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# Combining Landsat, Sentinel2 and Planet Lab satellite assets for resource-constrained land cover analysis in the tropics

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**Abstract:**

Private sector, high-resolution, daily-updated satellite assets have become a significant resource for remote sensing operations. A case in point is PlanetScope (PS), currently operating the largest collection of small Earth-imaging satellites. This paper discusses the opportunities and limitations of PS assets to monitor land cover change under resource constrained research environments typical of emerging economies in the tropics in the context of the *Alas Merta Jati* in Central Bali.

Land cover information can be extracted from multiscale imagery for fine-scale to coarse-scale insights based on spatial resolution; Landsat offers coarse, Sentinel2 medium and PS fine spatial resolution (table 1). Additionally, analysis tasks are impacted by the number of sensor spectra available, where fewer spectral bands generally compromise classification opportunities. Moreover, land cover and land use analysis in Bali's *Alas Merta Jati* have in the past been limited by a lack of appropriate data sources. Only in 2000 did the situation improve with the introduction of image data from Landsat 7 and 8. While Landsat offers amongst the three sources the deepest view into remote sensing history, Landsat bands B, G, R, NIR, SWIR1, SWIR2 have a spatial resolution of only 30 meters and are applicable to land cover and land use interpretation only at a coarse scale. The Sentinel2 network offers similar spectral coverage and a higher spatial resolution of 10 meters, with a combined revisit frequency of 5 days as opposed to Landsat's 16-day revisit cycle. Since 2016, the PS network has significantly improved the state of both spatial resolution and revisit frequency. However, even PS's latest 8-channel satellite *SuperDove* lacks short-wave infrared spectral bands required for soil variation as well as urban development measures, such as the Normalized Difference Built-up Index (Zha et al., 2003), widely deployed to monitor urban change. Moreover, PS assets have been deemed as lacking in some aspects of data quality (Frazier and Hemingway, 2021).

Given high levels of humidity in the tropics, satellite networks with high revisit frequencies can offer the best chance for cloud-free views. The high revisit frequency and high spatial resolution afforded by the PS satellite network enable previously unavailable opportunities for the analysis of remote sensing data in the tropics. For example, the SVM classification operating on PS assets (table 1) can detect the famous Balinese rice paddies robustly while they are almost imperceptible in the Landsat based results. Yet even imagery from PS requires additional ground-level information in order to disambiguate complex land cover conditions. The high growth and re-growth rates in the tropics as well as dynamics of Bali's informal economy require additional location-specific and context-sensitive knowledge in order to determine the actual conditions on the ground as described in related recent work (Böhlen, Iryadi and Liu, 2022). Moreover, PS assets come at a financial cost that can be unsustainable for resource-constrained emerging economies.

Because one size does not fit all, we propose an approach that combines advantages found across the discussed image assets. We propose an approach that uses freely available (Sentinel2) sources to regularly monitor an area of interest, and then switches to the highest resolution asset only if a condition of concern or interest has been detected and not adequately understood. Not unlike the *tip and cue concept* in which one monitors an area of interest with one sensor and then 'tips' another complementary sensor platform to acquire another image over the same area, we *tip and cue in this case based on economic constraints*. We have implemented this approach in an open source software system based on ORFEO and GDAL libraries, COCKTAIL, that allows one to perform this interpretation of tip and cue to automate the collection of Sentinel2 data, to perform simple band operations and data intensive classification tasks, and to then apply those same classification routines to PS data if deemed necessary ( table 1). We do not currently combine sensor data across the different satellite networks, and only use the freely available resource as a cue to move to the subsequent step. As COCKTAIL runs on Linux platforms, researchers can freely share code and analysis results remotely and asynchronously. This approach allows one to make productive use of the PS assets while minimizing costs; a fundamental requirement for resource constrained GIS research efforts typical of university as well as emerging economy contexts.

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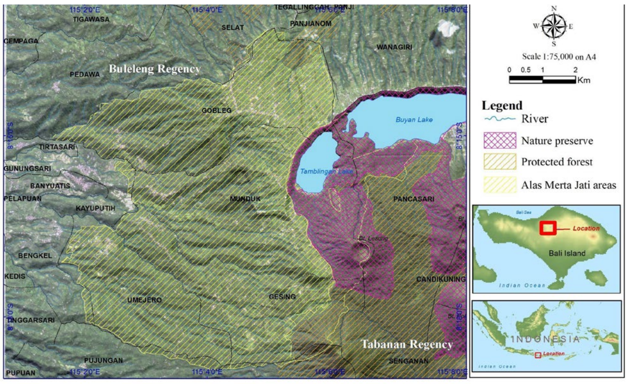
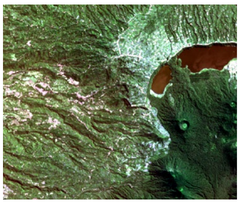
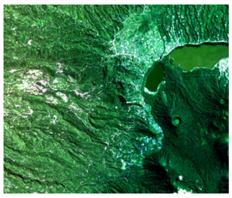
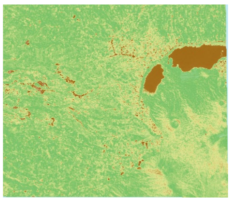
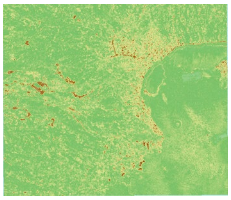
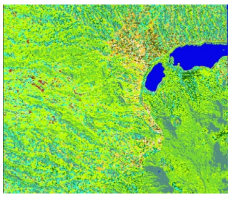
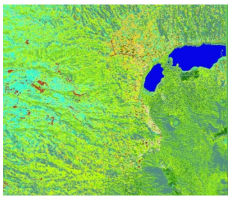
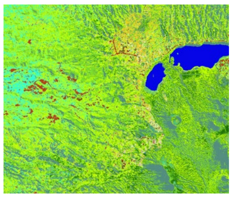
| | *Landsat (7, 8)* | *Sentinel2 (A, B)* | *Planet (Dove, SuperDove)* |
|---|---|---|---|
| *Available since* | 1999 / 2013; (2000 Indonesia) | 2015 | 2014 / 2022 |
| *Spectral bands and resolutions (units: meters)* | Coastal Aerosol, B, G, R, NIR, SWIR1, SWIR2 (30); Pan (15); Cirrus (Landsat 8 only, 30); TIR-1, TIR-2 (100) | Coastal Aerosol (60); B, G, R (10); IR1, IR2, IR3 (20); NIR(10); Narrow NIR (20); NIR2, SWIR1 (60); SWIR2, SWIR3 (20) | Dove: B, G, R, NIR (3.7); SuperDove: Costal Blue, Blue, Green I, Green, Yellow, Red, Red Edge, NIR (3.7) |
| *Revisit frequency* | 16 days (both) | 5 days (combined) | 24 hours (both) |
| *Cost to researchers* | Free (after 2008) | Free | Not free |
| *Satellites in orbit* | 1 | 2 | ~ 200 (6/2022) |
| *Map* |  | | |
| *Sample image*<br><br>*Alas Merta Jati, Central Bali*<br><br>*Sentinel: 07-26-2021*<br>*Landsat: 07-27-2021*<br>*Planet: 05-01-2021* |  |  |  |
| *Sample band operation*<br><br>*(Normalised Difference Built-up Index)*<br>*Sentinel: 07-26-2021*<br>*Landsat: 07-27-2021*<br>*Planet (4-band): n.a.* |  |  | bands not available |
| *Sample classification*<br><br>*(Support Vector Machine)*<br><br>*Sentinel: 07-26-2021*<br>*Landsat: 07-272021*<br>*Planet (4-band): 05-01-2021* |  |  |  |

Table 1. Overview of satellite assets, features and limitations. Band operations and classifications performed with COCKTAIL.

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