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MAPPING INFORMAL SETTLEMENTS USING UAS IN SUPPORT OF LOCAL CLIMATE MODELS

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urbisphere coupling dynamic cities and climate

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INTRODUCTION

Informal Settlements host around a quarter of the global population (UN-Habitat), in urban contexts all over the world. They have various forms, typologies, dimensions, locations and names (e.g. squatter settlements, favelas, poblaciones, shacks, barrios bajos, bidonvilles, slums).

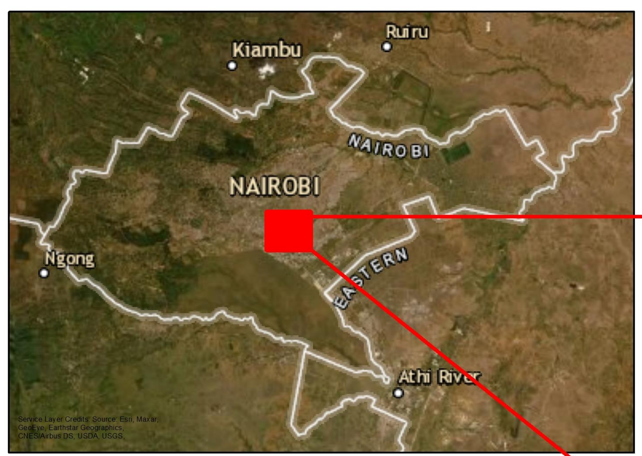
While urban informality is more common in the global south, housing informality and substandard living conditions are found in most countries. The former areas common characteristics may include: limited/no access to safe water, acceptable sanitation, lack of health security and durable housing, overcrowded and lack land tenure security. Such settlements are often located on city outskirts, away from many core urban activities.

Mapping the urban form of such areas is challenging given their density, complexity, and diverse irregular morphology. Earth Observation can help in the mapping and monitoring of the extent, structure and expansion of such areas. Despite increasing data availability of very high resolution data with pixel size of less than 1m, standard approaches may not provide appropriate baseline for used in urban surface and climate models, because of the complexity (e.g., building: density, materials, low height).

Here we present a first attempt to delineate the urban form of the slum of Mukuru in Nairobi, Kenya using Unoccupied Aerial System (UAS) data. Information derived includes: number of buildings and heights, density of structures, vegetation cover and height of high vegetation, digital surface model (DSM) and digital terrain model (DTM) as these are to our knowledge unavailable.

These type of data are usually needed for many neighbourhood-scale urban climate models (e.g. Surface Urban Energy and Water Balance Scheme - SUEWS).

STUDY AREA AND INPUT DATA



The Mukuru Special Planning Area (red polygon, right panel) consists of 33 villages and is home to over 301, 683 people as of 2017.
The population density (inhabitants/ha) in Mukuru informal settlements is 92.56 and 186.95 in 2000 and 2020 respectively. Therefore, Mukuru's net increased inhabitant/ha 2000–2020 is 94.39. The mushrooming of structures are as a result of rural to urban migration of people seeking for jobs and better life. UAS operations (green polygon) allow detailed data collection for use in spatial analysis and climate modeling

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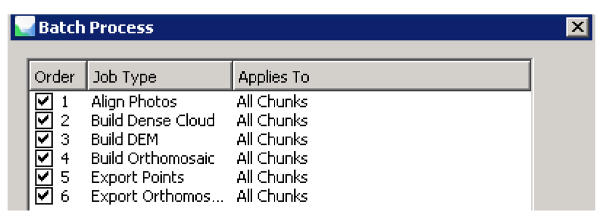
Photogrammetry

- Data collected: 20 February 2021
- 1177 images of 42 megapixel with post-processing kinematic (ppk) correction on position and elevation using the WINTRA fixed wing vertical take-off and landing (VTOL)
- UAS data analysis: performed in Agisoft Metashape ver 1.7 with batch process analysis (Agisoft manual, 2021)



Metashape

Classification and urban morphology

- 1 m UAS RGB orthoimage
- 1 m Digital Surface Model from UAS
- SAGA GIS: Basic Terrain Analysis for topographic variables
- QGIS EnMAP: Random Forests Classification - 5 classes: Buildings Vegetation (High, Low), Soil, Water
- DSM2DTM: uses moving window filtering (30 pixels/1 meter)
- Number of buildings and trees height extracted

RESULTS

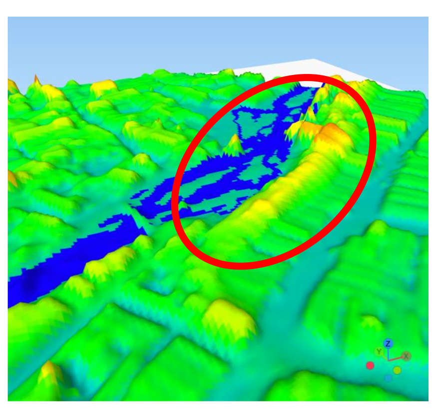
For the accuracy of the landcover product we use 100 random points per class.
The overall of the final product reach 91.5%, while by class we have the following user's accuracy):

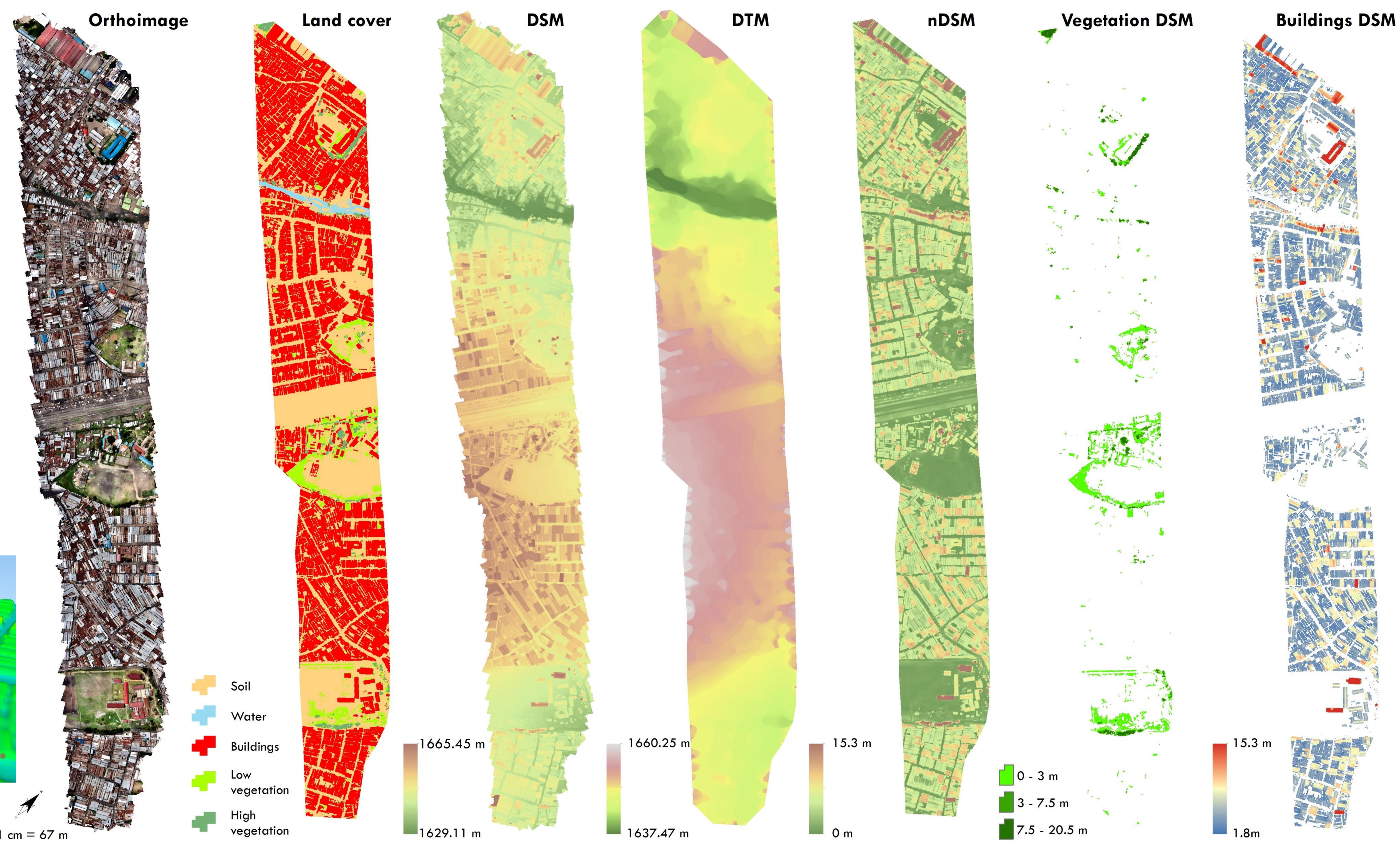
a) Buildings= 90.16%, b) Vegetation= 89.8%, c) Bare Soil=85% and d) Water= 100%.

The spatial resolution of the DSM product is 1m and we keep the same also for the DTM after the processing with the moving window.

Without in-situ measurements (because of COVID), DSM and DTM could not be evaluated. As initial data are corrected using PPK, large errors in the elevation are unexpected.

Visual inspection of building and vegetation heights shows overestimation in areas with varying slopes (e.g. riverbanks as shown in the image). This is directly related to the moving window approach which inevitably considers the lowest pixel values in the window as the surface height.





CONCLUSIONS

- Classification of orthoimages using only RGB information, are constrained by materials with similar colours and shadows, with algorithms performance poorer
- Filtering approach allowed urban morphology parameter to be obtained. These have a wide range of uses e.g. for urban climate modelling

Constraints and Future

- Volume of data collected require powerful computers to create products such as orthoimage and digital surface model (DSM)
- Multispectral imagery can improve distinguish spectral confusion from similar coloured materials
- Lack of terrain data - means the filtered approach was not evaluated. In flat areas, differences of <0.10 m observed. These are mainly dirt roads where the moving window does not much affect the values of the DTM.