A Comparative Study of UTM and Web Mercator Projections in GIS Analysis

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SSCI581-Concepts for Spatial Thinking

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1. Introduction

Firstly, understanding the earth's three-dimensional shape is pivotal for representing spatial data accurately. However, the transition from a Geographic Coordinate System (GCS) to a Projected Coordinate System (PCS) through map projection introduces some distortion, which this project aims to evaluate by examining the effects of two PCSs, UTM (Universal Transverse Mercator) and Web Mercator (Web Mercator Auxiliary Sphere). Overall, focusing on area and linear measurements across the diverse geographies of the Netherlands, Kenya, and Madagascar, the project indicates the significant impact of projection choice on the accuracy of spatial data analysis.

2. Study Areas

This project explores the projection effects on datasets from the Netherlands, Kenya, and Madagascar, chosen for their diverse geographies ranging from flat terrains and equatorial areas to island ecosystems. Concurrently, the Netherlands' low-lying landscapes serve as a case study for examining projection impacts on flat regions, while Kenya's equatorial position with its vast plains and elevations is best possible for exploring effects near the equator. In addition, Madagascar's varied topography of mountains and coastal plains further improves this study by providing perceptions into projection distortions across island geographies, offering a holistic view of mapping accuracy in diverse settings.

3. Data

This project utilizes four datasets in GCS format for a detailed spatial analysis across the Netherlands, Kenya, and Madagascar, focusing on provincial boundaries, floodplains, forests, and tortoise tracking data; furthermore, these datasets, sourced from reliable sources, encompass topographical maps, land use patterns, and administrative boundaries.

4. Methods

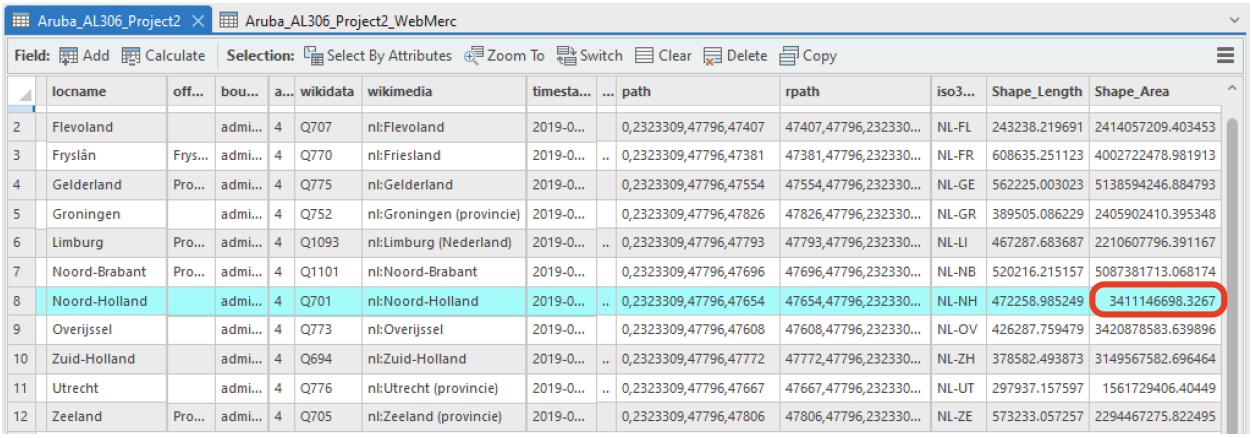
This study employs UTM and Web Mercator projections to ensure precise comparisons of spatial measurement accuracies across varied geographical landscapes, utilizing datasets like provincial boundaries, floodplains, forests, and tortoise tracking. For instance, the analysis is initiated by identifying the most suitable UTM zones for each study area, selecting Zone 32N for the Netherlands, Zone 37S for Kenya, and Zone 38S for Madagascar, to ensure geographic accuracy and relevance in data projection. However, it conducts a detailed comparative analysis of area and linear measurements between projections to assess distortion effects.

5.1 Results

5.1.1 Dutch Province Mapping: UTM vs. Web Mercator Analysis

The findings reveal notable differences in spatial representation across UTM and Web Mercator projections, with significant variations in area and linear measurements; furthermore Kenya and Madagascar also benefited from UTM's reduced distortion in linear and area measurements, respectively, highlighting the projection's suitability for regions with specific geographic traits. For instance, the area of North Holland Province displayed notable

discrepancies in size when projected in UTM (3411.14 sq km) compared to Web Mercator (9221.33 sq km), as illustrated in Figures 1 and 2.



Aruba_AL306_Project2 | Aruba_AL306_Project2_WebMerc

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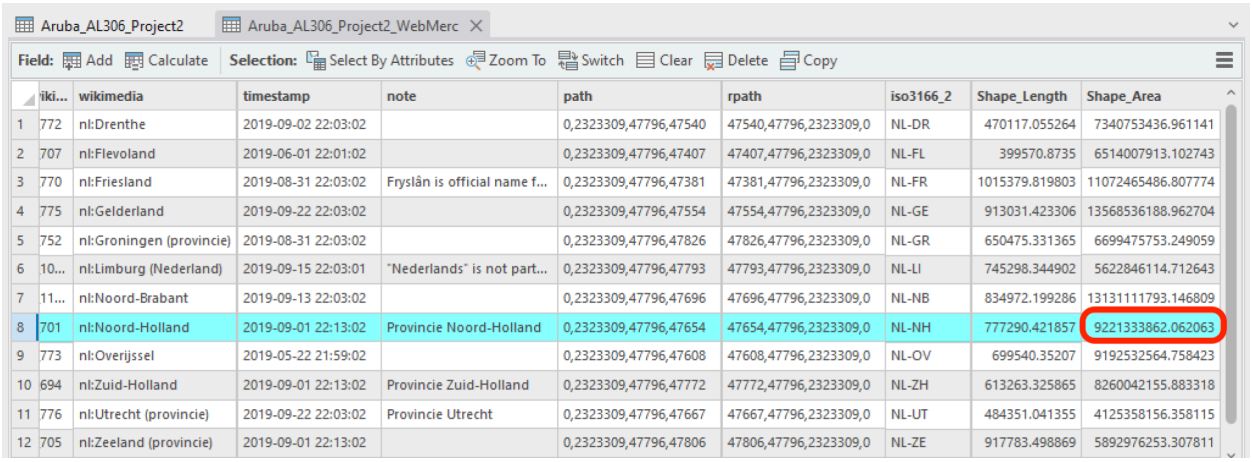
Figure. 1



Aruba_AL306_Project2 | Aruba_AL306_Project2_WebMerc

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5	752	nl:Groningen (provincie)	2019-08-31 22:03:02		0,2323309,47796,47826	47826,47796,2323309,0	NL-GR	650475.331365	6699475753.249059
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7	11...	nl:Noord-Brabant	2019-09-13 22:03:02		0,2323309,47796,47696	47696,47796,2323309,0	NL-NB	834972.199286	13131111793.146809
8	701	nl:Noord-Holland	2019-09-01 22:13:02	Provincie Noord-Holland	0,2323309,47796,47654	47654,47796,2323309,0	NL-NH	777290.421857	9221333862.062063
9	773	nl:Overijssel	2019-05-22 21:59:02		0,2323309,47796,47608	47608,47796,2323309,0	NL-OV	699540.35207	9192532564.758423
10	694	nl:Zuid-Holland	2019-09-01 22:13:02	Provincie Zuid-Holland	0,2323309,47796,47772	47772,47796,2323309,0	NL-ZH	613263.325865	8260042155.883318
11	776	nl:Utrecht (provincie)	2019-09-22 22:03:02	Provincie Utrecht	0,2323309,47796,47667	47667,47796,2323309,0	NL-UT	484351.041355	4125358156.358115
12	705	nl:Zeeland (provincie)	2019-09-01 22:13:02		0,2323309,47796,47806	47806,47796,2323309,0	NL-ZE	917783.498869	5892976253.307811

Figure. 2

Figures 3 and 4 indicate a stark contrast in the measured area of a specific Dutch province between two projection systems: under the UTM projection, the area is recorded at 37,777.05 square kilometers, while the Web Mercator Projection System inflates this figure to 100,641.43 square kilometers, highlighting the notable impact of projection choice on geographical data representation.

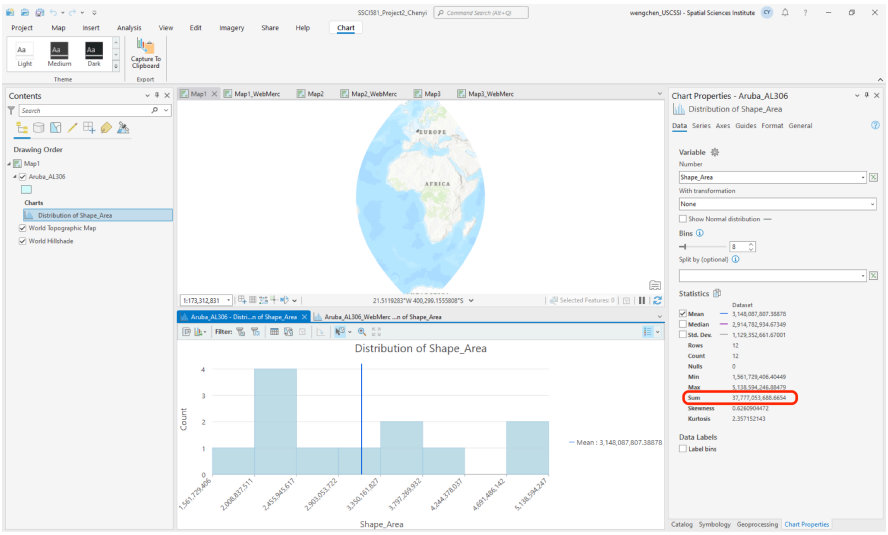

Figure. 3

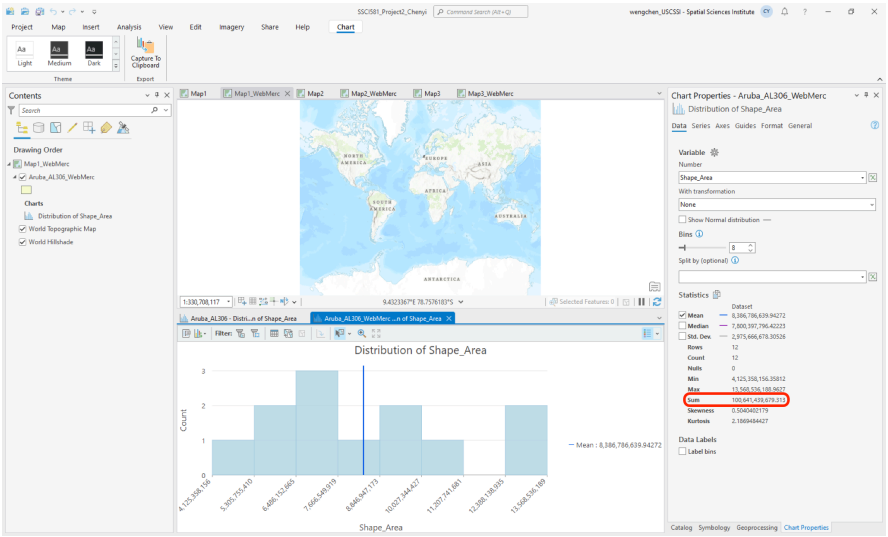

Figure. 4

Figure 5 distinctively compares the UTM zone PCS and Web Mercator PCS by presenting their overall maps side by side, showcasing noticeable differences in shape between the two projection systems. Hence, this visual comparison highlights the impact of projection choice on the geographic representation of areas.

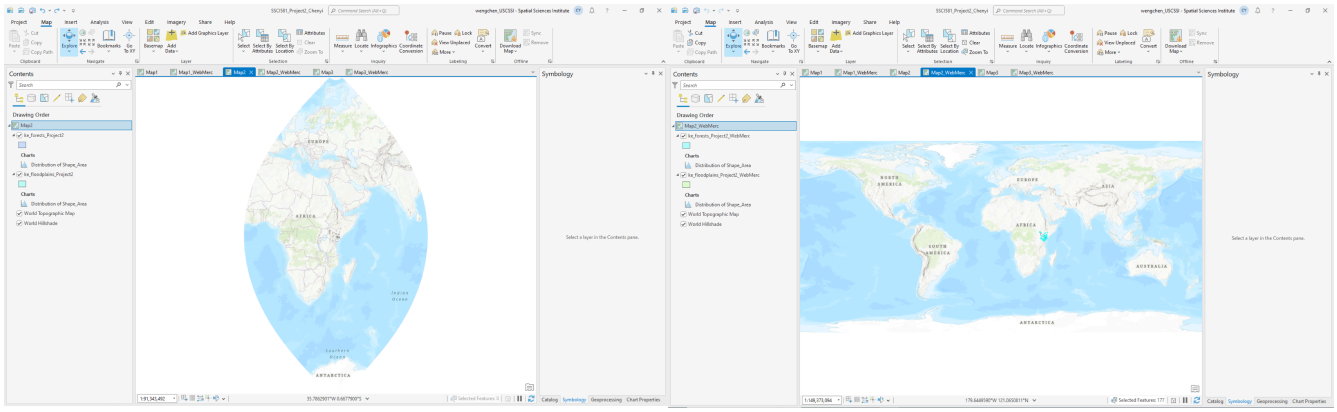

Figure. 5

5.1.2 Kenyan Floodplains and Forests: A Projection Analysis

Figures 6 and 7 demonstrate the area measurements of a specific floodplain in Kenya, highlighting the slight difference between the UTM and Web Mercator projections. Due to the UTM zone PCS records the floodplain at 1347.54 square kilometers, while the Web Mercator PCS slightly reduces the measurement to 1357.98 square kilometers, underscoring the nuanced impact projection choices have on spatial data accuracy.

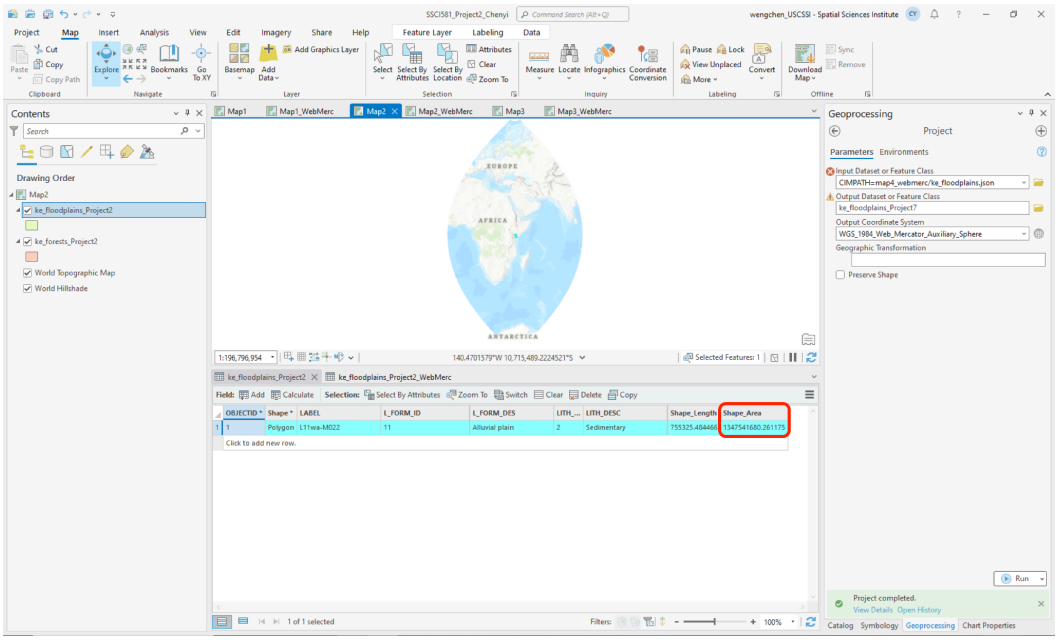

Figure. 6

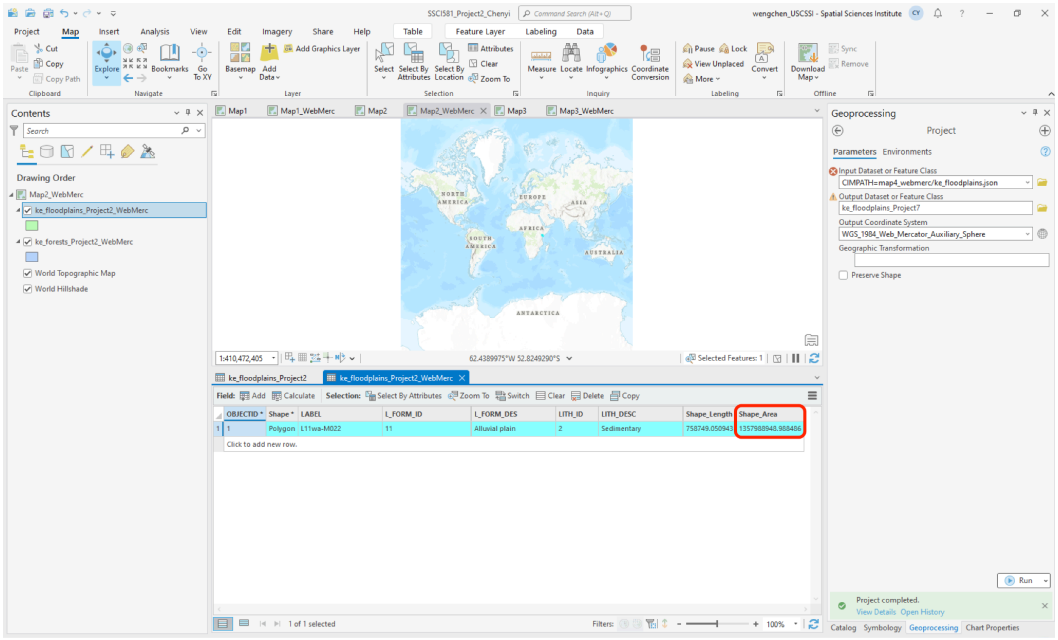

Figure. 7

Figures 8 and 9 compare the area measurements of a specific forest type and floodplain in Kenya using UTM and Web Mercator projections, respectively. Obviously, the UTM projection measures the forest at 3825.94 square kilometers, closely aligning with the Web Mercator projection's measurement of the floodplain at 3855.33 square kilometers. On the whole, these figures underscore the minimal discrepancies between projections for spatial data within the same geographical region.

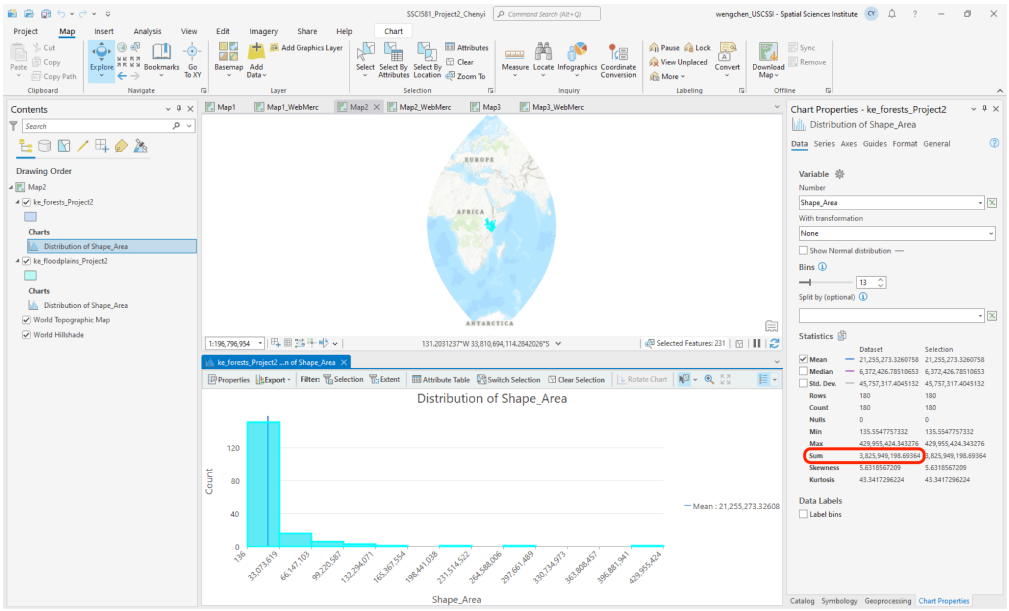

Figure. 8

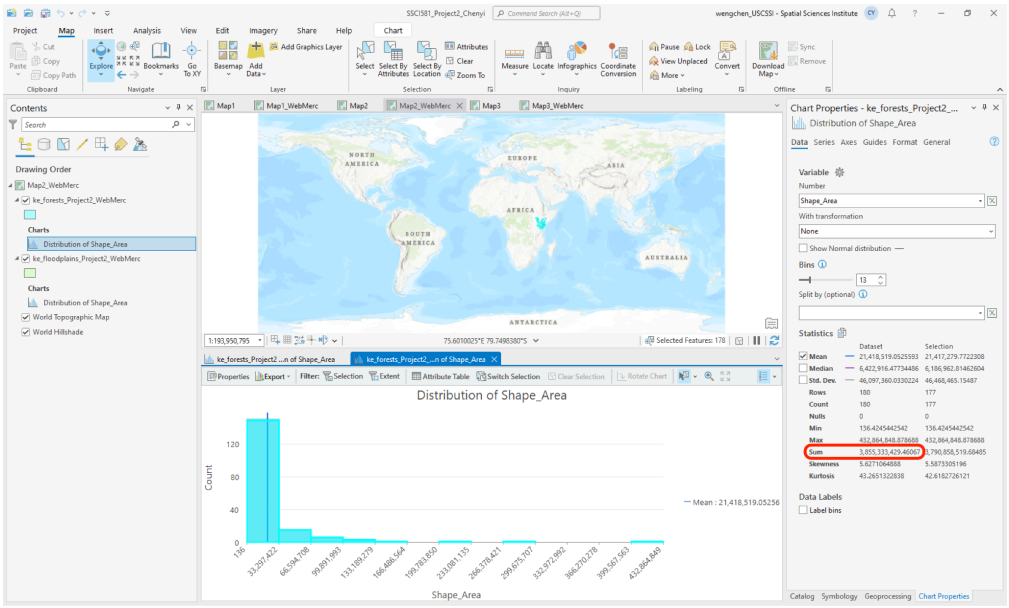

Figure. 9

5.1.3 Madagascar Tortoise Tracking: Analyzing Projection Impacts

Figures 10, 11, and 12 illustrate the measured distances between tortoises in Madagascar across three directions using UTM zone PCS, revealing distances of 1641.54 meters, 1569.49 meters, and 1828.09 meters respectively. Therefore, this analysis showcases the precise spatial relationships captured through UTM projections; concurrently, emphasizing the method's utility in tracking wildlife over varied terrains.

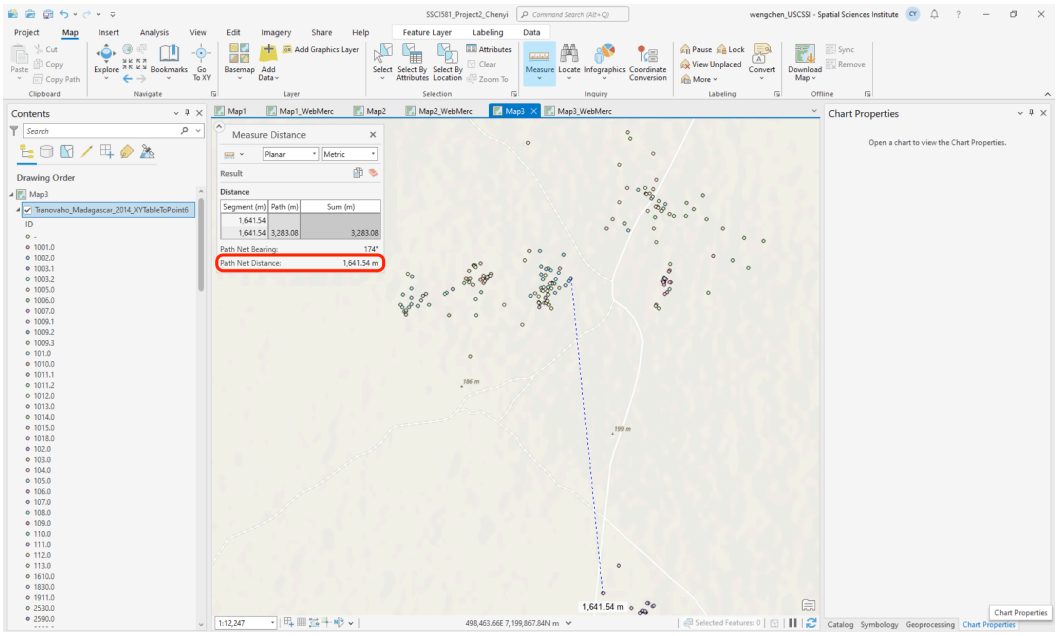

Figure. 10

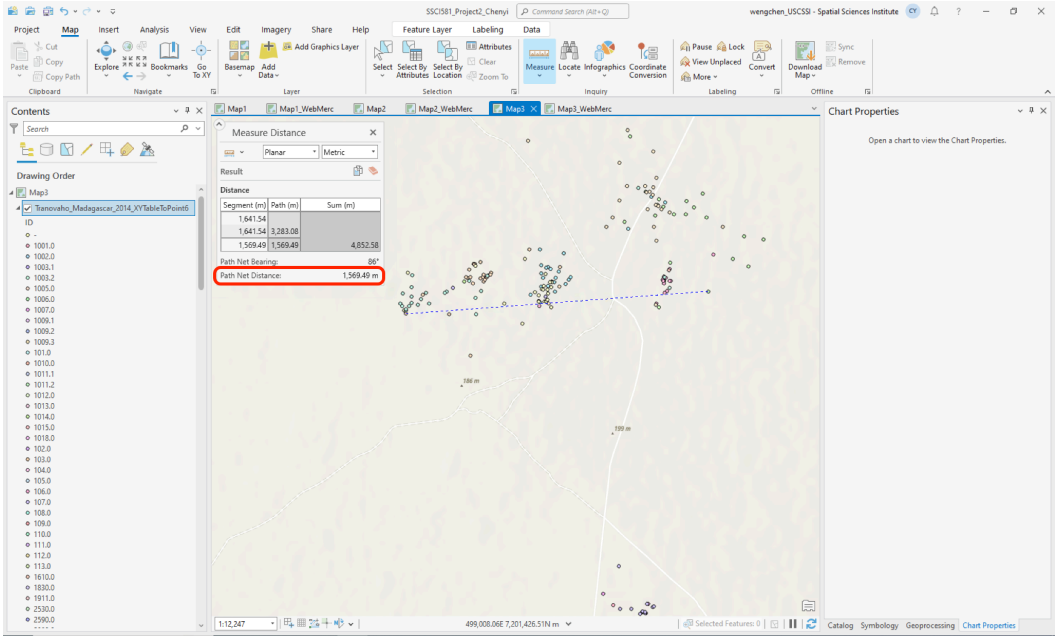

Figure. 11

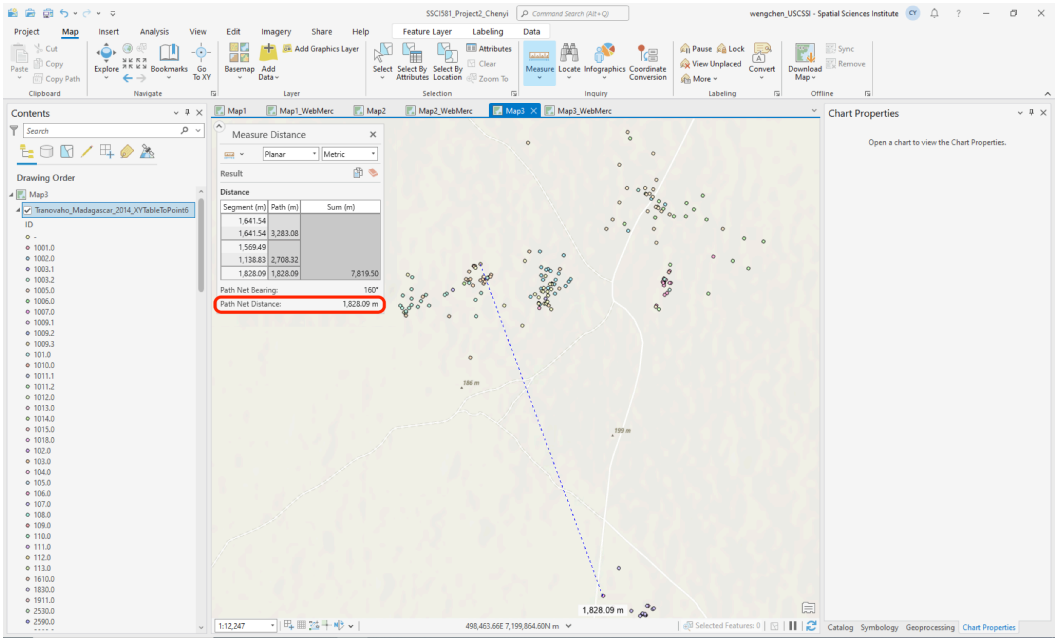

Figure. 12

Figures 13, 14, and 15 detail the distances between the same tortoises in Madagascar using the Web Mercator PCS, recording distances of 1825.56 meters, 1734.39 meters, and 2029.29 meters, respectively. Therefore, this demonstrates the variances in spatial analysis provided by Web Mercator projections, indicating its specific impact on accuracy in wildlife tracking and emphasizing the value of projection choice in geographical studies.

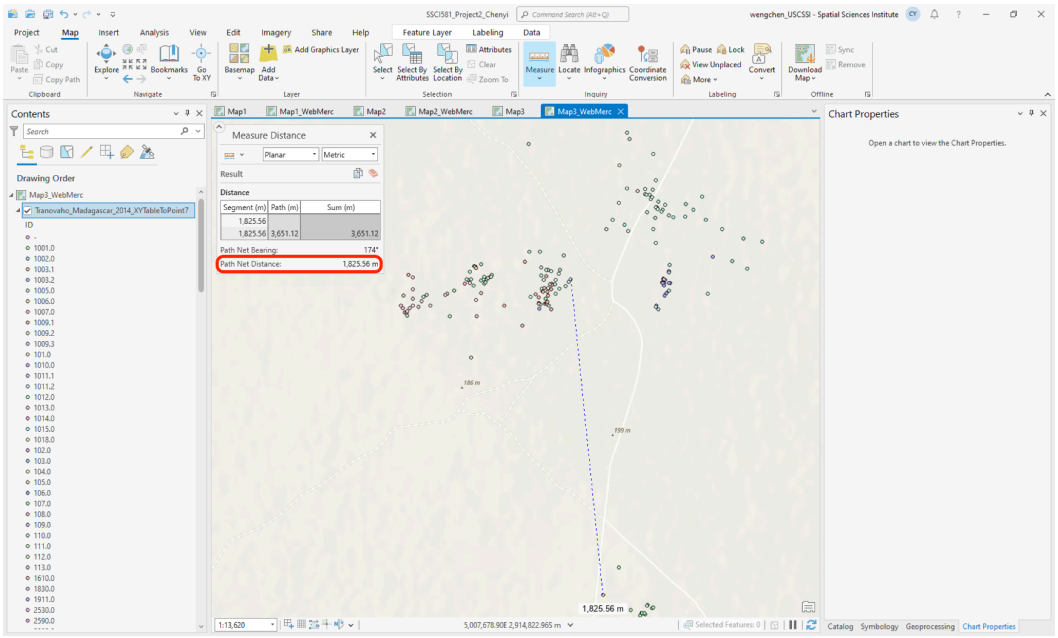

Figure. 13

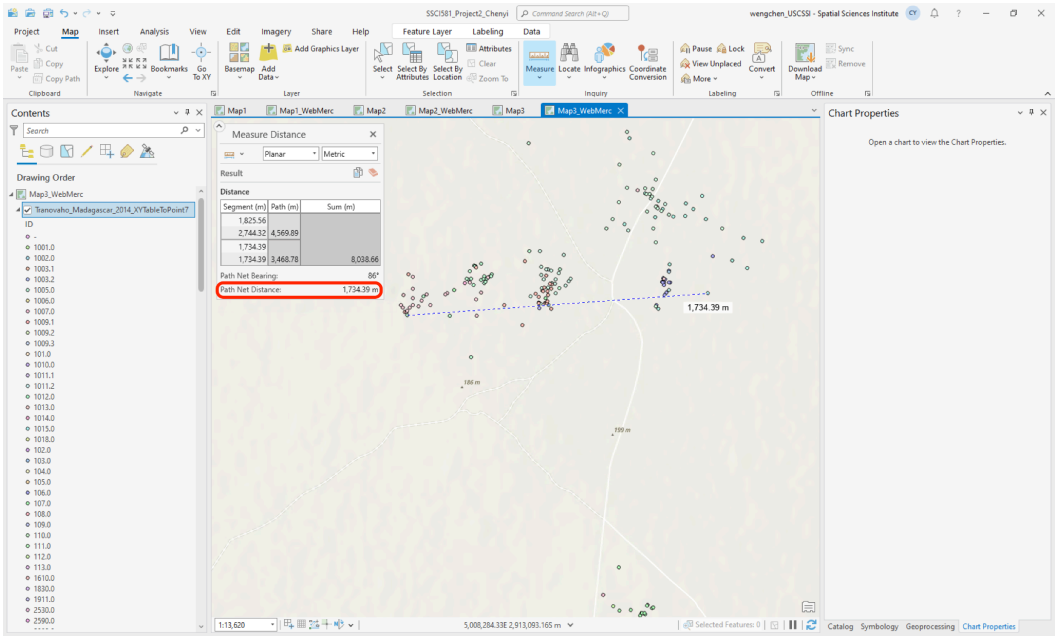

Figure. 14

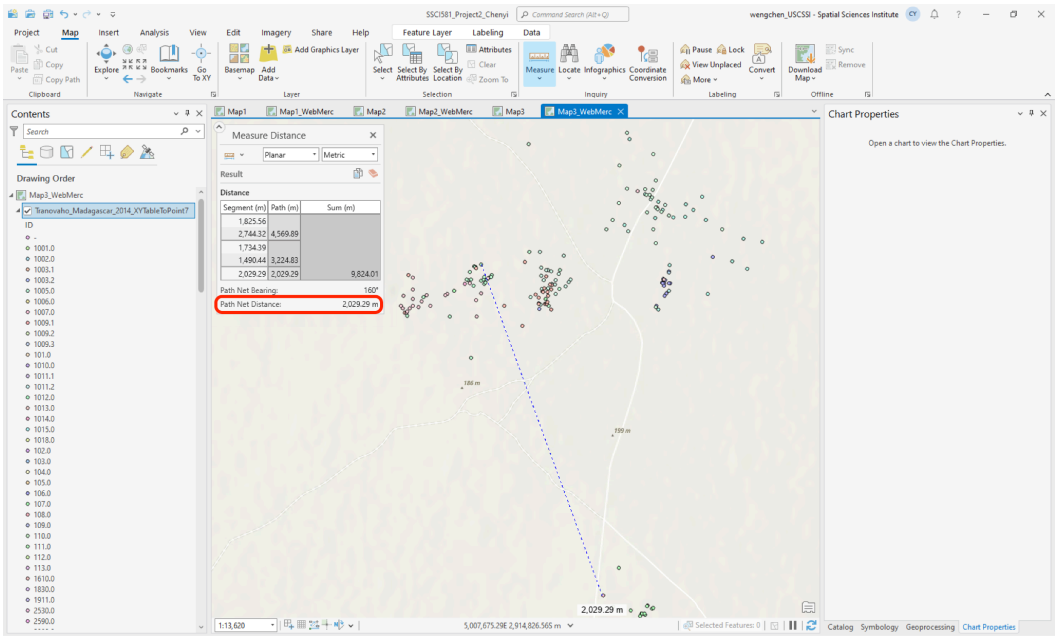

Figure. 15

5. Discussion

Firstly, the findings indicate that the choice of projection crucially influences spatial data accuracy, with Web Mercator often overestimating areas away from the equator and UTM zones showing less distortion. Secondly, this emphasizes the importance of carefully selecting projections suited to the geographic specifics of the study area to minimize distortion and enhance the reliability of spatial analyses. In short, the superior accuracy of UTM projections for area and linear measurements; also, emphasizes the importance of selecting appropriate projections for accurate GIS analysis.

6. Conclusion

First of all, this analysis not only reveals the disparities in area and linear measurements between projections but also highlights the potential for distortion, particularly with the Web Mercator projection further from the equator. To conclude, the findings advocate for further exploration into various projections tailored to specific geographical settings, aiming to refine GIS analysis practices and enhance data precision.