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FIG Geospatial Council of Australia

Collaboration, Innovation and Resilience: Championing a Digital Generation

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Evaluating Digital Elevation Models: A Comparison of Terrestrial, UAV, Satellite, and Airborne Sources in District Six, Cape Town

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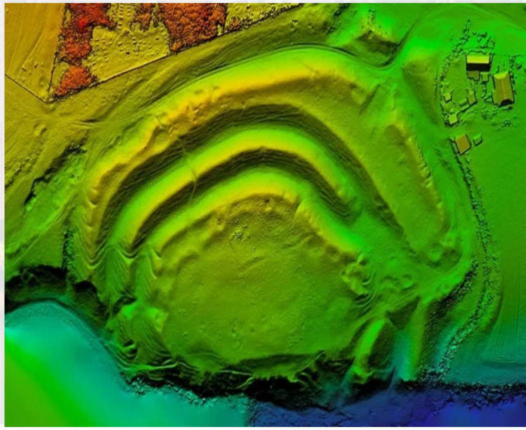


Presentation Outline

- Introduction
  - Research Background
- Methodology
  - Flow and design
  - Study Area
  - Traditional ground survey
  - UAV survey
  - Ancillary data (Satellite and airborne data)
- Results
- Analysis and discussions
- Conclusions

Research Background

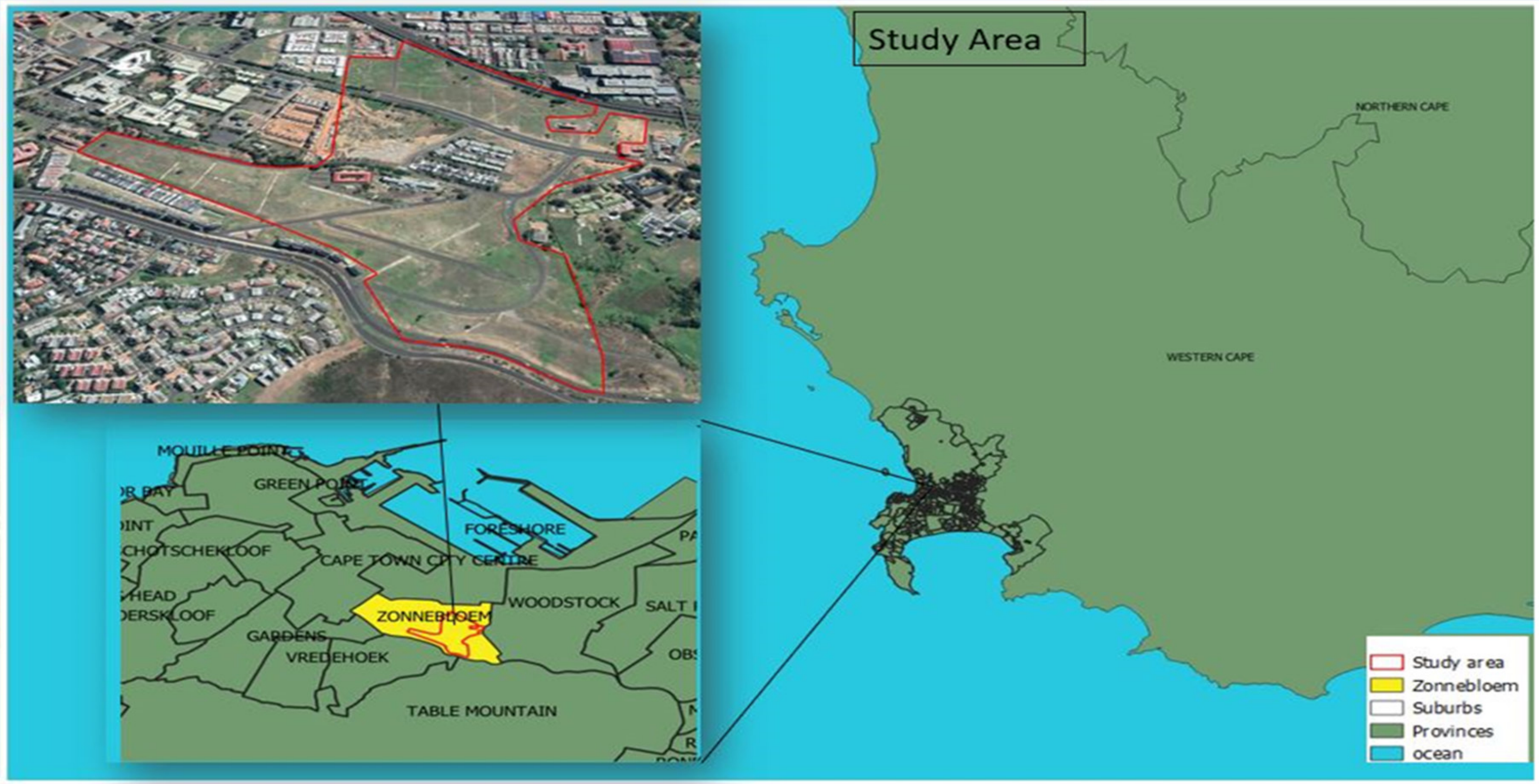
- Digital Elevation Models (DEMs) serve as vital tools across various fields such as urban planning, environmental oversight, hydrology, and disaster response. As cities expand and evolve, the need for high-quality, accurate, and dependable DEMs has become increasingly urgent (Elkhrachy, 2021)

- Terrestrial, UAV, satellite platforms, and airborne have emerged as prominent techniques for generating DEMs, each with unique benefits and drawbacks (Polat et al, 2015)

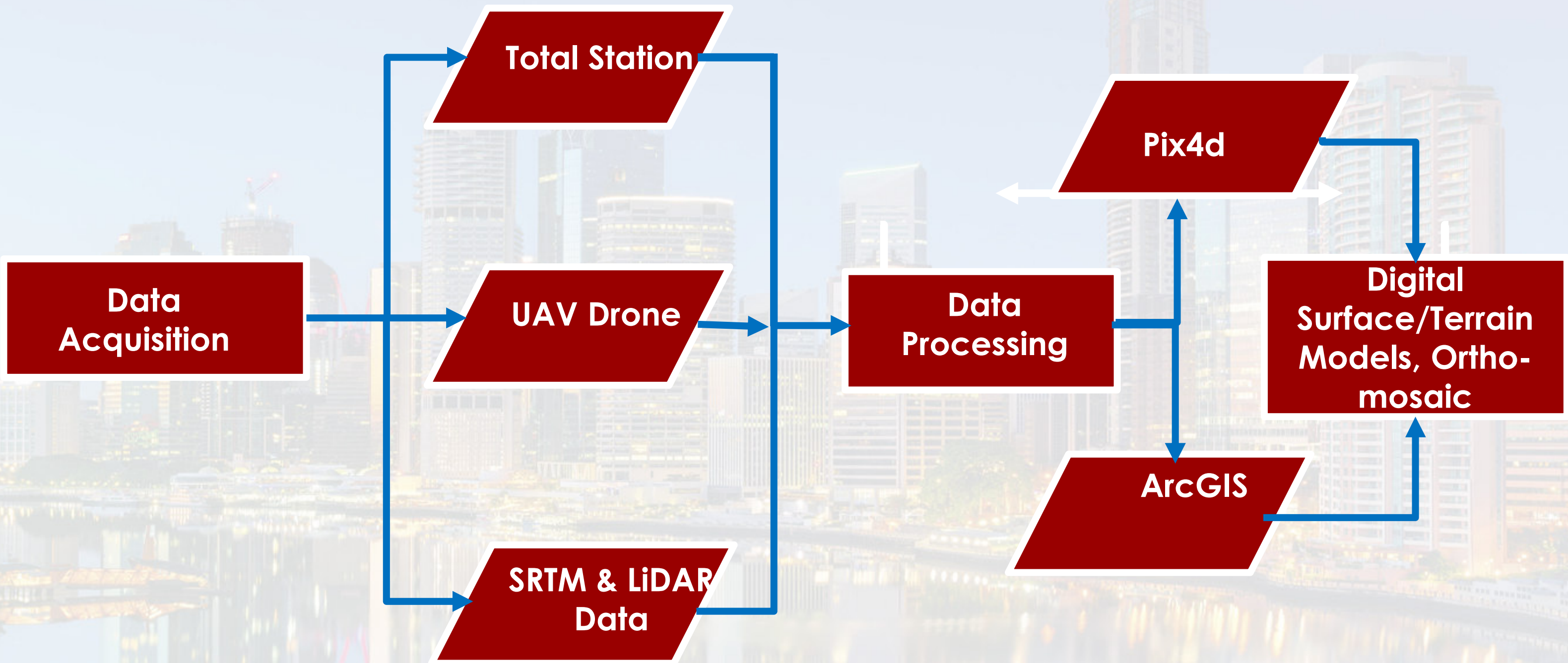
- Despite the wide availability of these varied data sources, there remains a significant gap in the literature concerning thorough comparative studies that assess their accuracy, especially within urban settings (Remondino et al, 2019).

- This study aims to assess and compare the accuracy of DEMs obtained from Total Station, UAV, SRTM, and LiDAR sources specifically in District Six. By utilizing rigorous techniques such as Root Mean Square Error (RMSE) analysis, the study will evaluate how closely these different sources match ground truth data collected from extensive field surveys (Pereira et al, 2020)

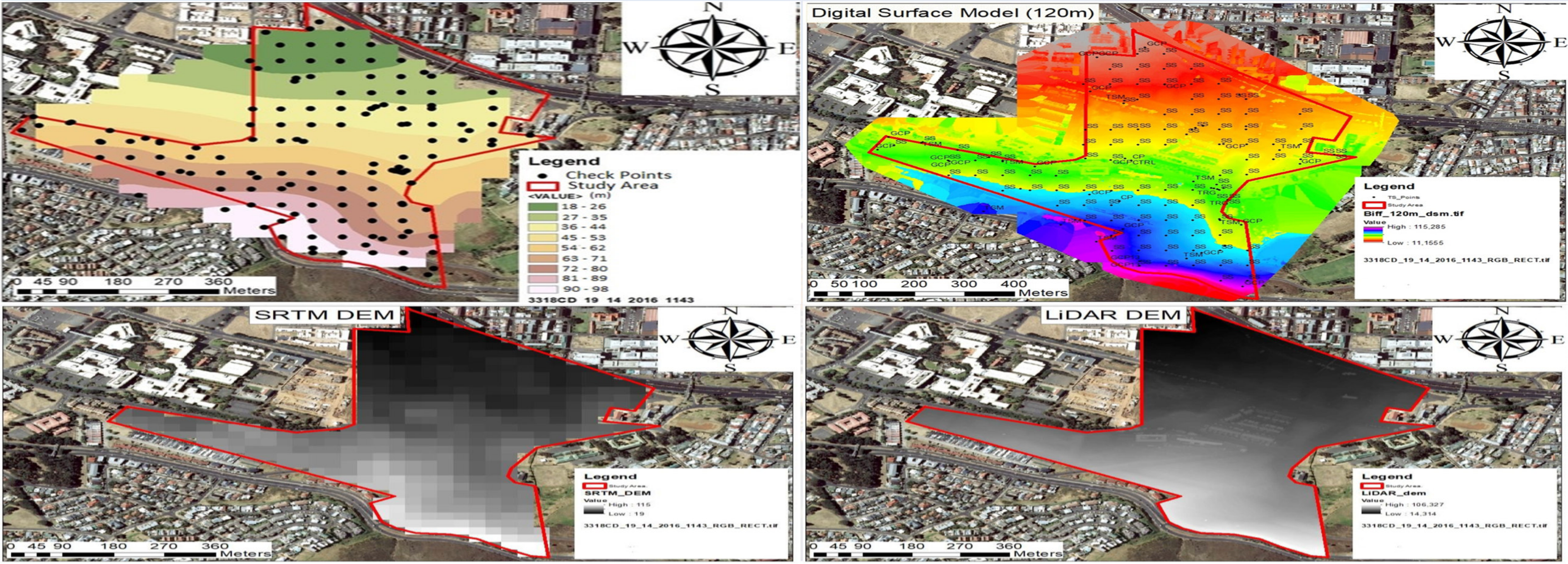
Study Area


Study Area
NORTHERN CAPE
WESTERN CAPE
MOUILLE POINT
GREEN POINT
FORESHORE
CHOTSCHEKLOOF
CAPE TOWN CITY CENTRE
ZONNEBLOEM
WOODSTOCK
GARDENS
VREDEHOEK
TABLE MOUNTAIN
Study area
Zonnebloem
Suburbs
Provinces
ocean

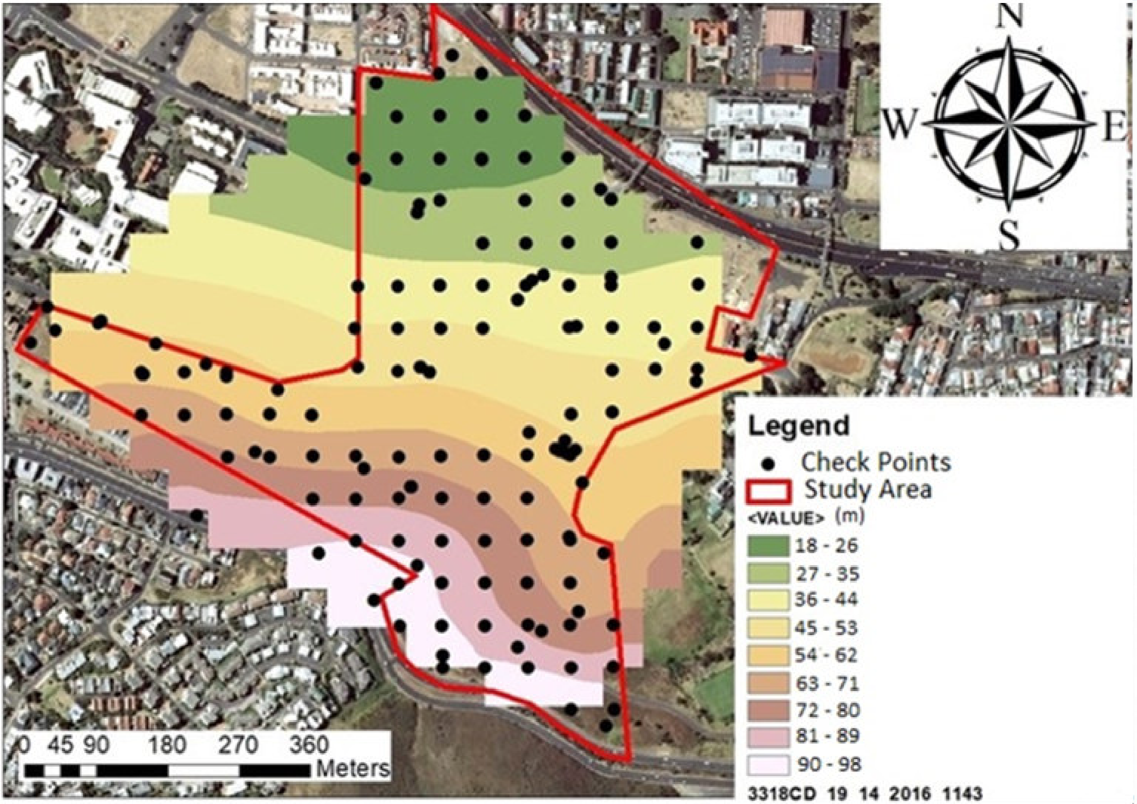
Methodology (Flow and Design)



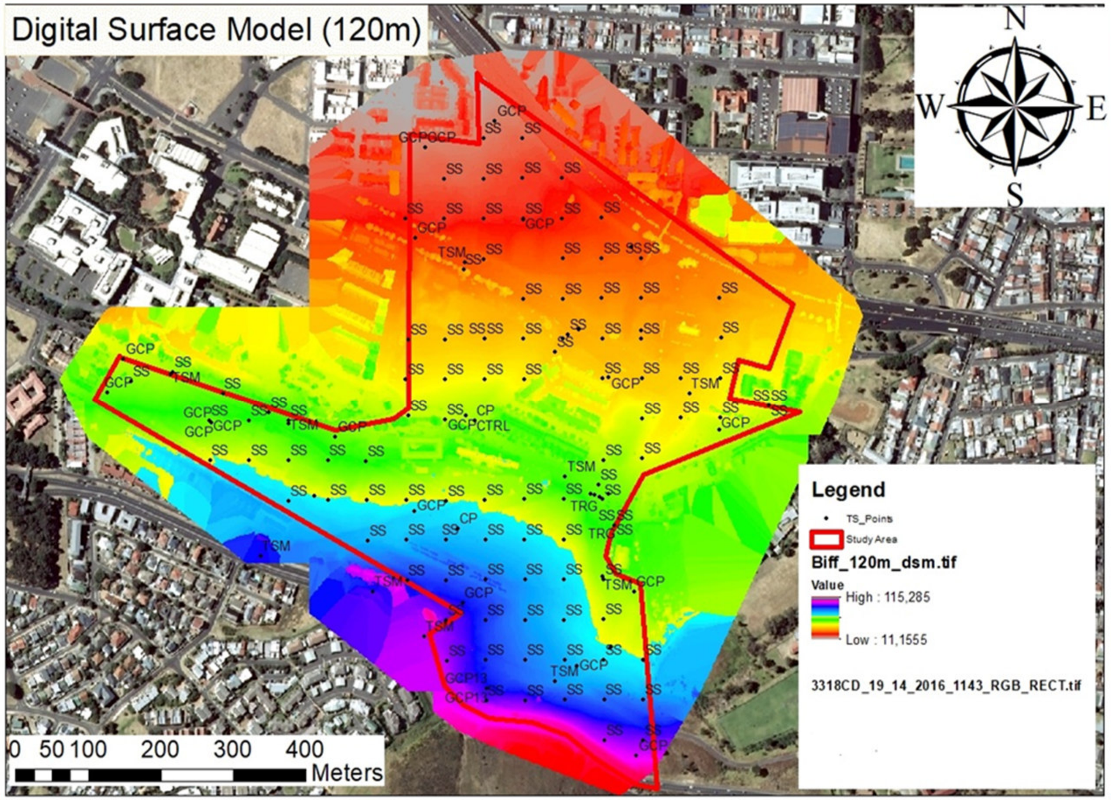
Results


Legend
Check Points
Study Area
<VALUE> (m)
18 - 26
27 - 35
36 - 44
45 - 53
54 - 62
63 - 71
72 - 80
81 - 89
90 - 98
0 45 90 180 270 360 Meters
Digital Surface Model (120m)
Legend
Biff_120m_dsm.tif
Value
High : 115.285
Low : 11.1555
0 50 100 200 300 400 Meters
SRTM DEM
Legend
SRTM_DEM
Value
High : 115
Low : 19
3318CD_19_14_2016_1143_RGB_RECT.tif
0 45 90 180 270 360 Meters
LiDAR DEM
Legend
LiDAR_dem
Value
High : 106.327
Low : 14.314
3318CD_19_14_2016_1143_RGB_RECT.tif
0 45 90 180 270 360 Meters
N
S
E
W

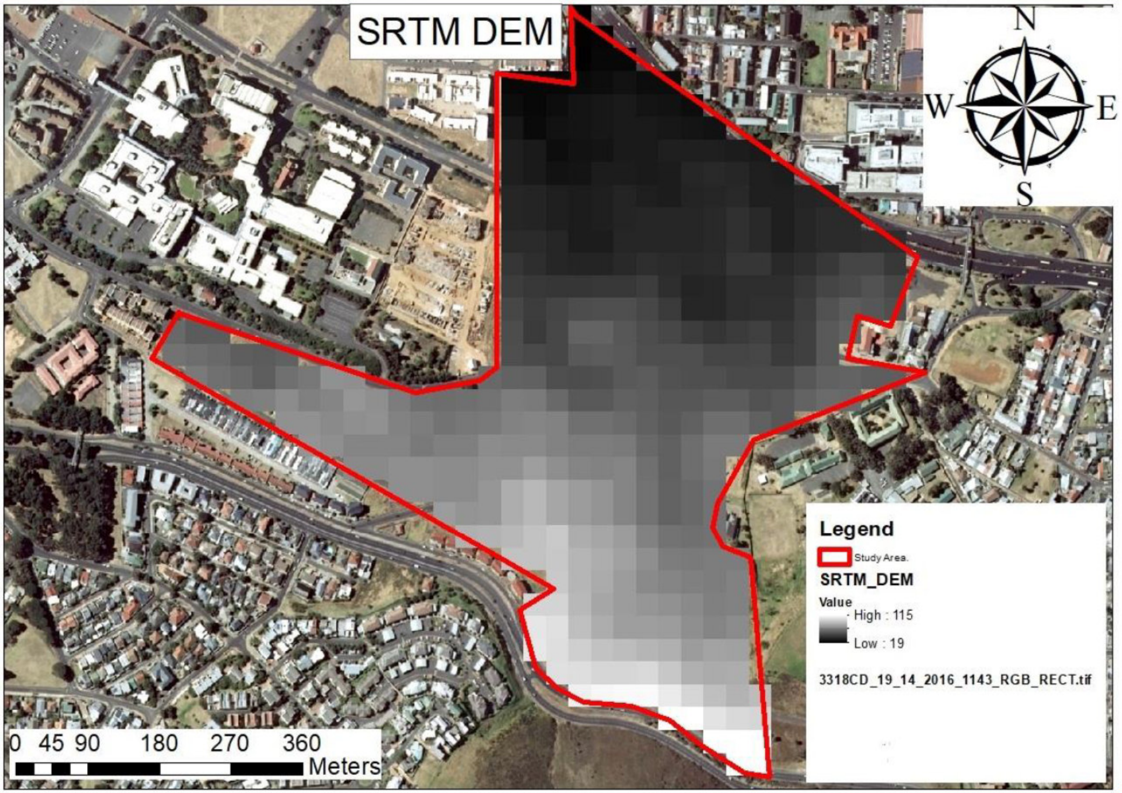
Total Station-generated DEM



UAV-generated DEM



SRTM-generated DEM



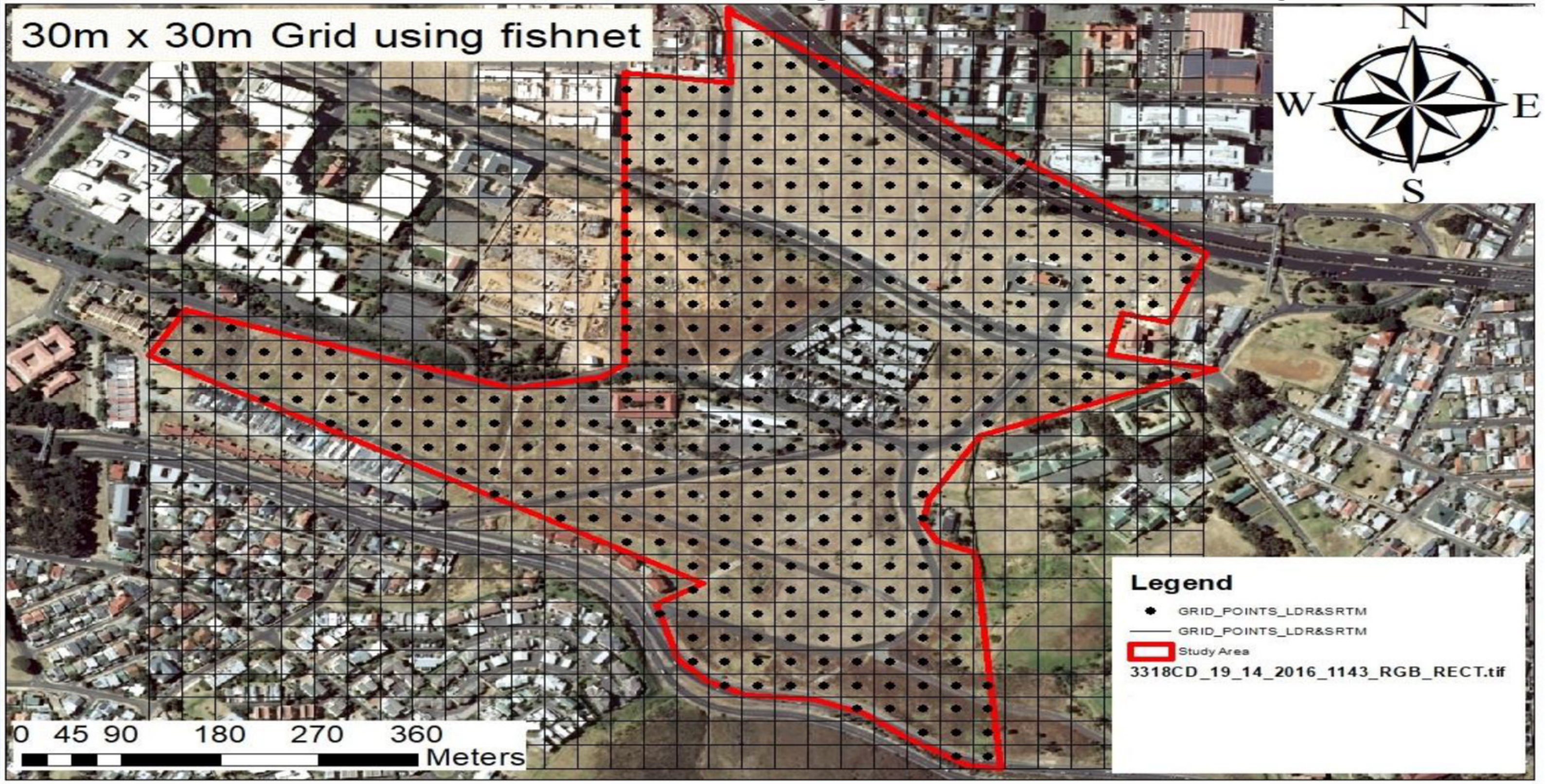
LiDAR-generated DEM

Results conti................

Absolute differences in height between, TS, UAV DEM, LiDAR DEM, and SRTM DEM data - 120 flight height at 157 checkpoints:

Differences in DEMs	Minimum (m)	Maximum (m)	Mean (m)	Standard Dev (m)	RMSE (m)
TS and UAV	-0,270	0,369	-0,042	0,067	0,079
TS and LiDAR	-2,867	0,751	-0,198	0,400	0,445
TS and SRTM	-14,170	11,676	-1,053	4,054	4,176
UAV and LiDAR	-2,868	0,718	-0,156	0,401	0,429
UAV and SRTM	-14,074	11,725	-1,011	4,054	4,166
LiDAR and SRTM	-14,040	11,785	-0,855	4,003	4,081

Relative differences in height: Fishnet Analysis



Results conti…………….

Relative differences in height between, UAV DEM, LiDAR DEM, and SRTM DEM data - 120m flight height at 369 grid points

Differences in DEMs	Minimum (m)	Maximum (m)	Mean (m)	Standard Dev (m)	RMSE (m)
UAV and LiDAR	-3,712	1,957	-0,170	0,500	0,528
UAV and SRTM	-12,079	14,124	-0,635	0,440	4,479
LiDAR and SRTM	-11,583	14,120	-0,465	4,363	4,382

Analysis and discussion conti……

- The absolute vertical accuracy of the TS,UAV, LiDAR and SRTM elevation data is significantly lower than the value of 16m specified in the SRTM data specification. The analyses presented in this paper indicate that the absolute vertical accuracy of less than 5m for the flight is less than the original SRTM requirement specification value of 16m

- The relative vertical accuracy of the TS, UAV, LiDAR and SRTM elevation data is less than 5m which is acceptable given the SRTM data relative accuracy specification of 6m. The relative vertical accuracy of the LiDAR and SRTM elevation data is less than 4.5 metres, which is acceptable given the SRTM data relative accuracy specification of 6 metres.

- The findings demonstrate that UAV-generated DEMs significantly outperform satellite-based and airborne methods in terms of accuracy and resolution. This supports the conclusion that UAV technology provides superior data for urban planning and heritage conservation, particularly in densely built environments like District Six.

Conclusion

- The results of this paper indicate that UAV Photogrammetry data are sufficiently precise. It is possible to use UAV Photogrammetry data for map-making, surveying, and topographical surveying applications with low-cost, time-saving, and minimal fieldwork benefits.

- SRTM data are frequently incorporated into global elevation models. Nonetheless, this data, with a resolution of 30m, is not favoured for sensitive geographical research. The error margin is significantly larger, even though the data is widely accepted and widely used.

- It was observed that LiDAR based data produced satisfactory results when compared to traditional ground data.

- This research suggests that integrating UAV-derived DEMs with existing datasets can enhance decision-making and contribute to preserving culturally significant areas like District Six. These findings corroborate those of comparable studies (Agüera-Vega et al, 2020) and further validate the use of UAVs for DEM generation and other general applications such as urban planning and heritage conservation, which offer cost and time savings.

The most relevant SDGs related to the presentation and theme of this session

1st relevant SDG: 11 SUSTAINABLE CITIES AND COMMUNITIES

2nd relevant SDG: 13 CLIMATE ACTION

3rd relevant SDG: 2 ZERO HUNGER

SUSTAINABLE DEVELOPMENT GOALS | International Federation of Surveyors supports the Sustainable Development Goals

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