A Technical Report for

PROJECT MAHAMPY: PHASE II

Investigating the effects of harvesting techniques on *mahampy* regrowth and using NDVI from drone imagery to assess *mahampy* wetland health.

October 2024

1. Summary

Mahampy is the local Malagasy word for a reed used as a traditional material for making mats, hats, and baskets. Project *Mahampy* aims to improve the livelihoods of women in rural Madagascar through the *Mahampy* Weavers' Cooperative whilst ensuring that the reedbeds upon which they rely are healthy, resilient and productive. Locally there are two main methods of reed harvesting, pulling the reed out from the root, and cutting the reed above ground. SEED Madagascar's Conservation Research Programme (SCRP) trialled these methods and monitored reed growth to gain an insight into which method promoted greatest reed health and regrowth post harvesting. In addition, for one year only, the impact of fire on the regrowth of reeds was also monitored due to a fire which occurred in two of the study sites in November 2021. Overall, the research shows that the pulling method consistently produces taller, faster-growing reeds, making it the most suitable approach for Mahampy collection.

Using drone imagery between August 2020 and July 2024 the False Normalised Difference Vegetation Index (NDVI) was calculated for each of the six wetlands in Sainte Luce. False NDVI is a measure used to approximate vegetation health, where the higher the value, the greener the wetland and the healthier the vegetation is. It was found that there was a difference in vegetation health between wetlands. Analysis of drone imagery indicated that False NDVI differed between wetlands but not over time and that the vegetation in Wetland 17 was healthier than other wetlands. Understanding how vegetation health differs between wetlands and over time, can help to inform future conservation efforts as well as provide information that may be useful to support local rural livelihoods.

2. Introduction

Wetland habitats within Madagascar play an important role both ecologically and economically. Globally, freshwater ecosystems are amongst the most vulnerable, with the 2020 Living Planet Index (LPI) reporting an 84% decline in freshwater populations since 1970 (WWF, 2020). Freshwater ecosystems support a disproportionately high amount of biodiversity and provide valuable ecosystem services such as carbon sequestration[1] and flood control (Zedler and Kercher, 2005). Madagascar has been recognised as a global hotspot of freshwater biodiversity with high levels of endemism (Benstead et al., 2003). Furthermore, in Madagascar, wetlands provide the raw materials needed for making products such as mats and baskets, they are also essential for house furnishing and cooking fuel (Andrianadrasana et al., 2005). Despite this importance, Madagascar's wetlands have received little research attention and are declining faster than its forests, with some regions in Madagascar losing over 60% of wetland coverage since 1960 (Bamford et al., 2017).

In Sainte Luce, a rural, coastal community in the Anosy region of southeast Madagascar, the wetland reed *Lepironia mucronata*, known locally as *mahampy*, is harvested by women and used as a weaving material. Culturally, *mahampy* is of great importance as it provides a traditional livelihood opportunity for women in Sainte Luce. *Mahampy* is important economically as selling products crafted from *mahampy* forms a vital source of income, particularly where there is little access to formal employment (International Monetary Fund, 2023). As with general environmental exploitation, unsustainable resource use is likely to lead to declines in *mahampy* reedbeds, thus impacting the livelihoods of the people who depend on them.

Within the wetlands found in Sainte Luce, two different techniques are used to harvest *mahampy* stems, the first involves individual stems pulled out of the rhizome (underground stem storing nutrients), where the longest stems are selectively harvested and used for weaving mats. Alternatively, reeds are harvested by cutting them near the base with knives, allowing multiple stems to be cut simultaneously. This enables several stems to be collected rapidly, but results in harvesting stems that are too short to weave and subsequently discarded. In the Mekong Delta (Vietnam) and KwaZulu-Natal (South Africa) reed cutting is discouraged due to concerns about its

[1] Carbon sequestration refers to the process where carbon dioxide is removed from the atmosphere and stored. Trees sequester carbon dioxide in their tissues, bark, and roots through photosynthesis.

impact on regrowth and reedbed health, yet no direct comparisons of harvesting techniques were conducted in these cases. (Triet, 2010; Traynor et al., 2010). If the rhizome is left intact when harvesting, as both pulling and cutting does, the plant has the potential to produce new stems as it has not been killed (Brotonegoro, 2003). There has been little research carried out in Madagascar on the impacts of various harvesting techniques on *mahampy* reedbed health.

Fire is also a factor that impacts *mahampy* wetlands. In Madagascar, fire is commonly used as a management tool for agricultural purposes, using a technique known as *tavy* [2] which can spread to nearby areas, including wetlands. As a result, fires can occur both naturally and due to human activity in rural regions. While the effects of burning on wetland habitats is well studied (Osborne, Kobziar and Inglett, 2013), the combined effects of fire and differing harvesting techniques that affect *mahampy* regrowth is novel. Species with underground rhizomes, such as *Lepironia*, are expected to be able to resist fire by resprouting following disturbance, however, it is not known how fire events affect *Lepironia* growth. Drier conditions have been shown to influence the severity of fires (Kotze, 2013), therefore, understanding the response of wetlands to fire is especially important in the context of severe and chronic droughts which are occurring with higher frequency in southern Madagascar (UNICEF, 2022). Due to the high prevalence of drought and use of *tavy* around Sainte Luce, it is urgently important to understand the link between fire and the sustainability of *mahampy* weaving as a livelihood. Particular focus should be placed on understanding which harvesting techniques are most sustainable after a fire event and determining whether any management interventions are necessary.

This Technical Report reviews the results from studies into the effect of harvesting technique on *mahampy* regrowth, and the effect of harvesting technique on *mahampy* regrowth after fire events. This report will also provide a summary of the *mahampy* reedbed health over time as estimated by the false NDVI from Drone Imagery.

3. Methodology

The project conducted research across six wetlands in the Anosy region of southeast Madagascar (24° 46' S, 47° 10' E) (Figure 1)

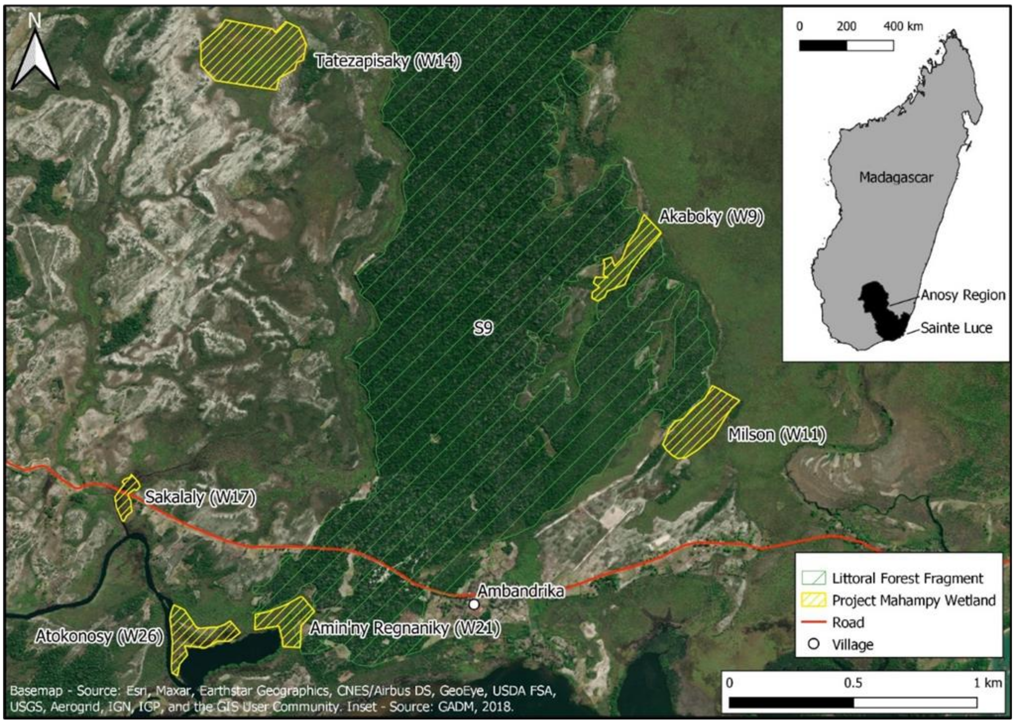

Figure 1: Sainte Luce study site. All wetlands were studied for wetland health and all except Wetland 14 were used to study harvesting technique.

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[2] Tavy is a swidden agricultural practice, that involves setting intentional fires to clear land for agriculture.

Participatory Monitoring

To investigate the effects of harvesting techniques on *mahampy* regrowth, a participatory monitoring programme was set up and led by the *Mahampy* Weavers' Cooperative of Sainte Luce with support from SEED's Conservation and Research Programme (SCRP). The Cooperative members were particularly interested in determining whether the harvesting techniques were detrimental to *mahampy* growth. Such participatory monitoring programmes not only respond directly to the research areas identified as most pressing by resource users, but they are especially appropriate in wetlands as the health of the environment directly relates to the participants' livelihood (Andrianandrasana et al., 2005).

Harvesting Technique

To investigate the effects of harvesting techniques on *mahampy* regrowth, Project *Mahampy* compared the condition and rate of regrowth of reedbed quadrats that were harvested using the different techniques of cutting or pulling. Two different data collection methods were used, referred to as Methods 1 and 2, to mitigate the impact of the sampling effort.

In the six wetlands, three 2m x 2m quadrats were set up. The *mahampy* in each quadrat was subjected to one of three following treatments, being pulled in accordance with the traditional local method (Pull), cut near the base of the stem (Cut), or left unharvested (Unharvested). The three treatments were applied to a quadrat in each of the wetlands. All members of the Mahampy Weavers' Cooperative were informed of the research and avoided further harvesting by any technique within the quadrats. Marked poles were erected around each quadrat to reduce entry by other weavers or resource users.

Method 1

The effect of harvesting technique on *mahampy* regrowth was investigated using Method 1 in wetlands 9, 11 and 21. These wetlands were visited six times between October 2022 and August 2023, and then another six times as a repeat of the investigation between December 2023 and August 2024.

Two months after the harvesting treatment was conducted, 25 of the regrown reeds were systematically selected using a grid and labelled in each quadrat, with their height, diameter, and condition recorded. Data collection began in November 2022 and was conducted monthly until July 2024. Reed condition was scored on a scale of 0-5 (Table 1). For specific reeds that were missing, they were recorded as Gone as it assumes reed mortality with complete stem and root loss. Reed density was also measured by counting the number of alive *mahampy* stems in four 50cm x 50cm sub-quadrats within each of the four corners of the quadrat and calculating an average.

Table 1: Description of the condition scores used to investigate the effect of harvesting technique on mahampy.

Condition	Description
0 – Dead	*Mahampy* is discoloured/dry/brittle.
1 – Very Poor	*Mahampy* is a pale colour throughout the reed with little root/growth.
2 – Poor	*Mahampy* is a pale colour throughout most of the reed and is inflexible.
3 – Fair	*Mahampy* is pale green or green throughout most of the reed and is flexible.
4 – Good	*Mahampy* is green and very flexible and may have evidence of flowering.

Method 2

The effect of harvesting technique on *mahampy* regrowth was investigated using Method 2 in wetlands 17 and 26. These wetlands were visited six times between December 2023 and August 2024.

Two months after the harvesting treatment was given, the height and diameter of ten randomly selected *mahampy* reeds were recorded. The condition of each of these ten randomly selected reeds was scored differently than in Method 1, and was scored on a scale of 1-4, (Table 2). The ten recorded reeds were randomly reselected at the beginning of each data collection session every two months.

Table 2: Description of the condition scores used to investigate the effect of harvesting technique on mahampy *after a fire.*

Condition	Description
1 – Dead	*Mahampy* is discoloured/dry/brittle.
2 – Poor	*Mahampy* is a pale colour throughout most of the reed and is inflexible.
3 – Fair	*Mahampy* is pale green or green throughout most of the reed and is flexible.
4 – Good	*Mahampy* is green and very flexible and may have evidence of flowering.

The overall coverage and density of *mahampy* within each quadrat was also recorded. Coverage was measured by determining whether “all”, “most”, “some”, or “none” of the quadrat was covered by *mahampy*. Reed density was measured by counting the number of live *mahampy* stems within four 50cm x 50cm sub-quadrats within each of the four corners of the main research quadrat, using the same as in Method 1.

Fire

To investigate the effects of harvesting techniques on the *mahampy* wetlands after a fire event, Project Mahampy compared the condition and rate of regrowth of reedbed areas in W17 and W26 that were burnt in a natural fire in November 2021. Quadrats within these wetlands had previously been set up to investigate the effect of harvesting technique in the same way. These study wetlands were visited 11 times between November 2021 and July 2023 to monitor the effect of harvesting technique on *mahampy* regrowth under the caveat of fire, using Method 2.

Drone Imagery

To gain an understanding of Sainte Luce’s *mahampy* wetlands on a larger spatial scale, SEED collected aerial imagery of the six target wetlands between August 2020 and July 2024 using a remotely piloted aircraft (Mavic Air DJI drone).

The six wetlands were sampled every four to six months to account for changes due to seasonality and time of year. The drone was flown on days without high cloud cover, rain, or high wind to minimise atmospheric effects on the imagery collected and reduce noise in each of the images. The drone was flown at an elevation of 100m, moving at a speed of 10 meters per second. High resolution true colour (RGB) photographs (4056 x 3040 pixel resolution) were taken every 10 meters. The drone’s camera was faced toward the ground throughout the flight to minimise image distortion. To ensure full coverage of each wetland (as predefined by spatial polygons identified from satellite imagery), digital flight paths were programmed and stored in Litchi (flylitchi.com). The collected photographs were stitched together in Structure from Motion (SfM) software using the GPS data embedded in each photograph. To achieve this, OpenDroneMap (opendronemap.org) was used to produce a single GeoTIFF file to be analysed in a Geographic Information System (GIS). Due to limited on-the-ground staff capacity, ground truth data were unable to be collected.

Quantum GIS (QGIS) was used to analyse aerial imagery and create maps of each wetland. False Normalised Difference Vegetation Index (NDVI) is an index that uses bands from the visible spectrum (i.e. red, green, and blue), using the following equation (Figure 2) and is used as a proxy measurement showing vegetation health. High False NDVI values are indicative of a healthier wetland, as a higher index indicates greener and denser vegetation, and greener wetlands are healthier (Schneider et al., 2008). False NDVI .tiff files were produced in OpenDroneMap and were then analysed in QGIS.

$$False\ NDVI = \frac{(green - red)}{(green + red - blue)}$$

Figure 2: Equation used to calculate the False Normalised Difference Vegetation Index (False NDVI). The colours refer to the colour bands that true images are split into.

4. Results

Mahampy Regrowth

The average reed height fluctuates over time (Figure 3). There was a statistically significant difference in height between the harvesting methods in months 4 ($p = 4.82x10^{-08}$), 6 ($p = 2.99x10^{-06}$) and 8 ($p = 0.0038$), however, there is no difference in height between the methods in month 10. There is a statistically significant relationship between reed height and harvesting method ($p = 4.71x10^{-14}$) across all months over both sample years. Figure 3 also demonstrates that the pull method had slightly less fluctuations in average height than the other harvesting technique of cutting or those left unharvested.

There was an increase of missing (*Gone)* and dead reeds with the number of months since harvest (

Figure 4). The condition of the *mahampy* changed significantly over time ($p = 2x10^{-16}$).

The group with the tallest mean reed height across both years and all wetlands was from the unharvested quadrats (Table 3). Of the harvesting techniques, the tallest reeds were obtained from the pull method, and the shortest reeds came from the cut treatment. All treatments had a statistically significant relationship between collection technique and density of reeds. Pull had the lowest average reed density per m^2 of the three treatments, ($p = 0.00022$, mean = 56.9, sd = 3.7). The cut method had a slightly higher average density ($p = 3.09x10^{-09}$, mean = 83.7, sd = 1.4). The unharvested reeds had the highest average density ($p = 1.55x10^{-08}$, mean = 91.3, sd = 11.1).

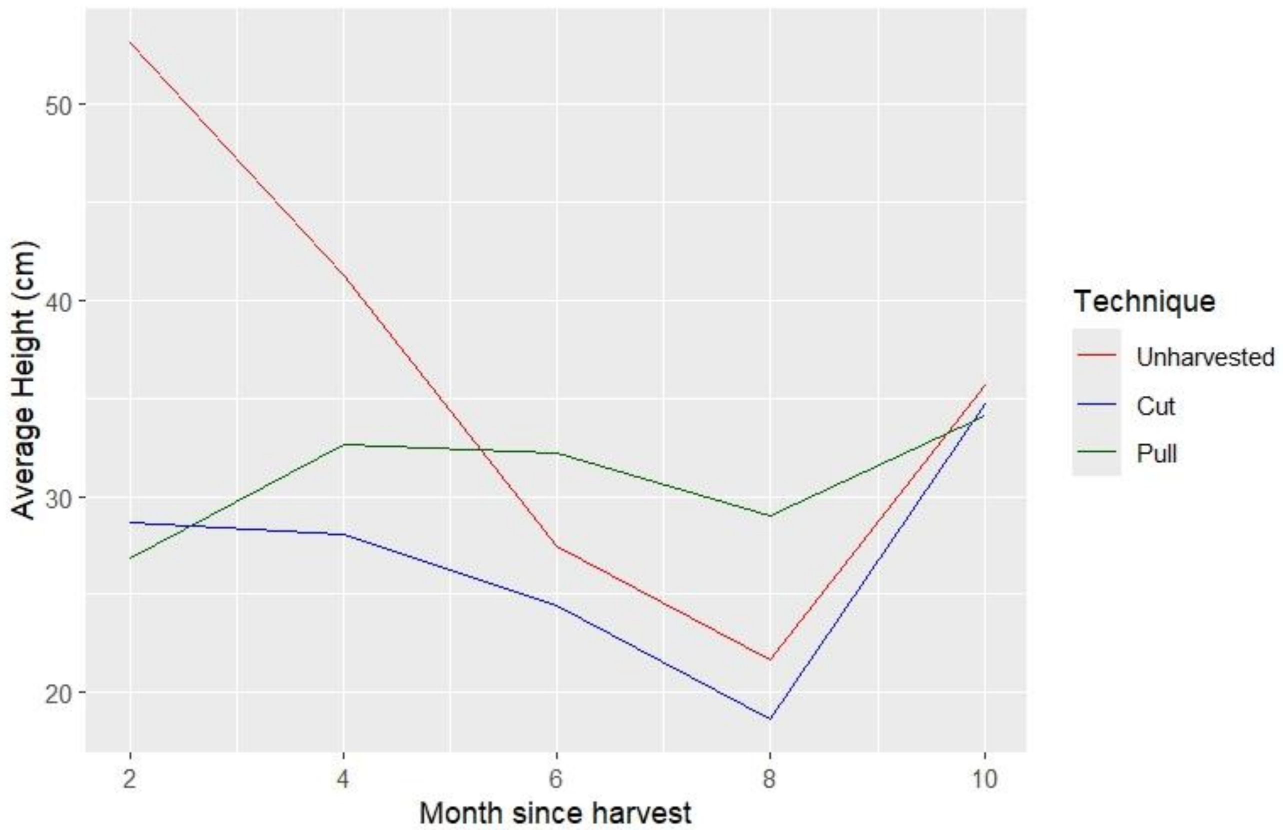

Figure 3: The average height of mahampy reeds in the months after harvesting, with different harvesting techniques.

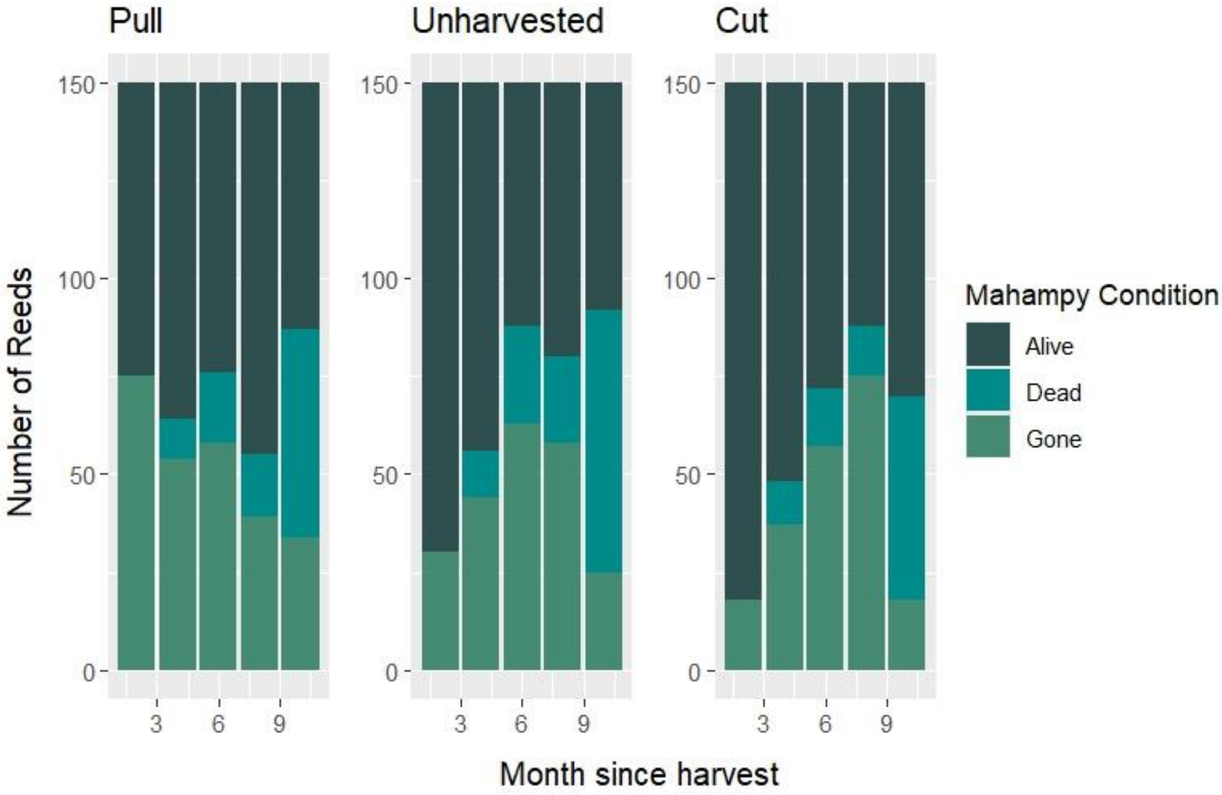

Figure 4: The condition of mahampy reeds in the months after harvesting with different harvesting techniques.

Table 3: The mean height of reeds, the proportion of reeds Gone *and the average density of reeds across both years and all wetlands, in relation to the harvesting techniques. * Indicates values that are statistically significant.*

Harvesting techniques	Mean Height across all years	SD for mean heights across all years	Proportion Gone at Month 10	Average density (per m^2)
Cut	25.8*	31.1	0.12*	83.7 *
Pull	30.1*	34.9	0.23*	56.9 *
Unharvested	35.1*	38.5	0.17*	91.3 *

Fire

There was no further research undertaken on the impact of fire on mahampy reed regrowth in year 2. The opportunity to study the phenomenon was taken in direct response to a natural fire event in November 2021. For the full results and outcomes of the fire monitoring in these wetlands please refer to the report on year 1.

Wetland Health

Arial surveys took place during two phases. The first phase ran between August 2020 and November 2021, after which, arial data collection was considered complete. Surveys were then restarted again in October 2022 as part of a second phase of data collection, continuing until July 2024. In total between August 2020 and July 2024, a total of 71 aerial surveys took place, once per quarter each year. The immediate effect of the fire in November 2021 was not captured in the data collection timeline due to the hiatus from November 2021 to October 2022. Due to adverse weather conditions and technical difficulties, the first aerial survey of Wetland 21 in August 2020 was not possible.

High resolution true colour images of each of the project's study wetlands from July 2024 are shown in Figure 5. False NDVI differs between wetlands (*ANOVA, df* = 5, $F = 20.520$, $p = 0.588 \times 10^{-13}$), however, does not vary over time (*ANOVA, df* = 1, $F = 1.064$, $p = 0.306$) (Figure 6). Wetland 21 had the lowest mean False NDVI value over time (-0.300), while Wetland 17 had the highest (-0.108).

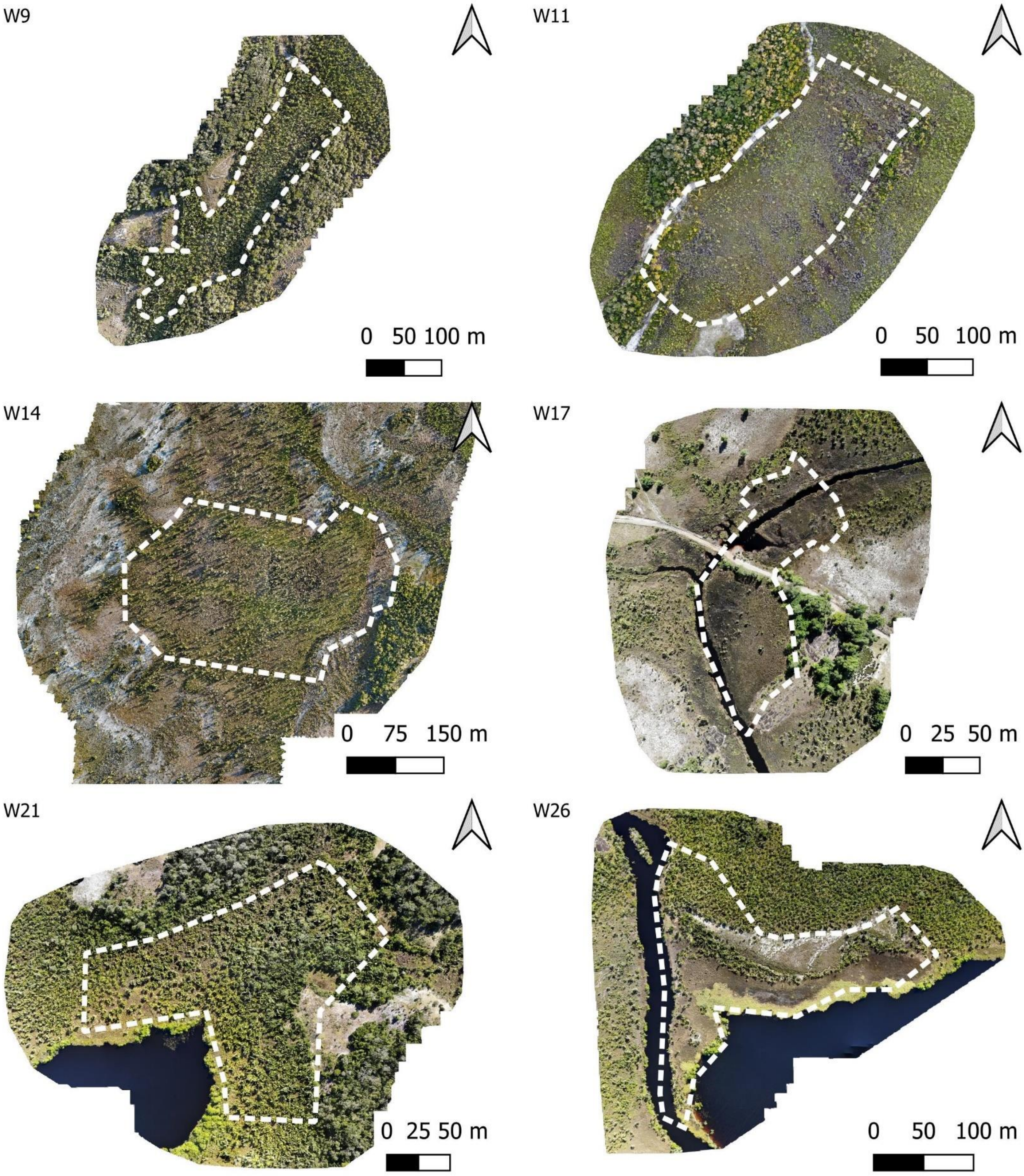

Figure 5: Panel of aerial images of all of Project Mahampy study sites collected in July 2024. The boundary of each wetland is highlighted with a white dotted line.

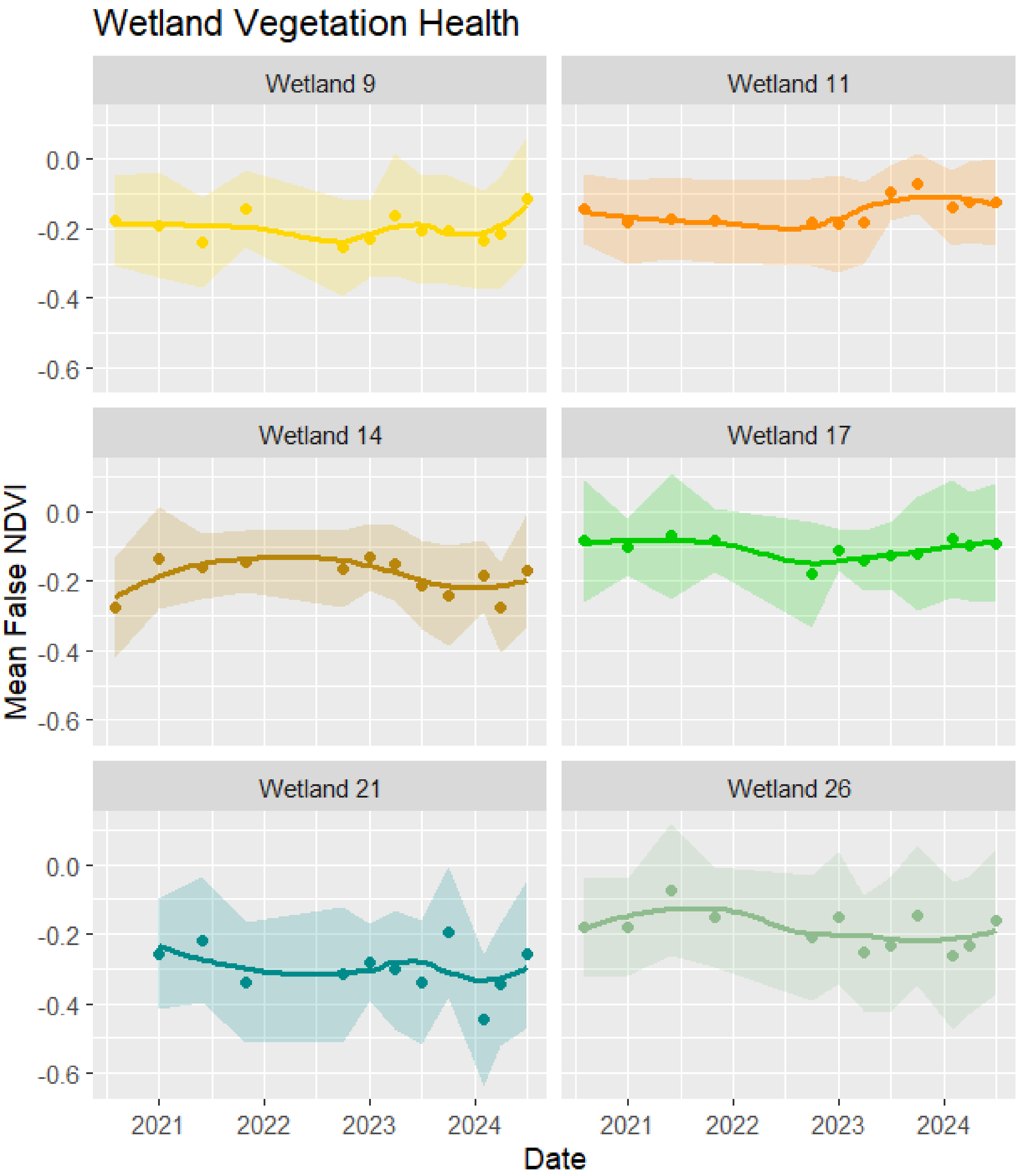

Figure 6: Plots showing the False NDVI values for each of the wetlands over time, the line of best fit was fit using LOESS, and the shaded area indicates the standard deviation around each point.

5. Discussion

Investigating the effects of harvesting techniques on *mahampy* reed growth for Project Mahampy aims to inform the sustainable use of this resource. The data collection across three wetlands indicates that the pull method resulted in the tallest average reeds across both years. The average height of the cut reeds was greatest 10 months after harvesting, however, the pull method had greater average reed heights in months 4, 6 and 8. As a community resource, these wetlands are visited frequently for collection, as often as once a week, therefore, the more consistent reed heights from the pull method would be most suitable when harvested.

The condition of the reeds changed significantly over time. There was a high proportion of dead or *Gone* reeds from both the pull and cut methods. Both methods had about half the reeds in a condition of dead or *Gone* by month 10 of survey. This result was to be expected as these reeds go through a natural cycle of death and regrowth, which is extenuated by harvesting. The fluctuations in growth and condition can also be explained by seasonality. August, which was month 8 in both years, is the middle of winter which would explain the shorter average height for each of the treatments and the increase of dead or *Gone* reeds in the cut method. On the other hand, the condition of the pulled reeds at month 8 had a lower proportion of dead and *Gone* reeds than the cut treatment, indicating the pull method would yield a more consistent reed population for collection.

The density of reeds was higher in the cut method in comparison to the pull method. This result is to be expected due to the collection technique. The cutting technique includes leaving a portion of the reed intact in the ground, therefore, there is still a presence of reed in the plot on which density can be measured, whereas with the pull method the reeds are removed completely. Therefore, it is to be expected that more reeds would be present in the cut plots.

Wetland health, calculated using False NDVI, does not vary over time. Wetland ecological communities are influenced by the movement and qualities of the water present (Lammers et al., 2015), and increased salinity can alter biomechanical properties (Zhu et al., 2020), the difference in access to water could account for the differences in vegetation health between wetlands.

Wetland 17 had the highest mean False NDVI and is located alongside a freshwater river influenced by the tide, and it is regularly inundated by river water during periods of high tide and/or recent rainfall within the catchment. The other five wetlands are each fed by water sources including smaller streams, pools of rainwater, and (in the case of Wetlands 21 and 26) rivers. Despite this, these five wetlands are not flooded to the same extent and frequency as Wetland 17. The frequency and duration of water cover over the wetland may influence vegetation health. Wetland and vegetation health is necessary for the continued utilisation of *Mahampy* for livelihood income in the rural communities of southeastern Madagascar.

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