Nowcasting From Space: Tropical Cyclones' Impacts on Fiji's Agriculture

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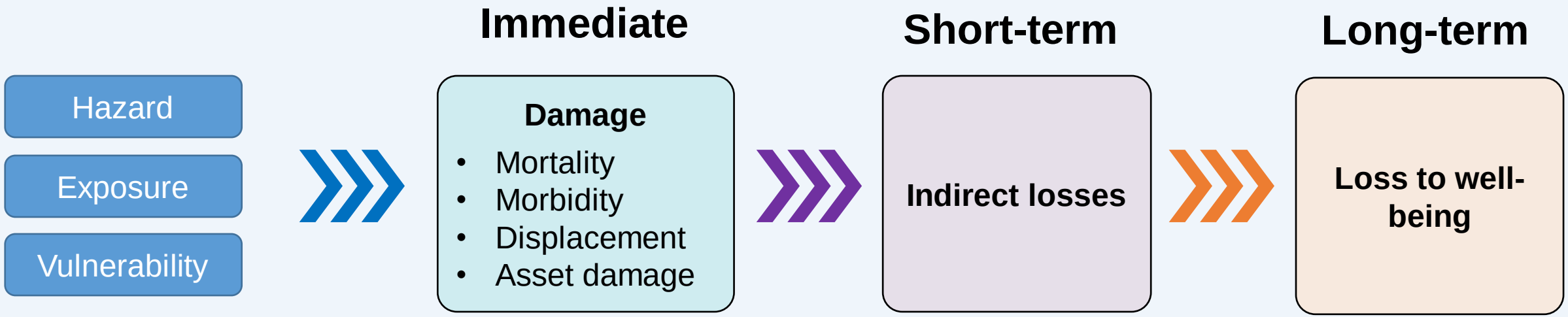
From the People of Japan

What happens when a disaster strikes?



Disaster damage assessments

Ground-based

Remote-sensed

Developing a nowcasting tool for cyclones

1) Combining historical satellite data with socio-economic or other datasets to identify cyclone vegetation damage patterns;

2) Identifying statistically robust damage correlates using regression analysis;

3) Employing the damage correlates for estimation of vegetation damage once the path of the cyclone is known.

Data: Fiji Cyclones

Cyclone	Date	Cyclone intensity	Costs in Fiji
Winston	15 February 2016	Category 5	USD 1.38 billion
Josie and Keni	2-10 April 2018	Category 1 and 3	USD 3 million
Harold	7-8 April 2020	Category 4	USD 40 million

Optical Satellite Data

Satellite source	Spatial resolution	Temporal resolution
The Copernicus Sentinel-2	10-60m	5 days
Terra and Aqua MODIS	250m	16 days

Cloudy and lower-quality pixels are masked

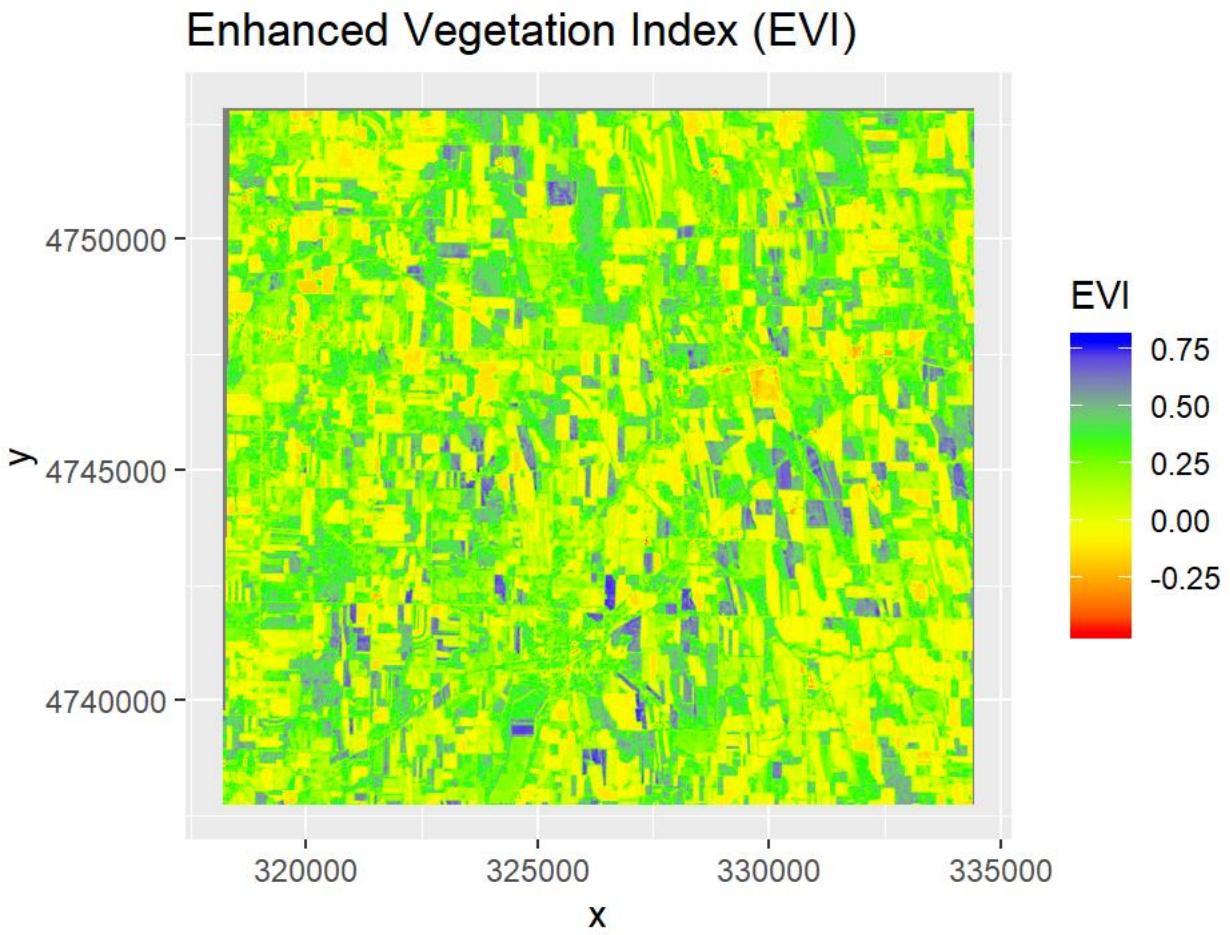
Lower-resolution MODIS data are used to supplement the missing Sentinel data

Optical Satellite Data

Enhanced Vegetation Index

Calculated using
the top-of-the atmosphere reflectance
(ρ) in the near-infrared, red and blue
spectral bands:

$$EVI = 2.5 \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + 6\rho_{red} - 7.5\rho_{blue} + 1}$$



Optical Satellite Data

Absolute (*EVIdiff*) and relative (*EVIch*)
EVI change post-cyclone as a proxy for vegetation damage:

$$EVIdiff = EVI_{postTC} - EVI_{preTC}$$

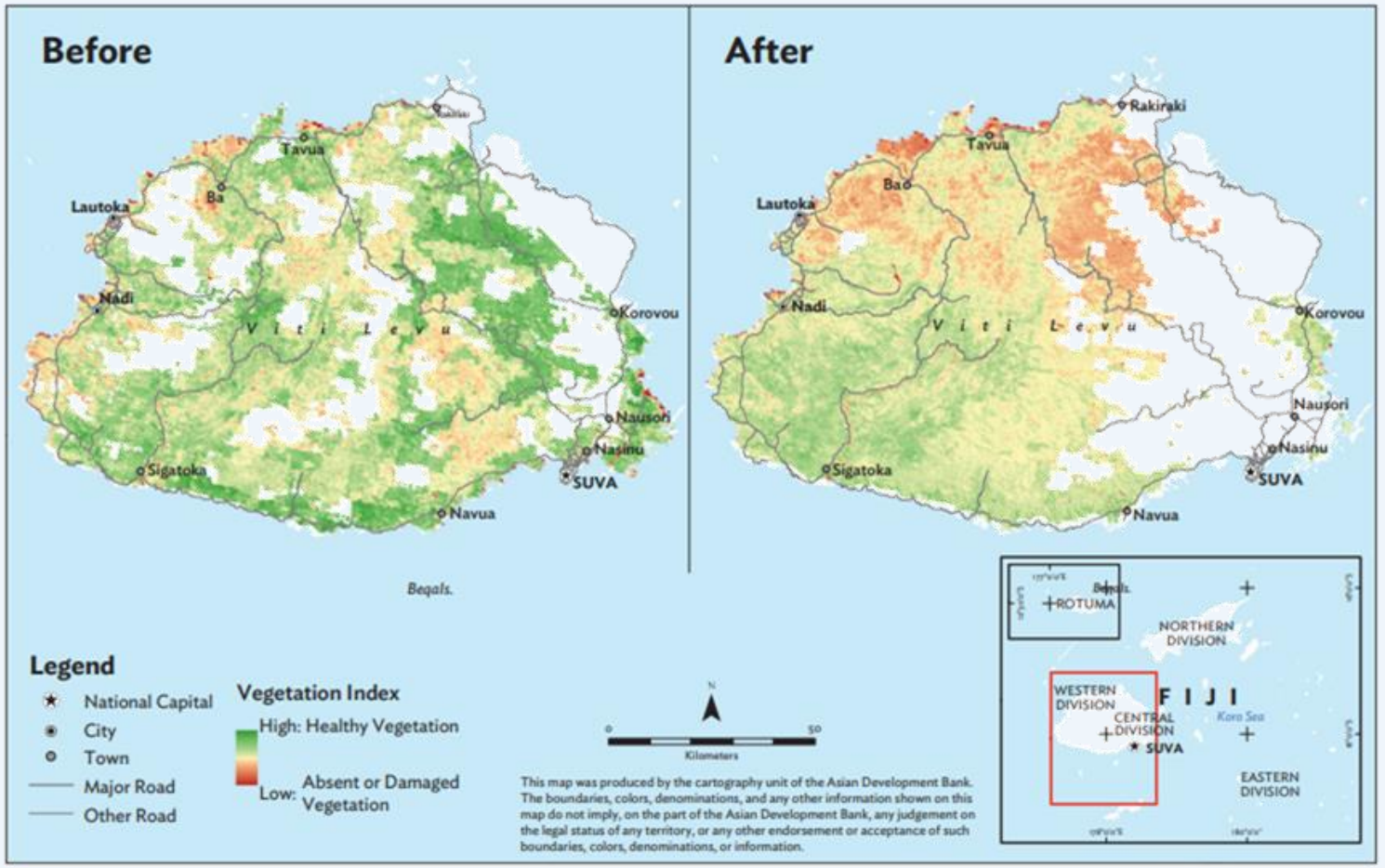
$$EVIch = \frac{EVI_{postTC} - EVI_{preTC}}{EVI_{preTC}}$$

District-level values calculated as the average of the grid-level EVI values in each district

Enhanced Vegetation Index

High EVI

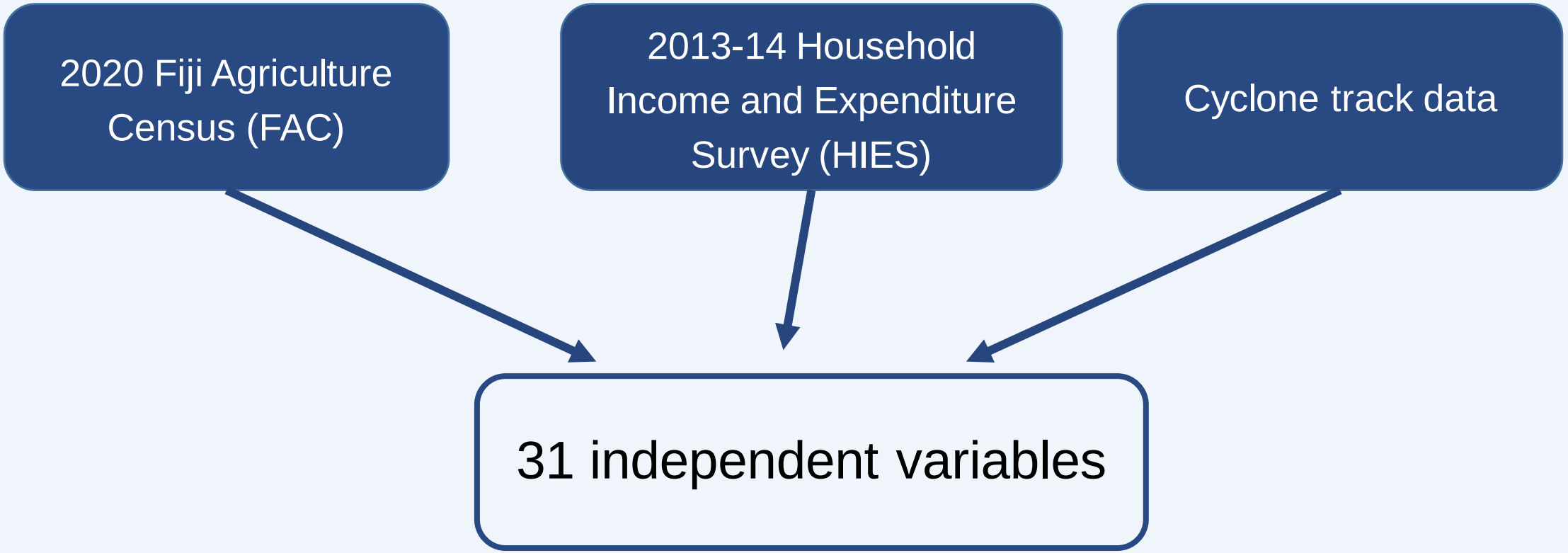
Low EVI



Note: Left panel shows the enhanced vegetation index before Tropical Cyclone Winston (2016) and the right panel shows the enhanced vegetation index after the tropical cyclone.

Sources: Authors' calculations using data from the Moderate Resolution Imaging Spectroradiometer and district boundary data from the Database of Global Administrative Areas (both accessed 31 January 2022).

Socio-economic and hazard intensity data



Regression analysis

Analysis at a district level

EVI change

HIES variables

FAC variables

Cyclone distance

$$EVI_{cd}^{x} = \alpha + \beta_1 HIES_d + \beta_2 FAC_{sd \subset d} + \beta_3 DIST_{cd} + \varepsilon_{cd}$$

Regression analysis

4 EVI variants:

- Absolute EVI change
- Relative EVI change
- Absolute EVI change < 0
- Relative EVI change < 0

X

4 cyclone grouping categories:

- All TCs
- Winston
- Josie & Keni
- Winston + Josie & Keni

16 regression models

Regression Analysis

1) Identification of potentially significant independent variables from the total list of variables, for each regression model

2) Running the regressions using the potentially significant independent variables

3) Evaluation of which independent variables are repeatedly significant across different regression models

Results

5 repeatedly significant variables identified

- ↑ Cyclone distance
- ↑ Fraction of land used for cassava plants → ↓ Vegetation damage
- ↑ Average household income

- ↑ Fraction of land used for banana plants → ↑ Vegetation damage
- ↑ Government transfers and remittances

Results

Repeatedly significant variables

Variable	Coefficient*
Cyclone distance	0.0899
Fraction of land used for growing banana	-0.6218
Fraction of land used for growing cassava	0.4136
Average household income	0.0092
Average household transfer	-0.0190

*Using the coefficient values from the model with the highest explanatory power

Results and need for improvement

Robustness of the cyclone distance variable suggests that
EVI change can be used as proxy for vegetation damage

The socio-economic damage correlates
likely not statistically robust enough for nowcasting use

Extensions of the study

For effective targeting of responses and support, richer data is important to provide more accurate estimates and stronger insights.

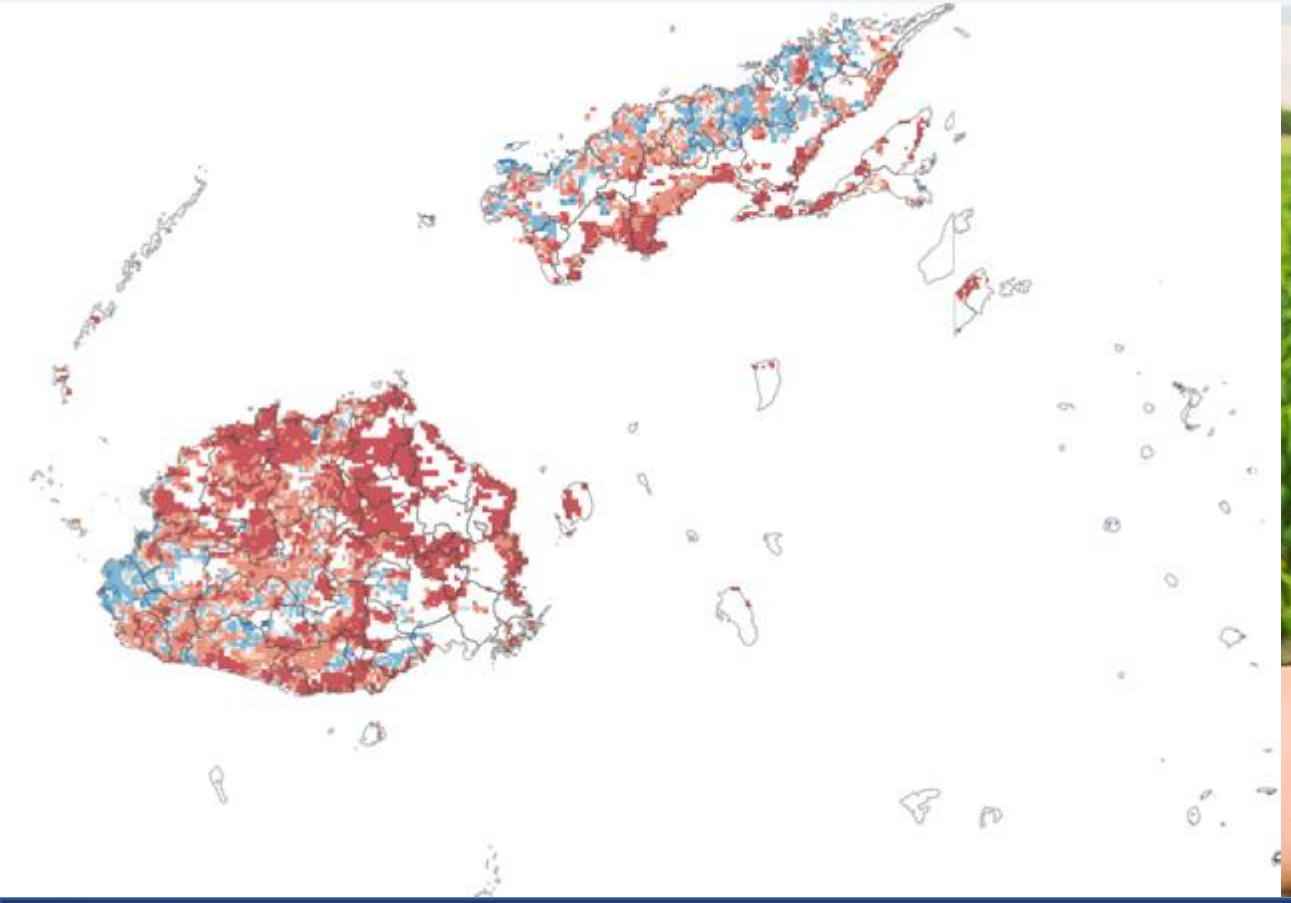
(i) Agriculture census data and maps at a subdistrict level and with geo-located information about crops to increase the number of observations for the analysis;

(ii) Granular data on households such as at the subdistrict or village level, location, income from specific crops, and other features to assess direct impact on households; and

(i) Data over a longer time period, such as through several rounds of household surveys, for understanding changes in income over time.

Agricultural Income Analysis

Cyclone vegetation damage → Agricultural income

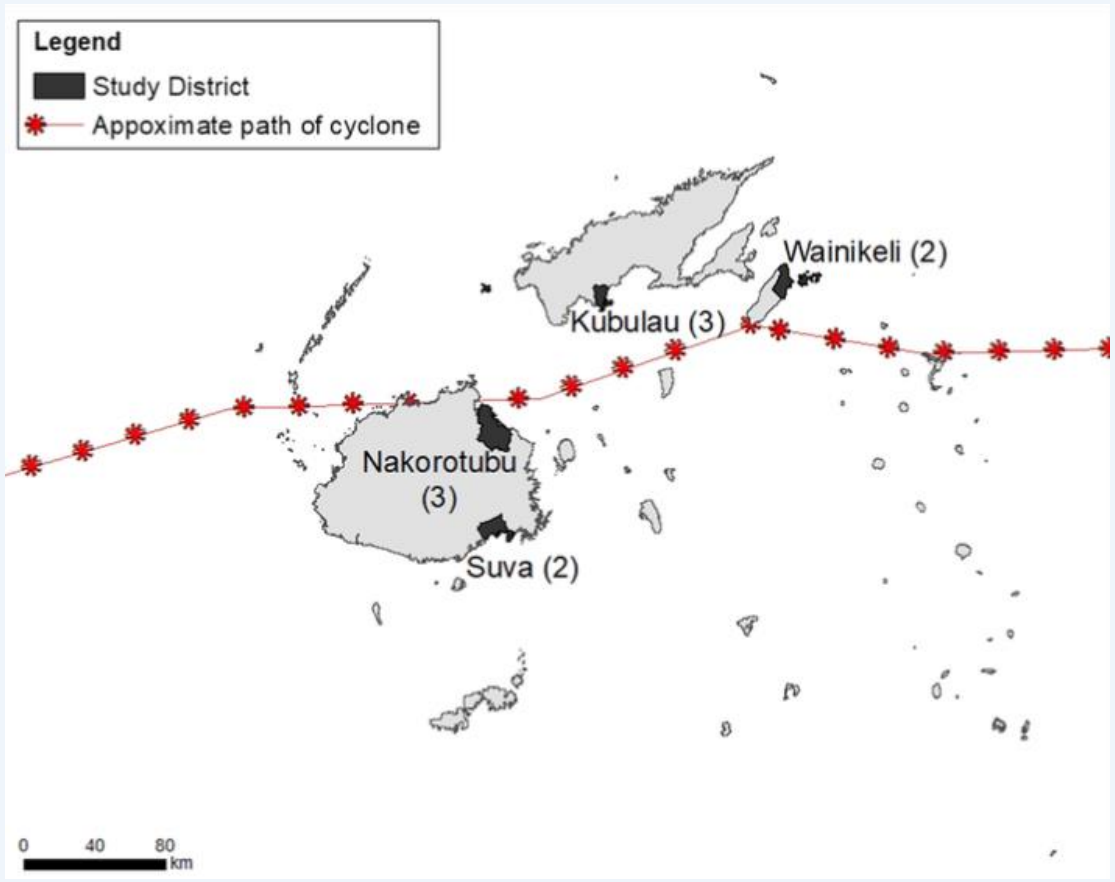


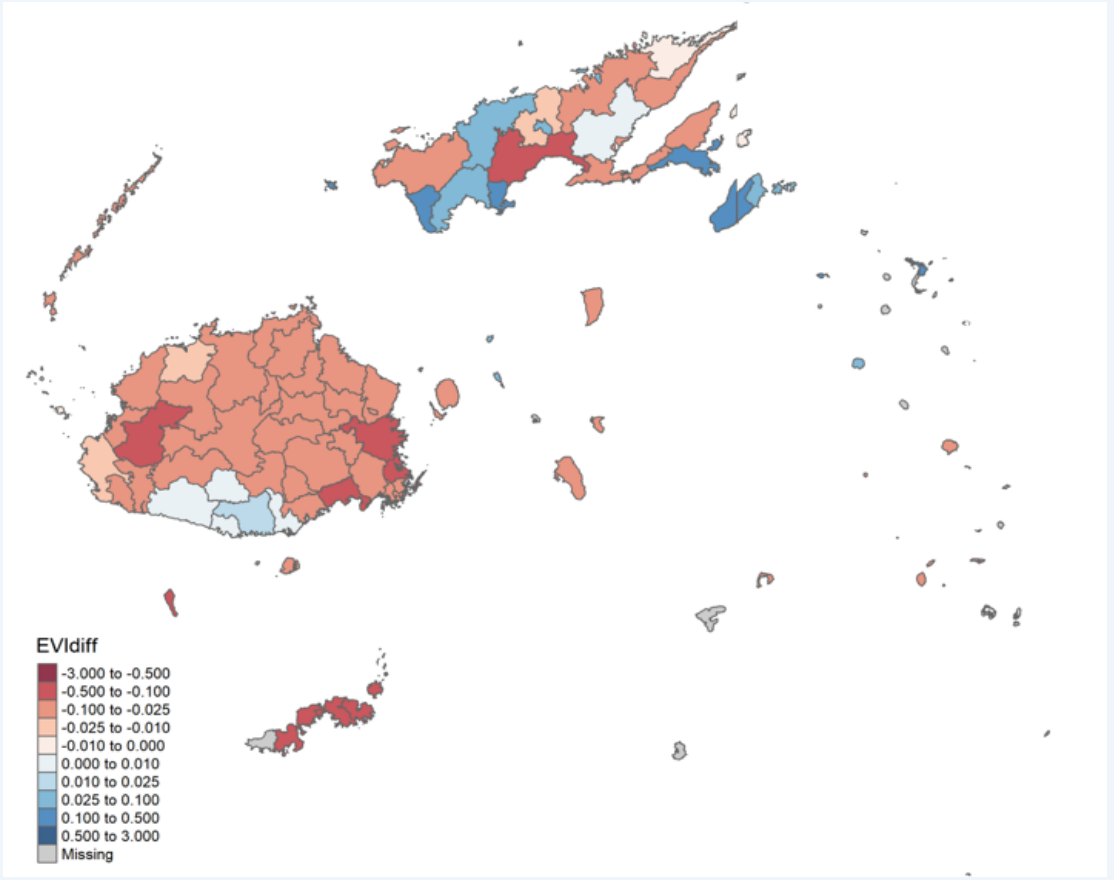
Agricultural Income Analysis

Year	EVIdiff	EVIch	Agricultural income change
2016 (Winston)	-0.077	-11.79%	-8.72%
2018 (Josie & Keni)	-0.035	-5.14%	5.55%
2020 (Harold)	0.002	0.44%	2.98%
Correlation coefficient	**0.79**	**0.80**	

Next steps

Once the cyclone path is known, create preliminary EVI estimates using actual cyclone path data and damage correlates





Thank you

Results for TC Harold

TC Harold associated with
a positive average EVI change value

The cyclone distance variable
not statistically significant

Measurement errors / positive effect of rainfall on vegetation growth / other factors?