STRENGTHENING SUSTAINABLE AGRICULTURE AND BIODIVERSITY ACROSS LANDSCAPES IN EASTERN & WESTERN GHATS OF INDIA (SABAL)
(GEF ID –10204: 2022-2027)

A CASE STUDY ON
PDMS INTERVENTION IN KG PUDI LANDSCAPE OF ANDHRA PRADESH

1. Introduction

Covering the soil with living crops is one of the main ways to build up the soil in a short time by adding organic matter to the soil along with getting additional income from the crops. Living crops increase soil carbon over a short period through a process called rhizodeposition (the release of photosynthetic starches into the soil through the root hairs (Hussain et al., 2023).

All living things get energy by consuming food. Plants are the primary producers of food (through photosynthesis), and every other organism ultimately gets energy by consuming food made by plants. Plants use CO_2 gas in the atmosphere to make food (carbon materials). About 40% of nutrients are used for stem development, 40% for root development and the remaining 30% is released into the soil from root hairs. These root secretions start the food chain in the soil (Duddigan et al., 2022). The quantity of exudate from the roots is high when the crop is in the vegetative growth stage. Some of these secretions, rich in carbon, also convert into soil organic carbon, which

(1) Increases soil biomass

(2) results in improved soil structure and water-holding capacity of the soil; and increases the water infiltration capacity of the soil; and

(3) Plant roots grow easily in such soil.

For these purposes and benefits, living roots should be maintained in the soil throughout the year, thereby continuously increasing organic carbon in the soil. The rate of increase of organic carbon in the soil by living roots is estimated to be 5-30 times faster than that of organic residues applied on top of the soil. APCNF farmers should make maximum use of this formula to quickly convert their soils (Duddigan et al., 2022).

2. Study area

Konda Gangupudi, commonly known as K.G. Pudi, serves as the microlandscape headquarters covering a total of nine villages: Kotaiah Garuvu, K.G. Pudi, Sangam Valasa, Pathavuru, Saravanipalem, S. Kota Sita Ram Puram (SKSR Puram), Bangaraiah Peta, Chittivanipalem, and Sontivanipalem. These villages are in the Vepada Mandal of Vizianagaram District in Andhra Pradesh State, collectively spanning approximately 1700 hectares. The geographical coordinates of the micro landscape extend from 18° 3′ 12" to 18° 5′ 28" N latitude and 83° 02' 44" to 83° 6' 11" E longitude (Fig 1). Situated 27 km (about 16.78 mi) from the sub-district headquarters in Vepada (tehsildar office) and 40 km (about 24.85 mi) from the district headquarters in Vizianagaram, the K.G. Pudi microlandscape is part of the Eastern Ghats region.

The primary sources of income for the local population include agriculture, wage labor, livestock rearing, and firewood sales. Notably, firewood collection and sale are predominantly practiced by tribal communities. The microlandscape features two major ecosystems: the forest ecosystem and rainfed agriculture ecosystems. The forest ecosystem includes barren hillocks and rocky areas with degraded patches at the top, surrounded by dry deciduous forest patches and degraded forests with bushes and shrubs intermittently occupied by Podu cultivation. In some

areas, agroforestry is promoted through cashew plantations, and individuals have also undertaken eucalyptus plantations. This forest is classified as a shrubby forest. The rainfed agriculture ecosystem covers a significant portion of the microlandscape, upon which the entire population depends. Over the past ten years, the region has received an average annual rainfall of 1375 mm (about 4.51 ft), with an average of 16 rainy days. The maximum rainfall occurs from July to September.

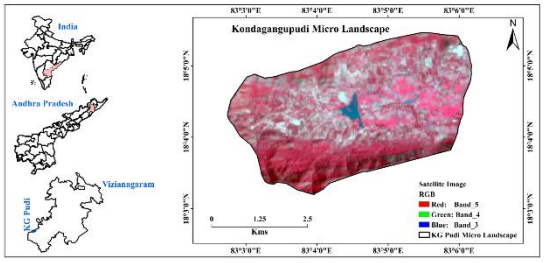

Figure 1: Study area map: KG Pudi Landscape, Vepada Mandal, Vizianagaram, Andhra Pradesh

3. Methodology

3.1 Data Collection

For NDVI analysis, data collection involves acquiring satellite imagery and relevant geographical information. High-resolution satellite images are used to analyse the vegetation from source Planet is suitable due to their appropriate spectral bands and temporal resolution. These images are typically obtained from Planet website (https://www.planet.com/basemaps/). Alongside the satellite imagery, ancillary data such as compact blocks data, topographic maps, and weather data are gathered to support the analysis (John et al., 2020).

Data preprocessing steps include radiometric and atmospheric corrections to ensure that the images are free from distortions and inconsistencies. This is crucial for accurate NDVI calculations. Table 1 below provides an overview of the satellite data characteristics (Gandhi et al., 2015).

Satellite	Resolution	Spectral Bands Used	Temporal Resolution	Source
Planet	3 meters	Red (Band 3), NIR (Band 4)	Monthly	https://www.planet.com/basemaps/

Table 1: Satellite data used

3.2 Image Processing

Image processing is essential to prepare the raw satellite images for NDVI calculation. Initially, the images undergo geometric correction to align them with ground coordinates accurately. This step is followed by radiometric correction to adjust for sensor and atmospheric effects, ensuring the data reflects true surface conditions. Software such as ERDAS Imagine, ENVI, or ArcGIS Pro can be utilized for these preprocessing tasks (Olaniyi et al., 2015).

Subsequent steps involve cloud masking to remove any cloud cover that might obscure the vegetation. This is achieved using algorithms that identify and mask cloudy pixels based on their spectral signatures. Once the images are pre-processed, they are clipped to the area of interest using shapefiles or boundary

coordinates to focus the analysis on the specific region under study.

3.3 Vegetation Indices Calculation

NDVI calculation is performed on the pre-processed satellite images, where the NIR and Red bands represent the near-infrared and red portions of the electromagnetic spectrum, respectively (Eq. 1). The resulting NDVI values range from -1 to +1, with higher values indicating denser and healthier vegetation. (Wang et al., 2021)

NDVI = (NIR - Red) / (NIR + Red) (Eq. 1)

The NDVI values are then classified into categories to interpret the vegetation health and coverage. For example, values close to +1 represent dense green vegetation, values around 0 indicate barren areas or built-up regions, and negative values correspond to water bodies or non-vegetated surfaces (Bid & Bengal, 2016). These classified NDVI maps provide a visual representation of vegetation distribution and health across the study area.

3.4 Accuracy Assessment

Accuracy assessment is crucial to validate the reliability of the NDVI analysis. This involves comparing the NDVI-derived results with ground truth data collected from field surveys or high-resolution imagery. Ground truth data includes GPS coordinates of vegetation types, species, and density, which are used to validate the NDVI classifications (Pal & Ziaul, 2017).

4. Results and Discussion

Monthly satellite data from January 2023 to December 2023 was downloaded and analysed using NDVI (Normalized Difference Vegetation Index) through remote sensing and GIS techniques. The focus was on agriculture compact blocks, where NDVI values were extracted and analysed to assess vegetation growth and health.

4.1 January to March 2023

In January, the Normalized Difference Vegetation Index (NDVI) values identified moderate to high vegetation indices. This suggests that the crops were experiencing healthy growth during the winter season. The relatively high NDVI values indicate that the vegetation was vigorous and thriving, benefiting from the favourable winter conditions that support robust crop development. This period is critical as it sets the foundation for the crops' subsequent growth stages, ensuring that they are well-prepared for the more demanding conditions of the approaching months. As February progressed, there was a slight increase in NDVI values, reflecting continued crop development and the presence of adequate moisture levels. This uptick in NDVI values signifies that the crops were maintaining a steady growth trajectory, supported by sufficient water availability and favourable climatic conditions. By March, NDVI values peaked, reaching their highest levels, which indicates that the vegetation had reached its maximum growth potential before the transition to the summer season (Fig 2). This peak growth period is crucial as it represents the culmination of the crops' development during the cooler months, ensuring they are at their healthiest and most productive state before facing the challenges of the summer.

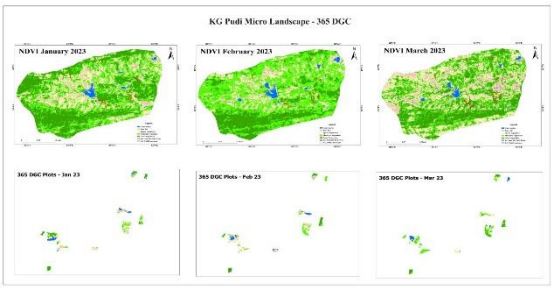

Figure 2: NDVI analysis: January to March 2023

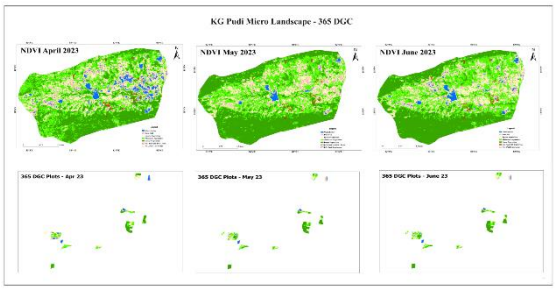

Figure 3: NDVI analysis: April 2023 to June 2023

4.2 April to June 2023

In April, NDVI values showed a moderate to high, indicating the conclusion of the winter crop cycle and the transition into pre-monsoon conditions. This period marked a shift in vegetation dynamics as the crops completed their growth phases, and the environment began to prepare for the upcoming seasonal changes. The moderate in NDVI values during this time is a typical response to the end of the winter season when crops have matured and harvesting activities commence.

By May, the NDVI values exhibited a more pronounced moderate, primarily due to escalating temperatures and a significant reduction in soil moisture content. The harsh climatic conditions during this month contribute to stress on vegetation, limiting their growth and health. However, in June, with the arrival of the monsoon, NDVI values began to show signs of recovery. The increased rainfall and subsequent improvement in soil moisture levels fostered the regrowth of vegetation. This period is characterized by the rejuvenation of plant life, as evidenced by the rising NDVI values, indicating the positive impact of monsoon rains on the agricultural and natural landscapes.

4.3 July to September 2023

July witnessed a significant increase in NDVI values, attributed mainly to the monsoon rains. This surge in NDVI indicates a robust growth of vegetation across the compact blocks, highlighting the positive impact of the monsoon season on plant health. The abundant rainfall provided essential moisture, fostering a conducive environment for the vegetation to thrive. As a result, the regions experienced a marked improvement in greenery, reflecting the overall health and vitality of the ecosystem during this period (Fig 4).

In August, the NDVI values reached their peak for the year, recording the highest levels of lush green cover and optimal crop health. This period, coinciding with the peak of the monsoon season, showcased the maximum vegetative growth and vitality, as the ample moisture availability continued to support the plants' needs. September maintained high NDVI values, indicating the sustained health and growth of vegetation due to the continued presence of sufficient moisture. This trend underscores the prolonged beneficial effects of the monsoon rains, ensuring consistent and robust vegetative health across the compact blocks well into the post-monsoon period.

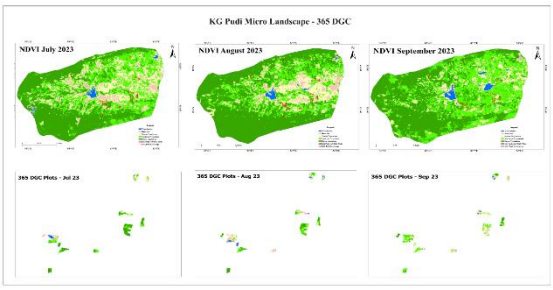

Figure 4: NDVI analysis: July 2023 to September 2023

4.4 October to December 2023

In October, the NDVI values were notably high, reflecting the robust post-monsoon growth of crops and the overall health of the vegetation. This period is crucial for agriculture as it sets the stage for the entire growing season. The elevated NDVI values indicate that the crops were thriving, benefiting from the moisture retained in the soil from the monsoon rains (Fig 5). This thriving vegetation not only supports agricultural productivity but also plays a vital role in maintaining the ecological balance by contributing to the carbon cycle and providing habitat for various species.

As November progressed, there was a moderate NDVI value, signifying the natural progression of crops towards maturity and subsequent harvesting. This moderate is typical during this time as mature crops are reaped, reducing the overall green cover temporarily. By December, the NDVI values had stabilized at moderate to high levels, corresponding to the initial stages of winter crop planting and early growth. This period marks the transition from one cropping season to another, with the newly planted winter crops beginning to establish themselves. The steady NDVI values during this time are indicative of successful early crop establishment, ensuring a promising start to the winter growing season.

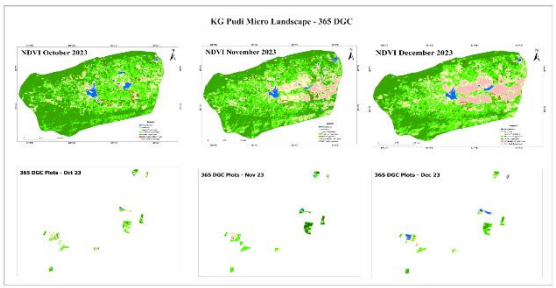

Figure 5: NDVI analysis: October 2023 to December 2023

The analysis of NDVI values across the twelve months of 2023 revealed that the agriculture compact blocks consistently exhibited high to very high vegetation indices throughout the year. This indicates that the agricultural practices employed in these blocks maintained a robust green cover, contributing to improved soil health and nutrient levels.

4.5 Key Observations

Sustained Vegetation Growth: High NDVI values throughout the year suggest that the compact blocks maintained a continuous green cover, which is essential for soil health and climatic resilience.

Seasonal Variations: While NDVI values fluctuated with seasonal changes, the overall trend showed strong vegetation growth during the monsoon and post-monsoon periods, with moderate levels during the pre-monsoon and winter seasons.

Impact of Monsoon: The monsoon season had a significant positive impact on NDVI values, highlighting the importance of rainfall in supporting vegetation growth and crop health.

5. Conclusion

The results from the NDVI analysis demonstrate that employing agriculture compact blocks with a year-round green cover approach positively impacts soil health, nutrient levels, and crop resilience. The consistent high to very high vegetation indices observed throughout 2023 indicate that diverse cropping systems and continuous soil coverage enhance the overall sustainability and productivity of agricultural landscapes. This approach not only supports better crop yields but also contributes to environmental sustainability by improving soil quality and resilience against climatic variations.

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