A Dynamic, Cloud-based LULC Mapping Methodology Using Sentinel-2 to Support Climate-Smart Landscape Management in Vulnerable Fijian Communities.

Kevin Davies[1], John Duncan[2], Renata Varea[3], Viliame Tupua[4], Eleanor Bruce[1], Bryan Boruff[2], Nathan Wales[3]

[1]The University of Sydney, [2]The University of Western Australia, [3]The University of the South Pacific, [4]Fiji Ministry of Forestry

PRESENTED AT:

AGU FALL MEETING
Online Everywhere | 1–17 December 2020

INTRODUCTION

Communities in Fiji rely on provisioning services from landscape resources such as agricultural and forestry-related production, and climate regulation determined by the mix of landscape resources across space. Accurate mapping and monitoring of patterns of land use and land cover (LULC) over time at scales relevant to livelihood processes is important for informing landscape management, land use policies, and climate-smart sustainable development (Duncan et al., 2020).

We are collaboratively developing a methodology with key landscape stakeholders to produce an inter-annual LULC map that addresses natural resource, agricultural, and forestry management use cases (Davies et al., 2019). The key requirements identified by stakeholders were that the LULC methodology be robust, is easily produced on an annual basis, and could be applied to other Fijian landscapes with different dynamics. Our approach uses publicly available remotely sensed data and geospatial tools.

Here we present the LULC methodology for the lower Ba River catchment area and adjoining Nalotawa forestry area on Fiji's main island of Viti Levu for 2019.

STUDY AREA IN FIJI

The Ba River lower catchment is located in the north-west of Fiji's main island of Viti Levu, Fiji (Figure 1).

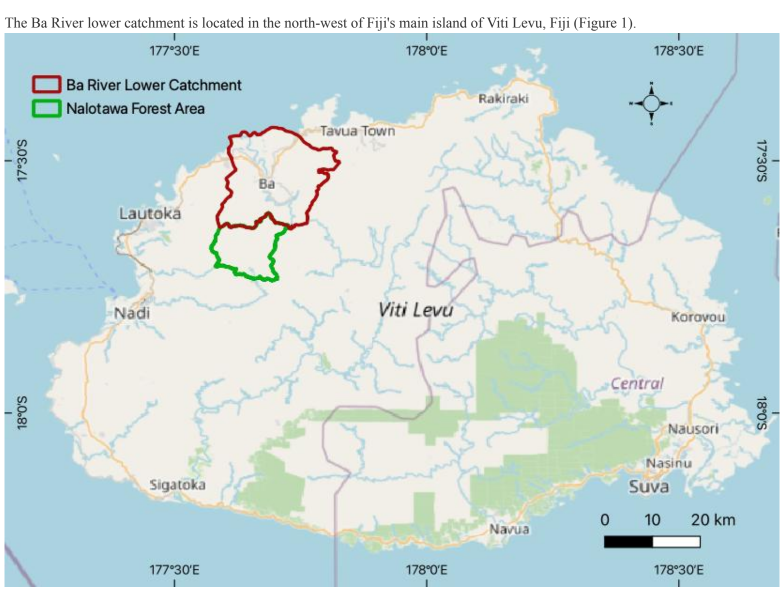

Figure 1: Lower Ba River catchment area (red) and the Nalotawa forestry area (green).

Mangroves are present along the coastal regions, mixed agricultural and sugarcane land uses dominate the mid-lower reaches of the catchment, and a mixture of forests, grassland, and agriculture are present in the highland areas (> 1000m ASL). There were approximately 248,000 residents in the catchment area from the most recent census in 2017 (Fiji Bureau of Statistics, 2018).

The Nalotawa forest area (Figure 1) has been included in Fiji's Emissions Reduction program as part of Fiji's commitment to REDD+. Forestry areas were included where there was high-risk of degradation or loss; were adjacent to large communities; or biodiversity hotspots (Fiji Ministry of Forestry, 2019).

METHODS

We used the open-source QField mobile GIS for field data collection (OPENGIS.ch, 2019), Collect Earth Online for image interpretation (CEO; Saah et al., 2019), and Google Earth Engine for image analysis (GEE; Gorelick et al., 2017). An overview of the workflow is presented in Figure 2.

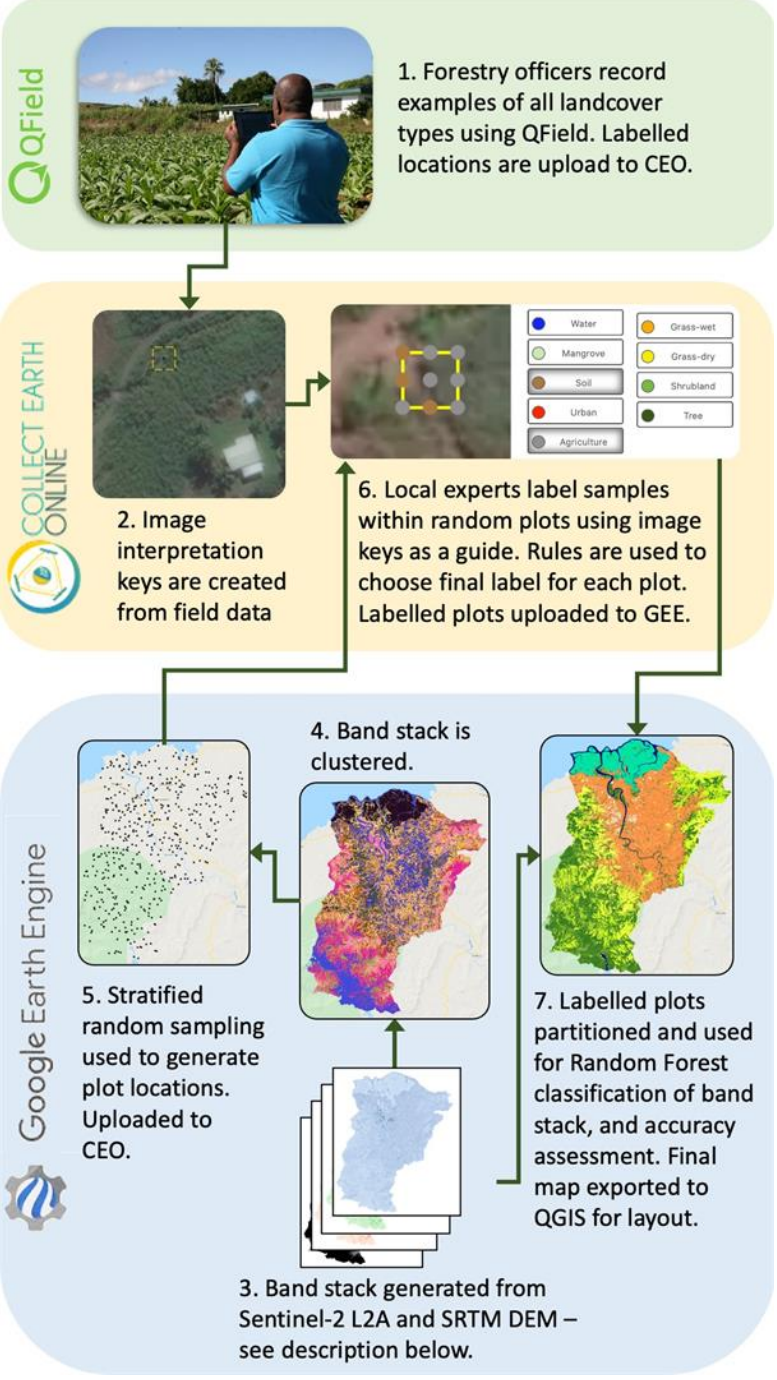

Figure 2: Workflow for producing the LULC map.

All available Sentinel-2 L2A images captured over the study area in 2019 were utilised. Images were cloud-masked and subset to the study area. A Normalised Difference Vegetation Index (NDVI) band was added to each image, and 12 monthly quality composites (maximum NDVI) were created.

The annual median of bands B2 to B8A and NDVI were created from the 12 quality composites. The 12 monthly NDVI bands representing the phenological profile were combined with the 9 annual median bands. The Shuttle Radar Topography Mission 30 metre digital elevation model was added, and all 22 bands were resampled to 10 metre pixel resolution to create the final band stack.

RESULTS

The combined LULC map for the Ba River lower catchment and the Nalotawa forest area (Figure 3) had an accuracy assessment of 73% (kappa 0.68).

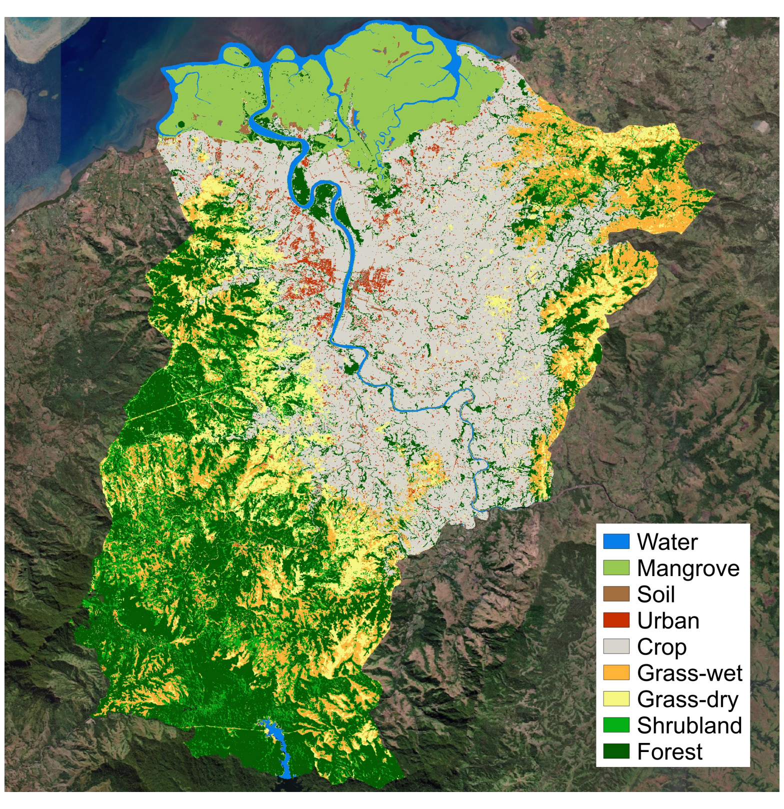

Figure 3: The 2019 land use/land cover map.

The LULC map captured important village-scale land cover (urban class) and land uses such as buildings and small-holder crop areas (Figure 4).

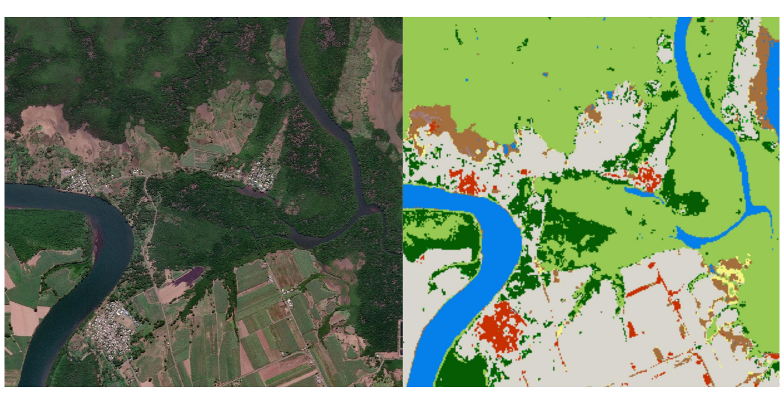

Figure 4: Close-up of villages (red class).

The annual median band values (Figure 5) showed the characteristic spectral response for vegetation for all classes except water. Urban areas had a weak vegetation profile suggesting mixed pixels in rural locations. The increasing variation between classes in the red-edge to NIR region (B5 - B8A) highlights the utility of these 20 metre pixel resolution bands for separating classes.

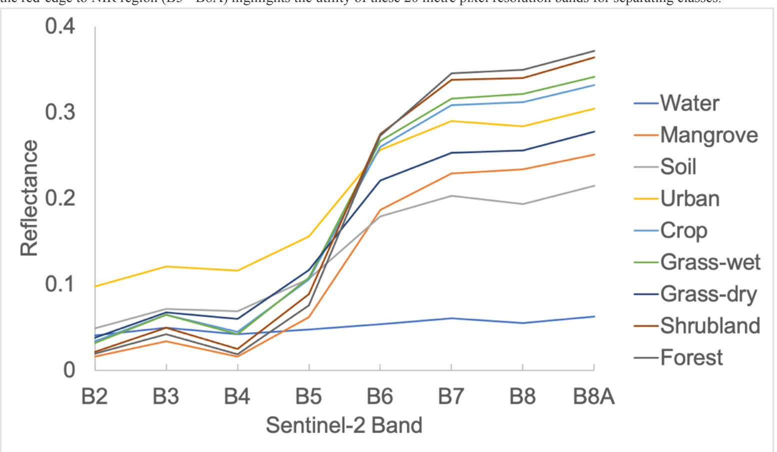

Figure 5: Annual median band values for training plots by class.

The NDVI profile (Figure 6) showed seasonal responses across all classes. There was little separation between the dense vegetation classes (mangrove, forest, shrubs) likely due to NDVI saturation.

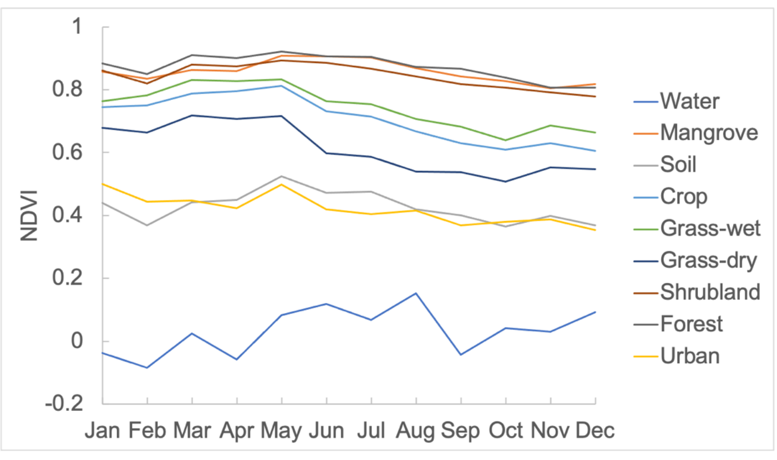

Figure 6: NDVI profile for training plots by class.

DISCUSSION AND CONCLUSION

An important outcome from this collaboration has been the transfer of skills and building of local stakeholder capacity to continue to update the LULC map, and to expand the map to include other communities, catchments and forestry areas across Fiji. The Ministry of Forestry will apply the methodology to other forest management areas to improve emissions reduction reporting requirements for REDD+.

Improvements to the methodology include investigating soil and atmospherically resistant vegetation indices as an alternative to the NDVI for characterising phenology. Further image interpretation is also required in the Nalotawa forest area to improve map accuracy.

The LULC methodology presented here provides information useful for landscape management, and an accessible point of reference to support co-development of adaptive landscape management strategies. The LULC map is produced at a spatial-scale relevant to understanding livelihood-landscape interactions and will assist in identifying priority actions for building climate resilience within the landscape.

ACKNOWLEDGMENTS

We thank the communities of Nawaqarua, Etatoko, and Koronubu-Vunibaka for their engagement in the co-development of the LULC map, and our collaborators for their ongoing contribution including the Ministry of Forestry and Pacific Community (SPC). This research was funded by the Australian Centre for International Agricultural Research (ACIAR; ASEM/2016/101).

For more information please visit our project website:

http://livelihoods-and-landscapes.github.io

ABSTRACT

Communities in Fiji rely on provisioning services from landscape resources such as agricultural and forestry-related production, and climate regulation determined by the mix of landscape resources across space. Accurate mapping and monitoring of patterns of land use and land cover (LULC) over time at scales relevant to livelihood processes is important for informing landscape management, land use policies, and climate-smart sustainable development. A methodology developed collaboratively with landscape stakeholders to produce an inter-annual LULC map that addresses natural resource, agricultural, and forestry management use cases is presented here. Key requirements identified by stakeholders were that the LULC methodology was robust, relatively easy to reproduce, and could be applied to other Fijian landscapes with different dynamics. Using publicly available remotely sensed data and geospatial tools, we applied the LULC methodology for two locations in the Ba Catchment, Fiji. Field orientation and key validation data were collected using the QField open-source mobile GIS, and labelled training and accuracy assessment data were collected in Collect Earth Online. Annual median multispectral surface reflectance and seasonal NDVI-based phenology metrics derived from Sentinel-2, and topographic variation from SRTM DEM provided the best discrimination between vegetation classes across the catchment from low-lying coastal areas to the highlands (> 1000 m ASL). A random forest model was trained and validated in Google Earth Engine to produce an inter-annual LULC map with a 10m spatial resolution. An important outcome from our work was the transfer of skills and building of local stakeholder capacity to continue to update the LULC map, and to expand the map to include other communities, catchments and forestry areas across Fiji. This capacity building included iterative stakeholder consultation, co-development of online training materials, workshops, and collaborative fieldwork.

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