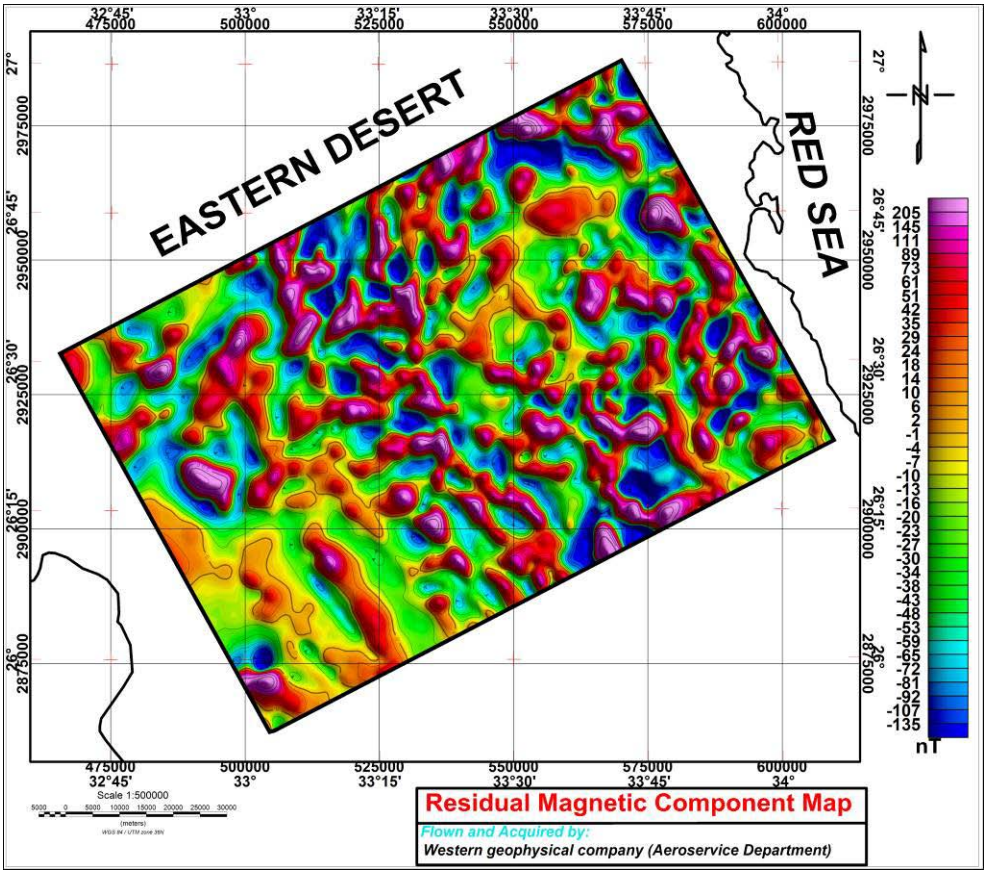

Figure 6: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Residual Magnetic Component of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

a) Discussion of Depth Calculation

The maps of the depths help us very much in delineate the general structures of basement surface. Two techniques of magnetic depth calculations are applied in the study area. The results of Analytic Signal (AS) and Source Parameter Imaging (SPI) are shown in figure (7) and (8) respectively.

The first look to the two maps show that the AS and SPI results are much closed to each other. At the two maps, the western part of the area shows more deeper depths representing the sedimentary rocks. The depths of this part is ranging from 600 m to more than 1000 m. The two maps show that the eastern part of the area is very shallow and has depths ranges from 152 m to less than 10 m because of the outcropping of the basement rocks in this part of the study area. This area is related mainly with the granitic and Metavolcanic rocks.

b) Interpreted Magnetic Basement tectonic Map

Magnetic method is used to give information from which one can determine the depth to the basement rocks and, thus, locate and define the extent of the sedimentary basins. Such information is of particular importance in previously unexplored areas such as the continental shelves newly opened for prospecting. It is also employed to map topographic features on the basement surface that might influence the structure of overlying sediments. Another application is the delineation of interasedimentary magnetic sources, such as shallow volcanics or intrusives that disrupt the normal sedimentary sequence (Dobrin, 1990).

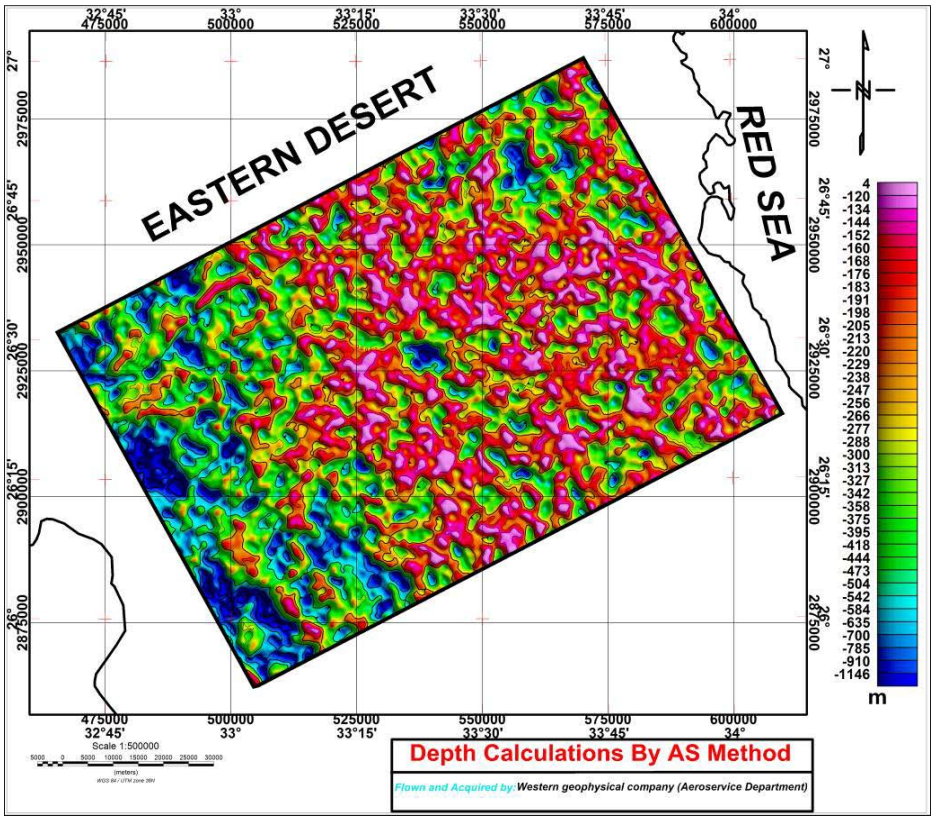

Figure 7: Colour Contour Map of Calculated Depths using Analytic Signal (AS) Technique at Qena - Quseir Shear Zone Area, Central Eastern Desert, Egypt

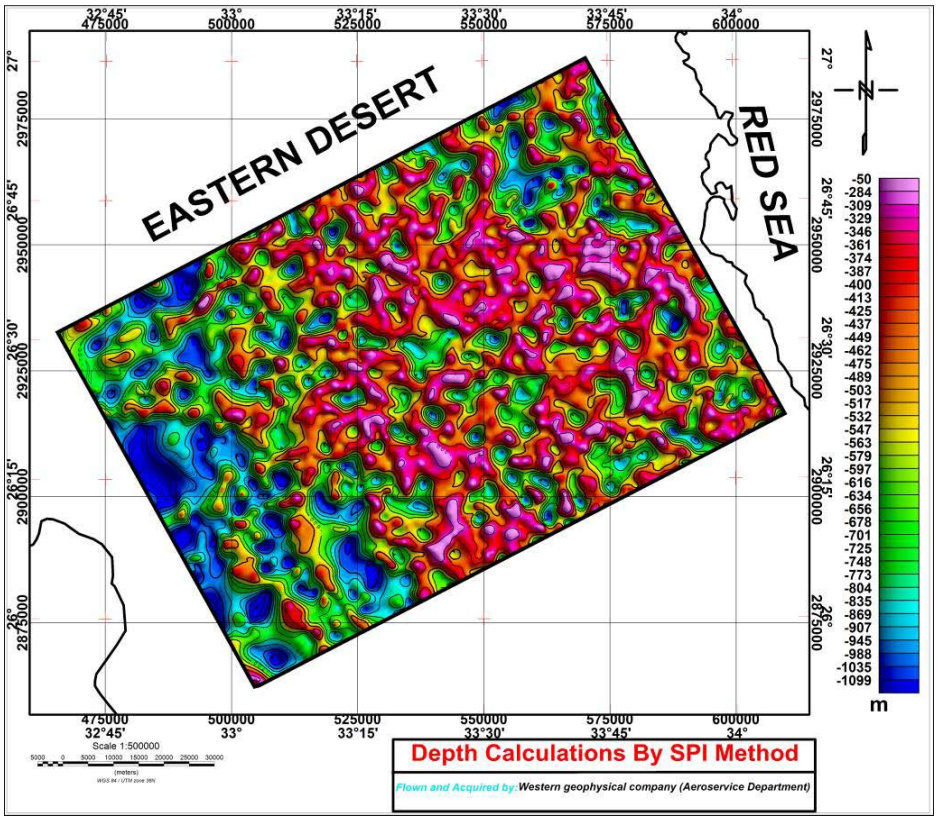

Figure 8: Colour Contour Map of Calculated Depths using Source Parameter Imaging (SPI) Technique at Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

The regional basement tectonic relief map (Fig. 9) was constructed through the integrated interpretation of the magnetic maps. Regional basement tectonic map shows three systems of faults which trending in NW-SE, E-W and NE-SW directions respectively. These faults also suffered from strike-slip movements trending in NE-SW.

c) *Discussion of the Results of 2D-Magnetic Profile Modelling*

To confirm the interpreted basement structural relief of the study area, 2D magnetic modeling was carried out along four profiles AA′, BB′, CC′ and DD′ (Figs. 10, 11, 12 & 13) oriented in N-S, WSW-ENE, NNE-SSW and NE-SW trends respectively. The magnetic susceptibility values were assumed for all rock units in the four modelled profiles and tabulated in table (1).

By comparing between the modelled profile AA′ (Fig. 10) which trends N-S with the basement tectonic map (Fig. 9), nine normal faults affect the area of consideration along the modelled profile AA′. These faults are denoted on figure (10) as numbers from 1 to 9. These faults are described as follow:

Table 1: Assumed Rock Unit Susceptibilities for the modelled Profiles

Rock Unit	Assumed Susceptibility (c.g.s)
Gβ	0.004
Gα	0.005
mgo	0.004
mvb	0.003
mva	0.003
vd	0.008
vf	0.007
mv	0.005
Basic Rocks	0.01
Acidic Rocks	0.015
Basement Rocks	0.01

1. *Fault (1):* trending in NW-SE direction and cutting in younger granitic rocks with 74 m fault throw.
2. *Fault (2):* trending in WNW-ESE direction and cutting in older granitic rocks with 21 m fault throw.
3. *Fault (3):* trending in NW-SE direction and cutting in older granitic rocks with 34 m fault throw.
4. *Fault (4):* trending in WNW-ESE direction and cutting in older granitic rocks with 264 m fault throw.
5. *Fault (5):* trending in ENE-WSW direction and cutting in older granitic rocks with 70 m fault throw.
6. *Fault (6):* trending in ENE-WSW direction and cutting in basic metavolcanic rocks with 69 m fault throw.
7. *Fault (7):* trending in ENE-WSW direction and cutting in younger granitic rocks with 48 m fault throw.
8. *Fault (8):* trending in NW-SE direction and cutting in basic metavolcanic rocks with 35 m fault throw.
9. *Fault (9):* trending in NW-SE direction and cutting in acidic metavolcanic rocks with 57 m fault throw.

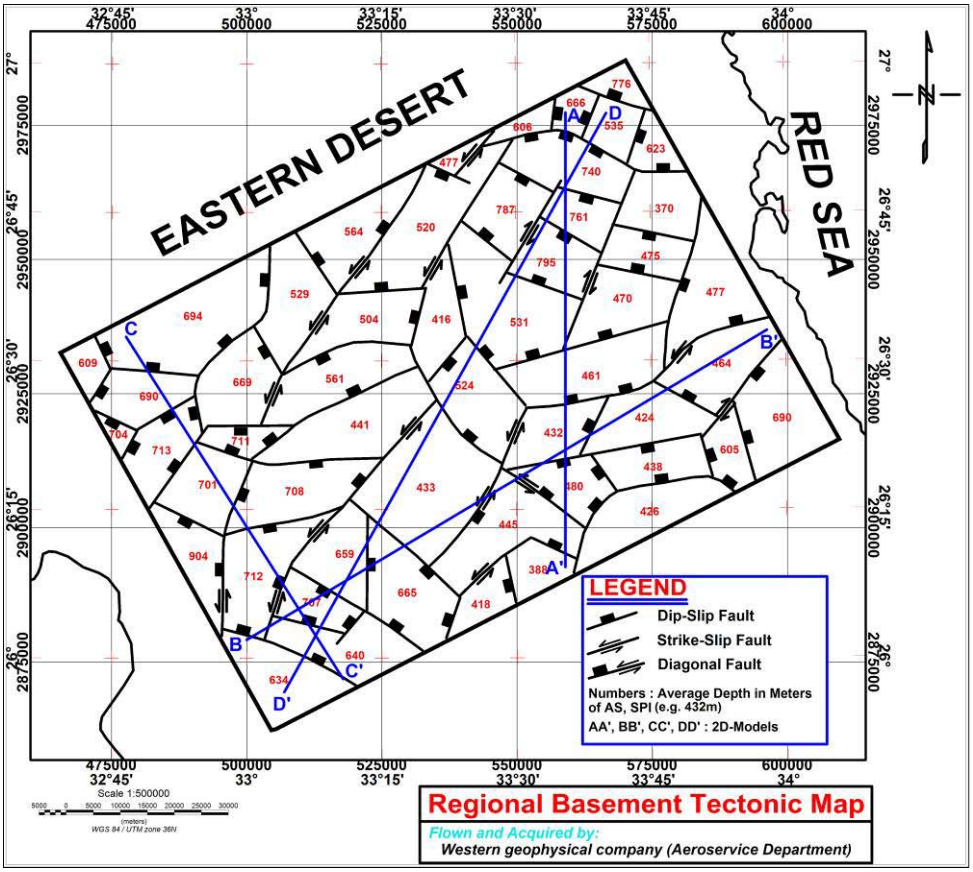

Figure 9: Interpreted Regional Basement Tectonic Map of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

The profile AA′ intersected with the profile DD′ to the north-east at point DD′ at ground elevation 400 m while it intersected with profile BB′ to the south-west at point BB′ at elevation 300m respectively.

The modelled profile BB′ shows that the area under consideration suffer from nine normal faults which appeared on the basement tectonic map (Fig. 9). These faults are denoted on figure (11) as numbers from 1 to 9. These faults are described as follow:

1. *Fault (1):* trending in NW-SE direction in basement rocks with 127 m fault throw.
2. *Fault (2):* trending in NW-SE direction in basement rocks with 108 m fault throw.
3. *Fault (3):* trending in N-S direction in basement rocks with 6 m fault throw.
4. *Fault (4):* trending in NW-SE direction in basement rocks with 232 m fault throw.
5. *Fault (5):* trending in NNE-SSW direction and cutting in acidic metavolcanic rocks with 12 m fault throw.
6. *Fault (6):* trending in NW-SE direction and cutting in younger granitic rocks with 25 m fault throw.
7. *Fault (7):* trending in WSW-ENE direction and cutting in basic metavolcanic rocks with 48 m fault throw.
8. *Fault (8):* trending in NNE-SSW direction and cutting in basic metavolcanic rocks with 8 m fault throw.
9. *Fault (9):* trending in NW-SE direction and cutting in post Hammamat felsite with 40 m fault throw.

The profile BB′ is intersected with profiles CC′ and DD′ to the south-west at points CC′ and DD′ with depths to basement reached 150 m and 400 m respectively. Another intersection point between the modelled profiles BB′ and AA′ is found at the middle of the profile and has a height above ground level of about 300 m.

The modelled profile CC′ which trends NNE-SSW shows that the profile area is suffered from eight normal faults which appeared on the basement tectonic map (Fig. 9). These faults are donated on figure (12) as numbers from 1 to 8. These faults are described as follow:

1. *Fault (1):* trending in E-W direction and cutting in basic rocks.
2. *Fault (2):* trending in NE-SW direction and cutting in acidic rocks with 23 m fault throw.
3. *Fault (3):* trending in NE-SW direction and cutting in acidic rocks.
4. *Fault (4):* trending in NE-SW direction and cutting in basic rocks.
5. *Fault (5):* trending in WSW-ENE direction and cutting in acidic rocks.

6. *Fault (6):* trending in NNE-SSW direction and cutting in acidic rocks.
7. *Fault (7):* trending in NW-SE direction and cutting in acidic rocks with 67 m fault throw.
8. *Fault (8):* trending in NW-SE direction and cutting in acidic rocks.

The profile CC′ is intersected with profile BB′ and DD′ to the south at points BB′ and DD′ with depths to basement reached 150 m for both of them.

The modelled profile DD′ which trends NE-SW shows that eleven normal faults which appeared on the basement tectonic map (Fig. 9) affect the present study area along this profile. These faults are denoted on figure (13) as numbers from 1 to 11. These faults are described as follow:

1. *Fault (1):* trending in NW-SE direction and cutting in younger granitic rocks with 205 m fault throw.
2. *Fault (2):* trending in NW-SE direction and cutting in older granitic rocks.
3. *Fault (3):* trending in NW-SE direction and cutting in older granitic rocks. with 34 m fault throw.
4. *Fault (4):* trending in NW-SE direction and cutting in older granitic rocks with 264 m fault throw.
5. *Fault (5):* trending in NW-SE direction and cutting in younger granitic rocks.
6. *Fault (6):* trending in NNW-SSE direction and cutting in metavolcanic rocks with 109 m fault throw.
7. *Fault (7):* trending in NW-SE direction and cutting in other basement rocks with 232 m fault throw.
8. *Fault (8):* trending in N-S direction and cutting in other basement rocks.
9. *Fault (9):* trending in NW-SE direction and cutting in other basement rocks with 48 m fault throw.
10. *Fault (10):* trending in WNW-ESE direction and cutting in other basement rocks with 67 m fault throw.
11. *Fault (11):* trending in NW-SE direction and cutting in other basement rocks.

The profile DD′ is intersected with profiles BB′ and CC′ to the south-west at points BB′ and CC′ with depths to basement reached 400 m and 150 m respectively. Another intersection point between the modelled profiles DD′ and AA′ is found at the north-east of the profile and has a height above ground level of about 400 m.

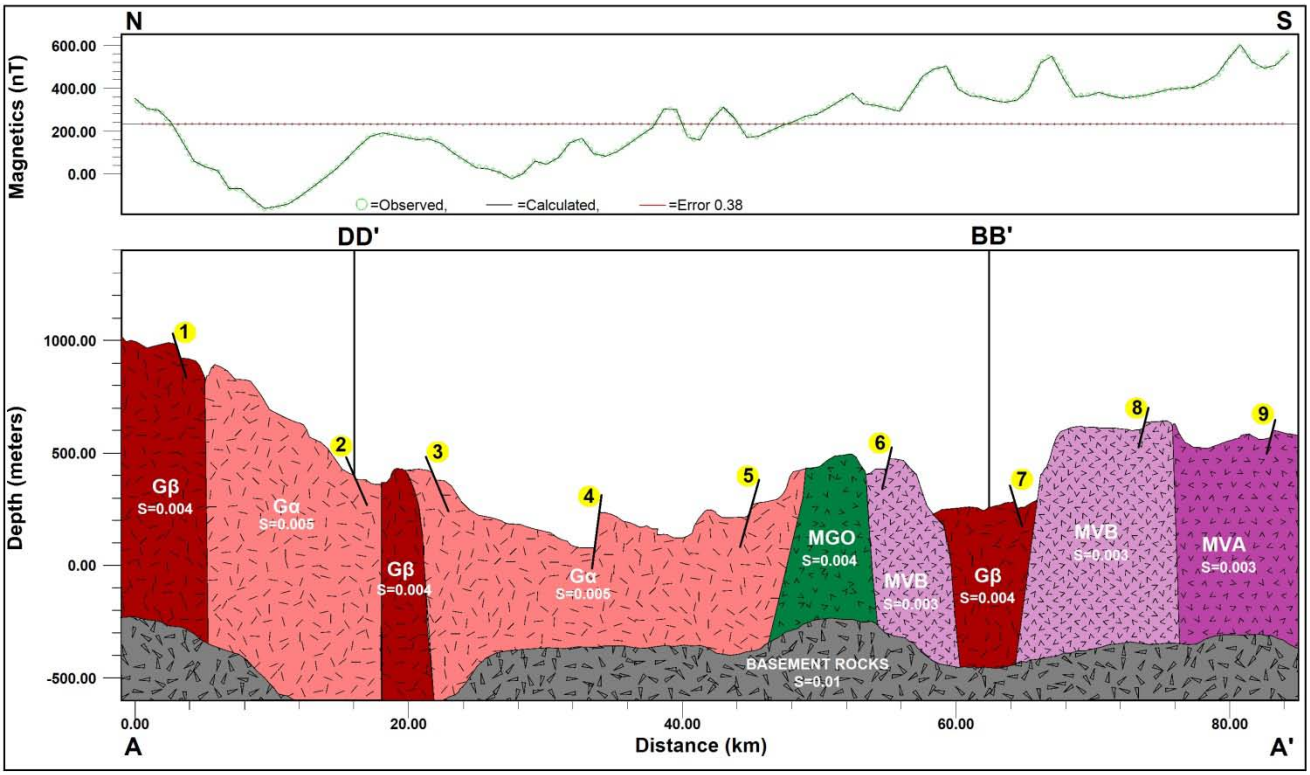

Figure 10: Two - Dimensional (2D) Modelled RTP Magnetic Profile AA′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

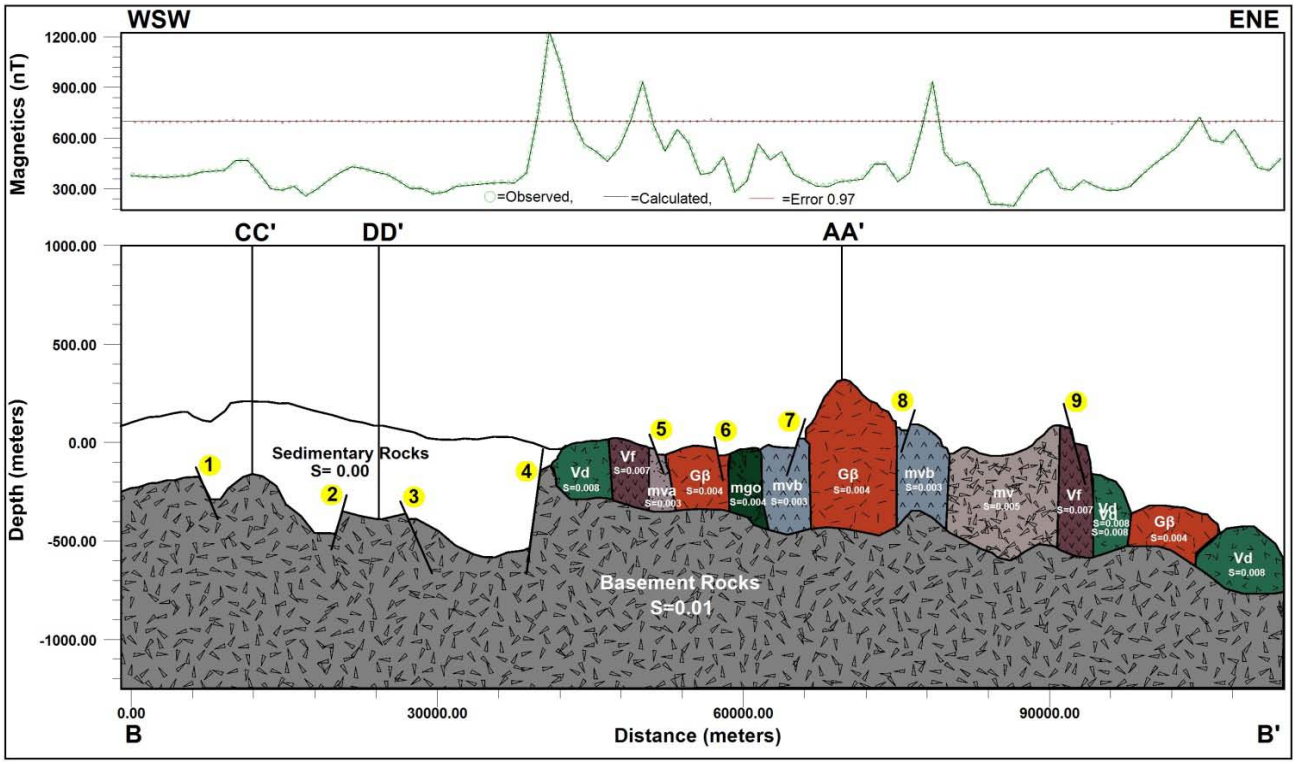

Figure 11: Two - Dimensional (2D) Modelled RTP Magnetic Profile BB′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

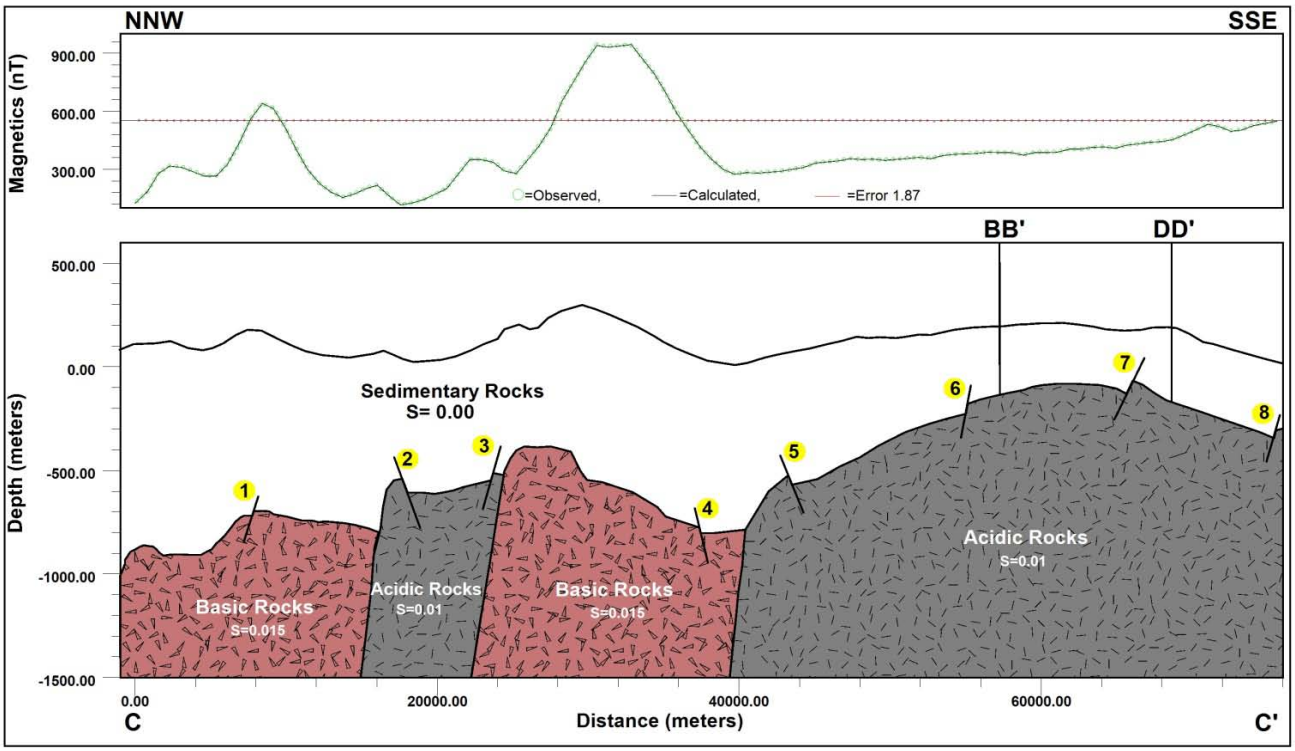

Figure 12: Two - Dimensional (2D) Modelled RTP Magnetic Profile CC′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

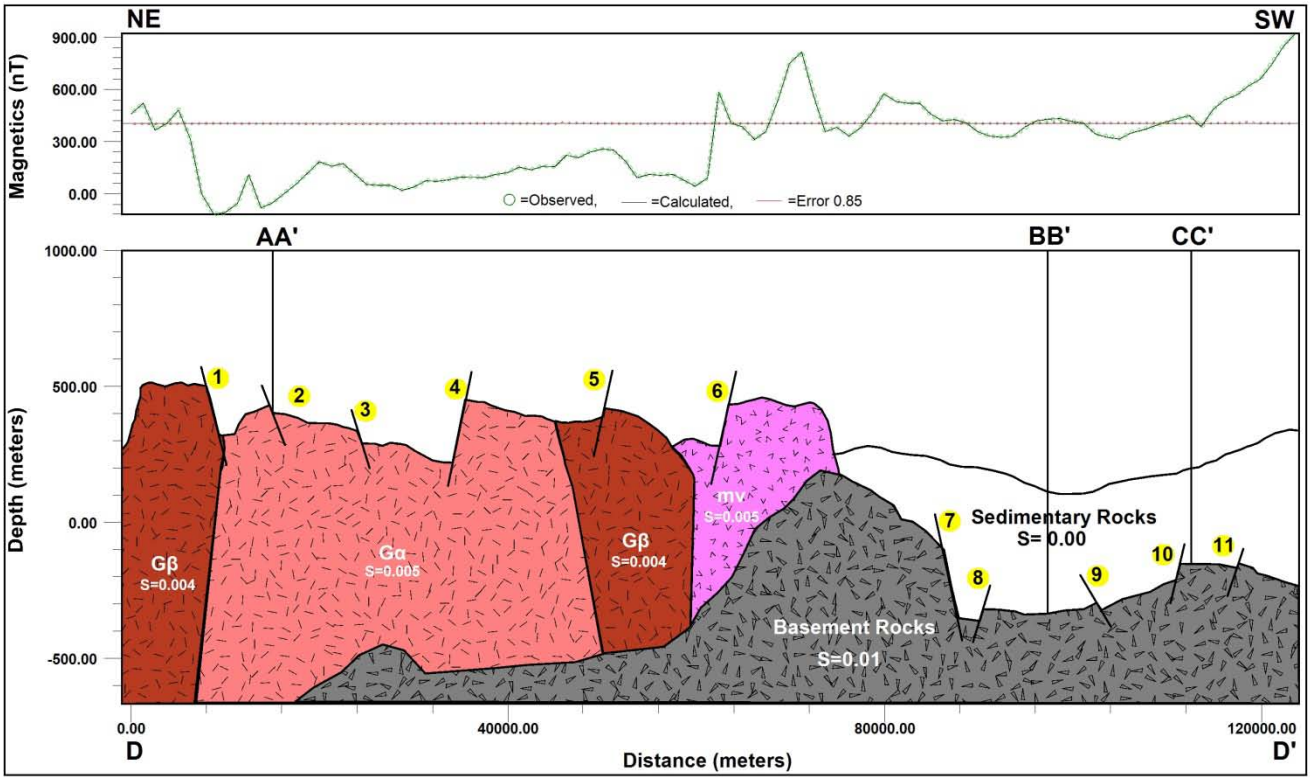

Figure 13: Two - Dimensional (2D) Modelled RTP Magnetic Profile DD′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

V. Conclusion

The similarity between the regional magnetic component map and RTP map is shown in the major anomalies, which reflect the magnetic response of the basement rocks, which exposed in the study area. This similarity also means that the sedimentary cover in the western part of the study area possesses low or negligible magnetization. Therefore, the deep-seated structures play the major and important role in defining the general tectonic framework of the area under consideration.

The two depth maps (AS & SPI) show that the western part of the area shows more deeper depths representing the sedimentary rocks. The depths of this part ranging from 600 m to more than 1000 m. The two maps show that the eastern part of the area is very shallow and has depths ranges from 152 m to less than 10 m because of the outcropping of the basement rocks in this part of the study area. Regional basement tectonic map shows three systems of faults which trending in NW-SE, E-W and NE-SW directions. These faults also suffered from strike-slip movements trending in NE-SW.

To confirm the interpreted basement structural relief of the study area, 2D magnetic modeling was carried out along four profiles AA′, BB′, CC′ and DD′ oriented in N-S, WSW-ENE, NNW-SSE and NE-SW trends respectively.

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Assessing the Floristic Diversity and Conservation Status of Remnant Forest of Wildlife Sanctuary, Ghana, using Geostatistics and Genetic Heat Index

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Keywords: species diversity; genetic heat index, conservation status, geostatistics, wildlife sanctuary, Ghana.

GJSFR-H Classification: FOR Code: 260199

Strictly as per the compliance and regulations of:

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Keywords: species diversity; genetic heat index, conservation status, geostatistics, wildlife sanctuary, Ghana.

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I. Introduction

Globally, biodiversity hotspots have declined markedly from 15.7% to 2.3% [1, 2]. The decline of these living organisms and ecological complexes are due to both catastrophic events and human land use [3, 4]. Forests within the tropical and subtropical regions are more biodiverse than in forests of other eco-zones and provide important but diverse ecosystem services such as biodiversity bank [4 - 6]. The rapidly increasing destruction of forest ecosystems is, therefore, a key threat to biodiversity conservation, particularly the interruption of gene flow by habitat loss and fragmentation [7]. The convention on biological diversity signed in 1992 in Rio de Janeiro advocates for sustainable management of natural, agricultural and forest ecosystems [8, 9]. The convention has increased the awareness and biodiversity research worldwide. However, to manage land resources sustainably, Neves et al. [6] have advocated for the adoption of a wide range of measures to describe the composition, species richness and species dominance since conservation and protection of the biodiversity of natural mosaics (i.e., forest reserves) have been a challenge. An example of such techniques and methods is the geostatistics [10, 11].

A study of spatial distribution of species in forests may portray the spatial structure and the spatial variability of biodiversity and their interactions, which are crucial for their conservation and management. There have been many reports on the efficiency of analytical techniques to describe quantitatively, the spatial pattern of organisms, environmental factors, and ecological processes. For instance, Escudero et al. [12] adopted better management techniques for the species and their habitats. Stenger et al. [13] used spatial assessment of biodiversity and recommended that minimizing the influence of human activities in critical. Moreover, Legendre et al. [14] also mentioned the appropriate statistical tests based on the spatial structure of the organisms. Telles et al. [7] also stressed that the disturbance to the demographic patterns and population increase could jeopardize their existence in the medium- and long-term.

In Ghana, land use conversions have caused the reduction of approximately 80% of its forest estate, destroying biodiversity and a resultant impact on the services the forest ecosystem provides for the rural populations [15]. Marfo[16] observed that many indigenous species such as *Milicia excelsa* and *Milicia regia*, the mahoganies (Khaya and Entandrophragma species), *Pericopsis elata*, *Nauclea diderrichii*, and *Triplochiton scleroxylon* which, mainly generate substantial revenues for Ghana's economy, have drastically reduced in numbers over the past.

The UENR wildlife sanctuary is not an exception to this human-induced biodiversity threats, considering the shrinkage of its area from 3.6ha in 1999 [17] to 2.4ha in 2017 (current study) mainly because of infrastructural expansion. The decline in the acreage of the sanctuary may threaten its floristic diversity, composition, structure, etc. The species may be subject to extinction in the near future, lest the subject of conservation. Nevertheless, for the sanctuary to be ushered under strict conversation requires that the status of the different flora components be studied. In this regard, floristic assessment of the Wildlife sanctuary is crucial in detecting the risk of extinction and changes in plant diversity over time. Information about the spatial distribution pattern of the floristic diversity of the sanctuary is also lacking. The present study, therefore, assesses the floristic diversity and composition, star ratings of species at the wildlife sanctuary and their ecological importance using their genetic heat indices. The knowledge of plant species status would serve as key indicators in enhancing conservation efforts of the Wildlife Sanctuary as well as management of protected areas in Ghana.

II. Materials and Methods

a) Study Area

The study was carried out at the wildlife sanctuary of the University of Energy and Natural Resources (UENR), Sunyani, Ghana (Figure 1). The University lies along the Sunyani-Berekum highway and covers an area of 120 acres (48.6ha). It shares a boundary with the Regional Administration, and the closest community is Fiapre towards Berekum. Forest tree outgrowths comprising indigenous tree species like *Ceiba pentandra*, *Triplochiton scleroxylon*, and exotic plant species such as *Eucalyptus grandifolia*, *Tectona grandis,* and *Senna siamea* surround the campus. The wildlife sanctuary is located in the eastern corner of the UENR campus at latitude 7˚20'50"N and longitude 2˚20'30"W and covers a total area of 3.6ha, which is about 7.4% of the UENR Campus area. The sanctuary was established to provide natural conditions for animals (wildlife) which would be used for research purposes and to serve as an educational site for students and visitors to the University [17]. On establishment, the sanctuary hosts over 68 species of plants belonging to 30 families. The well presented were Apocynaceae, Papilioniaceae, and the least dominant are Ulmaceae, Ebenaceae, and Sapotaceae. The dominant tree species was *Newbouldia laevis* and the least abundant was *Triplochiton scleroxylon*, while the dominant undergrowth was the *Psychotria spp*., which supports duikers [17]. The School of Natural Resources manages the sanctuary as a research station.

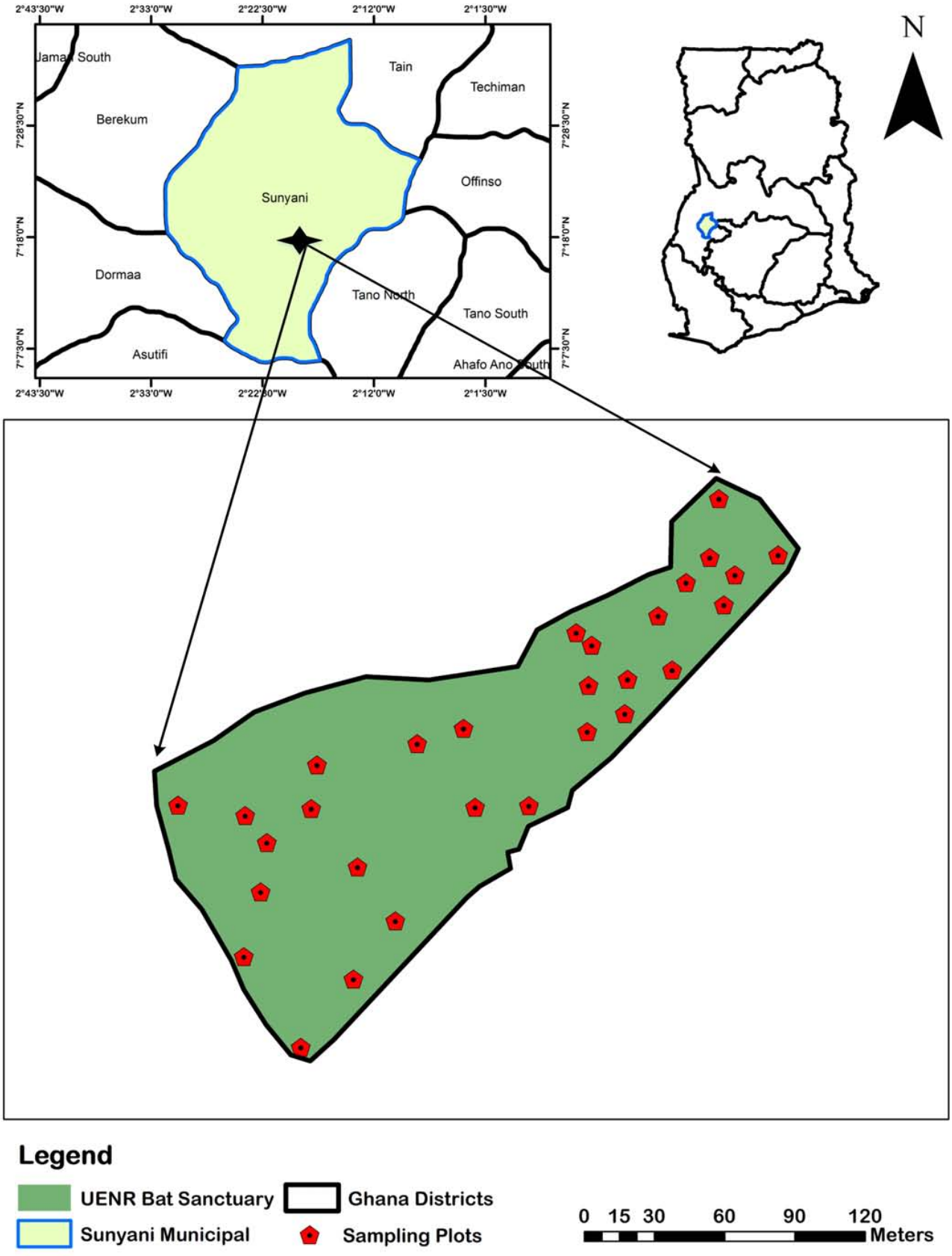

Figure 1: Map of Ghana showing Sunyani and location of the wildlife sanctuary

The Sunyani municipality is about 400 meters above sea level. The climate is characteristic of the tropical humid zone with two seasons, which include dry and wet seasons. The mean monthly temperature is between 23°C and 33°C. The lowest occurs around August, and the highest is observed around March and April. The relative humidity is high averaging between 75 and 80 percent during the rainy seasons and 70 and 80 percent during the dry seasons of the year, which is ideal for luxurious vegetative growth [18, 19]. Sunyani experiences a double maxima rainfall pattern which occurs in June-July and September-October with an annual average rainfall of about 1200mm, while the dry season occurs between December and February [20]. The seasonality offers farmers the opportunity to farm twice in a year. Thus, the main season and the minor season thereby boosting agricultural production in the municipality [18]. However, the rainfall pattern of the municipality might be changing over the years because of deforestation and depletion of water bodies resulting from human activities [20]. The area lies within the moist semi-deciduous forest type with some portions re-planted with *Tectona grandis*[17]. The dominant rock types underlying the area are the Precambrian Birimian formations, which have high mineral deposits. There is widespread masses of granite in the area. The soils, mainly Ochrosols, are fertile with high water holding capacity and support a wide range of crops [18].

b) Sampling design and data collection

The perimeters of the UENR Wildlife Sanctuary were mapped using a handheld GPS unit. Within the mapped Sanctuary, 29 sampling plots were randomly located using the "Create Random Points" algorithm in ArcGIS 10.4. A three-nest sampling plots of 10m x 10m, 5m x 5m and 1m x 1m were laid at the exact places located by the ArcGIS 10.4 software package (Figure 2). In the 10m x10m plot, Trees (individuals >10cm DBH) were sampled, Saplings (individuals ≥ 2cm and <10cm) were sampled from the 5m x 5m plots, while 1m x1m was used for the inventory of Seedlings (individuals <1m height or <2cm girth). Dead trees species were not considered due to difficulties in identifying them.

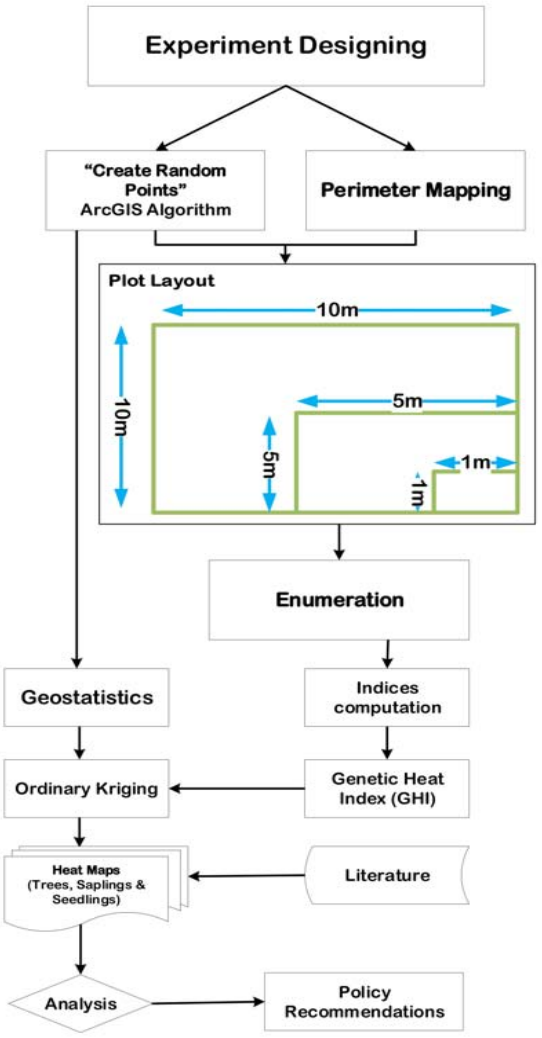

Figure 2: Experimental plot layout and analysis flowchart

c) Data analysis

The three indices were used to determine the species diversity are as follows;

a. Shannon Wiener's diversity index (H'):

$$H' = -\sum_{1=i}^{s} P_i InP_i \quad (1)$$

Where:

S is the number of species; Pi is the proportion of individuals or the abundance of the *ith* species expressed as a proportion of total cover; ln = Log base n [21].

b. The Species Richness (S) was determined using the expression as follows:

$$S = \sum n \quad (2)$$

Where: n is the number of species in a community.

c. The Genetic Heat Index (GHI) of the wildlife sanctuary was determined as follows:

$$\frac{\left[\left(\mathrm{BK} * \mathrm{BK}_{\mathrm{weight}}\right) + \left(\mathrm{GD} * \mathrm{GD}_{\mathrm{weight}}\right) + \left(\mathrm{BU} * \mathrm{BU}_{\mathrm{weight}}\right) + \left(\mathrm{RD} * \mathrm{RD}_{\mathrm{weight}}\right)\right]}{(\mathrm{BK} + \mathrm{GD} + \mathrm{GN} + \mathrm{RD})} * 100 \quad (3)$$

Where:

BK = number of black star species; GD = number of gold star species; BU = number of blue star species; GN = number of green star species; RD = number of red, scarlet and pink star species [22]. According to Hawthorne [22], Black Star species are rare internationally and uncommon in Ghana. Attention is being pursued to conserve the populations of these species. Gold Star species, on the other hand, are fairly rare internationally and locally. Blue Star species are also widespread internationally but are rare in Ghana or vice versa. Pink species are common and moderately exploited. They have a subgroup called promotable Pinks, where the government is encouraging their exploitation to reduce their numbers. Red, are common but are under pressure of exploitation.

The GPS points obtained during the study was exported to ArcGIS (v10.4). These data points were transformed from KMZ to shapefile. An attribute table was generated, and GHI data computed for each of the 29 plots points added. Ordinary kriging algorithm was used to interpolate GHI values calculated for each plot over the entire Wildlife sanctuary. Based on the Genetic Heat Index of floristic species, the conservation status of the wildlife sanctuary was ascertained and categorized [22]. The ArcGIS was used to categorized the spatial extent of the sanctuary into "very high conservation value" for GHI > 200; "high conservation value" (150 ≥ GHI < 200); "moderate conservation value" (100 ≥ GHI < 150); "low conservation value" (50 < GHI < 100) and "very low conservation value" (GHI < 50). The descriptive statistics such as mean and standard deviations of the data set were calculated.

III. Results

a) Star rating of trees, saplings, and seedlings

Figure 3 indicates the star ratings of species in the study area. Most (n = 18) of the Tree species identified and enumerated (58.1%) were Green star species, 29.0% species (n=9) had no known Star status, but three species (9.7%) were Blue star species. Only a Scarlet Star Tree species were identified. Similarly, a high proportion of the Saplings (n = 20; 66.7%) were identified as Green star species, 5 (16.7%) of the species had no known star status, and two Saplings (6.7%) were Blue star species. Only a species was of Pink star and Red star status, representing 3.3% each of the number of saplings identified. Moreover, a high proportion of the species (23) identified in the seedlings representing 76.7% were also Green star species, 3 (10.0%) were Blue species, and the rest had 1 (3.3%) species each. Generally, in each of the categories identified (i.e., trees, saplings, and seedlings), Green Star species were dominant in the sanctuary. Most of the Green Stars were of the Fabaceae, Lamiaceae and Meliaceae families. Compared to saplings and seedlings, a larger number of tree species were not identified as belonging any of the ratings.

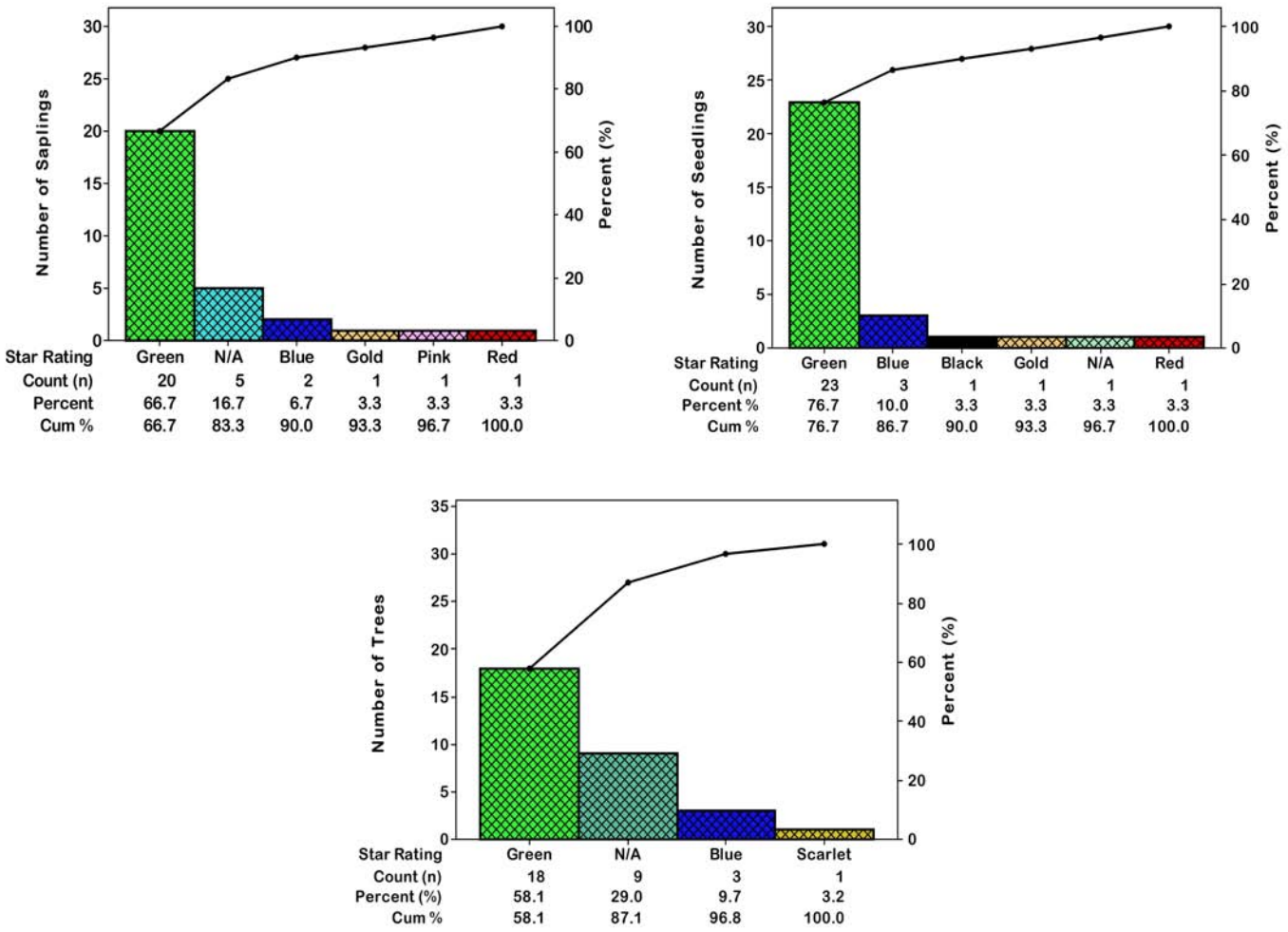

Figure 3: Pareto chart of Species Star rating of saplings. {A: Saplings (Individuals ≥ 2cm and <10cm DBH), B. seedlings (Individuals ≤1m height or <2cm DBH), and C: Trees (individuals > 10cm)} in the wildlife sanctuary

b) Diversity of the floristic component

The families of species and their frequencies are listed in Table 2. A total of 460 floral species were enumerated comprising 150 Trees, 112 Saplings, and 198 Seedlings. The individuals belonging to 58 species and 28 families. Fabaceae, Sapindaceae, Moraceae, Apocynaceae, and Rubiaceae were the most dominant families, representing about 15.7% (n = 14), 11.2% (n = 10), 8.9% (n = 8), 8.9% (n = 8) and 5.6% (n = 5) of the total families recorded. Concerning individual species, the first four (4) dominant Tree species were *Newbouldia laevis* (n = 37), *Holarrhena floribunda* (n = 16) and *Tectona grandis* (n = 11). *Newbouldia laevis* had the highest number of saplings (26 saplings) followed by *Milletia thonningii* (10 saplings). However, *Griffonia simpicifolia* (36) and *Selacia elegans* (34) were the most dominant Seedlings (Table 2).

Table 1 shows the Shannon Wiener's index (H'), Species Richness (S) and the mean Genetic Heat Index (GHI) for the three categories of species studied. Regarding Shannon diversity indices (H' ± Std Error), the Trees (1.05 ± 0.10) were more diverse compared to saplings (0.95 ± 0.10), and seedlings (1.03) within the study area. The species Richness (S) of 3.54 ± 0.3, 3.00 ± 0.30, and 3.66 ± 0.34 were obtained for Tree, Sapling, and Seedling, respectively.

Table 1: Shannon Wiener's diversity index, Species Richness, and Genetic Heat index of seedling, saplings, and trees

Stem group	Shannon Wiener's index (H')	Species Richness	Genetic Heat index (GHI)
Trees	1.05 ± 0.10	3.54 ± 0.30	8.13±2.0
Saplings	0.95 ± 0.10	3.00 ± 0.30	62.50 ± 22.5
Seedlings	1.03 ± 0.08	3.66 ± 0.34	269.38 ± 81.0

c) *The conservation status floristic components of the Wildlife sanctuary*

In the study, the Genetic Heat Index (GHI) was used as an indicator to assess the conversation status of the sanctuary. The mean Genetic Heat Index for Trees, Saplings, and Seedlings were 8.13, 62.50 and 269.38, respectively. Thus, the seedling of the area is of a "very high" conservative status compared to the Trees and Saplings. The genetic heat map (Figure 4) was produced to depict the spatial distribution of the conversation status (conservation hotspots) of trees, saplings, and seedlings, evident by their Genetic Heat Indices (GHI). For trees, the GHI ranges from "very low" conservation value to "moderate" conservation value. However, the "low" conservation spots for trees predominant (94.0%) and were mostly distributed throughout the entire sanctuary (Figure 4). Similarly, the GHI of Saplings ranges from "very low" conservation value to "very high" conservation value. Nevertheless, regarding the area coverage, the study observed that a relatively larger area of the sanctuary (60.1%) was of a "very low" conservation value compared to the areas of "very high" conservation value (6.8%; Table 3). Concerning seedlings, larger proportion (67.7%) of the sanctuary was of a high conservation status compared to a relatively a moderate conservation values.

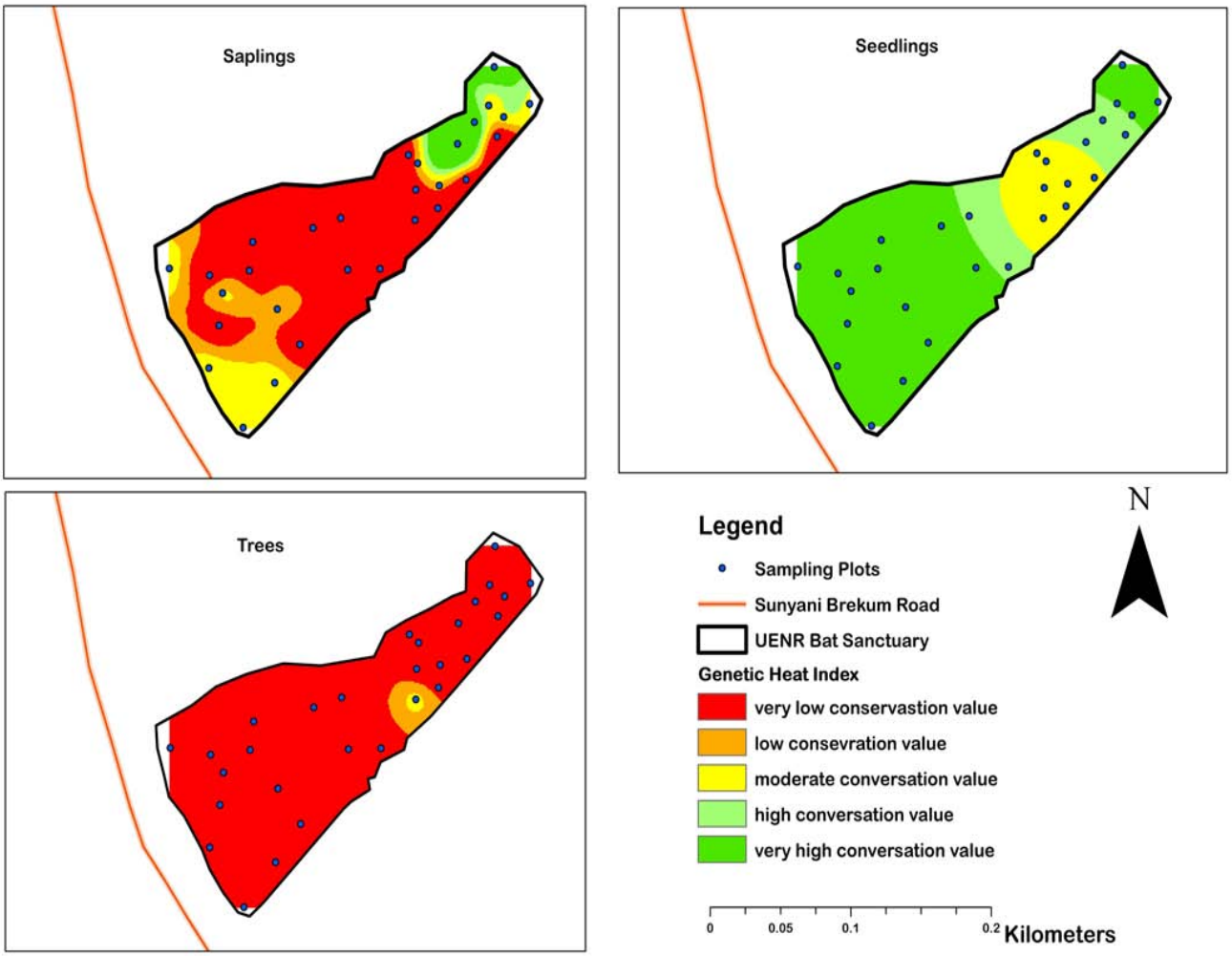

Figure 4: A heat map of flora diversity of the Wildlife Sanctuary

Table 2: Families of species and their abundances

Saplings			Seedlings			Trees		
Family	Scientific name	n	Family	Scientific name	n	Family	Scientific name	n
Fabaceae	*Acacia pentagona*	1	Sapindaceae	*Blighia unijugata*	1	Fabaceae	*Albizia zygia*	1
	Albizia zygia	1		*Deinbollia grandifolia*	1		*Berlinia grandiflora*	3
	Baphia nitida	1		*Lecaniodiscus cupanioides*	1		*Delinox regia*	1
	Dalbergia saxatilis	1		*Paullinia pinnata*	1		*Leucaena leucocephala*	2
	Griffonia simplicifolia	9	Combretaceae	*Combretum racemosum*	1		*Lonchocarpus sericeus*	3
	Millettia thonningii	10		*Combretum smeathmannii*	1		*Millettia zechiana*	1
	Senna siamea	3		*Combretum zenkeri*	2		*Senna siamea*	21
Sapindaceae	*Allophylus africanus*	5	Rubiaceae	*Morinda morindoides*	1	Moraceae	*Ficus exasperate*	5
	Blighia sapida	10		*Psychotria ankasensis*	2		*Miliciaexcelsa*	1
	Blighia unijugata	6		*Psychotria ivorensis*	24		*Broussonetia papyrifera*	2
	Deinbollia grandifolia	1	Apocynaceae	*Holarrhena floribunda*	1	Apocynaceae	*Funtumia Africana*	2
	Lecaniodis cuscupanioides	4		*Voacanga africana*	1		*Holarrhena floribunda*	16
Moraceae	*Antiaris toxicaria*	3		*Motandra guineensis*	4		*Voacanga africana*	2
	Broussonetia papyrifera	1	Asclepiadaceae	*Gongronema latifolium*	1	Mimosaceae	*Albizia adianthifolia*	2
	Ficus exasperate	3		*Parquetina nigrescens*	4		*Albizia ferruginea*	3
Meliaceae	*Cedrela odorata*	1		*Secamone afzelii*	4	Malvaceae	*Bombax buonopozense*	1
	Ceiba pentandra	2	Mimosaceae	*Albizia adianthifolia*	8		*Cola caricifolia*	2
Bignoniaceae	*Newbouldia laevis*	26		*Albizia zygia*	1	Meliaceae	*Azadirachtaindica*	2
Celastraceae	*Salacia elegans*	4	Moraceae	*Antiaris toxicaria*	13		*Cedrelaodorata*	1
Euphorbiaceae	*Mallotus oppositifolius*	3		*Broussonetia papyrifera*	2	Sapindaceae	*Blighia sapida*	2
Apocynaceae	*Holarrhena floribunda*	3	Papilionaceae	*Baphia nitida*	1	Boraginaceae	*Cordia senegalensis*	7
Annonaceae	*Uvaria chamae*	3		*Millettia thonningii*	10	Irvingiaceae	*Klainedoxa gabonensis*	1
Rubiaceae	*Rothmannia longiflora*	2	Bignoniaceae	*Newbouldia laevis*	23	Anacardiaceae	*Lannea welwitschii*	1
Lamiaceae	*Tectona grandis*	2	Caesalpiniaceae	*Griffonia simplicifolia*	36	Phyllanthaceae	*Margaritaria discoidea*	2
Phyllanthaceae	*Margaritaria discoidea*	2	Euphorbiaceae	*Mallotus oppositifolius*	14	Leguminosae-Papilionoideae	*Millettia thonningii*	1
Sterculiaceae	*Cola caricifolia*	1	Clastraceae	*Salacia elegans*	34	Rubiaceae	*Morinda lucida*	10
Araliaceae	*Cussonia bancoensis*	1	Dilleniaceae	*Tetracera affinis*	1	Bignoniaceae	*Newbouldia laevis*	37
Apocynaceae	*Motandra guineensis*	1	Menispermacee	*Triclisia dictyophylla*	2	Sterculiaceae	*Sterculia tragacantha*	1
Asclepiadaceae	*Parquetina nigrescens*	1	Annonaceae	*Uvaria chamae*	1	Lamiaceae	*Tectona grandis*	16
Menispermaceae	*Triclisia dictyophylla*	1	Connaraceae	*Cnestis ferruginea*	2	Annonaceae	*Uvaria chamae*	1

IV. Discussion

The status of conversation area is important to ascertain. To understand explicitly the flora diversity, it was important to categorize them into Trees (>10cm DBH), Saplings (<2cm DBH and <10cm DBH), and Seedlings (≤1m height or <2cm DBH). Though the Tree species were more diverse compared to the Seedlings, the sanctuary was richer regarding seedlings compared to the trees. The reason may be the activities of the bats. They aid in the dispersal of different tree species by passing seeds of species through their digestive tract. Hamalainen et al. [23] iterated that secondary seed dispersal by carnivores could have important consequences for plant dispersal outcomes, with implications for ecosystem functioning under a changing climate and across disturbed landscapes where dispersal may be otherwise limited. However, due

to competition for environmental factors and some things human disturbance, they are not able to the next phase of succession. Thus, the reason why most of the species in failed to appear within the sapling stage. For instance, none of the species such as *Griffonia simplicifolia* (family: Ceasalpiniaceae), the most abundant, was not able to migrate to Sapling and Tree stages. Under controlled conditions, Peltzer and Köchy[24] computed the competitive intensity and found the reduction in transplant growth by neighbors, was similar in both grass- and shrub-dominated habitats for transplants of Bouteloua, but was less intense in shrub-dominated habitats for the shrub Elaeagnus.

How rich a forest depends on the number and categories (usually defined as Star ratings) of species it has [25]. In this study, a star rating system developed by Hawthorne and Abu-Juam[25] and Hawthorne [22]was used to define the conservation status of each species recorded. In the study area, species enumerated were Green, Blue, Gold, Pink, Red and Black Stars. The Green star species dominated the three vegetation types (i.e., the Tree, Saplings, and Seedlings) with 58.1% of the total number of species in Trees, 66.7% of the total number of species in Saplings and 76.7% of the total number of species in Seedlings. The higher population of the Green Star species compared to other species star ratings in the sampling area could be because these species are dominant in Ghana and are of no conservation concern as described by Hawthorne and Gyakari[26]. A lesser number of Red Star and Scarlet species in both the Saplings and Seedlings reflects how uncommon red star species are in Ghana. Scarlet Star species used to be common, but they came under intense exploitation. Therefore, their exploitation is now restricted to control their extinction. Both the Trees and Seedlings had three (3) species each belonging to Blue Star whilst Saplings had none. Blue Star species though widespread internationally but it is a rarity in Ghana [26] and therefore need conservation concern. One (1) Pink Star species was found in the Saplings whileTrees and Seedlings had none. The Pink Star species are the tree species in Ghana that are common and moderately exploited as timber [25]. A Seedling a Black Star species (*Psychotria ankasensis*) was found. However, the mother tree could not be identified in the UENR's Wildlife Sanctuary. *Psychotria ankasensis* is a genus of flowering plants in the Rubiaceae family that is an endangered or facing extinction due to deforestation. Black Star species are species that are only found in Ghana (strictly endemic) or near endemic and thus urgent attention to conservation is needed [25]. Their presence within the UENR Wildlife Sanctuary could be due to the passage of their fruits through the digestive tract of the bats and resulted in their germination at the sanctuary. As a resukt of the activities of the bats,some species are being introduced that have "very high" conservation value into the area and attention must be directed towards strict conservation measures.

The Genetic Heat Index (GHI) for Trees, Saplings, and Seedlings were 8.13±2.0, 62.50 ± 22.5 and 269.38±81.0, respectively. The conservational classes defined by Hawthorne (1996) were used to classify the conservational values of each species recorded. The GHI of the tree species (8.125) ranges from "very low" conservation value to "moderate" conservation value as indicated. The GHI of saplings (62.50 ± 22.5) also ranged from very low conservation value to "very high" conservation value. The results of the study revealed that the conservation value of seedlings was very high. A GHI value of 269.38 ± 81 ranges from moderate conservation value to high conservation value. The high conservation value of seedlings might be due to favorable environmental conditions, which supports their growth.

V. Conclusions

The study assessed the floristic composition, diversity and conservation status of the UENR's wildlife Sanctuary using the Geostatistical tools and Genetic Heat Index. The findings from the Shannon diversity indices (H' ± Std Error) revealed that the Trees were more diverse (1.05 ± 0.10) compared to saplings (0.95 ± 0.10) and seedlings (1.03± 0.08) within the study area. The Seedlings had the highest Richness index (S=3.66 ± 0.34), followed Trees (S=3.54 ± 0.3), while the Saplings had the least Richness index (S=3.00 ± 0.30) among floristic components of the sanctuary.

Green star species were the dominant species in all the different diameter classes, representing 58%, 67%, and 77% of the total number of species of trees, saplings, and seedlings, respectively. Only a single black star seedling (*Psychotria ankasensis*) species was recorded. The families; including, Fabaceae, Sapindaceae, Moraceae, Apocynaceae, and Rubiaceae are the first five (5) most represented families in the study area. The least common species include Irvingiaceae, Anacardiaceae,Leguminosae-Papilionoi-deae, Bignoniaceae, Sterculiaceae, Caesalpiniaceae, Dilleniaceae, Menispermaceae, Connaraceae, Sterculia-ceae, Araliaceae Asclepiadaceae, Araliaceae, Menispermaceae, and Annonaceae. Trees had "very low" conservation value compared to saplings and seedlings. However, the seedlings were of a very high conservation status. The GHI of seedlings increased towards the southern part of the sanctuary whilst the spatial distribution of saplings was high in the northeastern part of the sanctuary.

On the whole, the study had demonstrated that land use conversions influence on floral species distribution could be analyzed successfully using

geostatistical tools and GHI mapping. The study recommended that since the conservation value of the seedlings within the wildlife sanctuary was very high, strict protection and proper management of entire floristic components should be undertaken to promote the sustainable conservation of the remnant forest in the wildlife sanctuary.

VI. Patents

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Author Contributions

N.O.P. conceived and designed the experiments; E.F.A. and A.A. performed the experiment, analyzed the data and contributed analysis tools. All authors wrote and proofread the paper.

a) Conflicts of Interest

The authors declare no conflict of interest.

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Textural Analysis, Erodibility Index Analysis and Hydro Network Pattern Delineation of Eocene Strata, South-Eastern Nigeria

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Abstract- Detailed field based studies were carried out on Eocene Strata of Nanka Sandstone, unit of Niger Delta. Textural analyses were carried out on twenty-one samples of the rock collected from various units across the study area. Gradistat v.8.0 was used to analyze the data obtained for sieve analysis. TRI-PLOT v. 1-4-2 was used to analyze the data obtained for pebble morphometry. The sieve analysis data were also subjected to the Erodibility Index Analysis (EIA) to estimate Erodibility Tendency (ET). By manual delineation, and the use of ArcGIS, the Hydro Network Pattern (HNP) was carried out. A reflection of a predominant shallow marine depositional environment controlled by tidal influence with its corresponding stratigraphy was observed. Very severe Erodibility Tendency (ET) was predicted based on very high values of Soil Loss (R) through the calculated erodibility indices, direct heavy raindrop impact on the sediments and the Hydro Network Pattern (HNP) which favor intense erosion of the study area. The criticality of this intense accelerated erosion is being factored by the friability and very high sand to clay ratio of Nanka Formation.

Keywords: *eocene strata, nanka sandstone, niger delta, textural analyses, erodibility index analysis (eia), erodibility tendency (et), hydro network pattern (hnp), soil loss (r), raindrop impact.*

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I. Introduction

Eocene Nanka Formation was early published under Anambra Basin, southern Nigeria by Nwajide (1980). The Eocene Nanka Formation is under Ameki Group, which is a lateral equivalent of the Agbada Formation in the subsurface Niger Delta (Short and Stauble, 1967) (Figure 1). This particular group consists of Nsugbe Formation (formerly called Nsugbe Sandstone), Nanka Formation (formerly referred to as Nanka Sandstone), and Ibeku Formation (formerly known as Ameki Formation) (Nwajide, 1980; Ekwenye, 2014). Above Ibeku Formation lies Nanka Sandstone, follows by Ogwashi-Asaba Formation, then Benin Formation which is topmost unit.

Quite a lot have been done on the palaeocurrent, palaeoecological and paleo environmental manifestations of outcropping units of Niger Delta (Nwajide, 1980; Arua and Rao, 1986; Arua, 1990; Obi, Mode, Ekwe, Nnebedum, Ede, Egbu, 2013; Chukwuemeka, Odumodu, Mode, 2014; Ekwenye, Nichols, Okogbue, Mode, 2016). Other works focus on the erosion of the area (Obiadi, Nwosu, Ajaegwu, Anakwuba, Onuigbo, Akpunonu, Ezim, 2011; Nwabineli, Otti, 2012; Osadebe, Abam, Obiora, Sani, 2014)

This study aims at making use of combination of textural analysis, Erodibility Index Analysis (EIA) and Hydro Network Pattern (HNP) to estimate erosion susceptibility of Nanka Formation as regards to its environment of deposition.

II. Methods

a) Field Methodology

The study covers an area of about 85.5625km2, with the boundary: latitudes 6°00´N and 6°05´N and longitudes 7°00´E and 7°05´E (Figure 2). Systematic logging of the exposures, and rock identification and sampling were done in towns – Aku, Ezinifete, Aguluezechukwu, Igbo Ukwu, Neni, Nnoha, Okpu-Agulu, Amaezike, Nwanchi, Aguluzigbo, Nanka, Isuofia, Umuchi Omeke, Ekwulobia (Figure 3). Most outcrops were in gullies. Global Positioning System (GPS) helped in spot locations and elevation. Outcrops were studied with lithological characteristics recorded and samples taken. Silva compass was used to measure the attitude of beds and other structures. Most exposures were mainly sandstones, intercalated by mudstones. The gully sites have general dimensions of approximately 550m, 300m and 50m as length, width and depth respectively. Because of such dimension and variable exposure of lithologies, the gully sites were studied station by station which enabled to undertake proper mapping.

b) Textural Analysis

i. Sieve (granulometric or grain size) analysis

Twenty-one sand samples were collected, at regular intervals, from sandstone units of the outcrops and labelled systematically from top to bottom. The samples were sun-dried at room temperature (25°C). The sediment samples were further disaggregated in the laboratory using a mortar and a rubber padded pestle (Pettijohn, 1957). Fifty gram of each samples were measured using a beam balance and sieved for 20 minutes with a Ro-tap sieve shaker using sieve mesh seizes of half-phi interval. The retained fractions were

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reweighed with a beam balance to an accuracy of 0.1g and recorded (Appendix 1). The data obtained were analysed with the aid of Gradistat v.8.0 software tool. Cumulative frequency curves of the data were plotted on an arithmetic log probability paper (Visher, 1969). Critical percentile phi values (φ5, φ16, φ25, φ50, φ75, φ75, φ84 and φ95) were extracted from the cumulative percentile curve and used to compute the univariate statistical parameters (Folk and Ward, 1957) namely: Mean Size (*x*), Sorting (σ), Skewness (*Sk*) and Kurtosis (*K*). Multivariate analysis of these parameters give prediction of the environment of study.

ii. *Pebble Analysis*

A total of six hundred pebbles were collected from three different locations (two hundred pebbles for each location) namely: *Nanka Outcrop 001, Nanka Outcrop 004 and Nanka Outcrop 005*. During sampling, deformed pebbles with distinct fresh breaks, flatness or clear primary elongation as well as those that show lithological in homogeneity were removed to ensure that readings obtained from caliper measurements were a true reflection of their dimension (Sames, 1966). The pebbles were divided into ten sub-populations of ten pebbles each out of the hundred pebbles for each location obtained after discrimination and measured on different days to eliminate operator bias (Sneed and Folk, 1958). The veneer caliper was used to measure the Long (L), the Intermediate (I) and the Short (S) axis (Dobkins and Folk, 1970). The following indices were determined for each pebble:

- Maximum Projection Sphericity (MPS)
  MPS= (S^2/LI) 1/3 (Sneed and Folk 1958)
- *Oblate - Prolate Index (OPI)*
  OPI= {[L-I/L-S]-0.5}/{S/L} (Dobkin and Folk 1970)
- Flatness Index (FI)
  FI= (S/L) % (Lutting, 1962)

The data obtained were computed with the aid of TRI-PLOT v1-4-2 software tool.

c) Erodibility index analysis

i. *Soil erodibility determination*

Eight rock samples from eight locations were taken from various depths for soil structural classification.

ii. *Indirect method analysis*

The sieve computation with Gradistat v.8.0 (see above section), instead of the laboratory test with hydrometer (*direct method*), was looked into to get information on the percentage of sand, silt and clay in the sediment samples taken from those localities. From such *indirect method*, erodibility index (K) was known using equation: K = ((SAN + SIL)/CLA) * (1/100) (Bouyoucos, 1935) SIL, SAN, and CLA are percent silt, sand, and clay respectively.

iii. *Erosion Prediction*

The rainfall factor or erosivity (R) was calculated from:

$$R = 0.5\ H \text{ (Roose, 1977)}$$

The mean annual rainfall (H) is circa 1875mm/year (73.875inches/year) for study area. Amount of soil loss in each of these sites was predicted using RUSLE (Revised Universal Soil Loss Equation):

$$A = 2.242\ R\ K$$

R is rainfall factor, A is soil loss converted to tons/ha/yr by multiplying by 2.242 and K is erodibility factor (Hudson, 1995).

d) Hydro network delineation

Manual delineation of watersheds with done using the study area topographic map. Contour lines in topo map were used to locate drainage divides. Representation of flow directions (arrows) were drawn perpendicular to each contour, in the direction of the steepest descent. Manual delineation of drainage divides is hard and time consuming task; and errors from this process are not uncommon. Therefore, through ArcGIS Hydro Data Model with associated ArcInfo functionality by using a DEM data of the study area from Earth Explorer, watershed and catchment boundaries were pinpointed accurately and automatically.

III. Results

a) Field Methodology

Eight localities were visited i.e. Nanka Outcrop 001 to 008. The sand units are generally poorly sorted, medium to coarse grain and friable (unconsolidated). The friability of the sand unit across the study area is due to the very high sand to clay ratio (Figure 4 – 7). Meanwhile, at the top of some units are lateritic reddish materials which would suggest areal exposure and at the base of some units are quartz pebbles which would also suggest a high energy condition, showing generally WSW to ENE pebble imbrication. Most sand units have mud clasts/ drapes while some are intercalated by mud laminar and beds. Decrease in suture force of the slope of the gully wall was also observed due to the tendency of slide.

b) Textural Analysis

i. *Sieve (granulometric or grain size) analysis*

Distribution plots of grain sizes for the twenty-one samples show grain size distribution of rock samples analysed. The gravel sand mud and sand silt clay diagrams were also plotted to identify the sample type, textural group and sediment name (Figure 10 & 11). The cumulative frequency (log-probability) plots are presented in Figure 12. Two-segment and three-segment curves are present with the three-segment curves being the most predominant. There are four two-

segment curves depicting the combination of traction and saltation, and suspension subpopulations and seventeen three segment curves depicting separated traction, saltation and suspension subpopulations. Table 1 summarizes the result of computed grain size parameters and their verbal terminology of all the twenty-one samples and the environment of deposition of each sample. The samples are generally medium to very coarse grained in size, unimodal, bimodal and trimodal. The samples are also generally poorly to moderately sorted. Skewness values show the samples are generally very positively (very fine) skewed, positively (fine) skewed, symmetrical skewed, negatively (coarse) skewed and very negatively (very coarse) skewed. The values are also predominantly mesokurtic, platykurtic, leptokurtic and very leptokurtic. The statistical parameters are also used to discriminate the environment following discriminant function analysis (Sahu, 1964). Two of discriminant functions were found relevant in the present study.

- $Y_{aeolian:beach}\,(Y_1) = -3.5688\,M_Z + 3.7016\,\delta^2 - 2.0766\,S_K + 3.1135\,K_G.$
- $\boldsymbol{Y_{beach:\,shallow\ marine}\,(Y_2) = 15.6534\,M_Z + 65.7091\,\delta^2 + 18.1071\,S_K + 18.5043\,K_G}$
- $\boldsymbol{Y_{shallow\ marine:\,fluvial\ (deltaic)}\,(Y_3) = 0.2852\,M_Z - 8.7604\,\delta^2 - 4.8932\,S_K + 0.0482\,K_G.}$

The following classifications were used in order to distinguish the different depositional environments:

- $Y_{beach:shallow\ marine} < 65.3650$---***beach environment***
- $Y_{beach:shallow\ marine} > 65.3650$---***shallow marine environment***
- $Y_{shallow\ marine:fluvial} < -7.4190$---***fluvial environment***
- $Y_{shallow\ marine:fluvial} > -7.4190$---***shallow marine environment***

Data obtained from the discriminant functions (Table 2) shows the twenty-one samples have *shallow marine* and *fluvial boundaries*. However *shallow marine* is the most dominant environment.

ii. *Pebble Analysis*

- *For Nanka Outcrop 001*

The total Oblate Prolate Index (OPI) for the pebbles was given as 24.99873538, while the mean OPI obtained was 0.249987354. The total Flatness Index (FI) was 2817.243993%, while the mean FI was 28.17243993%. Also, the value for the total Maximum Projection Sphericity (MPS) was 38.03225011 while the mean value of MPS was 0.380322501. Details of measurements are shown in Appendix 2 while the results of the computations are shown in Table 3.

- *For Nanka Outcrop 004*

The total Oblate Prolate Index (OPI) for the pebbles was given as -59.19296583 while the mean OPI was obtained as -0.591929658. The total Flatness Index (FI) was 3215.950318%, while the mean value of FI was obtained as 32.15950318%. Also, the value for the total Maximum Projection Sphericity (MPS) was obtained as 40.47722031 while the mean value of MPS was 0.404772203. The results of the computations are shown in Table 3.

- *For Nanka Outcrop 005*

The total Oblate Prolate Index (OPI) for the pebbles was given as 9.018641699 while the mean OPI was obtained as 0.090186417. The total Flatness Index (FI) was 2978.09253%, while the mean value of FI was obtained as 29.7809253%. Also, the value for the total Maximum Projection Sphericity (MPS) was obtained as 38.35189856 while the mean value of MPS was 0.383518986. The results of the computations are shown in Table 3.

Figure 13, 14 and 15 show their respective SHAPE (Sneed and Folk, 1958) triangular diagrams which display the dominance of plot points in P-B-E and VP-VB-VE regions suggesting *transitional E.O.D. and beach E.O.D* respectively, while few point are seen in CP-CB-CE region suggesting *fluvial E.O.D*.

c) Erodibility index analysis

From Table 4, soil loss rates predicted for the study area are generally very severe in a modified version (Chinatu, 2007). Annual soil loss erosion prediction ranges from 80.726 tons/ha/yr at *Nanka Outcrop 008* to 88.419 tons/ha/yr at *Nanka Outcrop 002*.

d) Hydro network delineation

The manually delineation of watersheds from a topographic map (Figure 16) shows the trajectory of flows, Atama watershed and Nanka subwatersheds. While, the ArcGIS Hydro Data Model with associated ArcInfo functionality by using DEM gave maps showing watershed, subwatersheds, flow trajectories and catchments (flow edge and edge catchments) which corresponded to the manually delineated one (Figures 17 & 18).

IV. Interpretation and Discussion

a) Textural Maturity

Data from granulometric analysis show that the clay portion never passes greater than 5% (values are mostly 0%); poor to moderate sorting was generally observed poor to moderate. Texturally, the sand is *submature to mature* (Folk, 1974). Poor to moderate sorting and major variations in skewness may indicate *fluctuating energy conditions or intermittent winnowing*. The log-probability (cumulative frequency) plots made an indication of either *a tidal flat or a shallow marine environment of deposition*.

b) Environment of Deposition

Nanka Formation depositional environment may be reconstructed by looking into its stratigraphic, lithological description, sieve analysis, pebble analysis and structural attributes. These description and analyses depict, in a general sense, *shallow marine depositional environment*. The presence of variegated and mudstone facies, and mud-draped sandstone are part of characteristics of *tidal channel, supratidal deposits and tidal flat (tide-dominated estuarine)*. Although, this may not be conclusive. It is important to look at Nanka Formation with regards to its environmental model approach (Figure 19). A correlation chart was also done to relate the basin signature to those of the litho-log.

c) Erosion Susceptibility

The determination of the erodibility indices of sediments showed that the particles in Nanka area are mainly unconsolidated and friable sandy sediments. These unconsolidated and friable sandy particles are known to have very low cohesive force and therefore are much more prone to removal and carriage by water as it is the medium peculiar in the area. However, high portion sand in sediment content favors high rate of infiltration and permeability of water into the rock which may increase tendency of landslide and erosion by increasing pore pressure, thereby decreasing the shear strength (resistance) of the units. The very high erodibility indices (K) and very high soil loss (R) values of the study area showed generally very severe tendency of erodibility.

The detachment and transportation of particles by water are aided by the direct raindrop impact on the sediments (Figure 20) and the hydro network pattern (due to the topographic setting) of the study area. All these factors the caused the accelerated erosion in the study area gave general geometry/ stage of active/ U-shaped at Nanka, Umuchiana and Agulu gully sites (Figure 21).

V. Conclusions

The detailed description of part of Eocene Nanka Formation and results from the textural analysis of twenty-one samples taken reflect a predominantly shallow marine depositional environment controlled by tidal influence with its corresponding stratigraphy. The results presented in this work provide clear knowledge of the geology of the area and region as a whole. Very severe erodibility tendency was predicted from the observation of very high values of soil loss (R) through the calculated erodibility indices, direct heavy raindrop impact on the sediments and hydro network pattern which favor intense erosion of the study area. Another factor that is critical to this intense accelerated erosion is friability and very high sand to clay ratio of the Nanka Formation. I would recommend, however, that detailed structural study of area is needed to identify the initiation of the gullies, extent of the tectonic events and their precise relationship with evolution of Benue Trough (southern) and Niger Delta.

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Occurrence of Mudbank after Tsunami off Vedaranyam, Southern Tip of East Coast of India

By P. Chandramohan, V. Kesava Das, R. C. Bragath & R. Ranjitha

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Keywords: mudbank, vedaranyam, east coast of india, palk bay, littoral sink.

GJSFR-H Classification: FOR Code: 040305

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Occurrence of Mudbank after Tsunami off Vedaranyam, Southern Tip of East Coast of India

P. Chandramohan [α], V. Kesava Das [σ], R. C. Bragath [ρ] & R. Ranjitha [ω]

Abstract- Mudbanks are the unique coastal phenomena with distinct patches of turbid and calm water with a high load of suspended sediment appearing close to the shore during rough sea. The occurrence and migration of mudbanks influence the coastal dynamics and coastline stability significantly. A typical mudbank formation was recently identified along the southern end of the east coast of India near Vedaranyam after the occurrence of Tsunami in 2004. A detailed study was carried out on the coastal morphology, geology, waves, currents, tides and other oceanographic parameters in the sea between Vedaranyam and Velankanni covering 35 km stretch during 2015 to 2016. The extent of clay deposition on the seabed and the formation of mudbank is more on the south side near Vedaranyam and reduce towards north near Velankanni. Such mudbank phenomenon was not existing before the occurrence of Tsunami in 2004. A lot of sediments washed into the sea elsewhere by the Tsunami waves got deposited in Palk Bay is found to be the primary reason for the recent formation of mudbank between Vedaranyam and Velankanni. It is noticed that during southwest monsoon season July and August, there is a deposition of mud composed of silt and clay at nearshore brought from the Palk Bay and also from the offshore deposits. The formation of mudbanks as clay deposit at nearshore gets retreated and disappears with the onset of northeast monsoon in October. This paper presents the detailed study on the reasons for the formation and behavior of this mudbank supported by various field observation.

Keywords: mudbank, vedaranyam, east coast of india, palk bay, littoral sink.

I. Introduction

Mudbanks are the distinct patch of turbid and calm water, wherein the silt and clay fractions of sediments float in colloidal form across the water column, and such feature appears more commonly in monsoon period. Active mudbanks are those areas where the waves are attenuated by viscous dissipation and calm water prevails even in monsoon season. Passive mudbanks are the same areas when the wave characteristics in the region are like those of the other places. Persistent mudbanks are those mudbanks which become active practically every year during the monsoon season when wave action becomes strong. These mudbanks need not remain permanently at a particular place, and they can shift from one region to another, but maintain their form (Gopinathan and Qasim, 1974).

The appearance of mudbanks is associated with an increase in the consistency of the sediments kept in suspension and the force associated with the driving agents such as wind, waves, tides, and currents near the shore. When the mud gets into suspension by the agitation influenced by the wave action, the wind and tide-induced currents to drive the entire floating mass slowly. The existence of mud floor at the nearshore is not enough to form mudbanks. The mud of the right texture must get consolidated at the precise depth where wave action could churn it up into a thick suspension. If during the active phase of the mudbank, the wave action is not strong enough to churn up the mud into colloidal suspension and bring it close to the surface, then there will be no movement in the form of suspended particles. Subsequently, the mud will settle on the sea floor, but it would appear again at the same position in the following year.

a) Mudbanks on Indian Coast

In India, the formation of mudbanks has been observed in the past at several locations along Kerala and south Karnataka coasts during south-west monsoon. Now it is not occurring at all the places. However, in Kerala, the predominant Alleppey mudbank appears almost every year between Thottapaly and Mararikulam and extends up to 10-15 km along the coast and 5-6 km offshore during southwest monsoon (Parvathy et al. 2015). Several studies have been carried out on Alleppey mudbank (Moni, 1970; Kurup, 1977; CMFRI, 1984 Mallik et al. 1988; Mathew, 1992; Narayana et al. 2008, etc.).

b) Morphology of Tamil Nadu Coast

The coastal zone of Tamil Nadu is endowed with varied landscape such as sandy beaches, beach ridges, backwaters, estuaries, intertidal mud and sand flats, dunes, cliffs, beach rocks, deltas, lagoons, mangrove forests and coral reef ecosystems. The coast has constantly been undergoing physical changes in the geological past and at present. There is a reduction of sediment supply from rivers which lead to beach recession at many places. Apart from the coastal geomorphic features, the Tamilnadu coast is protected by rocky shores facing the India Ocean between

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Thengaipattinam and Manappad, coral and oyster ecosystem in the Gulf of Mannar between Manappad and Mandapam, protected shallow bay with endangered flora and fauna in Palk Bay between Mandapam and Vedaranyam. The coastal area between Nagapattinam and Puducherry is occupied by low and narrow beaches, deltaic plain, palaeo-tidal flats, palaeo-lagoons and salt marshes. (Anbarasu and Rajamanickam, 1997). The coast between Puducherry and Chennai is a well-developed sandy belt with intermittent geomorphic features like tidal flats, estuaries, beach dunes and beach ridges.

The segment of the coastline between Vedaranyam and Velankanni forms the southern end of the east coast of India facing the Bay of Bengal. It is in the Cauvery draining basin with more lagoon and waterlogging wetlands. The coastal formation is composed of alluvial sediments brought by various storm drains. This region depicts a distinct depositional form of the coast, located near the southernmost end of the east coast of India, where the influence of Bay of Bengal ends. The tip of the southern end called *Point Calimere alias* Vedaranyam *alias Kodiya Karai,* comprises of a large wetland system with brackish water lagoon. The nearshore remains very shallow, and there is a formation of a shallow sand spit called Palk Strait running approximately 65 km long between Point Calimere (India) and Point Pedro (Srilanka). The offshore region in this stretch functions as a sink for the littoral drift moving along the east coast of India during northeast monsoon; and the littoral drift moving around the Srilankan Island towards the Indian Coast during the southwest monsoon (Jena, 1997).

During the southwest monsoon, this segment of coastline is considerably protected from waves by the Jaffna peninsula of the Srilanka Island. The wind effect is more on the coast because of the funneling effect caused by the two land masses viz. India and Srilanka. Such strong winds generate local waves, and hence the sea remains at times choppy during southwest monsoon with short-crested waves. However, this region receives unobstructed high waves during the northeast monsoon. The wave climate is relatively calm compared to the northern part of the east coast. The waves approach nearly parallel to the shore and hence the net volume of littoral drift is minimum along this stretch between Vedaranyam and Thirumullaivasal leading to the classification of nodal region with negligible annual net drift.

c) *Formation of Mudbanks between Vedaranyam and Velankanni*

The coastal stretch between Vedaranyam and Velankanni is 35km long, and the seabed in this stretch is composed of sand and silt. However, during southwest monsoon in July and August, there is a deposition of mud composed of silt and clay which give rise to the formation of mudbank. The accumulation of mud on the seabed is more severe between the intertidal zone and 500 m offshore than the other regions. The spread of the mudbank is observed to be 35 km along the coast and for1 km into the sea. Such mudbank phenomenon did not exist before the occurrence of Tsunami in 2004. A lot of sediments washed into the sea elsewhere by the Tsunami waves got deposited in Palk Bay is found to be the primary reason for the recent formation of mudbank between Vedaranyam and Velankanni. It is noticed that during southwest monsoon season in July and August, there is a deposition of mud composed of silt and clay at nearshore brought from the Palk Bay and also from the offshore deposits. This formation of clay deposit on the seabed and the movement of mudbank disappear with the onset of northeast monsoon from October. This seasonal deposition of clay causes a problem to fishermen as they find it difficult to push and beach their fishing boats on the shore. The intensity of clay deposition on the seabed is more on the south side near Vedaranyam and reduces towards north till Velankanni. The places further north like Nagapattinam, Tharangambadi, Poompuhar, etc. do not show such mud deposition on the seabed in southwest monsoon. The mud deposition on the seabed and the subsequent mudbank phenomenon remain as localized between Vedaranyam and Velankanni.

II. Materials & Methods

Data on the coastal morphology, geology, waves, currents, tides and other oceanographic parameters in the sea between Vedaranyam and Velankanni covering 35 km stretch were collected during 2015 to 2016. The seabed sediments were collected at 42 locations between Tharangambadi and Vedaranyam (Fig.1). The parameters on turbidity, salinity, and temperature were measured using *YSI Multiparameter Water Quality* probe at 2300 m offshore (Fig.1) for 32 days from 25.07.15 to 26.08.15. Tide data were recorded for 36 days from 20.07.15 to 26.08.15. The surface current speed and direction were measured using self-recording *Aanderaa RCM 9 current meter* for 32 days from 25.07.15 to 26.08.15 at 2300 m offshore at 4.7 m water depth. The wave measurement was carried out for six months using *Datawell Directional Wave Rider Buoy of 90 cm* off Vellapallam at 3000 m offshore in 6 m water depth from 01.08.15 to 14.01.16. Measurement locations of tides, currents, and waves are also given in Figure 1. Bathymetry survey was carried covering an area of 3000 m distance along the coast and 5000 m distance into the sea with dual frequency echo sounder.

III. Results and Analysis

The field data collected during July - August 2015 on various parameters have been used for analyzing the reasons for the formation of mudbank.

a) Seabed Sediments

In general, the nature of the seabed at nearshore from Velankanni to Vedaranyam is composed of sand and silt. But, it is noticed that during southwest monsoon particularly in July and August, deposition of silty clay is seen on the seafloor. The composition of the seabed sediments is shown in Table 1. The seabed sediment size classification shows the nearshore within 1500 m between Vedaranyam and Velankanni consists predominantly silt and clay with the absence of sand particles during August. The proportion of silt particle was relatively higher on the southern side whereas the clay particle was more on the northern side. The sampling was done during the period of formation of mudbank which indicated the deposition of silt and clay on the seabed. In the same season, the sediments collected further offshore indicated the presence of 95% sand fractions without any clay particles. It shows that the movement of clay and in turn the mudbank is restricted close to shoreline within 1500 m from the shore.

b) Tide

Tide data recorded for 36 days from 20.07.15 to 26.08.15 are shown in Fig.2. The measurement displays that the tides are semidiurnal, and the spring tidal range existed around 0.62m and, the neap tidal range around 0.27m. The tide measurement location is shown in Fig.3.

c) Currents

The maximum current speed reached up to 0.46 m/s and the mean current speed showed0.18 m/s(Fig.2). The current was uni-directional towards the north in July -August 2015. The current speed appears to change with tidal phases, increasing during flood tide and decreasing during ebb tide.

The region between Vedaranyam and Vellapallam is subjected to low tidal variation compared to the northern part of East Coast of India. Similarly, current speed remains minimum. This hydrodynamic regime favor a depositional regime of the suspended sediments.

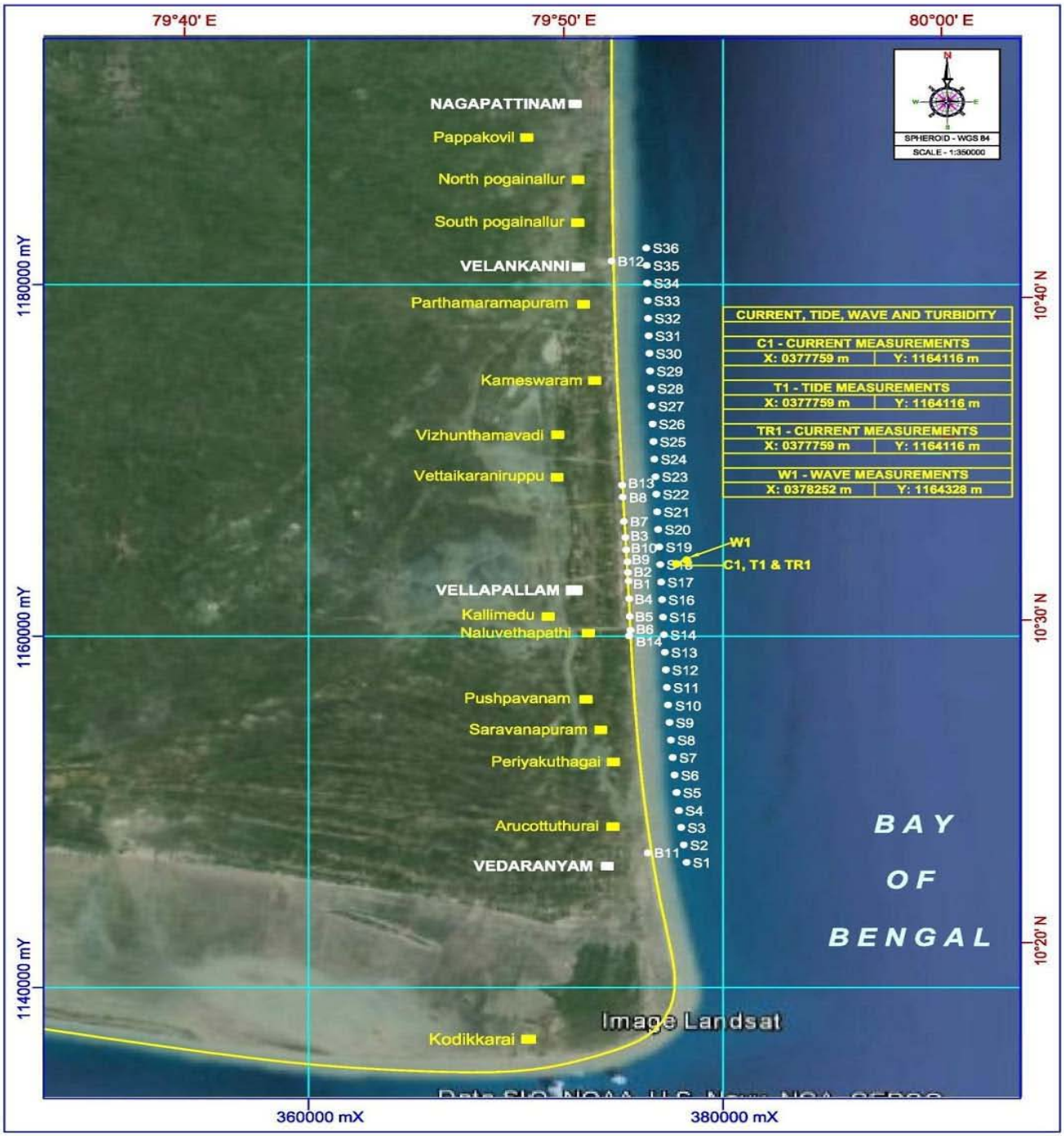

Figure 1: Sampling locations between Vedaranyam and Velankanni

Table 1: Composition of seabed sediments

Station No.	Distance from the shore, km	Silt %	Clay %	Station No.	Distance from the shore, km	Silt %	Clay %
S1	1.5	60.6	39.4	S22	1.5	54.0	46.0
S2	1.5	67.2	32.8	S23	1.5	48.6	51.4
S3	1.5	67.2	32.8	S24	1.5	52.4	47.6
S4	1.5	68.3	31.4	S25	1.5	54.0	46.0
S5	1.5	62.5	37.5	S26	1.5	55.1	44.9
S6	1.5	52.4	47.6	S27	1.5	50.4	49.6
S7	1.5	57.1	42.9	S28	1.5	58.8	41.2
S8	1.5	60.4	39.6	S29	1.5	54.0	46.0
S9	1.5	63.4	36.6	S30	1.5	55.6	45.4
S10	1.5	61.1	38.9	S31	1.5	56.4	43.6
S11	1.5	64.5	35.5	S32	1.5	43.2	56.8
S12	1.5	54.6	45.4	S33	1.5	45.1	54.9
S13	1.5	64.7	35.3	S34	1.5	54.3	45.7
S14	1.5	58.1	41.9	S35	1.5	52.4	47.6
S15	1.5	60.5	39.5	S36	1.5	54.6	45.4
S16	1.5	56.5	43.5	S37	1.0	57.0	43.0
S17	1.5	59.7	40.3	S38	3.0	61.2	38.8
S18	1.5	57.5	42.5	S39	5.0	60.5	39.5
S19	1.5	56.0	44.0	S40	1.0	60.4	39.6
S20	1.5	46.8	53.2	S41	0.5	60.4	39.6
S21	1.5	52.4	47.6	S42	0.5	58.1	41.9

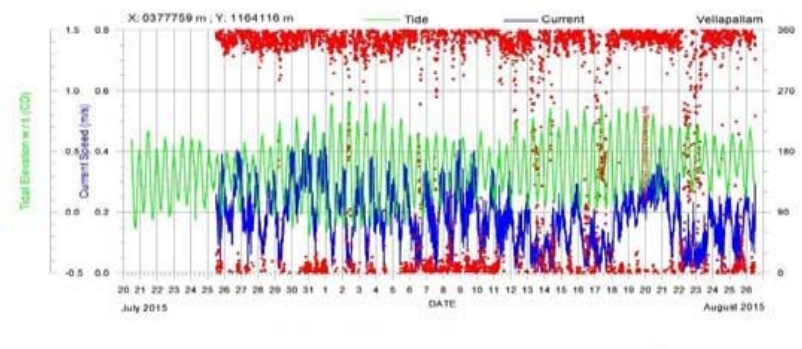

Figure 2: Variation of Tide, Current speed, and direction at study region

d) Turbidity, Salinity, and Temperature

The variation of temperature, salinity, and turbidity are shown in Fig. 3. During the measurement period, the turbidity varied from 12.2 to 270.3 NTU. Variation of turbidity appears to change with the tidal phases, showing high turbidity during the ebb phase and low turbidity during flood phase. The seawater temperature varied from 28.11 °C to 30.68 °C, and the salinity varied from 25.13 ppt to 39.06 ppt during the measurement period. There was a freshwater flow due to heavy rain, and hence the salinity level reached very low during the period 17.08.2015 to 26.08.2015.

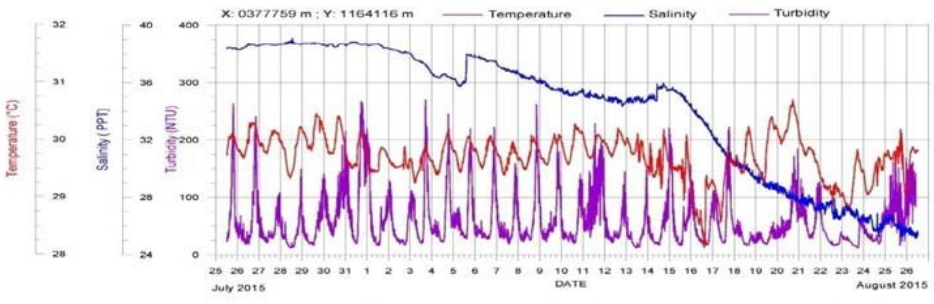

Figure 3: Variation of Salinity, Temperature, and Turbidity at study region

The turbidity level found to vary with flood and ebb tides, i.e., the ebb flow from shore into sea induce more friction on the sea floor and initiate more fine sediments into suspension (>100 NTU) which gives the understanding that in addition to turbulence caused by waves, the tide-induced currents over the tidal phase increase the turbulence to keep the sediment in suspension. It is also noticed that during flood tide, the suspended sediments are brought close to shore and get deposited resulting in low turbidity levels (<25NTU). The seawater salinity and temperature level remain more or less steady till there was a mixing of rainwater in this region.

e) Waves

The wave measurement was carried out for six months using *Datawell Directional Wave Rider Buoy of 90 cm* off Vellapallam at 3000 m offshore in 6 m water depth from 01.08.15 to 14.01.16 is given in Table 2. The Nagapattinam wave data mesaured in 1995 to 1996 were considered for the rest of the months. The typical wave roses representing southwest monsoon and northeast monsoon are shown in Fig. 4. During the measurement period of six months, the significant wave height (H_s) varied from 0.17 m to 1.99 m. The maximum wave height (H_{max}) ranges from 0.27 m to 2.77 m and zero crossing wave periods (T_z) varied from 2.35 to 7.69 seconds. The wave direction corresponding to peak energy (θ_p) during the measurement period mostly remained between 70° and 100°. The coastal orientation at this location is approximately N5°W. The measured wave characteristics at 15 m water depth at Nagapattinam is given in Table 3.

Table 2: Measured wave characteristics at 6.0 m water depth - Vellapallam

Month	Significant wave height H_s (m)		Maximum wave height H_{max} (m)		Zero-crossing wave period T_z (s)		Predominant direction θp (°N)
	Min	Max	Min	Max	Min	Max	Range
Measured in August 2015- January 2016							
August	0.18	0.78	0.30	1.44	2.38	6.78	70° - 160°
September	0.17	0.78	0.27	1.39	2.35	5.71	70° - 160°
October	0.20	0.87	0.30	1.80	2.45	7.69	70° - 100°
November	0.26	1.99	0.41	2.77	2.60	7.27	55° - 80°
December	0.72	1.52	1.20	2.59	3.60	5.71	55° - 100°
January	0.57	1.16	0.89	2.25	3.28	4.55	70° - 90°

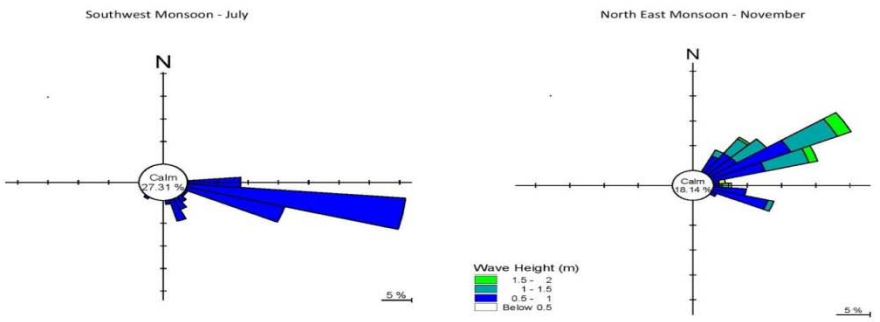

Figure 4: Rose diagram for wave height - SW and NE monsoon

Table 3: Measured wave characteristics at 15 m water depth - Nagapattinam

Month	Significant wave height (m)	Zero-crossing wave period (s)	Wave direction (Deg. N)
Measured in March 1995 –February 1996			
February	1.25	5	85
March	0.5	5	80
April	0.5	5	90
May	0.5	5	90
June	0.75	5	105
July	0.75	5	105

During northeast monsoon (October-January) the waves approach from the sector between 45°N to 90°N, but predominantly from 70°N. On the other hand, during southwest monsoon and fair-weather period, they approach from the sector between 100°N and 160°N but predominantly from 110°N. The wave activities are low, and the region remains calm during southwest monsoon (June to September). On the contrary, the tide-induced currents in July and August are strong and flows unidirectionally from south to north. The northerly currents bring the sediment particles from Palk Bay and deposits along Vedaranyam and Velankanni due to low wave energy environment.

f) Bathymetry

The variation of depth at near shore is even with contours running parallel to the coastline. The seabed remains very shallow typical to the terminal end of the east coast of India bordering the Bay of Bengal. This falls with a uniform slope with contours running parallel to each other. The depth contours of 2 m, 3 m, 4 m, 5 m, 6 m and 7 m occur at a distance of 420 m, 1020 m, 1870 m, 2725 m, 3825 m and 4800 m from the shoreline respectively. The nearshore area is very shallow up to 5 km. The thickness of deposition of silty clay at nearshore based on the difference in depth recorded from low frequency and high-frequency depths obtained from the dual frequency echo sounder is shown in Fig.5.

The loose form of silty clay sediments are found to be significant up to 500 m offshore, and this phenomenon is seen spread between Vedaranyam and Velankanni. The thickness of deposition was found to be up to 0.7 m.

IV. Conclusion

The sources of mudbanks can be of subterranean mud, coastal mud, rivers/ estuaries discharge and dredge waste. Since there are no dredging operations in this area, the mud does not originate from the dredging operation. There are no rivers, and the mudbank region is present with storm drains which carry limited discharge only during northeast monsoon. The mudbanks, on the other hand, are formed during southwest monsoon, and hence it can be seen that the river does not discharge the mud into the sea. The source of mudbanks may be coastal mud which is already present on the coast. It is also observed that mud gets deposited only in the nearshore and there is no such deposition in the offshore.

Hence it is concluded that the source of mudbank is the coastal mud deposited in Palk Bay south of Vedaranyam. The earlier studies do not indicate the existence of mudbank before the year 2004. The local fishermen report that the mudbank phenomenon started only after the 2004 Tsunami. The coastal stretch between Nagapattinam and Puducherry was severely affected by 2004 Tsunami, and a lot of sediments were washed into the sea which was carried towards the south and deposited inside the Palk Bay at Tsunami shadow zone. There was deposition of sediments reported inside Palk Bay particularly between Vedaranyam and Thondi. The northern currents are stronger during July and August, and this deposited sediments find the way to move north in the form of mudbank and deposit the clay between Vedaranyam and Velankanni. During the northeast monsoon, when the wave activities become high, the mud particles are stirred up, and the southerly currents carry them back into Palk Bay and deposit back once again. During the northeast monsoon and fair-weather days, the nearshore seabed along the stretch between Vedaranyam and Vellapallam show the composition of silt and sand without the presence of clay particles. However, the process of mudbank formation and sustenance along Kerala coast is slightly different as it is seen calm area only during southwest monsoon.

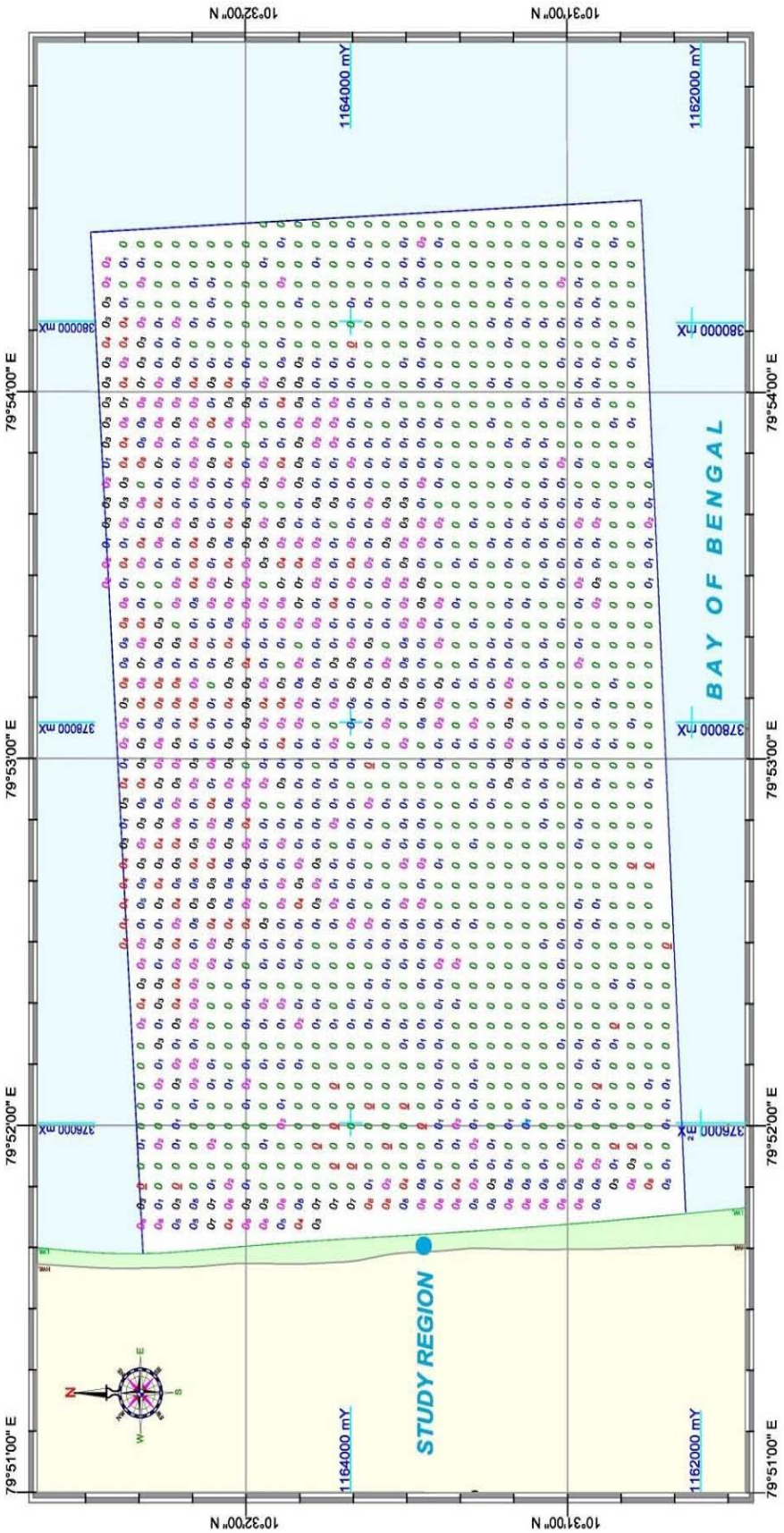

Figure 5: Depth of mud deposition

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Snowmelt Runoff Investigation in Tosh Nala using Snowmelt Runoff Model (SRM)

By Kishor Chandra Kandpal
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GJSFR-H Classification: *FOR Code: 040399*

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Abstract- The snowmelt runoff is foundation to various resource based economics i.e. Agriculture, Tourism, Horticulture and Hydropower. The Glacier in the Himanchal Pradesh Himalayas have been reported to be receding rapidly due to the global climate change. Due to its economic and scientific importance, it is mandatory to access theses resources and its release is essential to predict the flow during the snowmelt period. The essence of this study is to invent and develop a model for pragmatic purpose. The Snowmelt runoff model (SRM) has been widely used in simulation and forecasting daily streamflow in mountain basin where snowmelt is a major runoff factor. A degree day approach for the snowmelt runoff modelling is used here which integrates the input from Remote sensing data and metrological data including the parameter i.e. runoff coefficient, degree day factor, temperature lapse rate, critical temperature, rainfall contributing area and recession coefficient. This paper represents is simulate the daily snowmelt runoff in summer season i.e. 21st March to 10th July in the year of 2006 to 2010 respectively and also determining the contribution of snowmelt to the river. For developing the model, MODIS 8 day snow cover data are used for the runoff estimation. The basin is distributed into different elevation zone to increase the efficiency of the model. ASTER DEM to extrapolate temperature to each zone. In the SRM model used degree day approach, the model is developed for Tosh Nala, located at Himanchal Pradesh. The summer runoff was estimated as 20.50, 25.35, 23.86, 28.57, 40.29 m^3/s in the year of 2006, 2007, 2008, 2009, 2010 respectively. The analysis of results proves that the SRM model is best tool for computing the snowmelt runoff in the mountainous areas.

Keywords: snow melt runoff model (SRM), MODIS, SCA, rainfall contribution area (RCA).

I. Introduction

Glacier and snow cover area play an important role in hydrology of glacierised basin (Verbunt, M.et al., 2003). Snow plays a key role in the hydrologic cycle. Snow cover area is a fundamental parameter in the hydrologic cycle and climatology of the earth. Mountainous snow cover exists in many regions on earth and this snow cover can regulate climate cycle, global temperature, water cycle, monsoon intensity of inland areas and so on. In the Himalayas, the glaciers cover approximately 34,660 sq. km(Yongping, S. H. E. N et al. 2004) area and this is one of the largest concentrations of glacier-stored water outside the Polar Regions. Melt water from these glaciers forms an important source of run-off into the NorthIndian Rivers (perennial rivers of North India) during critical summer months. Himalayan glacier fed rivers supply water to one third of the world's population. Himalaya glaciers feed many significant rivers of Asia ensuring a year-round water supply to hundreds of millions of people in the Indian subcontinent and china (Taylor, 2005).These glacier, which release an estimated 8.6 million (Krishna, Akhouri Pramod.et al. 2011) cubic meter of water annually, have nourished seven great river of Asia – Ganga, Indus, Brahmaputra, Salween, Mekong, Yangtze and Huang ho.

In hydrology, snowmelt is surface runoff produced from melting snow. The snow melting caused by higher temperature accompanied with precipitation. Runoff from the glaciered basin is energy dependent, while that from a non- glaciered basin precipitation depend. Thus precipitation in glaciered basin is not directly converted into runoff, but rather is transformed and stored as ice and produce runoff during warm period. In western Himalayas, the temperature is lesser due to higher altitude and as a consequence the snowline in the western Himalaya is at a lower altitude than the eastern Himalaya. As distance from the sea is greater, both annual and diurnal range of temperature is greater in the western Himalayas. So it receives lesser precipitation than eastern Himalayas Anil Bose et al (2013). As in western Himalayas, the snowmelt commences in March, the snow line starts receding upwards and by the end of June to an altitude of 4,500m VajjaHari Prasad, et al. (2006). Changes in climate have rapidly impact on entire earth and also Himalayan glaciers. These glaciers are more sensitive due to changes the climate. According to NSIDC report, over the last 25 years, Gangotri glacier has retreated more than 850 meters (930 yards), with a recession of 76 meters (83 yards) from 1996 to 1999 alone. These process need detailed investigation and developed different model for estimating snowmelt runoff.

For snowmelt runoff modelling, two approaches are accessible i.e. energy balance approach and degree day method. The energy balance method needs more parameter. The degree day method are more applicable and needs less parameter. In this research used degree day method for estimation snowmelt runoff. The snowmelt runoff model (SRM) also referred to in the literature as the "Martinec Model" which is designed to simulate and forecast daily stream flow in mountain

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basin where snow melt is a major model; the main component is estimation of snow melt. SRM is designed to simulate and forecast daily stream flow in mountainous basins where snowmelt is a major runoff factor. Most recently, it has also been used to evaluate the effect of a changing climate on seasonal snow cover and runoff (Rango et al. 2008). For snowmelt runoff modelling, the two pragmatic approaches are accessible. They are energy balance approach and degree day method. In comparison to the energy balance approach, degree day approach is more practicable and needs minimum parameters for simulating snow & glacier melt runoff. It is widely used due to its being less complicated. The energy exchange at snowpack surface can be explained by four major components. They are shortwave radiation exchange and heat exchange, convective heat transfer and adventives heat transfer. These radiations exchange and heat transfer can be estimated if information on various parameters as cloud covers, albedo, wind, cloud temperature and dew point temperature are known Anderson et al. (1976). Information on these parameters is normally not available; therefore, degree-day approach is used for this study. Precipitation and temperature are the major factors for generating runoff in mountainous regions which are covered with snow and glaciers. More than 80% of applications of SRM have been performed by independent users. SRM also successfully underwent tests by the World Meteorological Organization (WMO) with regard to runoff simulation (WMO 1986). The snow cover area of a basin has a very important role to play in hydrological and climatological behavior (Baral and Gupta,1997). SRM can be applied in mountain basins of almost any size (so far from 0.76 to 917,444 km2) and any elevation range. A model run starts with a known or estimated discharge value and can proceed for an unlimited number of days, as long as the input variables - temperature, precipitation and snow covered area - are provided. As a test, a 10-year period was computed without reference to measured discharges (Martinec & Rango, 1986).

The present paper described the snowmelt process in a selected basin of Tosh Nala. The applied method includes the integration of remote sensing and geographic information system (GIS) and numerical modeling technique. Data measured in-situ, like show properties, precipitation, temperature etc, were used for the parameterization of the SRM model to calculate the contribution of snowmelt and rainfall of the basin for the year of 2006-2010. The snow covered area and its depletion with time were determined using satellite image. The general objective of this study is to simulate the daily snowmelt runoff in snowmelt season for the study area. Another objective of this paper is Simulation of river flows on daily basis in a summer season (21 March -10 July) and determining the contribution of snowmelt to the rivers.

II. Study Area

Tosh Nala is located on Kullu district at Himanchal Pradesh. The basin has total area including glacier is 375.46 square kilometer, with elevation ranging from 2163m to 6443m at mean sea level. Kullu is bounded on the north and east by Lahul and Spiti, on the south east by Kinnaur on the south by Simla. This catchment meets with the Parbati basin and finally becomes part of the Beas River at Bhuntar. Location map of the basin is given in Figure 1 and basin characteristics is given in Table 1.

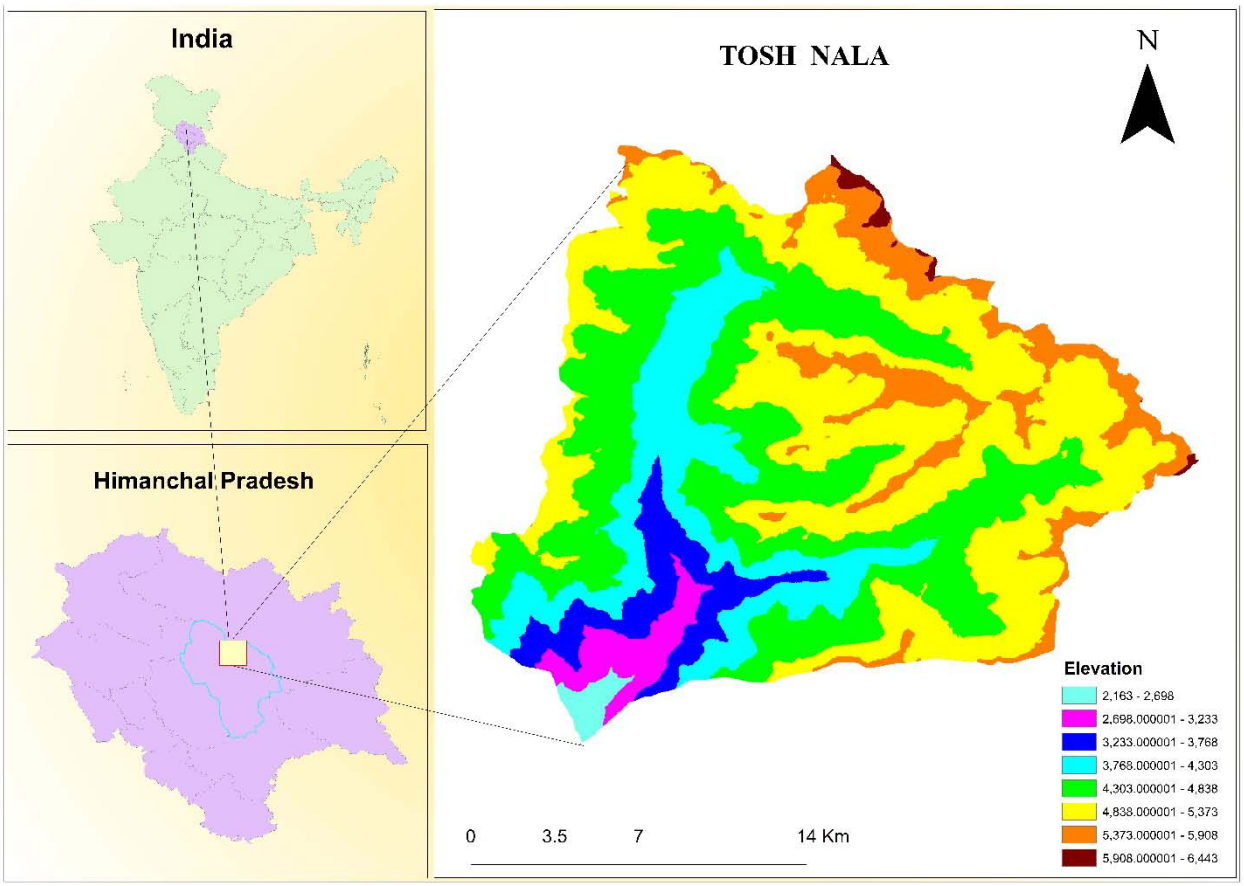

Figure 1: Location map of the Basin

Table 1: Mean hypsometric elevation and area for different elevation zone

Zone	Elevation range(m)	Mean hypsometric elevation(m)	Area(km^2)
Zone 1	2163-2698	2493	3.470323
Zone 2	2698-3233	3003	11.48433
Zone 3	3233-3768	3522	21.49467
Zone 4	3768-4303	4074	51.67062
Zone 5	4303-4838	4588	115.8388
Zone 6	4838-5373	5101	132.0446
Zone 7	5373-5908	5522	37.39416
Zone 8	5908-6443	6059	2.057855

III. Materials and Methods

a) *Data Requirements for SRM Model*

i. *Satellite Datasets*

For the Snowmelt runoff modelling, need a fixed and limited data i.e. Meteorological and Satellite data. Meteorological data such as Temperature and Precipitation data. MODIS (Moderate Resolution Imagining Spectroradiometer) is the 36-channel spectroradiometer on board AQUA satellite from NASA's Earth Observation System(http://nsidc.org/cgibin/snowi/search.p1). The MODIS/AQUA snow cover 8 Day Global 500m grid (MYD10A2) selected for this study comprises of data fields for snow cover extents over an 8 day repetitive period with approximately 500m spatial resolution entirely covering the Tosh Nala catchment. The catchment is delineated using the ASTER (Advanced Space borne Thermal Emission and

Reflection Radiometer) Digital elevation model downloaded from the USGS (U.S. Geological Survey). For detailed analysis of the cryosphere distribution over the study area, eight different elevation zones were extracted from the DEM. Table 1 shows the information about the satellite datasets used in this study such as product, spatial resolution, number of images and source.

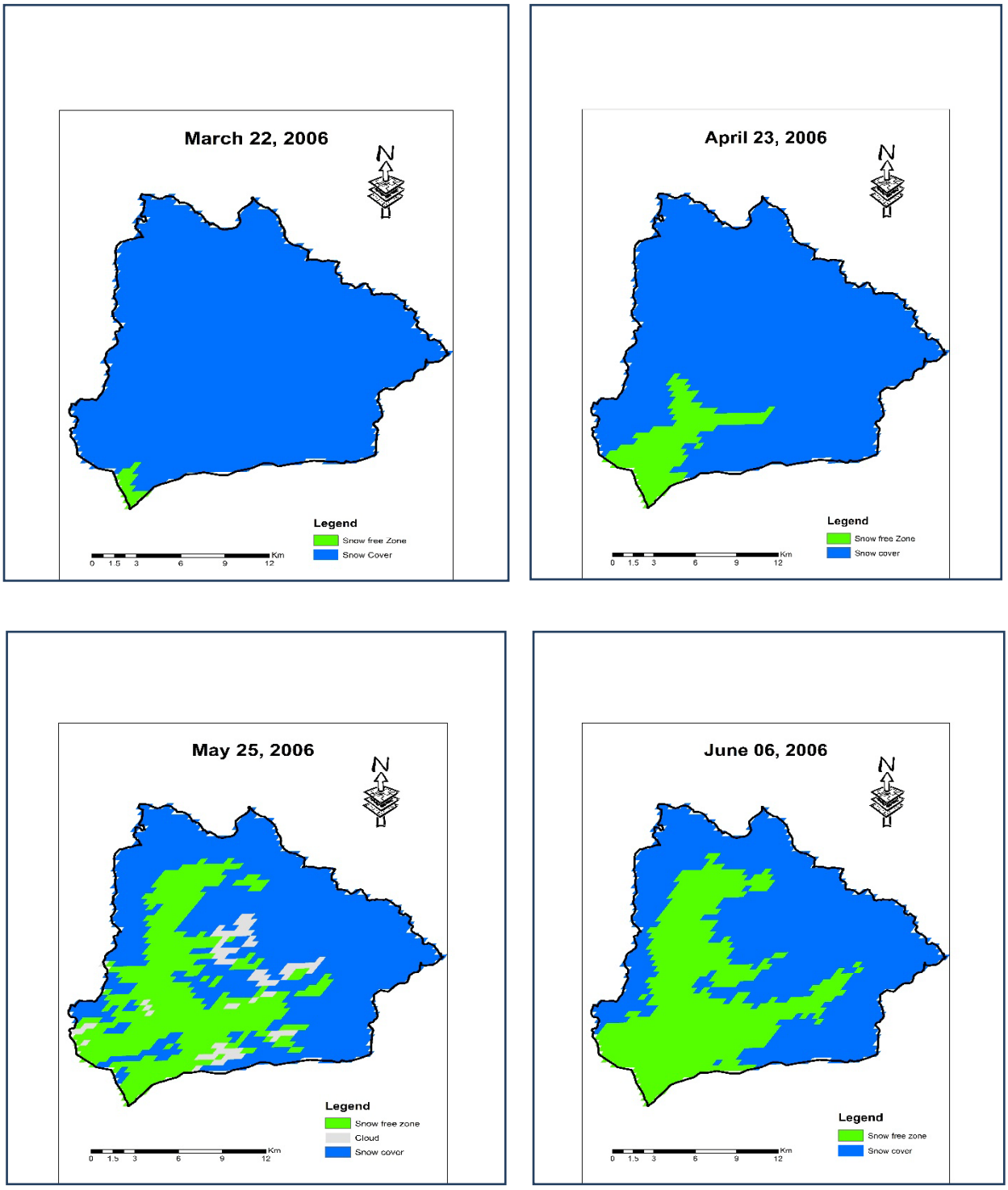

Figure 2: MODIS (MYD10A2) satellite images presenting the snow cover area for each month (summer season) in the Tosh Nala in the year 2006

Table 3: Description of Satellite data

DATA	Spatial Resolution	No. of Images	Source
MODIS (MYD10A2)	500m	70	NASA (National Snow and Ice Data Center Distribution Active Archive Center)
ASTER (DEM)	30m	——	USGS (US-Geological Survey)

ii. *Meteorological Data*

Meteorological data including temperature and precipitation are very important variables for estimation of runoff in snow and glacier covered area. When air temperature is raise, atmospheric water vapours fall into earth surface. Meteorological data have been taken from IISc. Bangluru. Maximum and minimum air temperatures and precipitation data from 2006 to 2010 available in daily format.

iii. *Description of the SRM Model*

The Snowmelt Runoff Model (SRM) is a conceptual, deterministic degree–day (temperature index method) model used to simulate and forecast daily rainfall and snowmelt runoff in mountainous regions. It can be usefully applied for the estimation of the consequences of climate change on snow cover and runoff from the alteration of the percentage of snow cover and temperature. SRM was designed by Martinec (1975) for small basins in Europe. The availability of remote sensing snow cover data provides flexibility to apply this model in large basins. The SRM has been applied in the Ganges River Basin, which has an area of 917,444 km2 and elevations up to 8,840 m (Martinec et al. 2007). This model has been used successfully in more than a hundred catchments located in different regions of the world. SRM was effectively tested by the World Meteorological Organization (WMO) for daily stream flows simulation (WMO 1986) and moderately to simulate the circumstances of real-time runoff predictions (WMO 1992). Initially, the user must provide a known or gauge stream flow value as the initial condition, and then it can be run according to the length of input data set variables, such as precipitation, temperature, and snow-covered area (SCA). Furthermore, the model requires a number of basin physical characteristics such as the basin area, zone area (in the case of zone-wise application) and the hypsometric (area–elevation) curve. The main Equation, on which the algorithm of the model is based, computes the water generated from rainfall and snowmelt, overlaid on the computed recession flow and converts this into daily stream flow from the catchment.

$$Qn+1 = [Csn \cdot an\,(Tn + \Delta Tn)\,Sn + CrnPn]A*10000/86400\,(1-kn+1) + Qn\,kn+1$$

Where

Q = average daily discharge [m^3s^{-1}]

c = runoff coefficient expressing the losses as a ratio (runoff/precipitation), with Cs referring to snowmelt and Cr to rain

a = degree-day factor [cm $°C^{-1}$ d^{-1}] indicating the snowmelt depth resulting from 1 degree-day

T = number of degree-days [°C d]

Δ T = the adjustment by temperature lapse rate when extrapolating the temperature from the station to the average hypsometric elevation of the basin or zone [°C d]

S = ratio of the snow covered area to the total area

P = precipitation contributing to runoff [cm]. A preselected threshold temperature, TCRIT, determines whether this contribution is rainfall and immediate. If precipitation is determined by TCRIT to be new snow, it is kept on storage over the hitherto snow free area until melting conditions occur.

A = area of the basin or zone [km^2]

k = recession coefficient indicating the decline of discharge in a period without snowmelt or rainfall

k = Qm+1/Qm (m, m + 1 are the sequence of days during a true recession flow period).

n = sequence of days during the discharge computation period. Equation is written for a time lag between the daily temperature cycle and the resulting discharge cycle of 18 hours. In this case, the number of degree-days measured on the nth day corresponds to the discharge on the n + 1 day. Various lag times can be introduced by a subroutine.

10000/86400= conversion from cm·km^2 d^{-1} to m^3 s^{-1}

b) Input Parameters

i. *Runoff Coefficient*

Runoff coefficient accounts the runoff losses, i.e. the difference between the available water volume (snowmelt + rainfall) and the outflow from the basin. The runoff coefficient is different for snow and rain. The SRM model can accept separate runoff coefficient for snow and rain. Runoff coefficient takes care of such

losses. Runoff coefficient can vary throughout the year due to changing soil moisture, vegetation and snowpack condition. For this present study, runoff coefficient used ranging from 0.6 to 0.8 (Kulkurni,2002).

ii. *Degree-day factor*

The degree day factor used to obtain snowmelt depth. The degree-day factor converts the number of degree –days into the daily snowmelt depth as follows;

$$M = aT$$

Where

M=Daily snowmelt Depth (cm)

a= Degree day factor (cm C d)

T=Number of degree Days (Cd)

Normally, calculation of melt factor (a) need to density of snow and density of water. So these type of absence of data, in this study used standard value of the degree day factor which is 0.5cm C d (Kulkarni, 2002) for summer season.

iii. *Temperature lapse rate*

Temperature decrease with the increase in altitude above mean sea level with a certain rate called temperature lapse rate. Since temperature variation is major factor for melting of snow/ice at high mountain peaks, so lapse rate is an important parameter in hydrological model such as SRM to determine the temperature variation with elevation. The lapse rate can be predetermined from historical data if temperature stations at different altitudes are available. Otherwise it must be evaluated by analogy from other basins or with regard to climatic conditions. The temperature lapse rate is the change in temperature with altitude. It is used to adjust temperature measured at the basin reference elevation to each zones hypsometric mean elevation. In this present study was used a lapse rate of 0.65°C per 100m.

iv. *Critical Temperature*

The critical temperature is pre-selected value of temperature which determines whether the precipitation event is rain or snow. In Win SRM, the critical temperature is used only in the snow melt season in order to decide whether precipitation is immediately contributes to runoff (if rain), or having delayed contribution (if snow). Model keeps the newly fallen snow in storage until it is melted on subsequent warm days. Generally, critical temperature is kept higher than the freezing point and diminished to 0 °C. Critical temperature was used in this study is 0 to 2^0C.

If Tm >=2^0C, so all precipitation is rain, if Tm<= 0^0C, all precipitation is snow. If Tm <= 2^0C and Tm >=0^0C, so precipitation will be considered as a mixture of rain and snow (Charbonneau, 1981).

v. *Rainfall contribution area, RCA*

Rainfall contribution area helps to determine whether the rainfall induced runoff is added to snowmelt induced runoff only from the snow-free area or from the entire zone area. For *RCA* = 0, it is assumed that rain falling on the snowpack early in the snowmelt season is retained by the snow which is usually dry and deep, and rainfall contributes to runoff only from the snow-free area. At some later stage, the snow cover becomes ripe (*RCA* = 1) and if rain falls on this snow cover, it is assumed that the same amount of water is released from the snowpack so that rain from the entire zone area contributes to runoff.RCA equals to 0 or 1 or combination of 0 and 1 were tried in this study.

vi. *Recession Coefficient, k*

The recession coefficient is an important parameter of SRM since (1-*k*) is the proportion of the daily melt water production which immediately appears in the runoff. Analysis of historical discharge data is usually a good way to determine "*k*". It varies from 0.73 to 1 for Tosh watershed.

IV. Methodology

In the SRM model used some type of variables and parameters. After to do the project, necessary to understand these variables and parameters and its analysis. The main step of the research are as;

- Analysis of metrological data such as temperature data and precipitation data from the station located inside and outside the study area and calculating model parameters for SRM such as temperature lapse rate.
- Using ASTER DEM (Digital elevation model), the study area divided into different elevation zones, the interval between each zone is 500 meter. The study area is divided into different elevation zones because in the mountains basin, every elevation zones has different air temperature, so the present study used different elevation zone recommended through SRM.
- The physical characteristics of the basin are necessary for the determination of the model parameter such as extrapolation of temperature data for different zones.
- Computation of zonal degree day from temperature lapse rate, mean hypsometric elevation and altitude of metrological station for adjusting the temperature for each zone.
- Computation of degree day from temperature data. This is used in the model for the calculation of daily snowmelt depth.
- The SRM model require the monitoring snow cover in the selected basin. A series of image from MODIS (MYD10A2) (AQUA platform) sensor is to be used for monitoring the snow cover extent.
- Analysis on the snow cover image, during summer season, in this section analysis about how much area are changes in the summer season with understand through satellite images and graphs.

- Simulation of the runoff using SRM model. The following variables are needed such as daily data of precipitation, daily data of temperature, snow cover area. The model parameter such as degree day factor, runoff coefficient for snow, runoff coefficient for rain, temperature lapse rate, critical temperature, rainfall contributing area, recession coefficient. In this present study some parameter are directly taken from standard value and some parameter are calculate through basin parameter.
- Analysis about the changes in different year for the discharge from the basin for instance how much water flow from the basin in year of 2006, 2007,2008,2009,2010.

V. Result

In this study, the snowmelt runoff model which is based on degree day method was used to simulate daily discharge from Tosh Nala, Himanchal Pradesh. The simulation period from 2006 to 2010 and each year simulation period from 21 March to 10 July (summer season). The basin was divided into 8 elevation zones. The SRM model input snow cover only in decimal (fraction) of zonal snow which was derived from the area of snow cover divided from total area of the basin. In this current study used MODIS daily 8 day data and the middle days snow cover data obtained from periodical snow cover method. In this periodical snow cover method linear interpolation method. The critical temperature was considered 2^0 C, degree day factor was used 0.5 (*Anil V. Kulkurni et al, 2002*). Cs and Cr was also considered 0.6 and 0.7 (*Anil V. Kulkurni et al, 2002*) respectively.

The model suggest stream runoff in summer as average an each year 20 to 40 m^3/s for Tosh Nala. The simulated discharge flow ranged from 3.93 m^3/s to 68.93 m^3/s. in each year. The stream flow start with low from March and starting from July, it went too high.

Table 4: Snow cover pattern for 2006-2010

Year	Maximum SCA (%)	Minimum SCA (%)
2006	97.36 (22, March)	54.59 (07, April)
2007	97.90 (22, March)	56.58 (25, May)
2008	96.95 (14,April)	43.01 (09, June)
2009	94.30 (07, April)	71.66 (01, May)
2010	93.48 (22, March)	57.68 (02, June)

From the table 1, the snow cover in the Tosh Watershed is maximum in 2006 i.e. 97.36 % on 22-03-06 and lowest is 54.59 % on 07-04-2006 and the same data in 2010 the highest snow cover is 93.48% and lowest is 57.68 %. For this study area, the highest snow cover are found in the year of 2006, 2007, 2008, 2009, 2010 are 97.36 %, 97.9 %, 96.95 %, 94.30 %, 93.48 % respectively, minimum snow cover for tosh watershed are respectively; 54.59 %, 56.58 %, 43.01 %, 71.66 %, and 57.68%.

a) Discharge data analysis

The snowmelt runoff model simulate the discharge from the Tosh Nala during the snowmelt season (21 March to 10 July) from 2006 to 2010. The result of average discharge data in the year of 2006, 2007,2008,2009,2010 are 20.50m^3/s, 25.35m^3/s, 23.86m^3/s, 28.57m^3/s, 40.029m^3/s respectively. According to the result the process of snowmelt runoff going on ascending order to year by year.

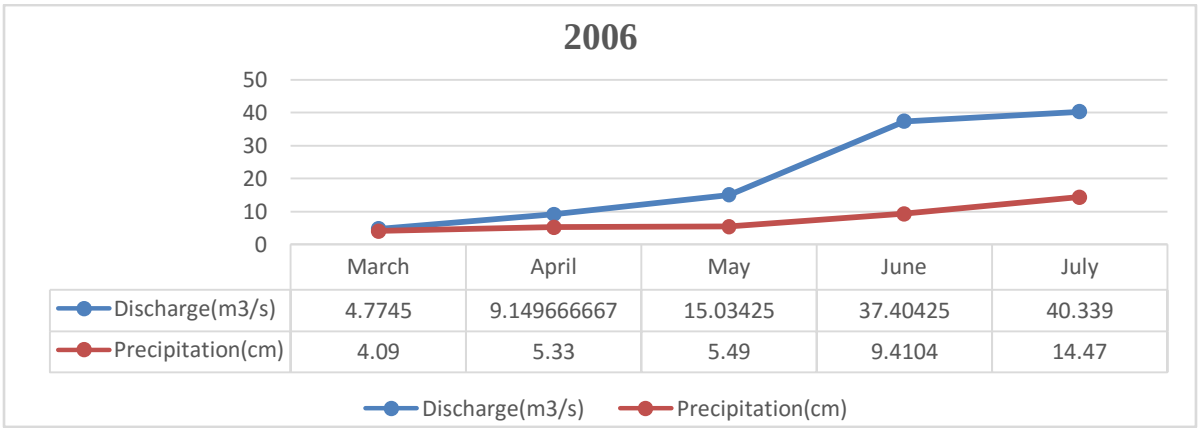

Figure 3: Compares the monthly precipitation and monthly discharge

It means the stream flow at Tosh Nala gradually exceed due to the snowmelt runoff, but in the year of 2010 that has occur highest stream flow from this basin because of in this year occurs highest precipitation comparison among other previous year. During this summer season the precipitation appears to be more

influencing factor than temperature because in this season the precipitation has almost high. Above the figure based on data 2006. As shown in the figure, monthly average discharge in m^3/s and monthly rainfall in cm. The discharge is change rapidly in the month of May and June of the year of 2006 because of in these month precipitation range between 5cm to 14.47cm and after these day the temperature is increased.

The simulated discharge of the Tosh Nala basin, below the following figure are represented the simulated discharge from 2006 to 2010.

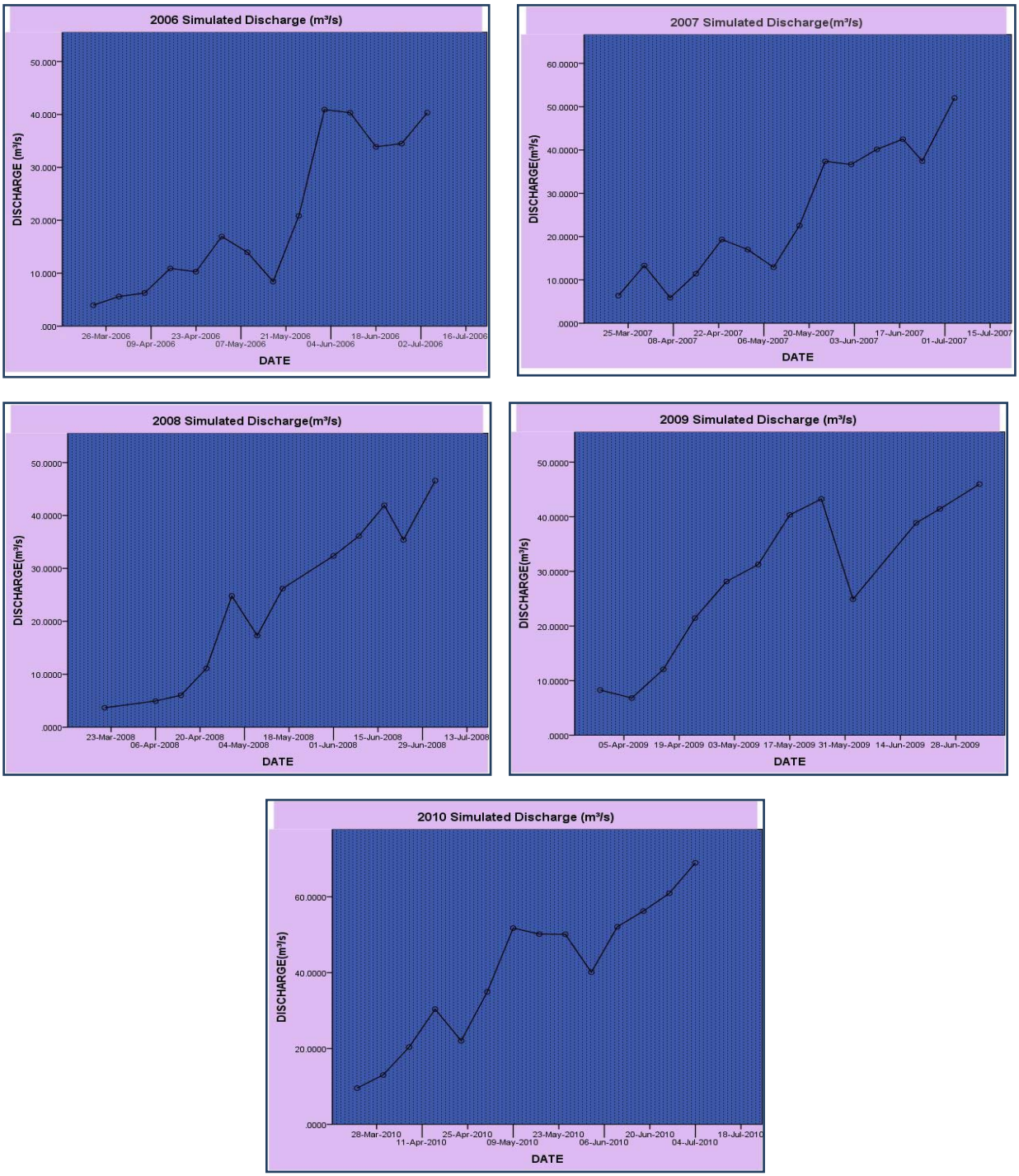

Figure 4: Simulated discharge from Tosh Nala

b) Contribution of snowmelt in runoff

Distinction between rain and snow is important in snowmelt runoff model because the contribution of rain to runoff can be see immediately. As the melting season (March to July) able snow cover gets depleted and it start limiting the snowmelt runoff more than the temperature snowmelt contributing to the runoff is usually delayed. In this study area the precipitation input

may be underestimated because of the precipitation station is in lower altitude. During this summer period most of seasonal snow cover (Zone 1 to zone 3) at lower to medium elevation is melted and the snow melt runoff mainly comes from snow cover at the high elevation (zone 4 to zone 6) and zone 7 and zone 8 are the glaciered area. So from these two zones are released too less discharge. Below the figure () represent the melt depth and contribute runoff, also represent from elevation zone 4 to zone 6, contribution of snow melt in the stream runoff is higher compared with the direct rainfall and zone 1 to zone 3 contribution of direct rainfall in the stream runoff is higher compared with the snowmelt.

The snowmelt contribute increased from May due to the increases in the temperature of the basin. There is a definite response in simulated snowmelt runoff to seasonal snow cover change i.e. an increasing discharge is associated with a decreases of snow cover.

c) Comparison between snow cover depletion curve and average temperature

In this present study, was used MODIS aqua 8 day snow cover data and daily 8 day snow cover data were interpolated by the method of linear interpolation for obtaining the middle days of these snow cover. In this section represent the relation between zonal snow cover (%) and extrapolated temperature by the lapse rate. Below in this table shown the average snow cover (%) in each zone for each month (summer season) and average temperature for each zone of the year of 2010.

Table 7: Monthly average SCA% and average temperature of the year of 2010

Months	Avg. SCA (%) (Zone 1)	Avg. SCA (%) (Zone 2)	Avg. SCA (%) (Zone 3)	Avg. SCA (%) (Zone 4)	Average SCA (%) (Zone 5)	Avg. SCA (%) (Zone 6)	Avg. SCA (%) (Zone 7)	Avg. SCA (%) (Zone 8)	Avg. Tem. (°C)
March	0.155	0.888	2.528	12.21	29.52	33.23	8.802	0.455	20.74
April	0.211	0.721	1.675	10.75	29.89	34.32	9.36	0.435	20.35
May	0.197	0.868	2.01	9.25	29.23	33.95	9.169	0.451	23.11
June	0.084	0.199	0.511	4.71	26.24	29.22	7.66	0.368	23.43
July	0	0	0	0	25.945	27.48	7.355	0.3	25.53

VI. Sensitivity Analysis

The snowmelt runoff model is sensitive to its parameter but it is mainly more sensitive to input variables i.e. snow cover, temperature data and precipitation. It is also more sensitive to temperature lapse rate. However degree day factor and runoff coefficient for snow should not be ignored for the best result. Before interpolation for the snow cover depletion curve used the MODIS daily 8 day snow cover data for the model. It means for this study area has only snow cover data available are interval between 8 days. For the SRM model needs to daily fraction of snow cover for input.

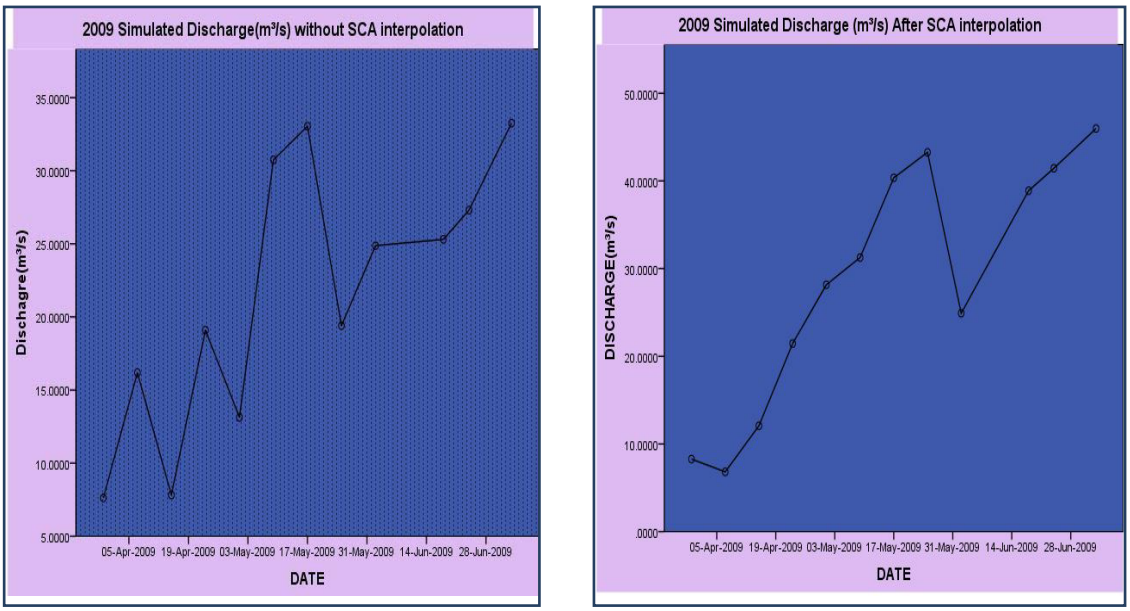

Figure 5: Difference between without SCA interpolation discharge and after SCA interpolation resulted discharge

In this section discuss about the how the snow cover is sensitive to SRM model. For instance for the year of 2007, the discharge data graph is too distorted. It means the discharge curve went on zig- zag shape and then after interpolation of the snow cover the discharge curve is keep regular. Below the figure we can see the clear difference between without interpolation of snow cover resulted discharge curve and after interpolation of snow cover resulted discharge curve.

a) Sensitivity for rain and snow runoff coefficient

The acceptable range for the rain runoff coefficient are the same as the snow runoff coefficient but the result of the rain runoff coefficient test differ substantially from the test on the snow runoff coefficient. At the start of the snow melt season, losses are usually very small because they are limited to evaporation from the snow surface, especially at high elevation. In the next stage when some soil becomes exposed and vegetation grows, more losses must be expected due to evapotranspiration and interception. Towards the end of the snow melt season, direct channel flow from remaining snowfields and glacier may prevail in some basins, which leads to a decrease of losses and to an increase of runoff coefficient. In this study, when put the Cr is 0 and Cs is 0.7 runoff volume was changed by 30% and when put the value of Cs is 0 and Cr is 0.7, the runoff volume was changed by 55% (went down). When put the value of snow runoff coefficient and rain runoff coefficient is 0, the resulted volume and discharge went fell down.

So the snowmelt runoff model (SRM) has more effect on the output (sensitive). According to this study temperature lapse rate, runoff coefficient for snow, runoff coefficient for rain, and snow depletion curve are too sensitive for this model.

b) Assessment of Result Accuracy

The SRM computer program includes a graphical display of the computed hydrology and of the measured runoff. A visual inspection shows at the first glance whether the simulation is successful or not but this research we have not measured discharge data. So checking of the accuracy of the simulation compared the result adopted (Kulkarni et. al, 2002, snow and glacier melt runoff model to estimate hydropower potential).

Table 8: comparison between (Kulkarni et. al, 2002) and simulated data

Referenced Data		Simulated Data				
Season	2002	2006	2007	2008	2009	2010
Autumn	16.49					
Winter	5.30					
Summer	21.08	20.50	25.35	23.86	28.57	40.029
Monsoon	49.13					

VII. Conclusion

Snowmelt runoff modelling at Tosh Nala is done through remote sensing data and metrological data using degree day method. Parameter such as melt factor, runoff coefficient, critical temperature, temperature lapse rate, recession coefficient and variable such as snow cover, daily temperature, daily precipitation.

During summer season high elevated catchment in this study area, two higher zone are glaciered area, which is not change according to months and almost of six zones are covered with snow in starting of summer season and then gradually melting months to months. Temperature and precipitation are found major factor in contributing runoff. Temperature data suggest that the melting season start from March to starting of the July.

Result have represent that:

- The SRM model is a suitable tool to calculate runoff from snow using metrological data and remote sensing derived snow cover maps.
- Satellite data accompanied with GIS method can be used to define the snow cover area and define the elevation zone. ASTER has been very useful in getting the basin boundary and in the snow cover estimation in different elevation zone of 500m interval.
- The SRM model is more sensitive to temperature lapse rate, runoff coefficient and snow cover depletion curve.
- The stream flow discharge is exceeds gradually year by year i.e. 2006 to 2010, the discharge is 20.50, 25.35, 23.86. 28.57, 40.029 m^3/s respectively.
- MODIS snow cover data is the most useful in this study because it is provided direct snow cover data for the study area. We have no need to any classification.

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j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon 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 for 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 of 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 criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to 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 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 avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

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

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

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 approaches 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. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a 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 limit the initial two items to no more than one line each.

Reason for writing the article—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 for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity 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.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets 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 for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate 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 to give the least amount of information that would permit another capable scientist to replicate 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 section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show 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.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the 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—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and 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.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as 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. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give 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 manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit 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 section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an 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 implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully 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 the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of 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 other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
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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