

Gt Aide (Global)1.1: A Freeware for Field Planning

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Abstract:- Field Planning is an integral part of geological studies which involves literature consultation, clear understanding of the area, potential risks etc and also about conducting surveys and collection of data and samples. Though many commercial and non-commercial software are available to accomplish field planning, they require formal training and understanding of complex theories and logic. At this juncture, GT Aide Global, a freeware becomes very handy helping tool for students and researchers of geology, geography and geo-informatics for planning field studies by creating grids, plotting tracks and sample points at great ease over Google earth where visualization is much appealing and informative. Gt Aide (Global)1.1 is meant for preparing various kinds of user defined grids, survey tracks and sampling points for geoscientific studies in any part of the globe which can be used for exploration, mapping, field planning and any similar studies. The software is developed in Visual Basic without using any formal database which makes the freeware handy. To make it more user friendly and simpler it is designed on 'click & retrieve' basis. The output data is viewed in notepad using shell command whereas the maps are visualized in Google earth as kml files. The freeware is meant for those who are not able to afford costly GIS software and also to get rid of their cumbersome working protocols. Gt Aide (Global) can be used by a user without undergoing any formal training. There are eight modules in the freeware meant for gridding of regular and irregular polygons, gridding of polygons with advanced options, sampling along survey tracks created, creating user-defined grids around a point, flexi grids in which user creates grids along a Baseline or along a given bearing, flexi lines are capable of generating nine types of lines/tracks with utmost ease. The converter module facilitates to convert UTM coordinates to geographic coordinates and vice versa. The module: UTM Zones can be used for understanding the zones and the last module 'BID Calculator' for determining bearing, intersection and destination points for a single data and multiple datasets as well. The radius of the earth at a particular latitude can also be determined using this module.

Keywords:- Field Planning, Flexi Grids, Flexi Lines, Kml Files, BID Calculator.

I. INTRODUCTION

Fieldwork is an essential part of geological studies, providing the opportunity to observe, measure, and collect data from the earth's structures directly. The first step in a field planning for a geologist is to clearly define the purpose

of the fieldwork. This can be a broad goal, such as understanding the geological history of an area, or more specific, such as investigating the presence of a particular mineral. Field studies are usually guided by a hypothesis or research question, which informs the planning process (Compton, 1985). Field studies in geology require meticulous planning to ensure effective and efficient data collection. The planning of a field study may be restricted within a polygon or along/around a line or around a point. It varies from case to case. Though there are a few number of commercial and non-commercial software viz; ArcGIS, QGIS, Surfer, FME, Global Mapper etc to accomplish this task, but they are complex and most of them are commercial and requires formal training to run them.

At this juncture, Gt Aide Global, a freeware becomes very handy helping tool for students and researchers of geology, geography and geo-informatics for planning field studies by creating grids, plotting tracks and sample points at great ease over Google earth where visualization is much appealing and attractive. The comprehensive freeware has mainly eight modules facilitating several tasks in connection with field planning. Gt Aide Global can be handled by any user without formal training. The software is coded in Visual basic and designed such a way that the map output is being converted to a kml (keyhole marked up language) file to open through a shell command over Google earth and the data output is loaded as text files in Notepad. Gt Aide Global is much advanced than that of Gt Aide GTP (Dinesh & Sajesh., 2018).

II. GRIDS, TRACKS AND SAMPLES

This module has many features like, gridding of irregular and upright polygons, plotting tracks within polygons, plotting sample points along the tracks with various options, retrieval of polygon boundary coordinates from polygon kml file, determination of polygon area and perimeter, creating rectangles from diagonal data, extracting grid centroids and grid corners etc The grid corners are extracted without any repetition that helps a user to plot samples at the grid corners exactly. The area and perimeter of any polygon can be calculated in various units. (Fig.1) The resultant table will open in notepad while the polygons as kml file in Google Earth. Further, polygons can be gridded at user defined intervals. The coordinates of the grid centroids will be automatically displayed in notepad. This menu also facilitates to create survey tracks within single or multiple polygons along E-W, N-S or along user defined angles. The software automatically retrieves coordinates of polygon boundaries from kml file that are created in Google Earth (Fig.2).

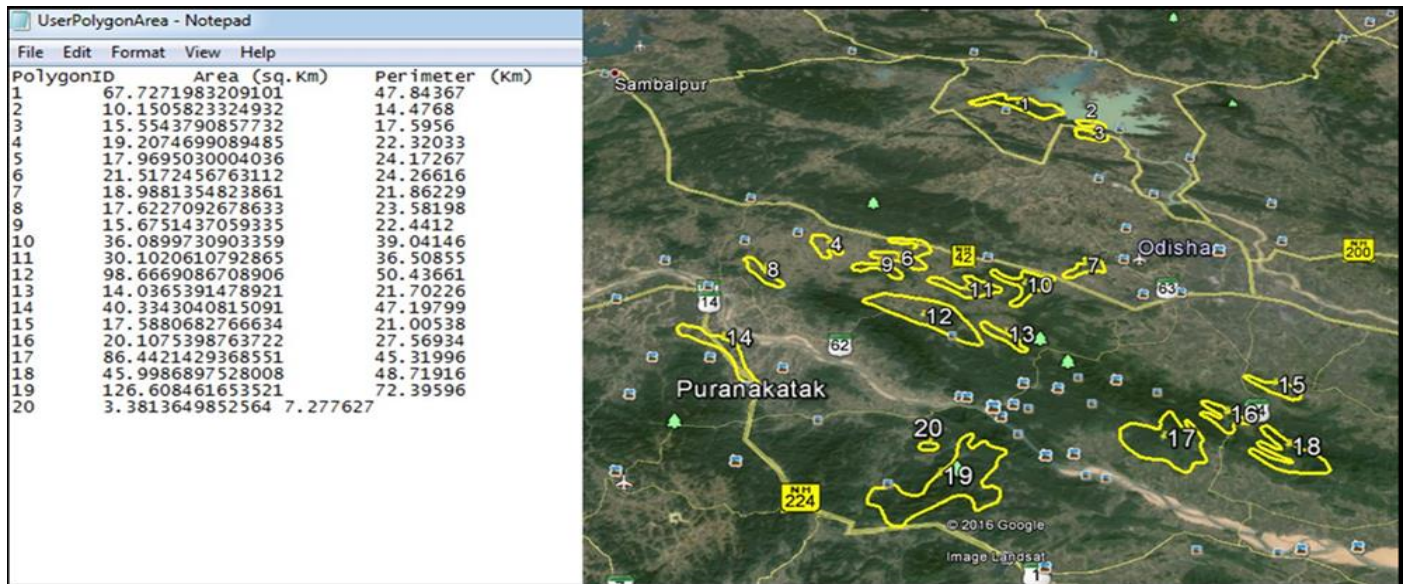


Fig 1 Areas of Multiple Polygons in Notepad and Polygons Plotted over Google Earth

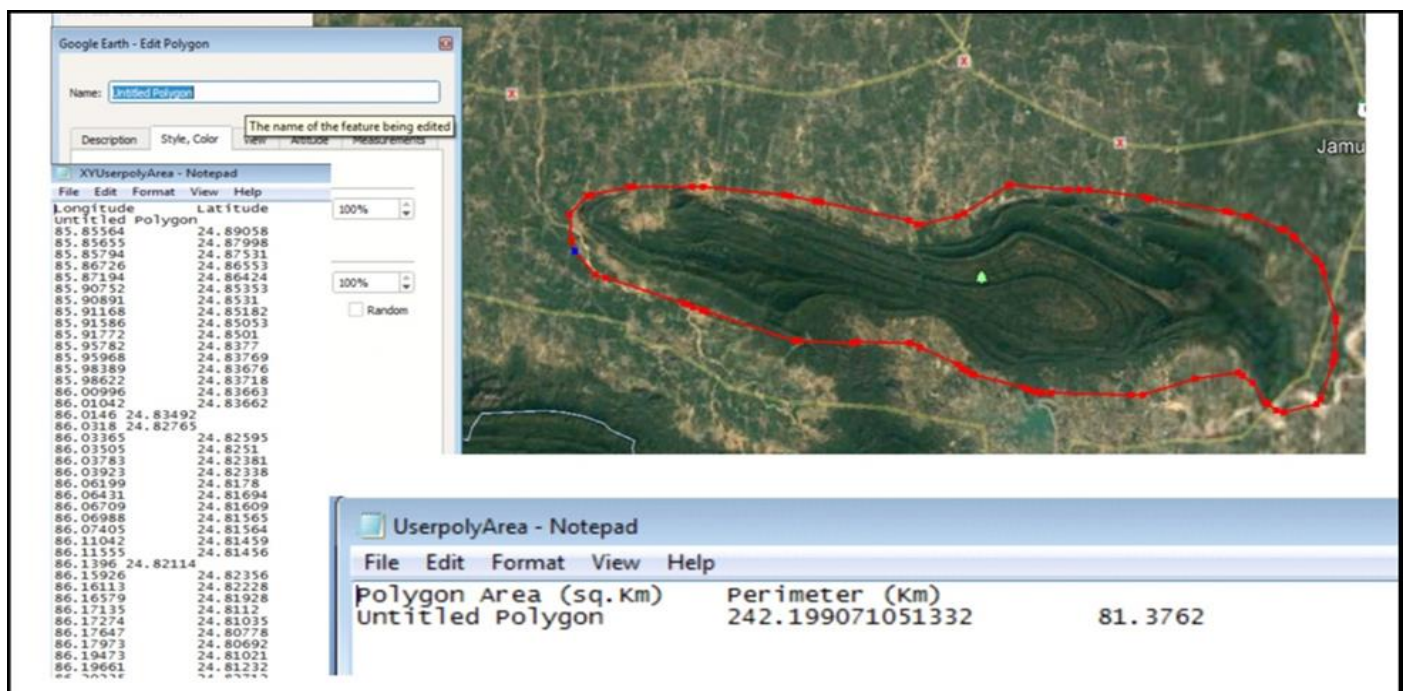


Fig 2 Extraction of Coordinates and Area of a Polygon Digitized in Google Earth

III. ADVANCED GRIDS, TRACKS AND SAMPLES

This module is introduced to create grids parallel to two adjacent sides of a CONVEX polygon. Further, survey tracks can be generated parallel and perpendicular to any side of the polygon and plotting sample points at exact intervals desired by the user. This may facilitate exploration Geologists/Planners/Researchers to plan their work at great ease. User has to paste a convex polygon data as shown in Table-1. One polygon data can be handled at a time. The data is pasted using the button ‘Paste Polygon Data’. Once the data is pasted, the respective polygon will be plotted in Google earth window and software calculates bearing, distance (m) of each polygon side and display in the white box placed at the center part. Internal Angles between

adjacent sides, polygon area and sum of internal angles are also calculated and displayed. This helps user to select suitable side of a polygon for gridding and plotting tracks. The module has three options for the user. Option-1 (Grids), Option-2 (Tracks) and Option-3 (Sampling).

In Figure-3, grids are created parallel to two sides of a convex polygon and the grid centroids and grid corners are also determined automatically. In Figure-4&5, tracks are plotted parallel and perpendicular to first side of the polygon and in Figure-6, samples @1000m interval are plotted along all tracks. There are various options to plot sample points along the tracks created. The geographical coordinates of end points of each track and sample points are also retrieved automatically.

Table 1 Data Format for Plotting Polygon

Polygon		
Poly-1		
1	75.11483	13.60544
2	75.13033	13.61449
3	75.12777	13.62548
4	75.11793	13.628
5	75.11099	13.61937
6	75.11483	13.60544
END		



Fig 3 Grids are Created Parallel to 1st and 2nd Sides of the Polygon

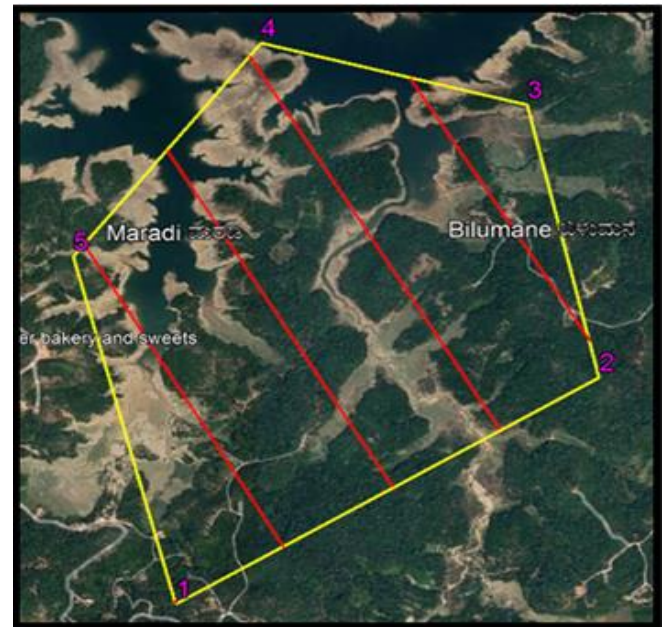


Fig.5 Tracks Created Perpendicular to 1st Side of the Polygon

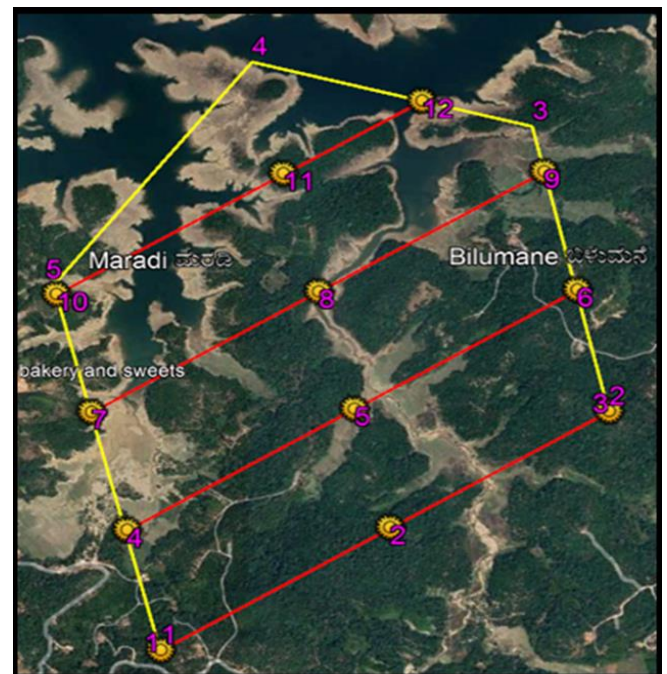


Fig 6 Samples Plotted at 1000m Interval along all Tracks



Fig 4 Tracks Created Parallel to 1st Side of the Polygon

IV. EXPLORATION AROUND A POINT ANOMALY

This module is designed to create eight types of grids around a point (Fig.7). User has to provide the geographical coordinates of the central point and the size of the grid either in terms of length along E-W and N-S or the area of the grid in respective boxes.

V. FLEXI GRIDS

This module is meant to create grids at any internal angle along user-defined baseline or bearing. There are 2 options given: 1) Grids along Baseline and 2) Grids along Bearing. Grids may be either left or right side of the baseline (Fig.8&9). This makes the process literally ‘Flexible’.

VI. FLEXI LINES

This module is designed for creating survey/Exploration Lines of various types. As the name implies, creation of survey/exploration tracks are most flexible. Six types of lines can be created by imparting necessary data in the green boxes (Fig.10) popping up while selecting a ‘Line Type’. Three types of lines are also generated by pasting data in the required format using ‘Paste LineData’ button (Fig.13). Thus total nine Line Types are available.

In Line Type-1, the geographical coordinates of diagonally opposite corner points: Point1 and Point2 are entered along with Line Interval(m) and bearing as ‘0’ for N-S lines and ‘90’ for E-W lines. In Line Type-2, perpendicular tracks are generated to the baseline joining two points at desired interval and length (Fig.11). In Line Type-3, the geographical coordinates of a Point with line interval (m), line length (m), bearing in degrees and number of lines on the left and/or right of the Point are to be entered (Fig. 11). The output lines will be opening in Google earth. In Line Type-4, geographical coordinates of two points: Point1 and Point2 are required along with line interval and line length in meters. The lines are created parallel to the bearing from Point1 to Point2.

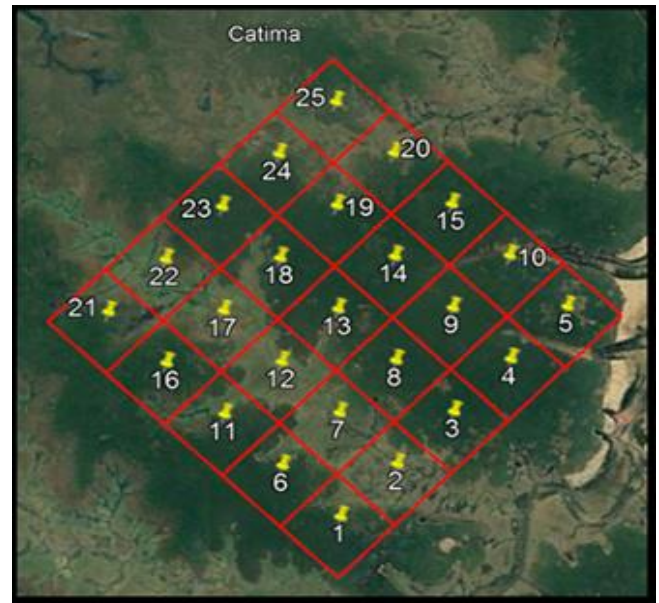


Fig 8 Grids with Interior Angle 90° Created at the Left side of the Baseline Connecting the End Points:17.5°, -13° and 17.75°, -12.75°

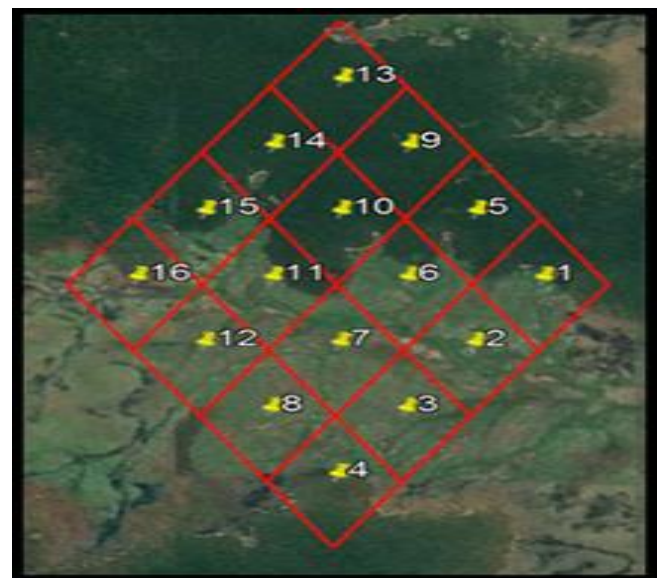


Fig 9 Grids at Right Side (1kmx1km) with Interior Angle 120° Created along Bearing 210° Plotted from a Point.

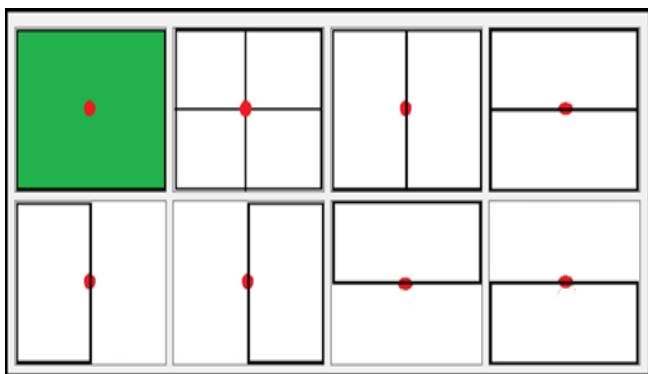


Fig 7 Eight Types of Grids Around a Point Anomaly

User has the option to give number of lines on the right and/or left. In Line Type-5, the data inputs are geographical coordinates of Point1 and Point2, line interval in meters or number of divisions between Point1 and Point2 and line length in meters. The lines would be drawn perpendicular and right side of the line joining from Point1 to Point2. In Line Type-6, the geographical coordinates of the central point, bearing, line interval and line length and number of lines on the left and/or right side are to be entered in the Data Input Window (Fig.11).

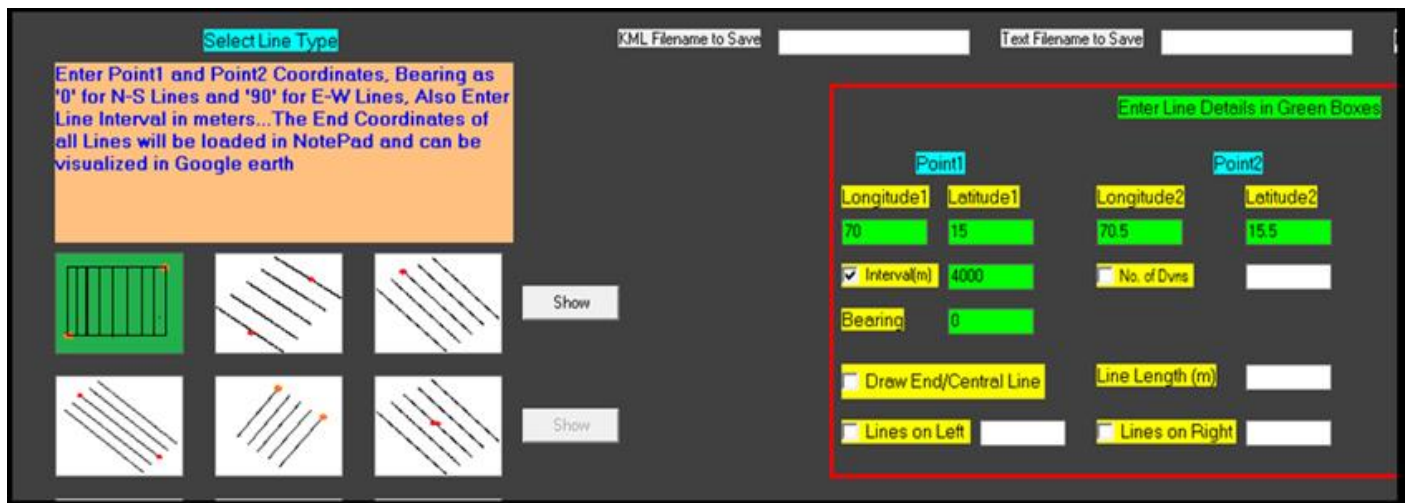


Fig 10 'Flexi Lines' Module Window Showing Data Input Pertaining to Line Type-1

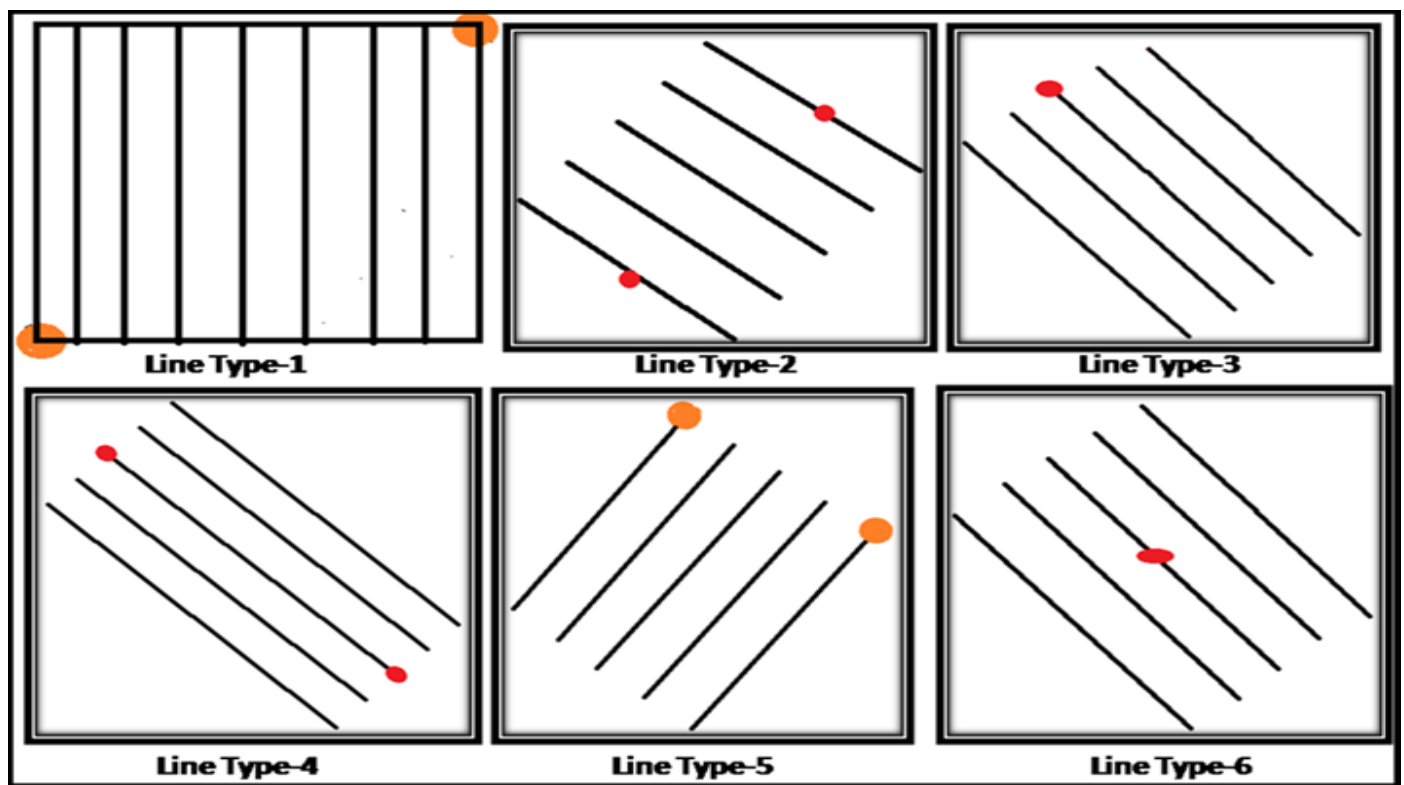


Fig 11 Line Types 1-6 of 'Flexi Lines' Module

Line Type-7 option (Fig.12) is kept to create tracks from multiple points along respective bearings with desired lengths as fixed by the user. The data input format is given below (Fig.13) and the output is shown in the Table.2

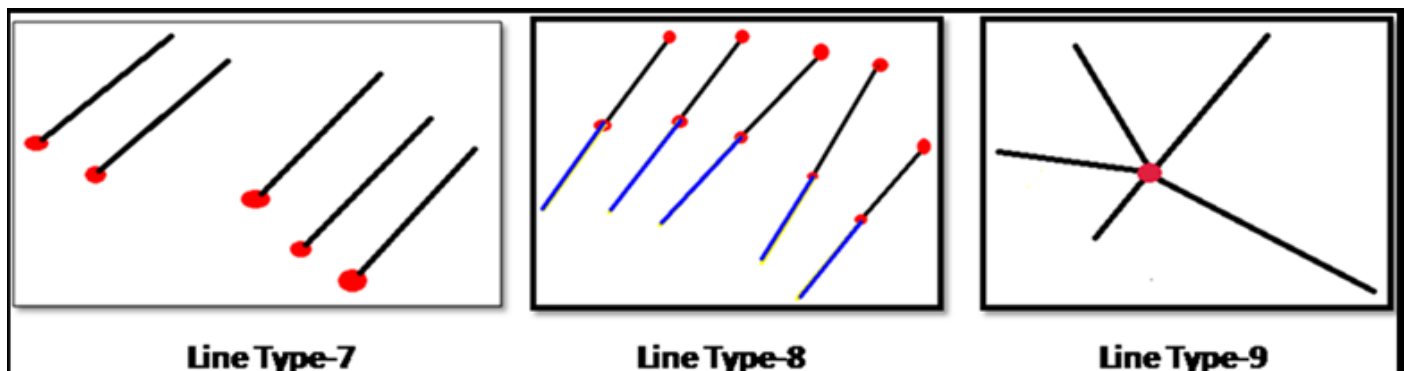


Fig 12 Line Types 7-9 of 'Flexi Lines' Module

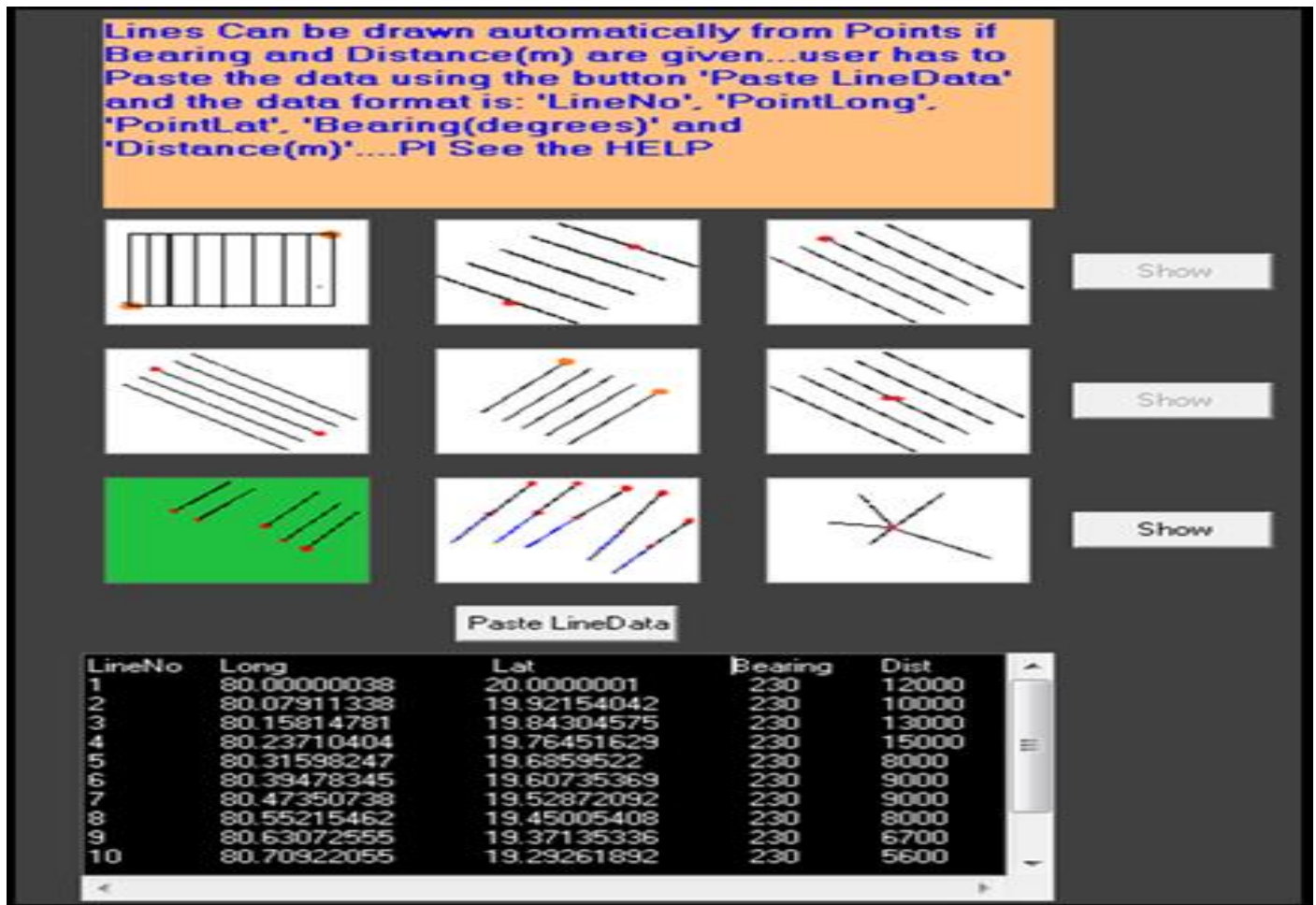


Fig 13 Line Type-7 has been Selected and Input Data (Line No., Longitude, Latitude, Bearing and Distance) Pasted

Table 2 Output Data of LineType-7 Showing Start and End Coordinates and Distance

LineNo	Long1	Lat1	Long2	Lat2	Distance(m)
1	80.00000	20.00000	79.91204	19.93082	11975.75804
2	80.07911	19.92154	80.00584	19.86389	9979.72160
3	80.15815	19.84305	80.06295	19.76810	12973.51589
4	80.23710	19.76452	80.12733	19.67804	14969.30596
5	80.31598	19.68595	80.25745	19.63984	7983.58288
6	80.39478	19.60735	80.32897	19.55547	8981.45315
7	80.47351	19.52872	80.40772	19.47684	8981.37885
8	80.55215	19.45005	80.49371	19.40394	7983.38472

Line Type-8 provides an option to extend tracks along the existing line bearing. The data input is nothing but end coordinates of tracks and the length required to be extended (Fig.13). Advantage is that one can extend any number of existing tracks to desired lengths. In Line Type-9, radial lines are created from a central point (Fig.13). The input data format comprises geographic coordinates of the central point that has to be entered in the pop up green boxes. Line number, bearing (degrees) and distance (m) are to be pasted using the 'Paste LineData' button. The software calculates the destination point coordinates using the start point, bearing and distance using the formula as given below.

VII. CALCULATION OF DISTANCE, AREA, BEARING, DESTINATION POINT AND INTERMEDIATE POINTS

The parameters like distance, area, bearing, destination point, intermediate points are being determined for gridding, area calculation, flexi lines and flexi grids module of the freeware.

➤ *Distance Calculation:*

The Haversine formula is an equation used to calculate the distance between two points on the surface of a sphere, such as the Earth. It takes into account the curvature of the sphere to provide a more accurate calculation of the distance (Sinnot, 1984). The formula is as follows:

$$d = 2r \arcsin(\sqrt{\sin^2((lat2-lat1)/2) + \cos(lat1)\cos(lat2)\sin^2((long2-long1)/2)})$$

Where:

- *d* is the distance between the two points in kilometers
- *r* is the radius of the Earth (mean radius = 6,371km)
- *lat1* and *lat2* are the latitudes of the two points in radians
- *long1* and *long2* are the longitudes of the two points in radians

The distances determined were tested and compared with that of other applications like Google earth and ArcGIS and found that our results are in good agreement with that of others

➤ *Area:*

The Shoelace Formula, also known as the Surveyor's Formula, is used to determine the area of a polygon given its

$$A = 1/2 * |(x1y2 + x2y3 + ... + xn-1yn + xn*y1) - (y1x2 + y2x3 + ... + yn-1xn + ynx1)|$$

Where A is the area of the polygon, xi and yi are the linear coordinates of the ith vertex, and n is the total number of vertices of the polygon.

To use the Shoelace Formula, the coordinates of the vertices of the polygon must first be converted to linear units. This can be done by multiplying the latitude and longitude values by the appropriate factor depending on the map projection used. For example, if the map projection is

vertices. The Shoelace Formula is also known as the Gauss Area Formula. It was first described by the mathematician and physicist Carl Friedrich Gauss in the early 19th century (Gauss,1995 & Weisstein,2021). The input data for determination of polygon area may be a kml file or excel data pertaining to polygon/polygons. The geographic coordinates of each vertex (corner) of the polygon will be automatically displayed on a separate notepad window while using a kml file.

The formula is based on the concept of calculating the signed area of a polygon, which is the area with a positive or negative sign depending on the orientation of the vertices (clockwise or anticlockwise). The absolute value of the signed area is taken to obtain the positive area of the polygon. The formula can be expressed as:

in meters, the latitude and longitude values must be converted to meters before applying the Shoelace Formula.

However, Gt Aide Global, first determines the nearest SW point of the given polygon and calculates accurate X and Y distances (coordinates) in meters from the point. Since the formula is meant for Cartesian coordinate system, polygons of small to moderate areas are recommended. However, the comparison of polygon areas determined using different software are shown in the Table-3.

Table 3 Comparison of Polygon Areas (sq.km) Determined Using Different Software

Polygon	Google earth	Arc GIS	Gt Aide Global
Poly-1 (44N-UTM)	2588	2581.5	2587.6
Poly-2 (38S-UTM)	3821	3805	3800.6
Santur-1 (43N-UTM)	364	363	363.3
Santur-2 (43N-UTM)	265	265.2	264.1

➤ *Bearing:*

The formula provided is to calculate the initial bearing (also known as forward azimuth) between two points on the surface of a sphere (i.e., the Earth). It is derived from the spherical law of cosines and the law of sines (Vincenty, 1975).

Bearing (θ) is being calculated in 0-360 degrees and the formula is given below:

$$\theta = \text{atan2}(\sin(\Delta\text{long}) \cdot \cos(\text{lat}2), \cos(\text{lat}1) \cdot \sin(\text{lat}2) - \sin(\text{lat}1) \cdot \cos(\text{lat}2) \cdot \cos(\Delta\text{long}))$$

Where θ is bearing and Δlong is difference between long1 and long2.

In this formula, θ is bearing in degrees, Δlong represents the difference in longitude between the two points, lat1 and lat2 are the latitudes of the starting and ending points, respectively, **atan2** is a mathematical

function that calculates the arctangent of the quotient of its two arguments. Unlike the regular **atan** function, which only returns values between -π/2 and π/2 radians (or -90 and 90 degrees), **atan2** returns values between -π and π radians (or -180 and 180 degrees). It is useful in applications such as navigation and robotics, where it is important to calculate angles in all four quadrants.

➤ *Destination Point*

Destination Point is determined by using the following formula which is known as the "direct Vincenty problem" and is used to determine the destination point given a starting point, initial bearing, and distance.

$$\varphi_2 = \text{asin}(\sin \varphi_1 \cdot \cos \delta + \cos \varphi_1 \cdot \sin \delta \cdot \cos \theta)$$

$$\lambda_2 = \lambda_1 + \text{atan2}(\sin \theta \cdot \sin \delta \cdot \cos \varphi_1, \cos \delta - \sin \varphi_1 \cdot \sin \varphi_2)$$

φ1, λ1: latitude and longitude of the starting point in radians

δ : the angular distance d/R between the starting point and the desired endpoint

θ : the initial bearing from the starting point to the desired endpoint in radians

ϕ_2, λ_2 : latitude and longitude of the desired endpoint in radians

- *R: the radius of the Earth*

The formula was developed by Thaddeus Vincenty in 1975 and is an improvement over the Haversine formula for accuracy over longer distances.

Gt Aide Global uses a function that determines the Destination Point for a given initial point, distance, and bearing: The software uses the Haversine formula and the 'asin' and 'atan2' sub-functions coded in VB6 to calculate the destination point. The function takes the initial latitude, longitude, distance, and bearing as input, and returns the destination point coordinates. The radius of the Earth in kilometers at the given latitude will be determined for more accuracy.

➤ *Intermediate Point*

The formula for calculating the intermediate point along a great circle path between two points is derived from the spherical law of cosines. The formula takes into account the fraction along the great circle route, the angular distance between the two points, and the latitude and longitude of the two points. The formula for calculating the intermediate point on a great circle path between two points is known as the "mid-point" formula or "mid-latitude" formula. It was first introduced by Charles Karney in his 2013 paper titled "Algorithms for geodesics" published in the Journal of Geodesy.

- *The formula is:*

- ✓ $a = \sin((1-f) \cdot \delta) / \sin \delta$
- ✓ $b = \sin(f \cdot \delta) / \sin \delta$
- ✓ $x = a \cdot \cos \phi_1 \cdot \cos \lambda_1 + b \cdot \cos \phi_2 \cdot \cos \lambda_2$
- ✓ $y = a \cdot \cos \phi_1 \cdot \sin \lambda_1 + b \cdot \cos \phi_2 \cdot \sin \lambda_2$
- ✓ $z = a \cdot \sin \phi_1 + b \cdot \sin \phi_2$
- ✓ $\phi_i = \text{atan2}(z, \sqrt{x^2 + y^2})$
- ✓ $\lambda_i = \text{atan2}(y, x)$

Where:

- ✓ f is the fraction along the great circle route, with $f = 0$ at Point 1 and $f = 1$ at Point 2
- ✓ δ is the angular distance between the two points, calculated as d/R , where d is the distance between the two points and R is the radius of the earth (mean or geodetic)
- ✓ ϕ_1 and λ_1 are the latitude and longitude of Point 1, respectively
- ✓ ϕ_2 and λ_2 are the latitude and longitude of Point 2, respectively
- ✓ ϕ_i and λ_i are the latitude and longitude of the intermediate point, respectively (Karney, 2013).

The reference, Karney (2013), is for the calculation of geodesics. This paper discusses algorithms for calculating the shortest path between two points on an ellipsoid, taking into account the non-spherical shape of the Earth. The algorithms presented in this paper are more accurate than the Haversine or Vincenty methods, but are also more complex and computationally intensive.

VIII. CONVERTER MODULE

The conversion of Geographic Coordinates (GC) to that of UTM and vice versa is being included in this module (Steven Dutch, 2011). User is also able to make use of this module to change format of longitude and latitude data from one to another. In Fig.14, the 'converter' window shows the boxes to enter geographical coordinates (longitude and latitude) to convert into UTM Easting and Northing with UTM Zone number and UTM Easting, Northing and UTM Zone number to convert into geographical coordinates. One can also find out the UTM Zone by entering longitude and determine western boundary, eastern boundary and central meridian by entering UTM Zone. User can convert coordinates of multiple points from geographical coordinates (Lat Long) to UTM coordinates and vice versa (Fig.15) by pasting data (tab delimited) in the following format from EXCEL as given in the Tables- 4 & 5 and the output data are also shown in Tables-4 & 5. Point No. can be a number or string and the Hemisphere "N" or "S" should be in another column.

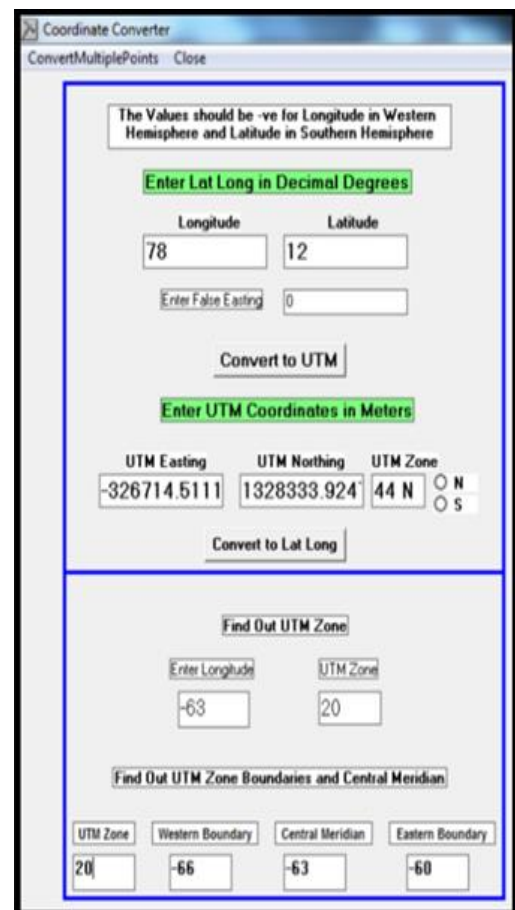


Fig 14 Conversion of Coordinates and Determining UTM Zone Parameters

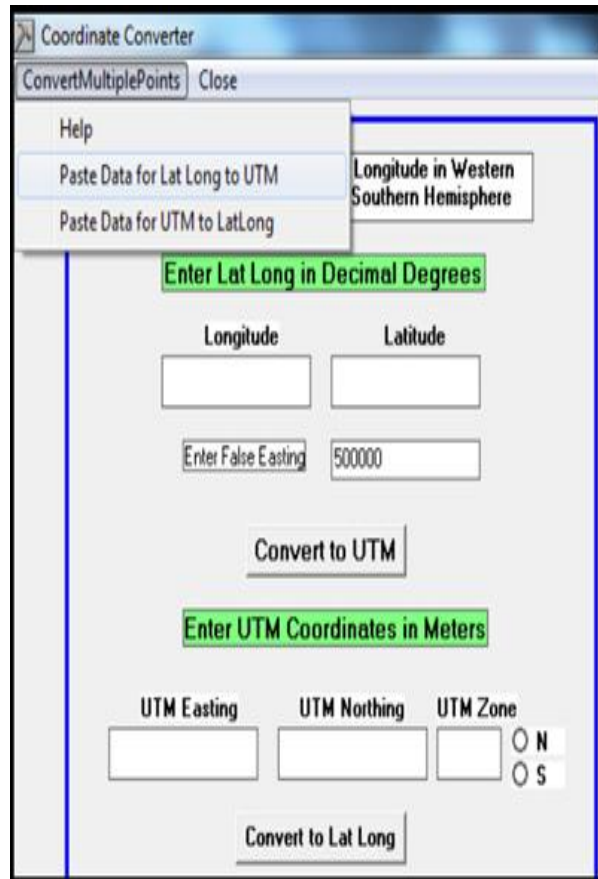


Fig 15 Sub-Menu for Converting Coordinates of Multiple Points from Lat-Long to UTM and vice versa

Table 4 Input data format for Converting Geographic Coordinates to UTM Coordinates and its output in UTM Coordinates.

Input			Output			
PointNo.	Longitude	Latitude	Point No.	Easting	Northing	Zone
1	-87.3442	12.40988	1	462585.9	1371902	16N
2	-88.7867	11.99863	2	305475.8	1327033	16N
3	120.3479	-10.78554	3	209967.9	8806478	51S
4	110.9877	10.78665	4	498651	1192390	49N
5	78.90776	15.98776	5	276091.8	1768708	44N

Table 5 Input Data format to convert from UTM Coordinates to Geographic Coordinates and its output coordinates in Geographic Coordinates

Input				Output			
Point No.	Easting	Northing	Zone	Hemisphere	Point No.	Longitude	Latitude
1	462585.9	1371902	16	N	1	-87.3442	12.4098
2	305475.8	1327033	16	N	2	-88.7867	11.9986
3	209967.9	8806476	51	S	3	120.3479	-10.7855
4	498651	1192389	49	N	4	110.9877	10.7866
5	276091.8	1768708	44	N	5	78.90776	15.9877

IX. UTM ZONES

This module facilitates to plot all UTM zone boundaries over Google earth with labels of zone numbers (Fig.16). This helps for a better visualization of UTM zones to a user.

The zone parameters such as central meridian, left and right longitude boundaries and bottom and top latitude boundaries etc are being displayed while selecting a zone.

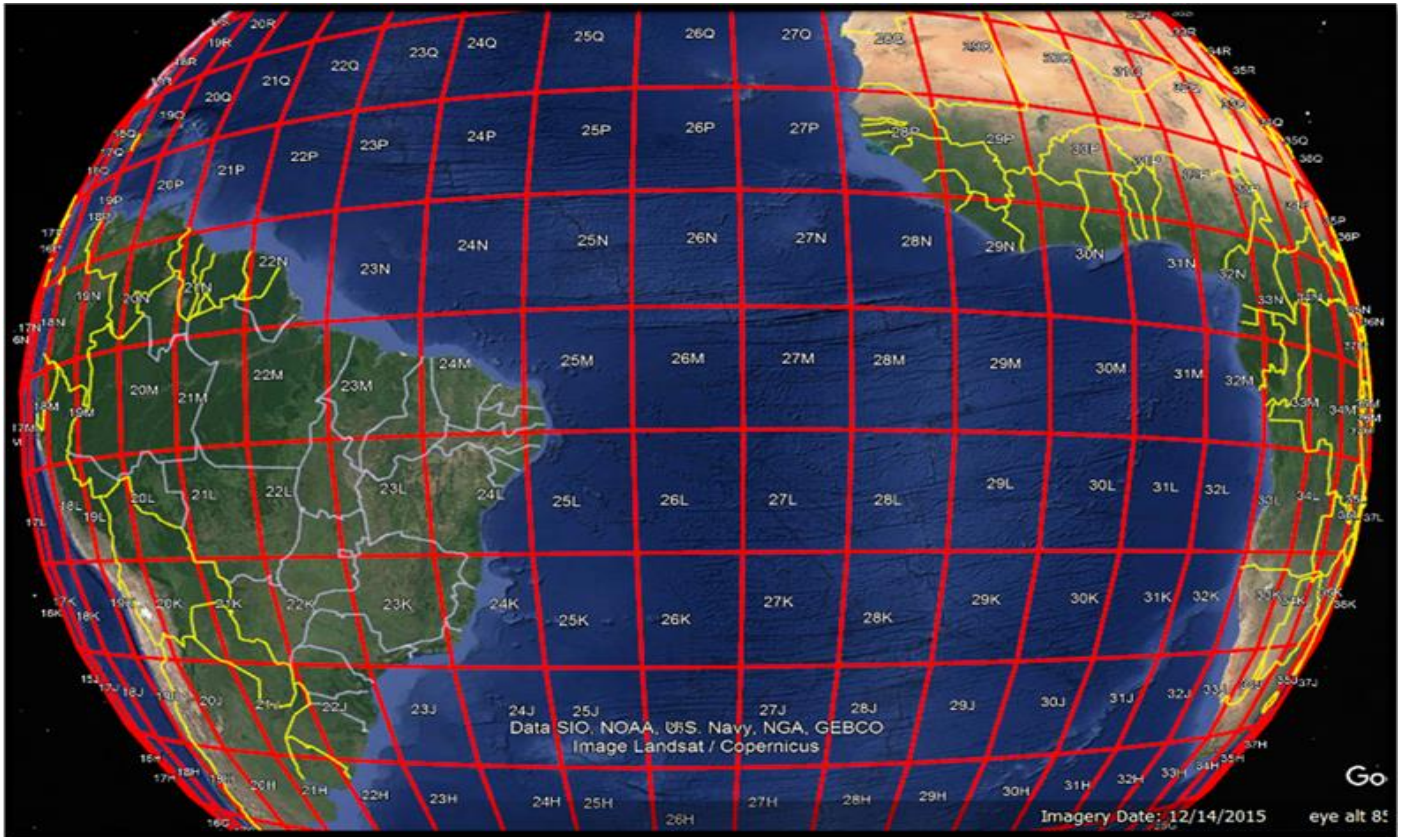


Fig 16 Image Showing All UTM Zones are Plotted over Google Earth

X. BID CALCULATOR

BID stands for Bearing, Intersection and Distance (Fig.17). This module facilitates to calculate Bearing of a line, coordinates of Intersection Point of 2 lines on a 2D surface and coordinates of a Destination Point. In addition, Earth Radius at different latitudes is also calculated. The data format for each item is given below. The data may be copied from EXCEL and paste in the respective menu of BID Calculator of GtAide Global.

Bearing is calculated for a line whose geographical coordinates are entered in the respective boxes and press ‘Calculate’ button. The results would be Initial Bearing and Distance. GtAide Global also facilitates to determine bearing of several lines. Bearing of multiple lines can be determined using the menu ‘Batch Conversion’----> ‘Bearing’ ----> ‘Paste Excel Data’.

Intersection point of two lines in two dimension is determined using the formula shown above. Hence, the determination of intersection points is intended to lines having short distances. GtAide Global also facilitates to determine intersection points for several paired lines under the menu ‘Batch Conversion’ ----> ‘Intersection’----> ‘Paste Excel Data’.

Destination: GtAide Global determines Destination Point provided the geographical coordinates of initial point, bearing and distance in kilometer are given. The formula for determining the Destination Point longitude (λ_2) and latitude (ϕ_2) are given above. Multiple data can be handled using the menu ‘Batch Conversion’ ----> ‘Destination’----> ‘Paste Excel Data’.

Earth Radius: Radius of Earth at a given Latitude (WGS84) is calculated as per WGS1984 spheroid. For South Latitudes -ve sign is given. The Radius is calculated in Kilometer. User may enter latitude in Degrees, Minutes and Seconds or as Degree decimal and get the exact radius at the given latitude. The formula (Moritz, 1980) used is given below.

$$r = \sqrt{((a^2 \cos^2 \phi + b^2 \sin^2 \phi) / (a^2 \cos^2 \phi + b^2 \sin^2 \phi))}$$

Where:

- *r is the radius of the Earth at the given latitude*
- *a is the equatorial radius of the Earth (6,378,160 meters)*
- *b is the polar radius of the Earth (6,356,774.719 meters)*
- *ϕ is the latitude of the point in radians*

Earth radius for several latitudes can also be determined by using the menu ‘Batch Conversion’ ----> ‘Earth Radius’----> ‘Paste Excel Data’.

The screenshot displays four distinct calculation modules within a single window:

- Bearing Calculator:** Includes input fields for Start Long, Start Lat, End Long, End Lat, Init Bearing, and Distance (Km), with a Calculate button.
- Coordinates of Intersection Point of 2 Lines:** Features two lines (Line-1 and Line-2) with their respective Start Long, Start Lat, End Long, and End Lat fields, plus an Intersection Point section for Longitude and Latitude, and a Calculate button.
- Coordinates of Destination Point:** Contains input fields for Initial Long, Initial Lat, Distance (Km), Bearing (deg), Dest. Long, and Dest. Lat, with a Calculate button.
- Earth Radius at a Given Latitude (WGS84):** Shows a Latitude section with sub-fields for Degree, Minutes, Seconds, and Deg. Decimal, and a Radius (Km) field with a Calculate button.

Fig.17: BID Calculator Module Window

XI. CONCLUSION

The freeware GtAide Global is a unique software that can be used for multi-tasking in field studies and exploration. The teachers, students and research scholars pertaining to graduate and postgraduate courses of geology, geography and similar courses may be benefited by using the freeware for gridding of polygons, plotting survey tracks and sample points, visualizing the results over Google earth and Notepad just by clicking would be a great experience. The freeware does not warrant any formal training. Conversion of large number of coordinates from UTM to geographic coordinates and vice versa are being done with great ease. Creating survey lines parallel or perpendicular to a given line are designed with utmost flexibility even easier than any GIS software available. Likewise, grids, lines along a given baseline or bearing. It is sure that the users of GtAide would enjoy using it and the teachers can give more tasks in the class there by the students would learn many techniques and visualize the things in a better way.

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