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Comparing The Accuracy of Different Map Projections and Datums Using Truth Data

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Abstract

Positional inaccuracy is a major public engineering problem, and the cause of errors which lead to inaccurate measurements. The main challenge faced by many researchers is the accuracy. Hence, this paper involved comparing various map projections and datums effect on accuracy using 7 parameter method and root mean square errors (RMSE) test. In order to prepare data for analysis, sets of points in the study area, which is located in north of Iraq in Sulaymaniyah Governorate (Arbat City), were selected as follows: first set of ten checkpoints (reference points) was selected randomly. The cartographic parameters for these points were (Lat. /Long. coordinates) and datum was WGS84 using Differential GPS. Then other sets of points were ten Ground Control Points (GCP) for the same positions, but in this case were Cartesian coordinates with different projections and datums. The idea was to convert coordinates system of the second set points to geographic coordinate system for all specified projections using 7 parameter method. After that calculate RMSE between transformed coordinates and original coordinates (first set of checkpoints). The projection and datum that will guarantee less RMSE will be the best for study area. In this method required acquire ground control points (GCP) and global position system points (GPS points), for the purpose completing the study all the needed coordinates were measured using DGPS. Not only datum transformation from global datum (WGS1984-UTM-Zone-38N) to local datum (Karbala1979-UTM-Zone-38N) were performed, but also producing new maps for the purpose of comparisons. The results demonstrated that UTM projection and local datum (Karbala1979-UTM-Zone-38N) were the best for study area according to RMSE test.

Keywords: GCP, Map, Projection, GPS, 7 Parameter Method.

الخلاصة

عدم الدقة الموقعية هو مشكلة الهندسة الرئيسية، وسبب الأخطاء التي تؤدي إلى قياسات غير دقيقة. التحدي الرئيسي الذي يواجه العديد من الباحثين هو الدقة. لذا فقد تضمنت هذه الورقة المقارنة بين مختلف إسقاطات الخرائط والمراجع الجغرافية على الدقة باستخدام طريقة 7 معلمات وفحص RMSE. لذا فمن أجل إعداد البيانات للتحليل، تم اختيار مجموعتين من النقاط لمنطقة الدراسة، التي تقع في شمال العراق في محافظة السليمانية (مدينة أربات) على النحو التالي: تم اختيار المجموعة الأولى من عشر نقاط مرجعية بشكل عشوائي. وقد كان المرجع الجغرافي لهذه النقاط هو WGS84 قيست باستخدام نظام تحديد المواقع العالمي. بعد ذلك استخدمت مجموعة أخرى من النقاط "عشر نقاط ارضية محكمة" في نفس المواقع، ولكن في هذه الحالة كانت الإحداثيات الديكارتية. وكانت الفكرة هي تحويل نظام إحداثيات النقاط الثانية إلى نظام الإحداثيات الجغرافية لجميع الإسقاطات المحددة باستخدام أسلوب المعلمة 7. بعد ذلك حساب متوسط جذر أخطاء المربع بين الإحداثيات المحولة والإحداثيات الأصلية (المجموعة الأولى و نقاط المرجعية). وسوف يكون المسقط و المرجع الجغرافي الذي يضمن أقل RMSE الأفضل لمنطقة الدراسة. في هذه الطريقة المطلوب الحصول على نقاط التحكم الأرضي و نقاط الموقع العالمي لذا تم الحصول على جميع الاحداثيات المطلوبه باستخدام نظام الموقع العالمي. ليس فقط تم تحويل مرجع الجغرافي العالمي إلى مرجع المحلي ولكن أيضا إنتاج خرائط جديدة لغرض المقارنات. وأظهرت النتائج أن مسقطUTM والمرجع المحلي-Karbala1979 كانوا الأفضل لمنطقة الدراسة وفقا لاختبار RMSE.

الكلمات المفتاحية: - مساقط الخرائط، نظام الموقع العالمي، نقاط الضبط الارضي.

1 Introduction

Positional accuracy, has received considerable scholarly attention in recent years, is a major area of interest within the fields of Geomatic engineering, Geodesy and cartography. Positional accuracy is a common condition which has considerable impact on all map applications and productions. In the history of development remote sensing data, accuracy has been thought of as a key factor in reducing errors and

producing rigorous data. The main challenge faced by many researchers is the projection distortion and corresponding inaccuracy. There is an urgent need to choose the projections fit to the study purpose and coincident with study area. A much debated question is whether the selection of specified projection type effect on the positional accuracy. This paper assesses the influence of projection and datum on accuracy to do so ten reference points ,obtained by Differential GPS, compared to ten Ground Control points (GCP) for the same location using Root Mean Square Error (RMSE) test. In this paper all projection used or assessed were conformal which preserve the shape and angles due to two reasons, firstly these types of projections are widely used in map applications and surveying secondly to avoid biased data. Throughout this paper, the term 'RMSET' will refer to total Root Mean Square Error for all reference points. The reference points or truth data were measured using GPS in study area which is located in Arbat City which is located in north of Iraq in Sulaymaniyah Governorate. Differential Global Positioning System (DGPS) is of a higher accuracy than the absolute observation due to the use of reference station where coordinates are known to ascertain accuracy. The systems utilized as a part of DGPS observations are static, quick static, unpredictable, and real time kinematics. Among DGPS procedures, the static tactic is of a higher accuracy because of a few methods utilized as a part of the data collecting process. Information fetched after field overview should be ready to get a desired outcome. DGPS information after post handling still contains blunders (Ansah, 2016; Okwuashi, 2014; Peprah and Mensah, 2017).

The Glossary of the Mapping Sciences (Congalton and Green, 2009) defines positional accuracy as "the degree of compliance with which the coordinates of points determined from a map agree with the coordinates determined by survey or other independent means accepted as accurate." To guarantee the objectivity and meticulousness of the evaluation, it is basically critical that the reference information be autonomous from the information being tested. Thus, control points or digital elevation models used to create the spatial products being tested are unsuitable sources of reference data. In order to evaluate the accuracy, the accuracy and quality of reference data should be at least one order better than the data to be evaluated. The reference points should lie clear of vegetation and structures. A map delivered and used to group the control points (Elkhrachy, 2017). In the mapping application, vertical exactness is assessed by vertical Root-Mean-Square-Error (RMSE). This statistical method has been broadly used since the late 1970s. It specifies the discrepancies between the estimations of the DEM elevations and the estimations of reference GPS elevations. Individual point differences are additionally called residuals, and the RMSE serves to total them into a solitary measure of predictive power (Elkhrachy, 2017). A large and growing body of literature has investigated projection distortions and transforming (Mátyás, 2011).

(Gaspar, 2011) proposed a numerical model utilizing the idea of multidimensional scaling, summed up to separations and bearings measured on the surface of the Earth, is displayed and tried, with the goal of mimicking the primary geometric elements of early nautical graphs. Beginning with a specimen of focus characterized by their latitudes and longitudes, the procedure comprises in modifying their positions in a plane so the contrasts between the underlying (spherical) and last (planar) distances and directions between them are limited. By contrast to Clark 1880-Karbala 79 datum, World Geodetic System (WGS84) represents the most accurate geodetic survey datum nowadays. Iraq geodetic datum (Clark 1880-Karbala 79 datum), which was established by "POLSERVICE" company during the 1974 has

proven useful for a long time, but during the recent years, some problems in Iraq geodetic datum were discovered when measured by GPS (Abd-Alrahman,2014).

Coordinate transformations are widely used in geodesy, surveying and related disciplines. For instance, in geodesy three dimensional (3D) Cartesian coordinate transformation methods are used to convert coordinates related to the local geodetic control network to the world geodetic system (WGS84). These methods have included 7, 8, 9 parameters transformation (Octavian , 2006).

Changing your products between cartographic parameters sometimes incorporates changing between the geographic coordinate frameworks. Since the geographic coordinate frameworks contain datums that depend on spheroids, a geographic change likewise changes the spheroid. There are a few techniques, which have distinctive levels of exactness and reaches, for changing between datums. The exactness of a specific transformation can extend from centimetres to meters contingent upon the technique and the quality and number of control points accessible toward characterize the transformation parameters. A geographic transformation dependably changes over geographic coordinates. A few methods change the geographic coordinates to geocentric (X,Y,Z) coordinates, change the X,Y,Z coordinates, and change over the new values back to geographic values. A more perplexing and precise datum change is conceivable by adding four more parameters to a geocentric transformation. The seven parameters are three linear shifts (DX,DY,DZ), three angular rotations around each axis (rx,ry,rz), and scale factor(s) (Kennedy and Kopp , 2000).

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{new} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1+s) \cdot \begin{bmatrix} 1 & r_z & -r_y \\ -r_z & 1 & r_x \\ r_y & -r_x & 1 \end{bmatrix} \cdot \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{original}$$

Usually, they require to be predestined from some control points at which coordinates in the two coordinate systems are known. Principally, same coordinates at 3 points are enough to the solution of the 7-parameters method. If more points are known, a least squares adjustment can be performed to reduce the effect of errors in the given coordinates (Abd-Alrahman , 2014).

1.1 The specific objective of this study was

- To better understand the relation between positional accuracy and projections and datums
- To explore the influence of map projection and datums in producing errors
- To evaluate various conformal map projections for accuracy
- To determine which map projection and datum appropriate for the study area?

1.2 The aim of research

It is my experience of working with positional accuracy that has driven this research. It is hoped that this paper will contribute to a deeper understanding of influence by choosing projection and datum on accuracy. The experimental work presented here provides one of the investigations into how use truth data to calculate errors stem from using different projections and datums.

2 Materials and Methods

2.1 Data acquisition

In this research, we used satellite images (Figure 1). Raster DEM downloaded from the www.earthexplorer.usgs.gov as shown in (Figure 2) for the study area, which is at the north of Iraq in Sulaymaniyah Governorate, Arbat City. Satellite images and DEM used as ancillary data to extract cartographic parameters required by software. All coordinates including X, Y and Z were measured using Differential GPS.

2.2 Fieldwork

Sets of points for the study area selected as follows: ten checkpoints were selected randomly (Table 1). The cartographic parameters for these points were (Lat/Long coordinates) and datum was WGS84 using Differential GPS. Then other sets of points were ten Ground control points (GCP) for the same positions, but in this case were Cartesian coordinates with different projections and datums measured using Differential GPS. The satellite image and DEM were projected to different projections using ArcGIS 10.5 and ERDAS imagine 2014. All the geographic coordinates will be used in radian system for easy calculations.

2.3 Project Ground Control Points

After measuring the Ground Control Points using DGPS (Table 2) for the same positions of checkpoints which were measured using DGPS too. The points were projected to the following cartographic parameters using ArcGIS 10.5, ERDAS imagine 2014 and Global Mapper (Figure 3).

1. Gauss Kruger/ WGS84
2. Traverse Mercator/WGS84
3. Lambert conformal conic /WGS84
4. Lambert conformal conic /Karbala poliservice 1979- Clarcke 1880 RGS
5. Universal Traverse Mercator/WGS84 (UTM).

Note that all the projections, which were used are conformal.

2.4 Using the seven-parameter transformation method

All Ground Control Points (the 10 GCP) will be converted to Geographic coordinate system /WGS84 Using ERDAS Imagine 2014 and Global Mapper the seven-parameter transformation is one of the most commonly used transformation methods in geodetic system and surveying, which preserves shape, so the angles are not changed. It is applied in the process of reducing data from GNSS surveys and is also used extensively in photogrammetry and laser scanning. The three-dimensional conformal coordinate transformation involves seven parameters (three rotations, three translations, and one scale factor), 3D translation is the shift in origin of one coordinate system to the other. Let's consider a case where coordinates have been given in two systems, the nonlinear equations relating these unknowns and coordinates from both systems that are given by a general equation:

$$X = S.O.C + F \qquad [1]$$

Where C=vector of 3-D Cartesian coordinates into the global coordinate system

S = scale factor

O = is the orthogonal matrix of the three successive rotation matrices

F = is the 3-D shift vector of the origins.

2.5 Root Mean Square Error

In positional accuracy assessment, the NSSDA-specified and accepted measure of accuracy is the mean square root of squared differences between the map or sample points and the reference points. This term is called the root-mean-square error, or

RMSE (AL-Hameedawi *et.al.*, 2017). RMSE is estimated from a sample of the map or truth data and reference points. The mean square root of the square of the differences is used instead of the mean of the simple arithmetic differences to compensate for the fact that the errors can have both positive and negative values. The corresponding locations on the geospatial data set being assessed. The equation for calculating RMSE in mapping applications is (Congalton and Green , 2009).

$$\mathbf{RMSE} = \sqrt{\sum_{i}^{n}(Ei)^2 / n} \qquad [2]$$

Where

$E_i = E_{ri} - E_{mi}$ and E_{ri} equals the reference position at the certain sample point, E_{mi} equals the observed position at the certain sample point, and n is the number of samples.

After of converted all Ground Control Points with different projections and Datums to Geographic coordinate system /WGS84 Using Erdas Imagine 2014 and Global Mapper where the resulted points are called transformed points which were 10 points in radian for each projection. Then the Root Mean Square Error (RMSE) was calculated between the 10 checkpoints and transformed Ground Control Points (10 GCP for each projection). It is clear that the less RMSE the better result therefor we will choose the projection and datum to study area that will gain less RMSE.

3 Results and Discussion

Usually, when WGS84 is used in your mapping process, some problem arises, e.g. with too much distortion, and potentially for simplicity as it is used in development environments. . WGS84 is used by the GPS. You can use it to your products, but in schematic representation, if you use WGS84, the map users will come to perceive Iraq as a short fat-shaped state. If you are not sure check the difference between datum and projection.

1 Gauss Kruger/ WGS84

This projection resembles the UTM however the cylinder is longitudinal along a meridian as opposed to the equator. The outcome is a conformal projection that does not keep up genuine headings. The central meridian is set in the district to be featured. This focusing limits distortion of all properties in that area. This projection is most appropriate for areas that extend north– south. The Gauss– Krüger (GK) coordinate system depends on the Gauss– Krüger projection. Gauss– Krüger organize framework. Gauss– Krüger splits the world into zones six degrees wide. The scale factor of each zone is 1.0 and a false easting of 500,000 meters. The central meridian of zone 1 is at 3° East. A few places likewise include the zone number circumstances one million to the 500,000 false easting value. GK zone 5 could have a false easting value of 500,000 or 5,500,000 meters. Three degree Gauss– Krüger zones exist too. After RMSE were calculated the total RMSE was “2.574997” and the RMSE for each point was the results were as in Table 3 which was regarded high value (Kennedy and Kopp 2000).

2 Traverse Mercator/WGS84

Like the Mercator beside that the cylinder is straying along a meridian instead of the equator. The result is a conformal projection that does not keep up veritable headings (Kennedy and Kopp , 2000). The transverse Mercator projection is extensively used, and is particularly fitting for locale with a huge extended north-south however little extending east-west. A scale factor of each zone is 0.9666. It is, for example, the projection used for the Ordnance Survey National Grid for maps (and

propelled things) of Great Britain (Ordnance Survey, 1995b). After RMSE were calculated the total RMSE was “2.574997478” and the RMSE for each point was the results were as in Table 4 which was regarded high value.

3 Lambert Conformal Conic (LCC)

This projection is truly outstanding for middle latitudes. It is like the Albers Conic Equal Area projection with the exception of that the Lambert Conformal Conic projection depicts shape more precisely than territory (Kennedy and Kopp , 2000). The conformal adaptation of the conic projections is normally named after Lambert. Who initially created it in 1772 (Snyder, 1987). The full name is the Lambert conformal conic. This is a to a great degree broadly utilized projection, and it is most likely consistent with say that LCC and the transverse Mercator between them represent 90% of base guide projections around the world. A LCC projection may likewise be shaped with two standard parallels, as with every single conic projection. For this situation, it is what might as well be called one standard parallel somewhere between, with an extra scaling connected. The outcomes were as demonstrated as follows.

A. Lambert conformal conic /WGS84

After RMSE were calculated the total RMSE was “0.924478995” and the RMSE for each point was the results were as in Table 5 which was regarded low value.

B. Lambert conformal conic / Karbala poliservice 1979- Clarke 1880 RGS

After RMSE were calculated the total RMSE was “0.915811213” and the RMSE for each point was the results were as in Table 6 which was regarded low value and less than pre-mentioned one. See Figure 4.

4 Universal Traverse Mercator (UTM) / WGS84

The UTM projection limits distortion inside that zone. This implies when you need to demonstrate objects in a several UTM zone, it begins turning into a poor decision of guide projection. Distortion is less close to the central meridian, and as you move away it compounds. This makes it more fitting for limit locales and is not appropriate for world maps. The Universal Transverse Mercator is terrible for little scale (less-nitty gritty) maps like world map books and ideal for mapping limited locales. After RMSE were calculated the total RMSE was “0.903507948” and the RMSE for each point was the results were as in Table 7 which was regarded the best result.

3.1 Findings

3.1.1 Projections

The used method represents a viable alternative to compare conformal projections, which are used in GIS applications and surveying. This process has the ability to outperform all previous methods because it calculates Root Mean Square Errors for different points measured in independent ways to avoid biased results. Our method has many interesting applications in Geomatic Engineering. Of major fundamental interest is that we can select the best projection based on the nature of the study area, whether it is wide or narrow or high mountain area or flat area.

The key decisive principal basic advantages are:

- Our procedure is a clear improvement on previous methods.
- We believe this solution will assist researchers to make decisions fast.

- This solution improves on advances previous methods by utilising field work, including GPS and remote sensing data.

To assess accuracy of specified projections and datums, RMSE analysis was used to test positional accuracy. Changes in RMSE for different projections were identified compared using excel sheets. The difference between Root mean Square Error for each point and Root mean Square Error Total was tested as follows: The sets of analyses highlighted the impact of using a specified projection where the results demonstrated that UTM was the best projection for the study area, then Lambert Conformal Conic/Karbala 1979 Clarke 1880 (RGS) and the other two projections acquired nearly the same results.

3.1.2 Datum

The most interesting finding was that that local datum Karbala 1979 Clarke 1880 (RGS) gains less RMSE total when compared to WGS84. RMSE tests highlighted that Karbala 1979 Clarke 1880 (RGS) outweigh on WGS 84 this was clear in analysis the accuracy between RMS Lambert Conformal Conic /WGS84 which achieved score of RMSET was "0.924479" whereas Lambert Conformal Conic/Karbala 1979 Clarke 1880 (RGS) achieved score of RMSET was "0.915811".

3.1.3 Interpretation

The results and discussions of this study indicate that UTM was the best projection of the study area. These findings further support the idea of Shape Conformal which guarantee accurate representation of small shapes and minimal distortion of larger shapes within the zone (Kennedy and Kopp , 2000). Regarding to Lambert Conformal Conic projection.

This projection is one of the best for middle latitudes, it is like the Albers Conic Equal Area projection with the exception of that Lambert Conformal Conic depicts shape more precisely than area. The State Plane Coordinate System utilizes this projection for all east– west zones. The region is Minimal distortion close to the standard parallels. Areal scale is decreased between standard parallels and expanded past them. Concerning distance it amends scale along the standard parallels. The scale is lessened between the parallels and expanded past them (Kennedy and Kopp 2000).

The interpretation of regarding datum is that a local datum approximates the geoid in the district substantially more intently than does the worldwide datum, or a datum streamlined for a more extensive area (Iliffe , 2003).

This was a significant evidence that for this study area, it is better to use local datum as highlighted in Figure (5). See Table 8 and Figure 6 for more information. Figure 7 compare the results obtained from the RMSE analysis of XY POINTS. RMSE-tests were used to analyses the relationship between various projections relating accuracy. The results show that big difference between UTM and Traverse Mercator this was due to HIGH difference in RMSE TESTS WHEREAS UTM and Lambert Conformal Conic were nearly at the same positions because of low difference in RMSE TEST.

4 Conclusion

This paper has argued that using different projection types and different datum will affect the positional accuracy. To prove this effect numerically two sets of points for the study area selected as follows:

1. Ten checkpoints were selected randomly. The cartographic parameters for these points were (Lat. / Long. coordinates) and datum were WGS84 using Differential GPS. Then other sets of points were ten Ground control points (GCP) for the same

positions, but in this case were Cartesian coordinates with different projections and datums measured by Differential GPS. The ancillary data (satellite image and DEM) were used for the sake of software requirements.

2. 7-parameters method was chosen to transforming coordinate systems. All the projections used were conformal to avoid biased results. One of the more significant findings to emerge from this study is that UTM projection was the best choice for the study area and the best datum was Karbala poliservice 1979- Clarke 1880 based on RMSE tests.
3. The following conclusions can be drawn from the present study first UTM was good for study area since distortion is less close to the central meridian, and as you move away it intensifies. This makes it more fitting for limit districts and is not appropriate for world maps.
4. Regarding the datum the relevance of local datum is clearly supported by the current findings due to lower results in RMSE test. Further research regarding the role of map projections and datum in positional accuracy would be interesting.

This research extends our knowledge of selecting cartographic parameters that fit for our purpose and developing or creating new local datum and projection for Iraq.

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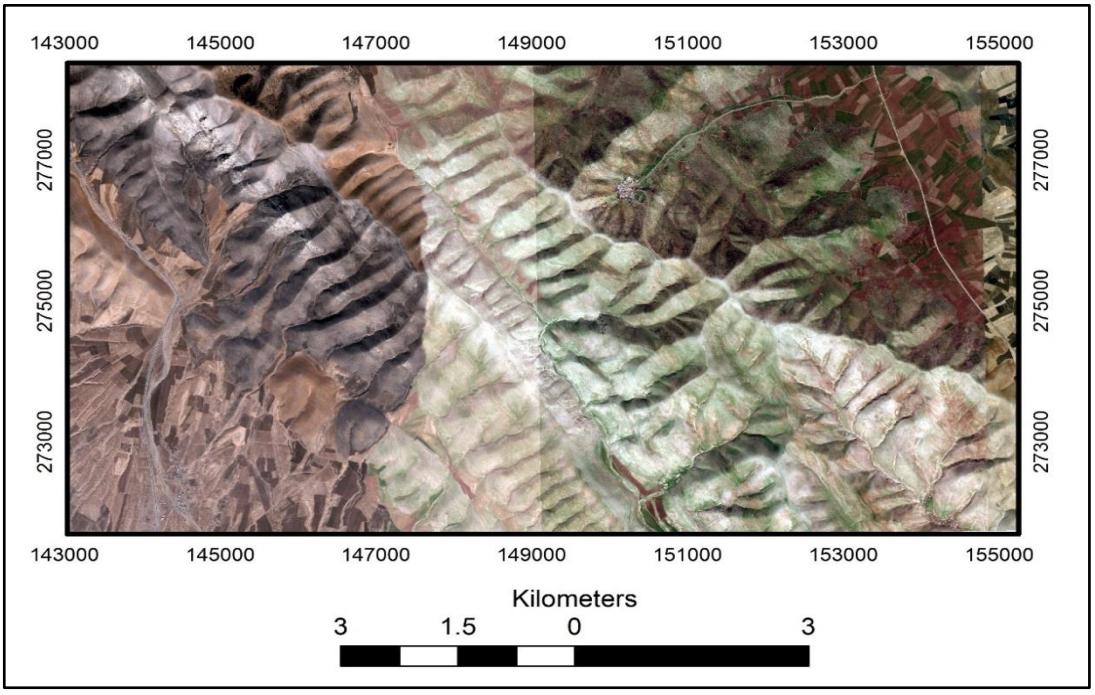


Figure 1. Satellite image, 2012.

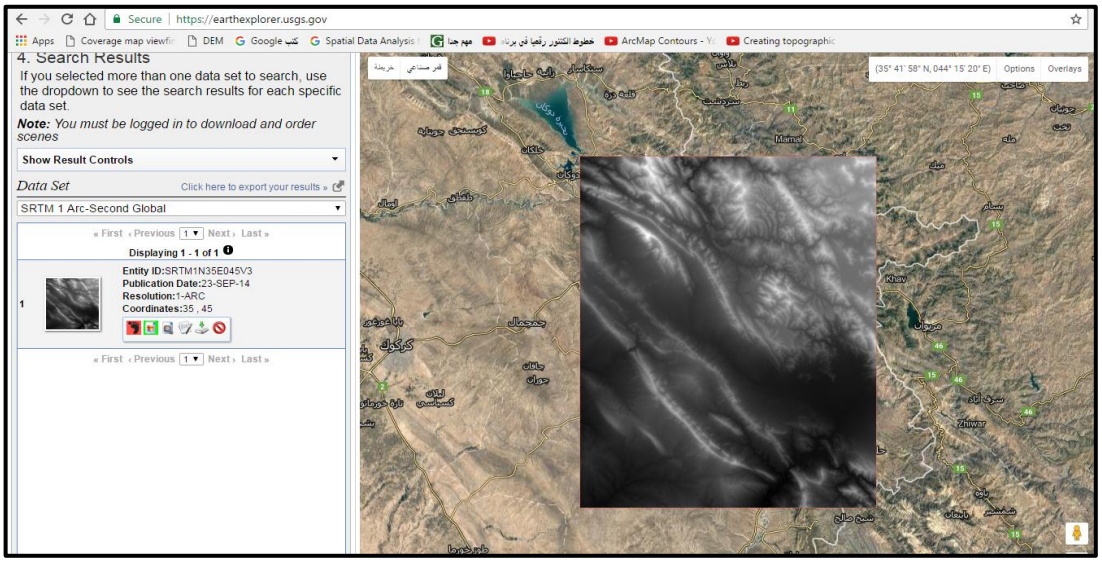


Figure 2. Snapshot of DEM.

Table 1. Ten Checkpoints (Reference points) measured using DGPS / GCS-WGS84.

ID	Longitude In RAD.	Latitude In RAD.	Longitude In DEC.	Latitude In DEC.	Z in Meter
1	0.795311	0.619275	45.54963	35.46757	32767
2	0.795543	0.619275	45.56292	35.46757	32767
3	0.795775	0.619275	45.5762	35.46757	32767
4	0.796007	0.619275	45.58949	35.46757	32767
5	0.796239	0.619275	45.60278	35.46757	32767
6	0.796471	0.619275	45.61607	35.46757	32767
7	0.796703	0.619275	45.62935	35.46757	32767
8	0.796935	0.619275	45.64264	35.46757	32767
9	0.795311	0.619151	45.54963	35.46047	32767
10	0.795543	0.619151	45.56292	35.46047	943.7143

Table 2. Example of Ten Ground control points (GCP) projected to Traverse Mercator/WGS84.

ID	X	Y	Z
1	142245.2	276463.9	32767
2	143465.1	276463.9	32767
3	144685	276463.9	32767
4	145904.8	276463.9	32767
5	147124.7	276463.9	32767
6	148344.6	276463.9	32767
7	149564.4	276463.9	32767
8	150784.3	276463.9	32767
9	142245.2	275656.2	32767
10	143465.1	275656.2	951.8571

Table 3. RMSE for Each point for Gauss Kruger/ WGS84.

points	x Residual	Y residual	z residual	rmst
1	1.00000000002876000000E-06	2.19999999999665000000E-05	0	2.2022715545513100000E-05
2	4.00000000000400000000E-06	1.89999999999912000000E-05	0	1.9416487838939900000E-05
3	5.99999999995049000000E-06	1.60000000000160000000E-05	0	1.7088007490632700000E-05
4	8.99999999992573000000E-06	1.29999999999297000000E-05	0	1.5811388300741900000E-05
5	1.20000000000120000000E-05	9.99999999995449000000E-06	0	1.5620499351793400000E-05
6	1.39999999999585000000E-05	6.99999999997925000000E-06	0	1.5652475842452100000E-05
7	1.69999999999337000000E-05	2.99999999997524000000E-06	0	1.7262676501562500000E-05
8	1.90000000001023000000E-05	0.00000000000000000000E+00	0	1.9000000000102300000E-05
9	-1.00000000002876000000E-06	1.89999999999912000000E-05	0	1.9026297590433200000E-05
10	1.00000000002876000000E-06	1.60000000000160000000E-05	8.142857	8.1428570000157200000E+00

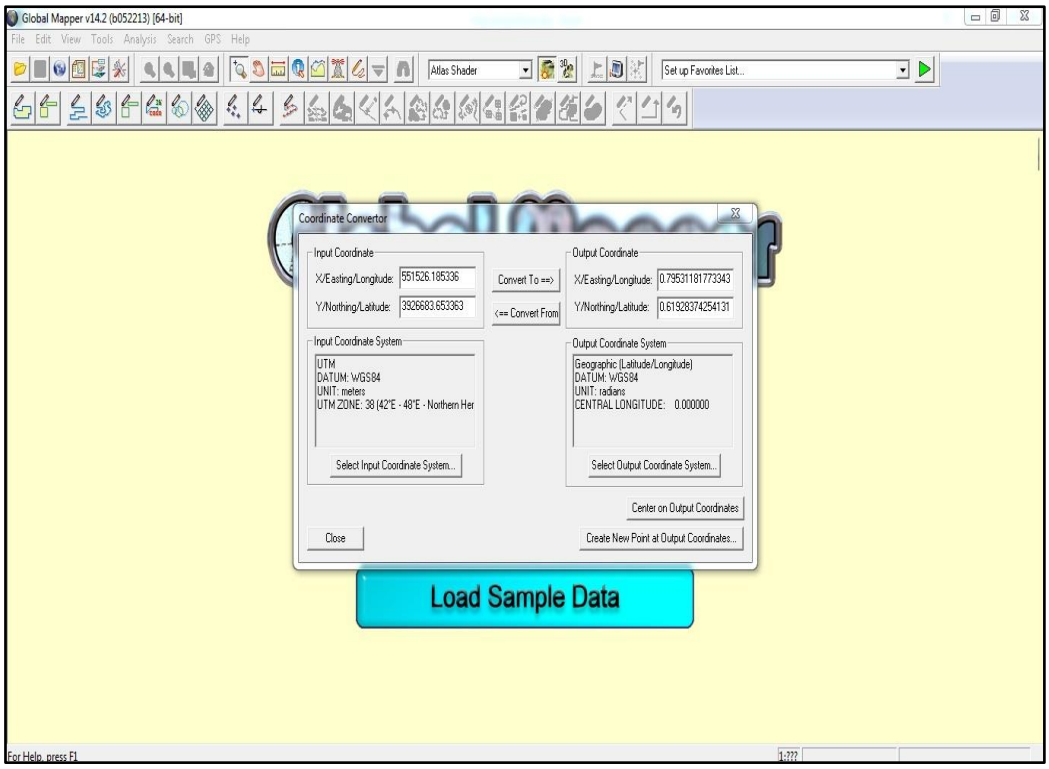


Figure 3. Example of transforming point to another coordinate system using Global Mapper software.

Table 4. RMSE for Each point for Traverse Mercator/WGS84

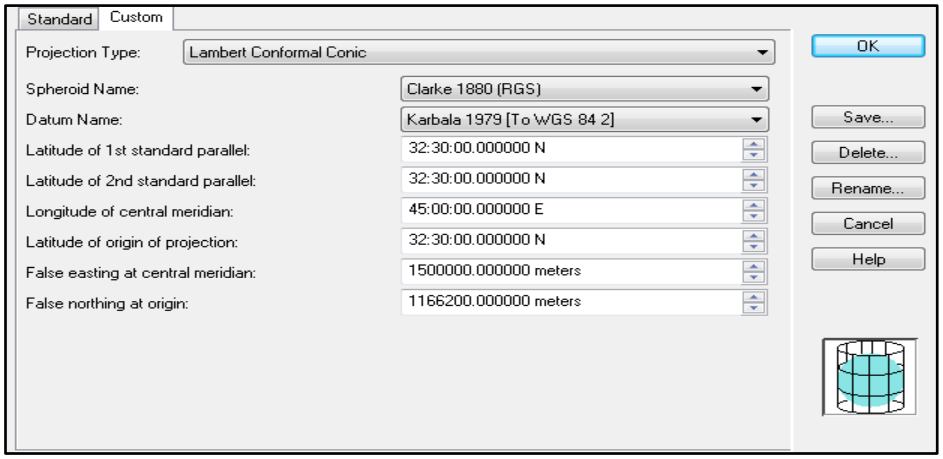
Points	x residual	Y residual	Z residual	RMSE
1	1E-06	2.2E-05	0	2.20227E-05
2	4E-06	1.9E-05	0	1.94165E-05
3	6E-06	1.6E-05	0	1.7088E-05
4	9E-06	1.3E-05	0	1.58114E-05
5	1.2E-05	1E-05	0	1.56205E-05
6	1.4E-05	7E-06	0	1.56525E-05
7	1.7E-05	3E-06	0	1.72627E-05
8	1.9E-05	0	0	1.9E-05
9	-1E-06	1.9E-05	0	1.90263E-05
10	1E-06	1.6E-05	8.142857	8.142857

Table 5. RMSE for Each point for Lambert conformal conic /WGS84

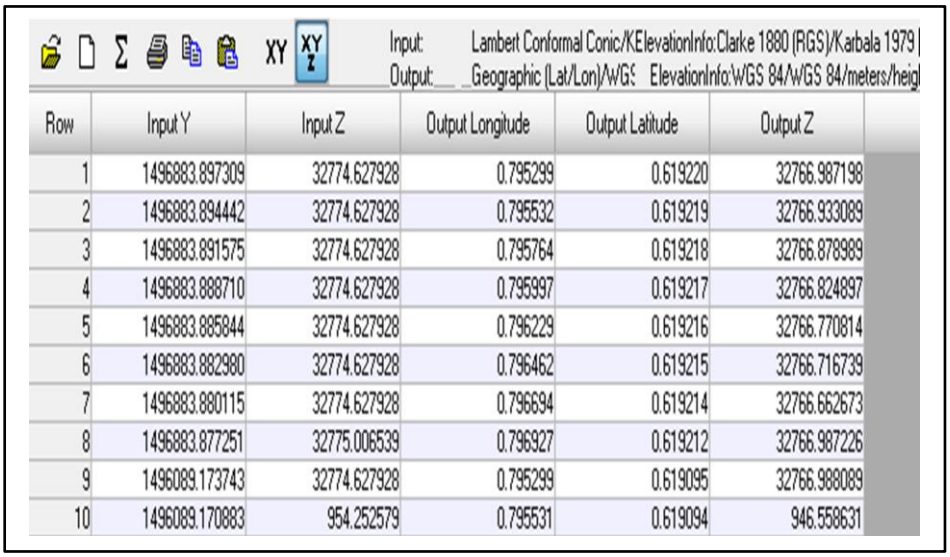
points		x Residual	Y residual	z residual	RMSE
1		-1.2E-05	-5.5E-05	0	5.63E-05
2		-1.1E-05	-5.6E-05	0	5.71E-05
3		-1.1E-05	-5.7E-05	0	5.81E-05
4		-1E-05	-5.8E-05	0	5.89E-05
5		-1E-05	-5.9E-05	0	5.98E-05
6		-9E-06	-6E-05	0	6.07E-05
7		-9E-06	-6.1E-05	0	6.17E-05
8		-8E-06	-6.3E-05	0	6.35E-05
9		-1.2E-05	-5.6E-05	0	5.73E-05
10		-1.2E-05	-0.61915	2.857143	2.923459

Table 6. RMSE for Each point for Lambert conformal conic / Karbala poliservice 1979-Clarke 1880 RGS.

Points	x Residual	Y residual	z residual	RMSE
1	-1.2E-05	-5.5E-05	-0.0128	0.012802
2	-1.1E-05	-5.6E-05	-0.06691	0.066911
3	-1.1E-05	-5.7E-05	-0.12101	0.121011
4	-1E-05	-5.8E-05	-0.1751	0.175103
5	-1E-05	-5.9E-05	-0.22919	0.229186
6	-9E-06	-6E-05	-0.28326	0.283261
7	-9E-06	-6.1E-05	-0.33733	0.337327
8	-8E-06	-6.3E-05	-0.01277	0.012774
9	-1.2E-05	-5.6E-05	-0.01191	0.011911
10	-1.2E-05	-5.7E-05	2.844345	2.844345

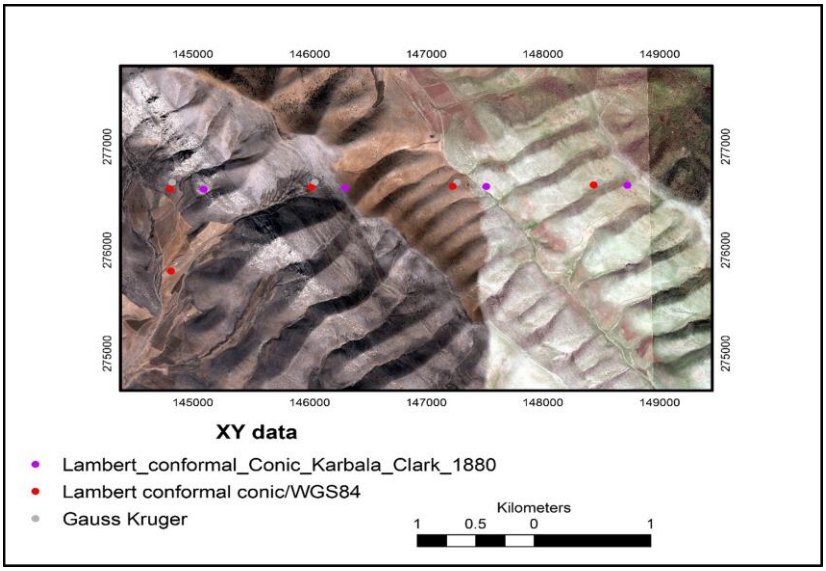


A



Row	Input Y	Input Z	Output Longitude	Output Latitude	Output Z
1	1496883.897309	32774.627928	0.795299	0.619220	32766.987198
2	1496883.894442	32774.627928	0.795532	0.619219	32766.933089
3	1496883.891575	32774.627928	0.795764	0.619218	32766.878989
4	1496883.888710	32774.627928	0.795997	0.619217	32766.824897
5	1496883.885844	32774.627928	0.796229	0.619216	32766.770814
6	1496883.882980	32774.627928	0.796462	0.619215	32766.716739
7	1496883.880115	32774.627928	0.796694	0.619214	32766.662673
8	1496883.877251	32775.006539	0.796927	0.619212	32766.987226
9	1496089.173743	32774.627928	0.795299	0.619095	32766.988089
10	1496089.170883	954.252579	0.795531	0.619094	946.558631

B



C

Figure 4. Interface for calculations. A: Cartographic Parameters for Lambert conformal conic / Karbala poliservice 1979- Clarke 1880 RGS. B: transforming process. C: Comparisons between various projections note that the points were exaggerated for better understanding.

Table 7. RMSE for Each point for Universal Traverse Mercator (UTM) /WGS84.

Points	x Residual	Y residual	z residual	RMSE
1	1E-06	9E-06	0	9.06E-06
2	2E-06	8E-06	0	8.25E-06
3	3E-06	6E-06	0	6.71E-06
4	4E-06	5E-06	0	6.4E-06
5	4E-06	4E-06	0	5.66E-06
6	5E-06	3E-06	0	5.83E-06
7	6E-06	2E-06	0	6.32E-06
8	7E-06	0	0	7E-06
9	0	8E-06	0	8E-06
10	1E-06	7E-06	2.857143	2.857143

Table 8. Comparisons.

Root Mean Square Error Total (RMST) for Specified Projections	
RMST Traverse Mercater	2.574997478
RMST Gauss Kruger	2.574997
RMS Lambert Conformal Conic /WGS84	0.924479
RMST Lambert Conformal Conic/Karbala 1979 Clarke 1880 (RGS)	0.915811
RMST UTM	0.903508

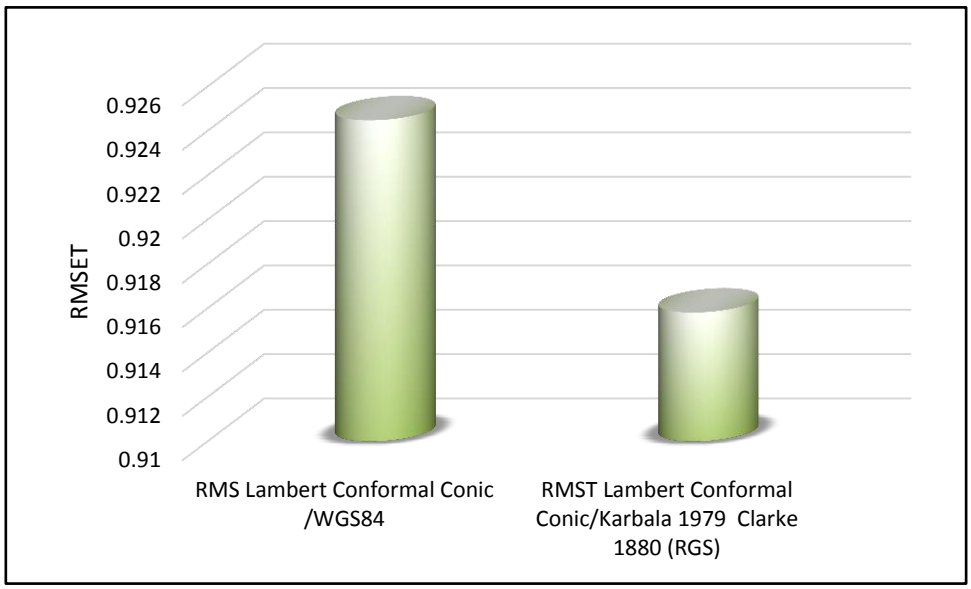


Figure 5. Comparisons datums according to RMSE total test (WGS84 Vs Karbala 1979 Clarke 1880 (RGS)) for the same projection and study area.

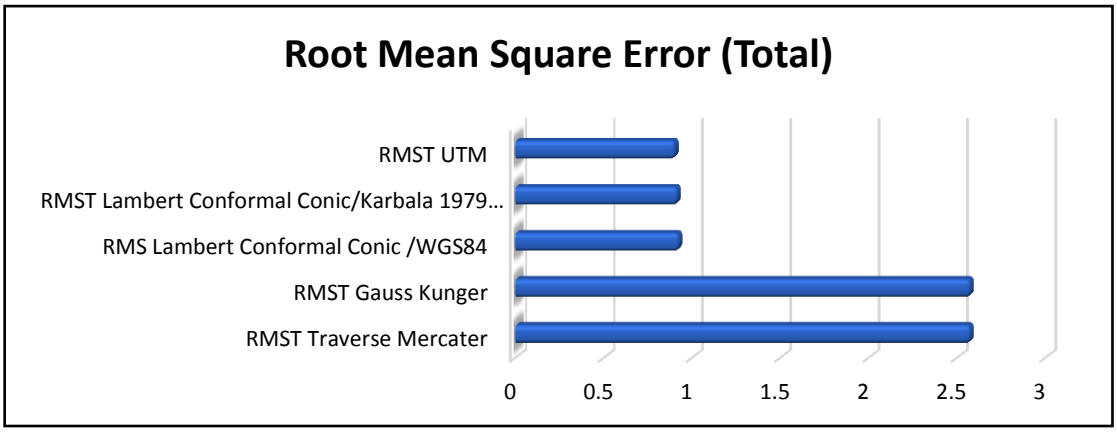
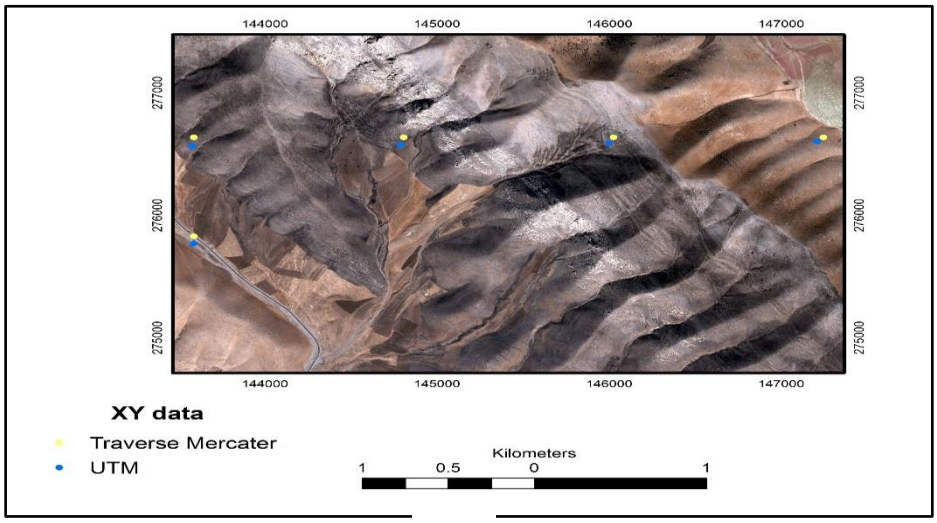
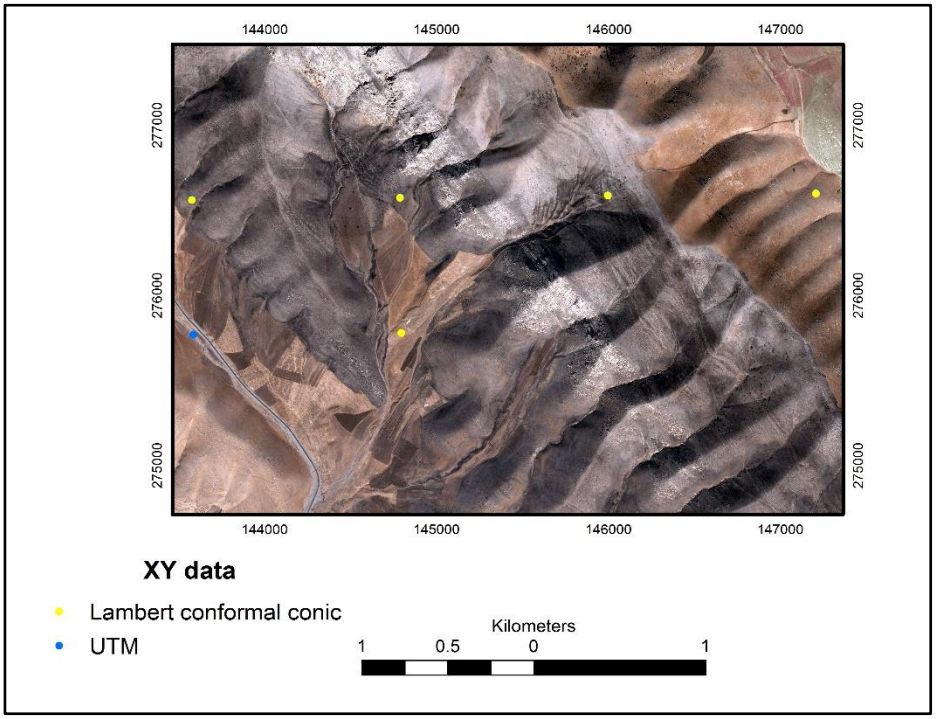


Figure 6. Comparisons projections accuracy according to RMSE total test for study area.



A



B

Figure 7. A: Adding XY points with different coordinate system (UTM Vs Traverse Mercator) Note the difference in position due to RMSE High Difference. B: Adding XY points with different coordinate system (UTM Vs Lambert Conformal Conic) Note the correspondence in position due to RMSE Low Difference. Note that the points were exaggerated for better understanding.