

MODIS NDVI Modified Z-score for Evaluating Drought Incidence of Rice Areas in the Mekong Delta

Jorrel Khalil S. Aunario and Alice G. Laborte
International Rice Research Institute

Extrême climate events such as flood, drought, high temperature are expected to increase in frequency and intensity with climate change. Mapping and characterization of food production areas at risk can help in better targeting innovations and in enhancing the resilience of affected communities. In this study, we used two decades of the Moderate Resolution Imaging Spectroradiometer (MODIS) Normalized Difference Vegetation Index (NDVI) [1][2] from 2003 to 2022 to map drought incidence in rice areas in the Mekong Delta, a densely populated region and an important source of rice for domestic and export markets.

Drought Incidence in the Mekong Delta

Our analysis shows that around 63,000 ha of rice land in the Mekong Delta are prone to drought stress. These areas were found to be affected by drought at least half of the time from 2003 to 2022; and 952,000 ha more are moderately at risk, having drought periods in five to nine out of 20 years. Annual maps (Fig 3) seem to have captured the major drought events of 2004-2005, 2015-2016 and 2019-2020 [3]. Fig 4 show how severe these events were in terms of vastness of affected regions each year. We were also able to look at the distribution of severity in terms of percent of time drought was detected, number of events, and longest dry event duration in each year. Majority of the affected regions experience one drought event in a year that lasts about 1-2 months, but there are significant areas which experience more than 4 months of drought that could be one continuous episode or broken into several events in the year. The methodology presented here can be used to map drought incidence and risk in other geographic regions.

Incidence (%)	Area (ha)
(75 – 100] Extreme	961
(50 – 75] High	62,503
(25 – 50] Moderate	1,381,312
(0 – 25] Low	3,305,765
0 No incidence	647,443

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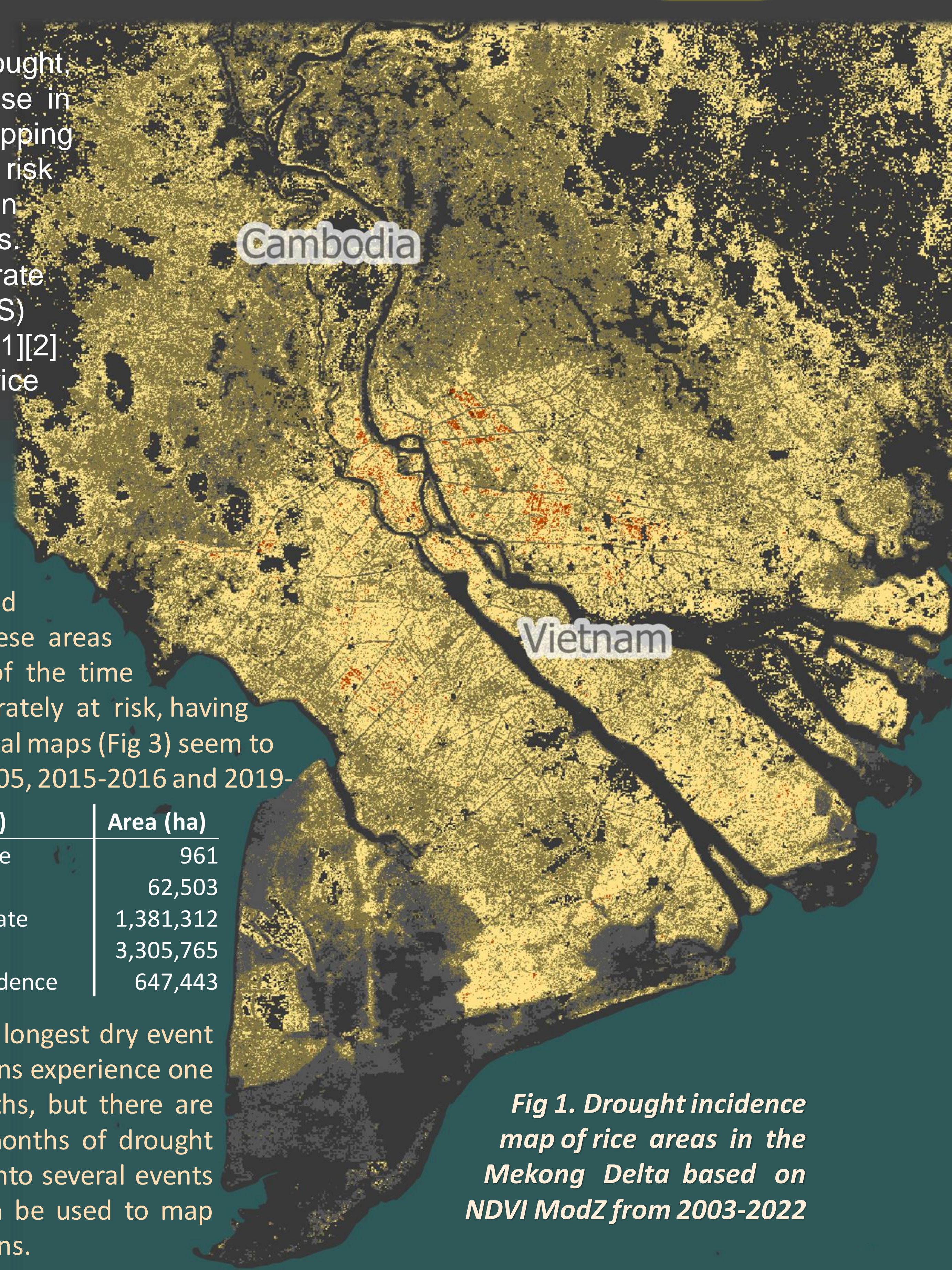


Fig 1. Drought incidence map of rice areas in the Mekong Delta based on NDVI ModZ from 2003-2022

NDVI Modified Z-score

NDVI is a robust indicator of vegetation health and water deficiency. Modified Z-score, similar to the Standard Z-score, is a statistic which measures how far a variable is from the mean and is used in finding outliers; but instead of referencing from the mean, it is referenced from the median. It is calculated as:

$$ModZ = \frac{0.6745 (x_i - \tilde{x}_i)}{MAD}$$

x_i is NDVI at acquisition date i for each year, \tilde{x}_i is Median NDVI at acquisition date i across years, MAD is the Median Absolute Deviation.

Drought is detected in a given year if at least 3 consecutive ModZ scores (equivalent to at least 24 days) are lower than -1.645 (Z-value at alpha=0.1). Non-rice areas were then masked out from the resulting maps using our MODIS Rice Extent Map.

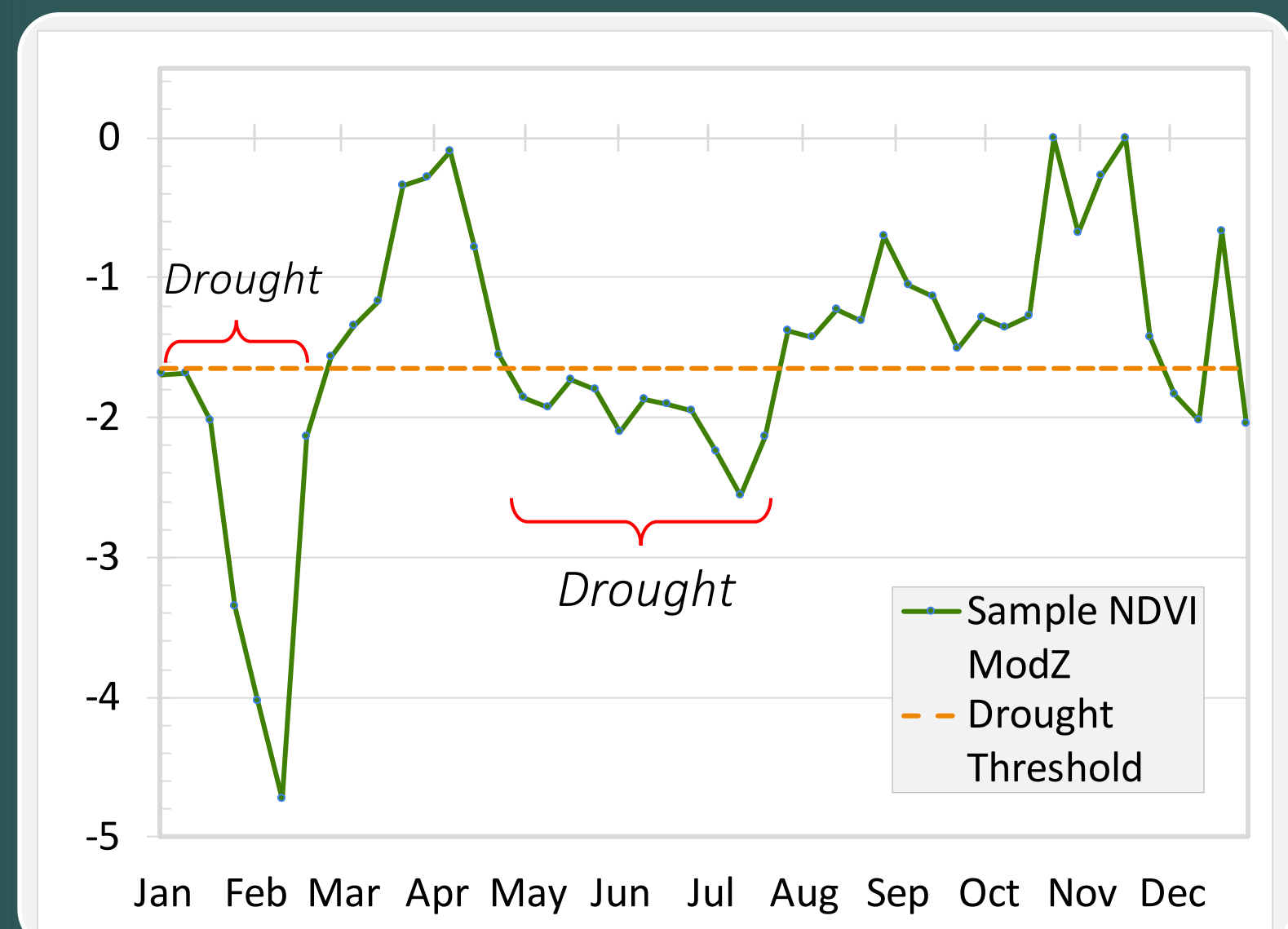


Fig 2. Sample NDVI ModZ in a year showing consecutive below threshold periods indicating drought events

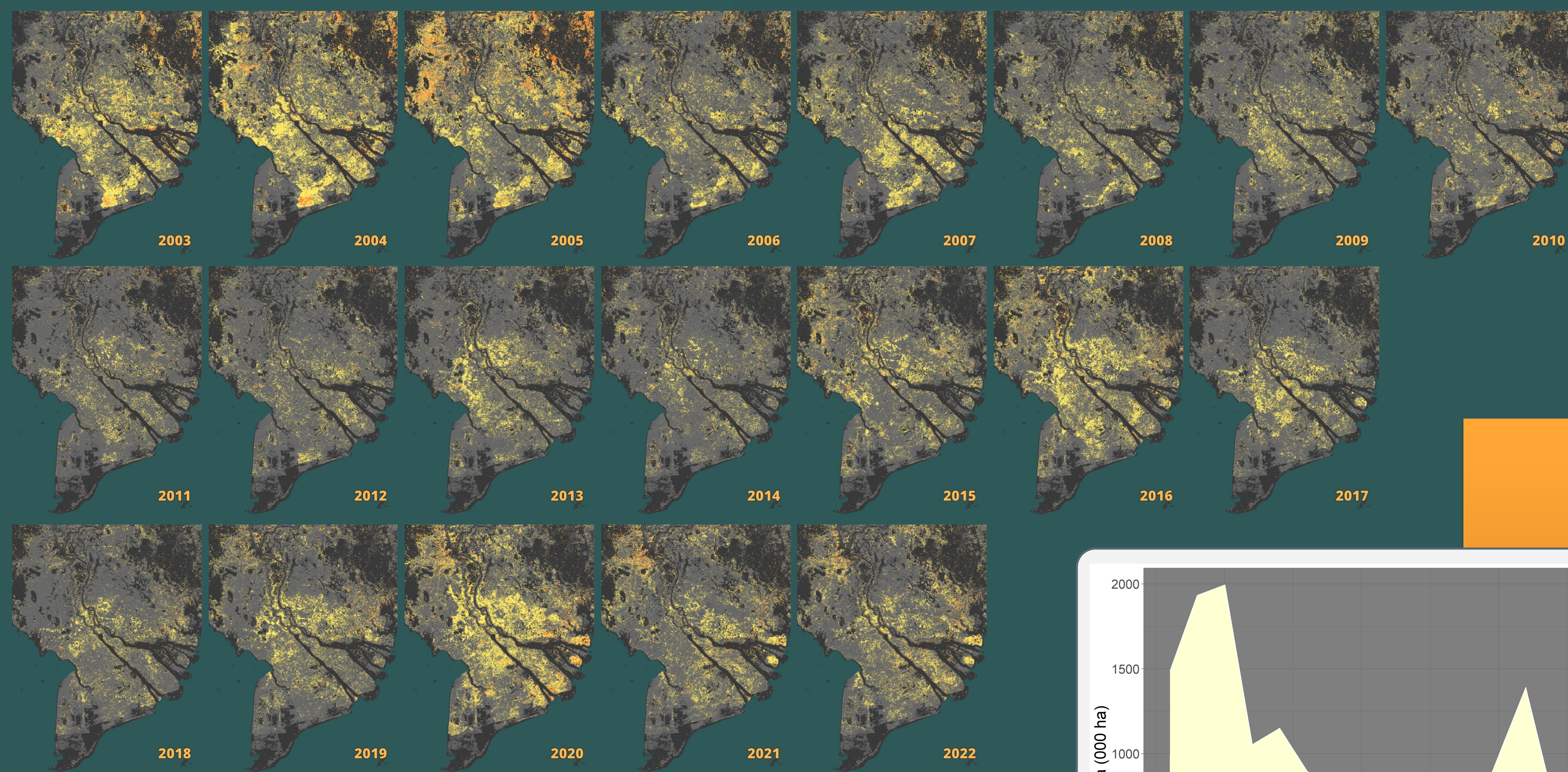


Fig 3. Annual drought maps of the rice areas in the Mekong Delta from 2003 to 2022.

References

- [1]Didan, K. (2021). MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V061 [Data set]. NASA EOSDIS Land Processes Distributed Active Archive Center. Accessed 2023-09-22 from <https://doi.org/10.5067/MODIS/MOD13Q1.061>
- [2]Didan, K. (2021). MODIS/Aqua Vegetation Indices 16-Day L3 Global 250m SIN Grid V061 [Data set]. NASA EOSDIS Land Processes Distributed Active Archive Center. Accessed 2023-09-22 from <https://doi.org/10.5067/MODIS/MYD13Q1.061>
- [3]UNDP (2020). Viet Nam drought and saltwater intrusion in the Mekong Delta [Assessment Report]. Accessed 2023-09-27 from <https://vietnam.un.org/en/34876-viet-nam-drought-and-saltwater-intrusion-mekong-delta>

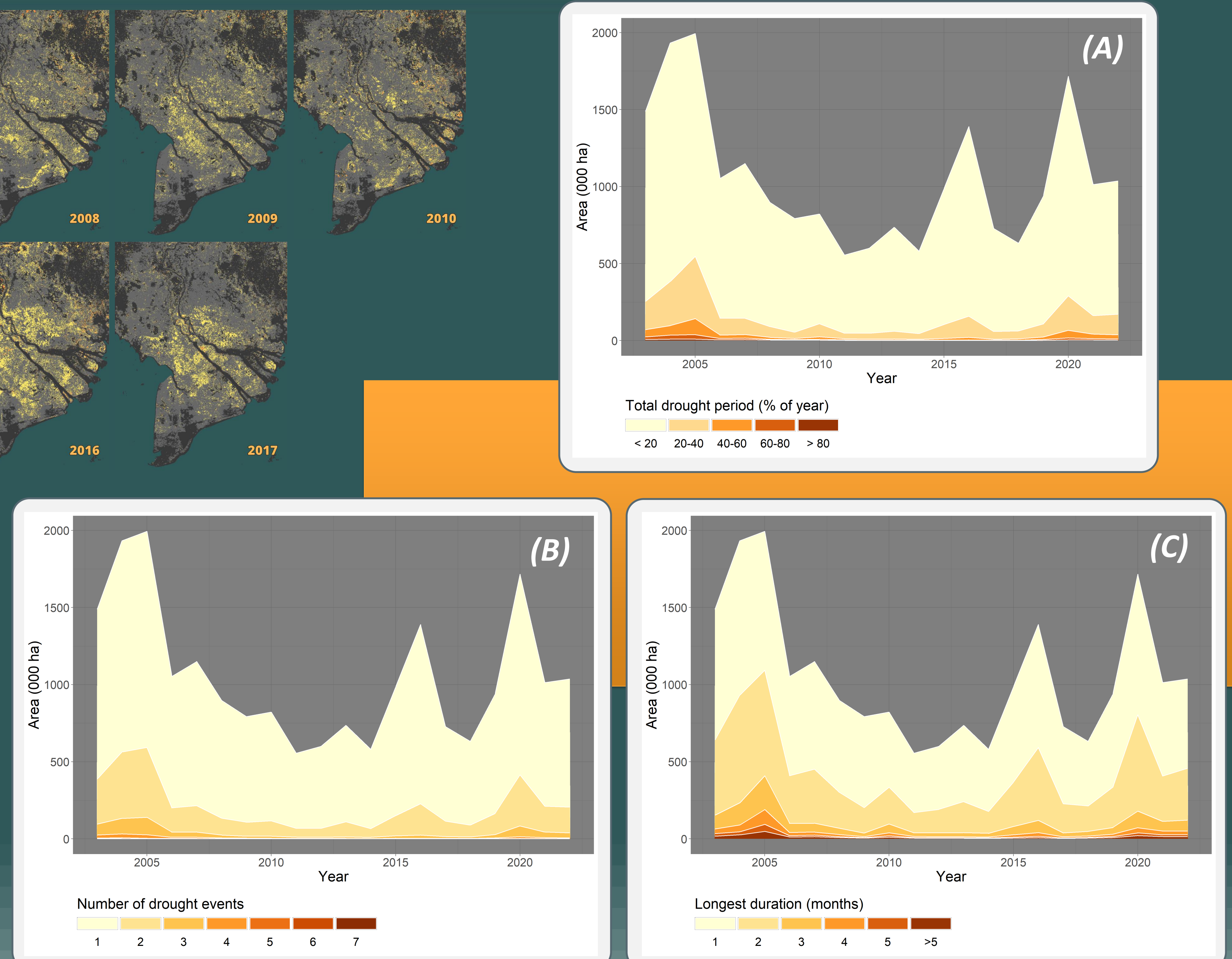


Fig 4. Distribution of the degree of severity in terms of (A) percent of time drought was detected in a year; (B) number of drought events in a year; and (C) the duration of longest dry event.