Enhancing oil palm sustainability in Malaysia and Indonesia: identifying climate risks and automated replanting blueprint with remote sensing

マレーシア・インドネシアのオイルパーム生産性向上：気候変動脆弱性評価と再植栽点自動設計

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Poster audio guide ポスターの音声ガイド:
日本語 English

Abstract: Palm oil, predominantly produced in Malaysia and Indonesia, faces several challenges from climate change, particularly the frequent occurrence of El Niño and La Niña events (El Niño-Southern Oscillation, ENSO), and labor shortage. My research aims to address these challenges by: 1. Identify risk climate for each region using satellite data to support adaptation planning. 2. Developing an automated replanting blueprint tool using UAV data. The climate analysis incorporates seven variables, representing water components in the soil, plant body, and atmosphere. Their correlation with palm oil yield and response to ENSO were analyzed. The replanting blueprint utilizes deep learning to detect terraces where oil palms are planted. Python programming was used to identify planting locations automatically. This research ultimately contributes to the sustainability of palm oil production in the face of climate and labor challenges. **概要:** 主にマレーシアとインドネシアで生産されるパーム油生産は、頻発するエルニーニョやラニーニャ現象（ENSO）を引き起こす気候変動や、労働力不足等の課題があります。本研究はこれらの課題に対し、1.衛星を用いて気候リスクをマッピングし、適応計画の立案を支援する、2.UAVデータから自動再植栽設計ツールを開発することを目的とします。脆弱性解析には、土壌、植物体、大気中の水分を表す7変数を使用します。これらの気候変数とパーム収量との相関、ENSOへの反応を分析しました。再植栽設計では、斜面のテラスを深層学習で検出し、植栽位置をPythonプログラミングで自動で特定しました。本研究は、気候変動と労働力不足という課題の中で、持続可能なパーム油生産に貢献します。

I. Introduction

Palm oil is a vital crop for both daily products and industrial use, predominantly produced in Malaysia and Indonesia. However, its production faces challenges, including water-related stress from climate change, particularly during ENSO events, and labor shortages, especially in Malaysia. Effective adaptation requires region-specific climate insights, yet, the regional variability of climate stress remains underexplored. Additionally, existing tools for identifying replanting locations are either not freely available or their algorithms are closed, limiting their accessibility for palm oil producers. **Objectives of this study:** 1.Identify regional water-related stress and climate risk variables under ENSO conditions for regional adaptation planning. 2. Develop a freely accessible, automated replanting blueprint tool. パーム油は日用品や工業用途に欠かせない作物で、主にマレーシアとインドネシアで生産されています。しかし、ENSOによる水ストレスやマレーシアでは労働力不足などの課題に直面しています。
本研究の目的：1. ENSO下での地域ごとの水ストレスと気候リスクを特定し、適応計画に活用すること、2. 無料で使える自動再植栽設計ツールを開発すること。

II. Methodology

- ENSOが収量に影響する月を特定
- 収量と気候の相関、気候のENSO下の変量からリスクを算出

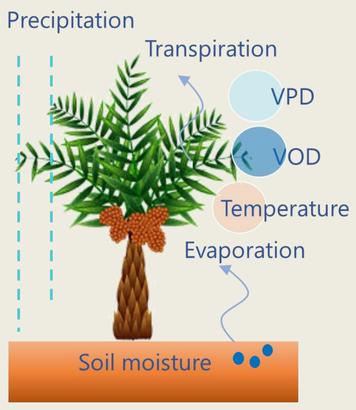


Fig 1. Target climate variables

Table1. Data

Element	Source
Precipitation	GPM IMERGE L3
Temperature	ERA5
VPD	Calc from ERA5
Evaporation	GLEAM v4.1a
Transpiration	GLEAM v4.1
Soil moisture	AMSRE/2
VOD	AMSRE/2
ENSO index	MEI.. V2
Annual yield	Countries' gov.

Climate risk during ENSO リスク因子の把握

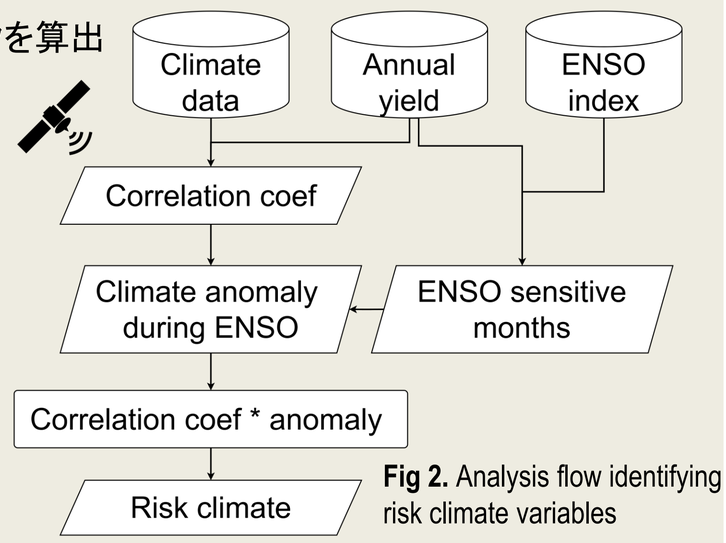


Fig 2. Analysis flow identifying risk climate variables

Replanting blueprint 再植栽地点の自動設計

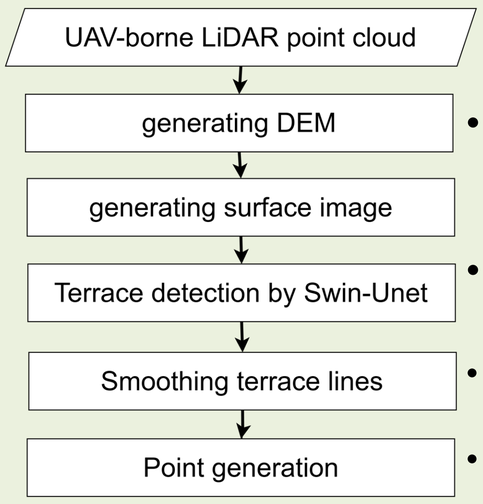


Fig 3. Process flow for blueprint

- Detect terrace lines by Swin-Unet from UAV LiDAR DEM.
- Series of processing coded by Python.
- UAV LiDAR DEMからテラスをSwin-Unetで抽出
- Pythonで処理をコーディングする。

III. Results and Discussion

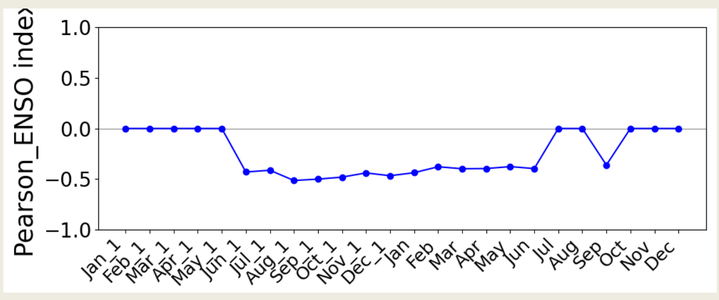


Fig 4. Monthly response of annual yield to ENSO index in Lampung province

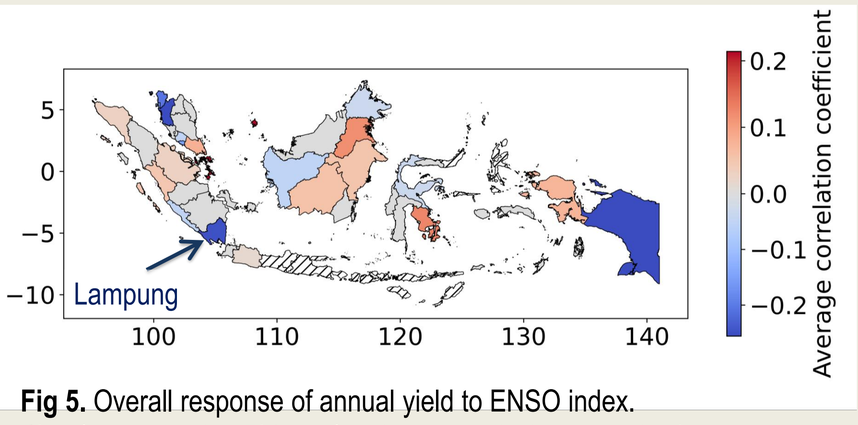


Fig 5. Overall response of annual yield to ENSO index.
Blue / red indicates El Nino / La Nina sensitivity, respectively.

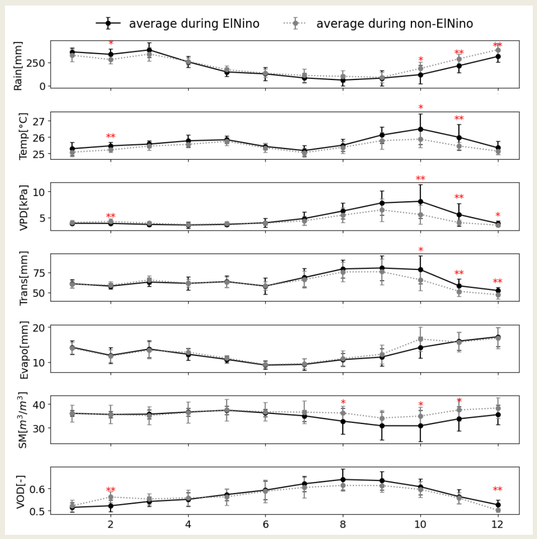
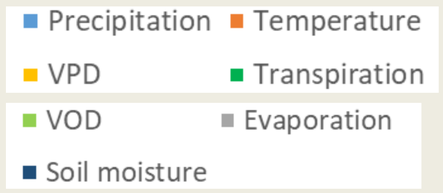
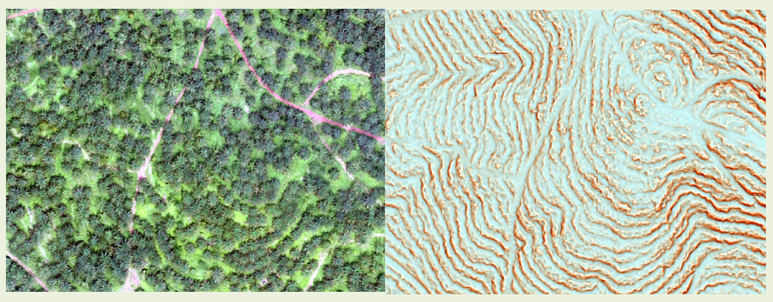


Fig 6. Climate anomaly during El Nino in Lampung

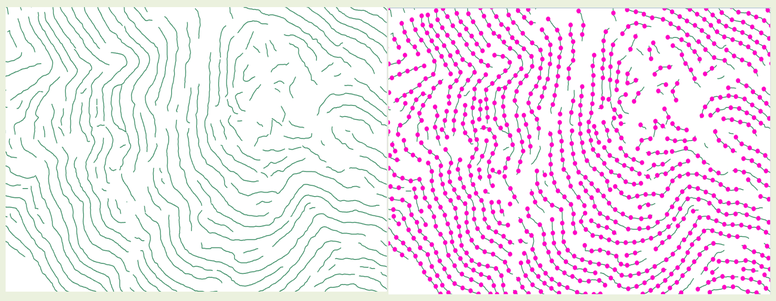


- High VPD and less moisture are high risk during El Nino.
- Decomposing risk climate in each region contribute to effective adaptation planning.
- VPDの増加と水分減少がEl Nino時のリスク
- リスク因子の把握は効果的な適応計画に役立つ

Fig 7. Risk climate variables in Lampung province. Filled / hush color means increase in / reduction of climate variable, respectively, during El Nino or La Nina.



LiDAR point cloud — Terraces enhanced image



Detected and refined terrace lines — Generated planting points

Fig 8. From point cloud to planting points by Blueprint programming

Code is available in GitHub.
コードはGitHubにて公開

Future work: 1. Future prediction for vulnerability using Global Climate Model. 2. Improve code for more general replanting specification.
今後の展望: 1.全球気候モデルを用いた脆弱性の将来予想. 2: より一般的な植栽仕様に基づいたコードの整備

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