Using Historical Documentary Evidence to Understand Java's Climatic Variability since the 1860s: A Preliminary Analysis

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Regional Perspectives

The island of Java has just 7% of Indonesia's total area, yet a population of 135 million (almost 60% of Indonesia's total population) lives on the island (1). About 55% of the country's most important staple food, rice, is also produced on Java (2). Future anthropogenic global warming is expected to create new patterns of hazards and likely put the societies and agricultural infrastructure in Java under higher risks. At present, droughts, floods, landslides, outbreak of crop pests and diseases are some the common types of climate-related hazards in Java (3). The occurrences of these hazards might be linked to the annual and interannual variability of Java's regional precipitation. Among the most important mechanisms controlling this variation are El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) (Figure 1). Agricultural hazards are possible because the first planting (wet season) is vulnerable to flood, whereas the second planting (dry season) is vulnerable to drought (Figures 1 and 2).

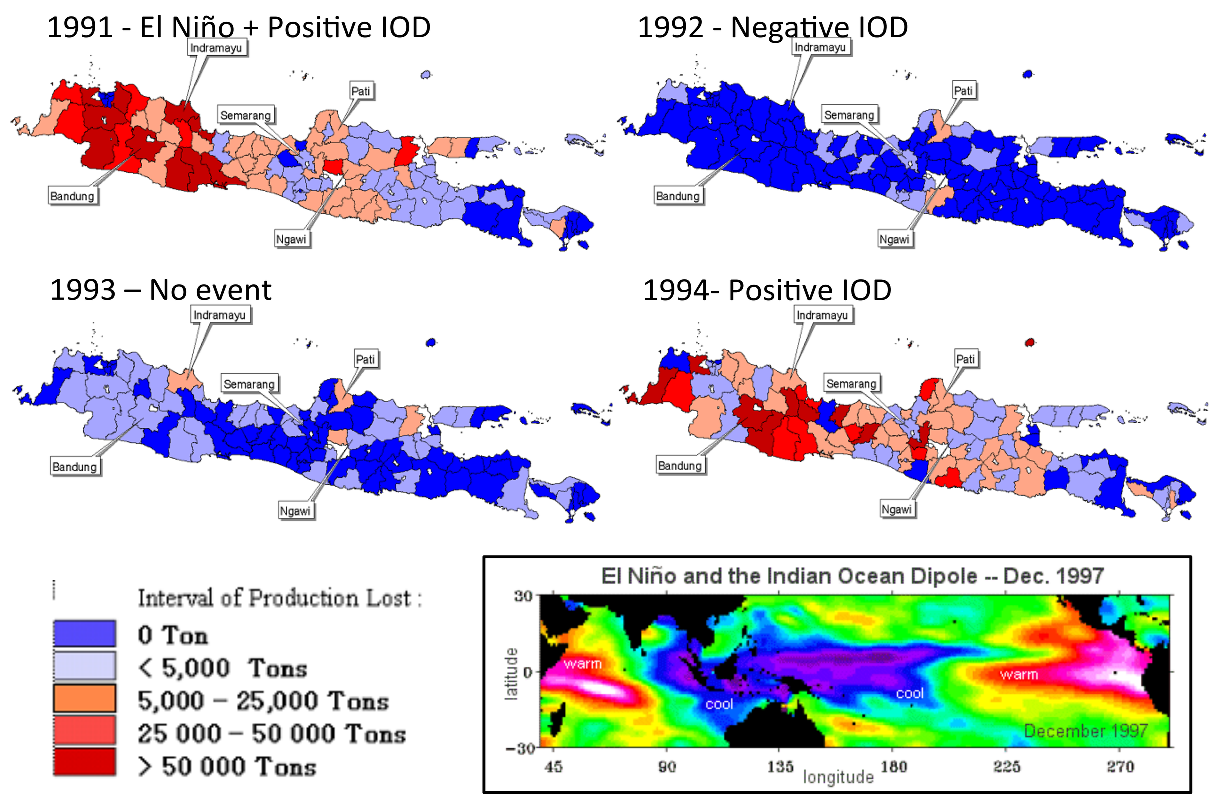


Figure 1 Rice production loss by district, drawn from field data (4). El Niño and positive IOD events, as seen in the lower right-hand panel (5), tend to prolong the dry season, thus increasing the vulnerability of the dry season planting to drought and lowering the annual production.

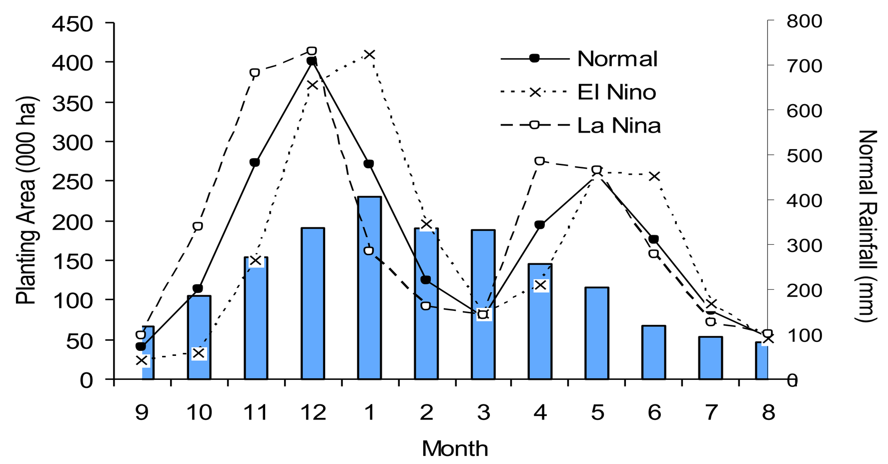


Figure 2 Planting seasons in West Java and shifts experienced during El Niño and La Niña (6). Two main seasons predominate in Java - the Asian (Wet) Monsoon occurs during the boreal winter and the Australian (Dry) Monsoon occurs during the boreal summer. El Niño events generate droughts by delaying wet season rainfall by as much as two months, further delaying the wet season planting and could potentially delay plantings of the dry season crop during the post-El Niño year.

Linking Disasters and Climate

Given the availability of reliable colonial and post-colonial historical accounts chronicling the occurrences of climate-related hazards in Java and Madura since the 18th century, it may be possible to analyze the long-term connection between disasters and climate. Our preliminary work, focusing on the rice production data since the 1860s (Figures 3 and 4), provides a foundation for further work, whose primary objective is to investigate whether historical archives from Java can be used for semi-quantitative climate reconstruction, in comparison to natural proxies. The development of future climate change adaptation strategies in this crucial region is likely to benefit from this historical work.

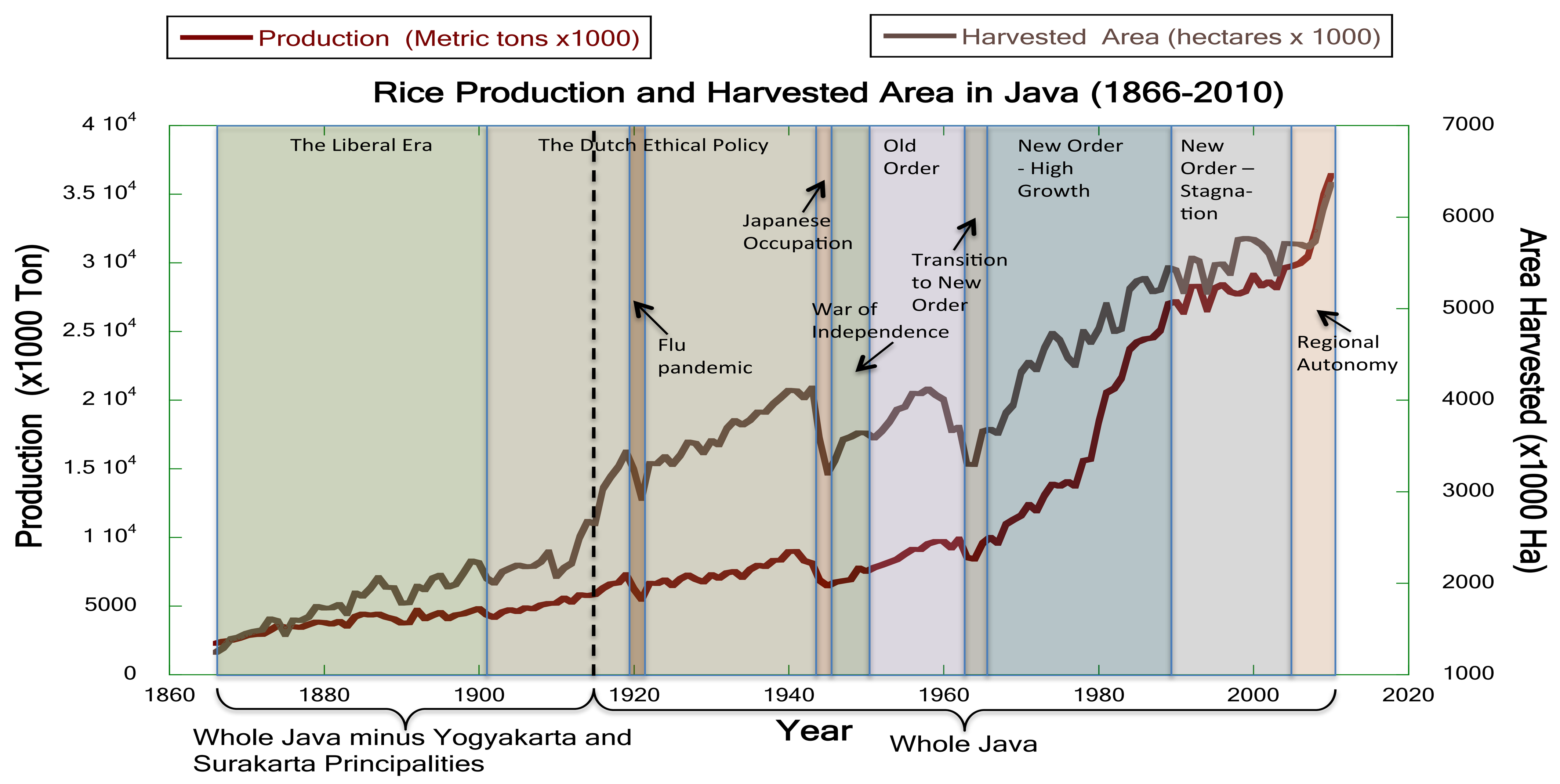


Figure 3 Time series of Java and Madura's annual rice production and harvested area (including irrigated and non-irrigated paddy fields, first and second crops). We compiled data from various available statistics (7-18). Data sets that overlap temporally were cross-checked, and assumptions as well as data collection techniques were examined. Adjustments were made accordingly. Data from Yogyakarta and Surakarta principalities (accounting for 10% of Java's total area) prior to 1916 could not be found. The time series have long-term trends that shift according to large-scale changes in technological trends, agricultural policy decisions, and economic and sociopolitical situations. Climatic variations can possibly explain many of the smaller-scale shifts.

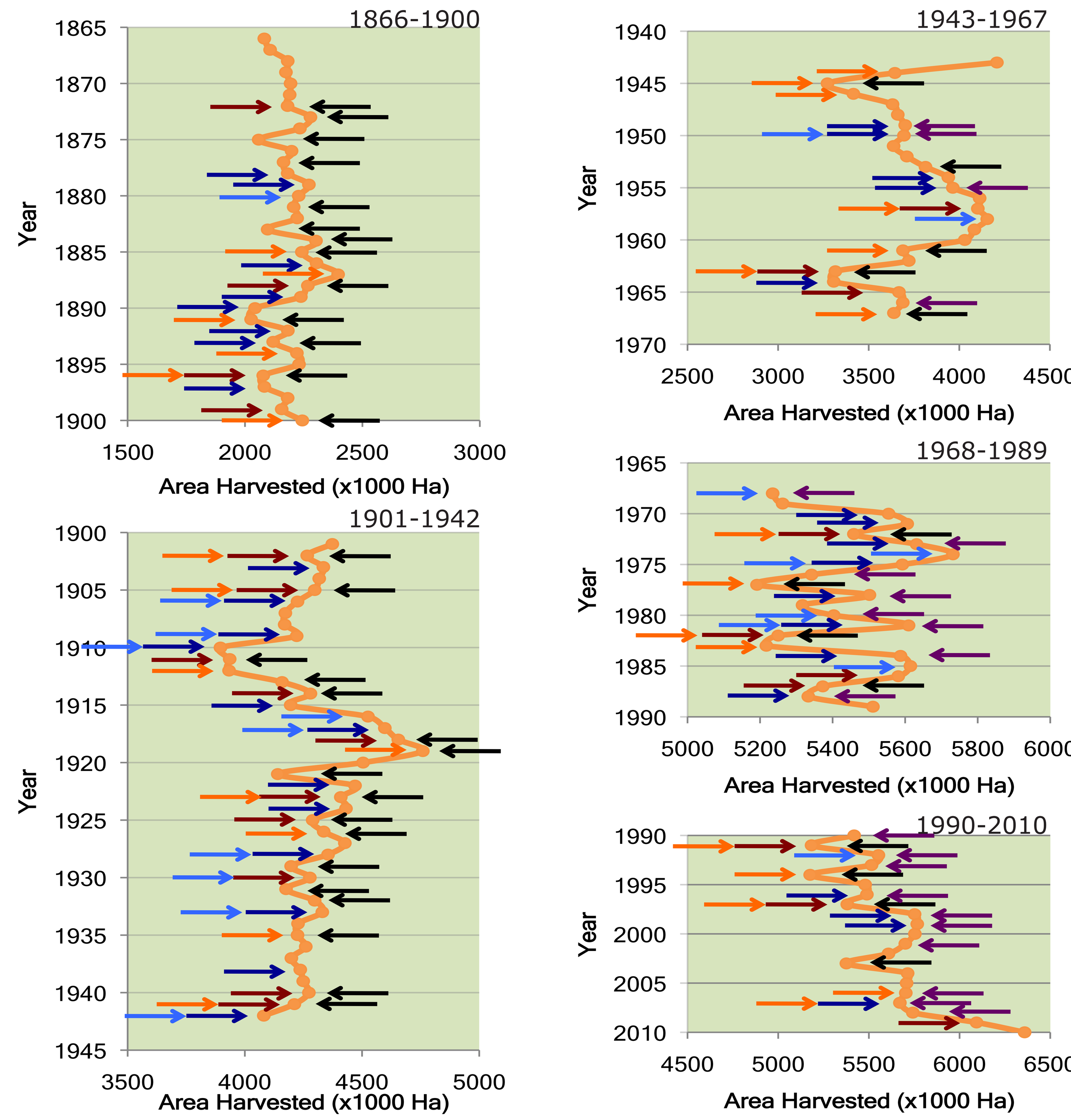
Figure 4 Detrended harvested area for five time-blocks (1866-1900, 1901-1942, 1943-1967, 1968-1989, 1990-2010).

The time blocks were carefully selected based on the trends shown in Figure 3. Absolute harvested area time series were detrended using linear regressions, and each series was presented as valid for the year directly following the end-year of the series (the series were normalized to the value for 1901, 1943, 1968, and 2011, respectively).

Harvested area was used here primarily because harvested area can be directly linked with the expanse of crop failure for a given year, and it appears to correspond with climatic variations better than rice production or yield. Annual rice production could better track climatic variations if converted to annual growth rate data (19).

Arrows on the left show when El Niño or La Niña and/or positive or negative Indian Ocean dipole occurred. The classification was generated based on sea surface temperature anomalies calculated from instrumental data for certain regions in the Pacific Ocean and the Indian Ocean (20). The instrumental data compiled by the Hadley Centre only extend back to 1876, thus no classifications were made for 1866-1876.

Arrows on the right show when excessively dry or excessively wet years occurred, based on historical documentary evidence. Historical data were compiled from both primary and secondary sources (21-30). A careful assessment was done to ensure that we included only events that are substantial and widespread (not too local) and likely to be caused by rainfall variations (too much rain or too dry). Inferences of wet years for 1866-1900 and 1901-1942 were intentionally omitted because historical evidence for wet years during these intervals were not well recorded in the available data. To maintain consistency, no historical classifications were given for 1866-1876.



El Niño | Positive IOD | Historical evidence for widespread occurrences of at least one of the following: famine, drought, or crop diseases

La Niña | Negative IOD | Historical evidence for widespread occurrences of at least one of the following: flood, landslide, or crop failure due to excessive rains

Major Observations

- The years in which there were reliable reports of drought-related disasters often coincide with El Niño and/or positive IOD years (both often occur simultaneously).
- During El Niño and positive IOD years, harvested area tend to decline from the previous year. Prior to 1940, the link between climate and harvested area appears more obscured, possibly indicating the dominance of non-climatic factors such as labor availability and crop diversity (paddy vs. other crops).
- Many floods and landslides tend to occur during years marked as La Niña and negative IOD years.
- There seems to be more reports of disasters due to excessive rainfalls toward present, possibly indicating that infrastructures are becoming more vulnerable to floods. Famines have also been largely absent on Java since 1968.
- No clear link emerges between harvested area and La Niña and/or negative IOD years. This is probably because the peak of La Niña and negative IOD often occurs during the dry season. Although there were numerous reports of crop failures due to floods, often there were also reports of increased crop intensity from the same year.

Future Work

- Translating historical events into a more quantitative data set, to be compared against instrumental precipitation data and natural proxy data (e.g. tree-rings and corals)
- Investigating the spatial variation of disasters, given the west-east precipitation gradient across Java
- Comparing growth rate of production with climatic variations

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