The Community-Based Restoration Monitoring System (CBRMS)

A guide to using CBRMS in peatland restoration monitoring

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Foreword

The Center for International Forestry Research (CIFOR) has been working with communities at the site level in Riau to ascertain the economic, social and political dynamics contributing to forest and land fires in the province, and determine their imaplications. During 2022 and 2023, with support from Temasek Foundation (TF) and Singapore Cooperation Enterprise (SCE), CIFOR is conducting Participatory Action Research (PAR) with partners including the University of Riau (UNRI) and Sedagho Siak by working together with village governments, farmer groups, fire care community groups (MPAs) and family welfare empowerment groups (PKKs) in the villages of Penyengat and Kayu Ara Permai.

The Community-Based Peatland Restoration Monitoring System (CO-PROMISE), originally developed in response to the need for a robust but viable means for monitoring peatland restoration efforts, combined participatory measurement, science and technology, and demonstrated the value of community-based observations in monitoring conditions in peatlands. The system provided an alternative for broadening existing monitoring coverage areas. Initially, CO-PROMISE was designed specifically for use in monitoring restoration activities in peatlands. However, due to the need for a community-based restoration monitoring tool that could cover not only peatlands, but other areas as well; and the need to mainstream the use of such a system for different ecosystems, CO-PROMISE was reworked to become the CIFOR-ICRAF flagship product known as the Community-Based Restoration Monitoring System (CBRMS).

This guide was developed to provide an overview of, and step-by-step guidelines to using CBRMS as a means for involving local communities in monitoring the impacts of peatland restoration activities. It was prepared under the Scaling-up Community Based Fire Prevention and Peatland Restoration project supported by Temasek Foundation. It is intended for use mainly by villagers involved in monitoring groundwater level, soil temperature and plant growth variables in peatland restoration projects. Other potential users are community groups, smallholder farmers and field technicians.

August 2023

The authors

Acknowledgements

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List of abbreviations

AGB	aboveground biomass
API	Application Programming Interface
CBRMS	Community-Based Restoration Monitoring System
CIFOR	Center for International Forestry Research
cm	centimetres
CO-PROMISE	Community-Based Peatland Restoration Monitoring System
CO_2e	carbon dioxide equivalent
DBH	diameter at breast height
FAO	Food and Agriculture Organization of the United Nations
FIRMS	Fire Information for Resource Management System
g	grams
H	height
ha	hectares
ICRAF	World Agroforestry
ID	identification number
IPBES	Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services
Mha	million hectares
MPA	*Masyarakat Peduli Api* (fire care community group)
NASEM	National Academies of Sciences, Engineering, and Medicine
NDC	Nationally Determined Contribution
ODK	Open Data Kit
PEATMAP	a global peatland map

PKK	*Pemberdayaan Kesejahteraan Keluarga* (family welfare empowerment group)
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
tCO_2e	metric tons of carbon dioxide equivalent
WD	water depth (average water table depth below the peat surface)
yr	year
ρ	wood density (in g cm^{-3})

1 Introduction

Tropical peatlands in Indonesia cover about 13.5 to 21 Mha area in several islands of Indonesia (Anda et al., 2021; Murdiyarso et al., 2010). Intact peat swamp forest in main Sumatera and Kalimantan islands of Indonesia is less than 7% of all peatland areas (Figure 1) (Miettinen et al., 2016). where about more than 90% had been degraded and covered by secondary forests, plantation forests, agriculture and shrubs Indonesian government has been enforcing peatland restoration to reduce emission from degraded peatland through rewetting and revegetation activities, and targets to reach 2 million ha by 2030 under its **nationally** determined contribution (Enhanced NDC).

Restoration of degraded peatland ecosystems is fundamental to achieving sustainable development, principally through climate change interventions, poverty eradication, food security, water regulation and biodiversity conservation. Restoration is defined as any intentional activity that initiates or accelerates the recovery of an ecosystem

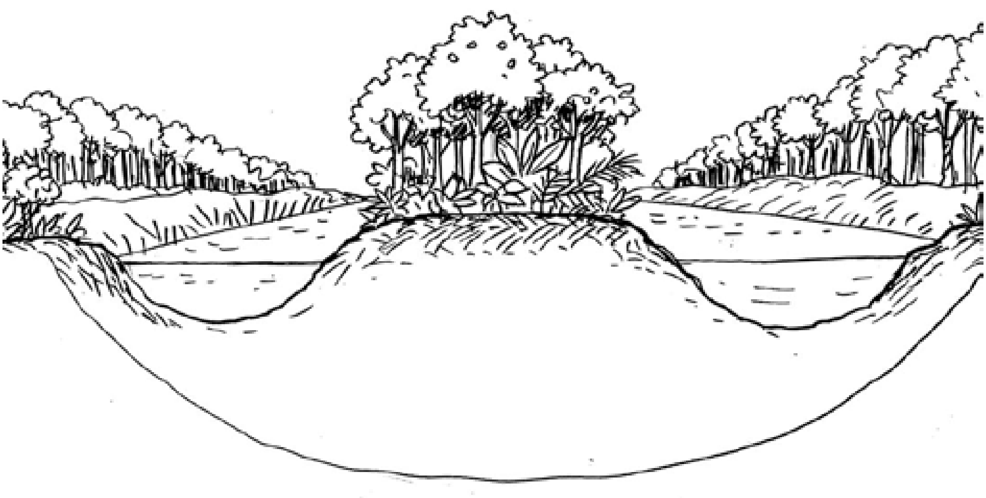


Figure 1. Illustration of intact peat swamp forest

from a degraded state, whatever the form or intensity of degradation (IPBES 2018). It is important to retain and enhance the capacity of ecosystems to provide for the present and future needs of millions of people, enable the function of natural processes, and conserve threatened biodiversity (Aronson and Alexander 2013).

Monitoring is a crucial element of any peatland ecosystem restoration process, and well-designed monitoring programmes can improve the effectiveness of restoration efforts. Monitoring can measure progress toward restoration goals, and further improve the efficacy of the restoration process itself. In addition, monitoring an ongoing project can directly enhance restoration outcomes and improve future restoration decision making. Learning from restoration monitoring can occur through trial and error or, more efficiently, through a structured process of monitoring and formal evaluation and associated adaptive management (NASEM 2017).

Restoration monitoring does pose challenges and frequently faces constraints, including limited funds and human resources. Traditional ecological restoration monitoring is often undertaken manually and can involve transects (Anderson and Gaston 2013). It is expensive, lacks local involvement and integrated data, and can be difficult in remote areas where internet access is problematic. As restoration monitoring should be tied to specific targets and measurable goals and objectives identified at the start of a project, the establishment of baseline data, and the collection of data at appropriate intervals after restoration commences, are fundamental to achieving proper measures of success (McDonald et al. 2016).

Despite well-established peatland's groundwater level monitoring networks using sensor-based equipment combined with the Internet of Things (IoT) already being available, their coverage is limited, and they are unable to show restoration impacts on a local scale. For these reasons, by considering requirements and learning from problems, limitations and emerging technologies, we developed the Community-Based Peatland Restoration Monitoring System (CO-PROMISE) to combine participatory measurement, science and technology, and to demonstrate the value of community-based observations in monitoring conditions in peatlands. The system provided an alternative for broadening existing monitoring coverage areas. Initially, CO-PROMISE was designed specifically for use in monitoring restoration activities in peatlands. However, due to the need for a community-based restoration monitoring tool that could cover not only peatlands, but other areas as well; and the need to mainstream the use of such a system for different ecosystems, CO-PROMISE was reworked to become the CIFOR-ICRAF flagship product known as the Community-Based Restoration Monitoring System (CBRMS) (Figure 2).

The new system offers the capacity to work offline, is compatible with more affordable smartphones, allows safe storage on cloud systems, is transparent and accessible, and facilitates local community involvement. It is designed as an organized system for collecting, processing and validating data necessary for measuring implementation progress and impacts, while empowering communities to participate in monitoring processes. The mobile application is designed to be user friendly and reliable, and offers high flexibility for modification based on user requirements.

Figure 2. Community-Based Restoration Monitoring System application

2 Monitoring system frameworks

2.1 System workflow

The system is designed to facilitate monitoring processes on the ground; to process raw measurement datasets; to summarize information on restoration progress; and to present that information in a dashboard (Figure 3). Trained community members from multiple restoration sites are currently taking measurements in the field; inputting measurements into data forms; and submitting them to a cloud database using the Android-based CBRMS application. The mobile app was developed from an Open Data Kit (ODK) framework and has the flexibility to set up and/or modify forms. It can operate offline when inputting measurement data, though does require an internet connection to submit data to the cloud database. The system is designed to provide near real-time monitoring data. Once data is submitted from the field, the cloud database will update automatically, and the online dashboard will automatically calculate the new data and update the information in the CBRMS Interactive Dashboard.

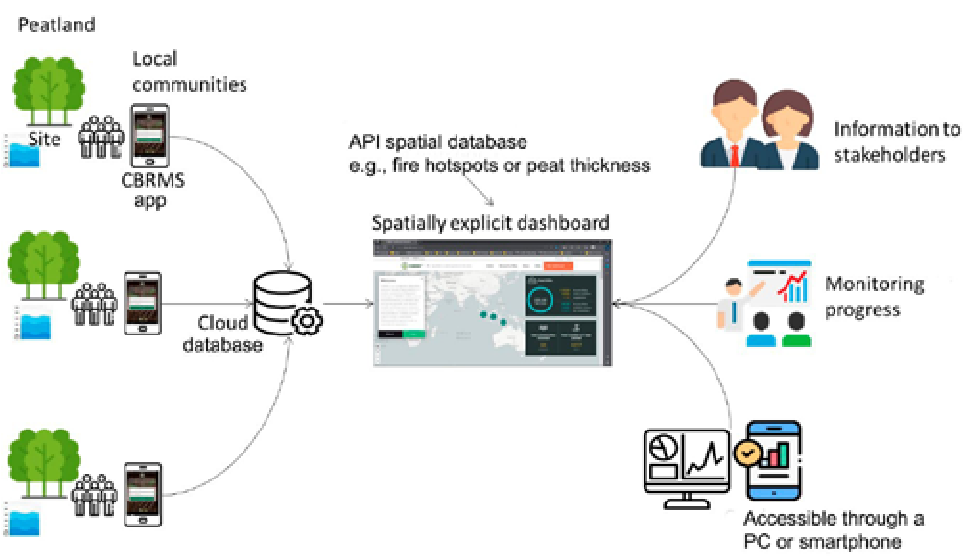


Figure 3. System workflow

2.2 Barcode tagging

In ensuring well-structured time series monitoring data, the database requires each monitored object to have a unique identification number (ID). The system uses alphanumeric identification to indicate multiple pieces of information; combinations of letters and numbers in an object's ID provide information on its site location and plot details, and any custom monitoring information that may be required.

Long ID characters and large sets of data are time consuming to type manually, and typing errors can frequently be an issue. These were a persistent problem during the testing period. So, to eliminate human error and to shorten the time needed to input an ID, we introduced a barcode system for identification details (Figure 4).

Barcodes can be printed in weather-proof material and attached to monitoring objects using cable ties to prevent accidental removal (Figure 5). The mobile app includes a feature that can read barcodes using the device's camera. Barcode scans are a more reliable and less time consuming and error-prone means for inputting ID details into the application's forms.

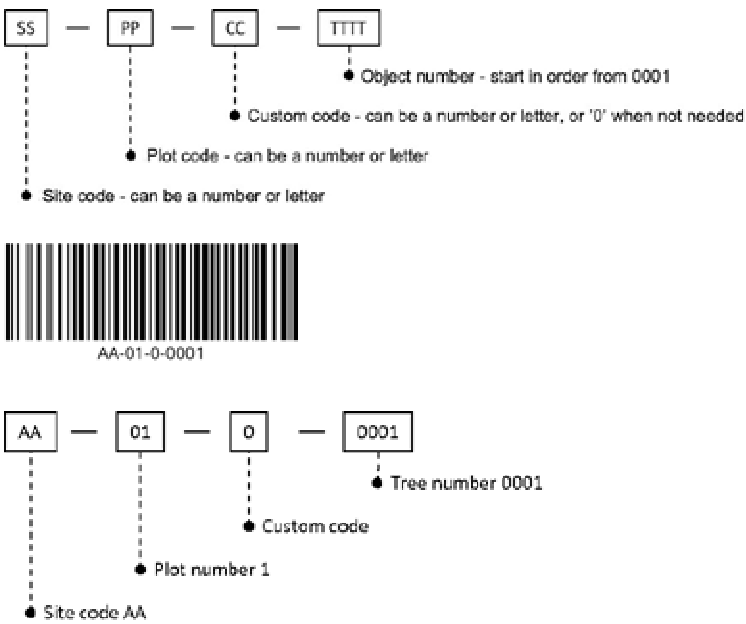


Figure 4. Example of a barcode ID for tree monitoring

Figure 5. Barcode to facilitate tree monitoring

2.3 Using parameters for monitoring restoration

2.3.1. Peatland's groundwater level monitoring

Peatlands are greatly influenced by their hydrological conditions. Monitoring water table and soil moisture levels is critical for assessing a peatland's condition (FAO 2021). Most degraded peatlands have dried out following deforestation and/or been drained for conversion to agricultural land. The lower groundwater levels resulting from drainage lead to emissions from peat oxidation and subsidence, and increased fire risk.

To restore peat hydrology in degraded peatlands, rewetting employs canal blocking to raise and maintain groundwater levels at recommended levels. Controlling groundwater levels can help retain soil moisture, prevent peat fires and reduce carbon dioxide emissions from peat decomposition. In peatland's groundwater level monitoring, the impacts of canal blocking in an action arena are gauged by determining groundwater level, soil moisture, and peat subsidence parameter values and comparing them to those in a control area where no canal blocking has been applied (Figure 6).

2.3.2. Tree monitoring

Tree growth is a key ecological parameter for forests and thus of high importance as an indicator (Dobbertin et al. 2013). Increment is defined as tree growth within a defined period, and can be expressed as increases in height, diameter and volume parameters.

In further analysis, these parameters can be linked to external and internal factors to ascertain growth performance in different sites and under contrasting environmental conditions. Fundamental to measuring trees is an understanding of how individual trees grow in different situations. Thus, tree growth over time is a key parameter for forest sciences such as forest ecology; growth ecology; silviculture (assessing site quality, planning treatments, etc.); assessing and predicting wood volume, biomass and carbon sequestration; and forest management (Woo et al. 2019). Survival rate is another critical field performance criterion, as no matter how well a species performs, there is little point in continuing to plant it if its survival rate is low (Elliott et al. 2013).

Figure 6. Peatland's groundwater level monitoring

Tree monitoring applies a census-based approach where each tree is measured periodically (Figure 7). Basic information on species and date of planting is collected to set the baseline for the growth period and identify each species' performance. The main measurement parameters are height, diameter and survival rate. Additional parameters, such as canopy width, disturbances or specific treatments, can also be included. Trees are generally divided into the following growth phases: seedling (height < 1.5 m); sapling (height > 1.5 m and diameter < 10 cm); pole (height > 1.5 m and diameter 10–20 cm); and tree (height > 1.5 m and diameter > 20 cm). Following planting, the initial parameter measured is height until the stand's height reaches 1.5 m (the sapling phase), after which stem diameter is also measured. Tree monitoring demonstrates which species perform well and are suitable for revegetation in specific peatland areas. Once planted number, species, survival rate and growth data has been recorded and submitted, it is translated to provide information on carbon sequestration rates, and displayed on the dashboard.

Figure 7. Tree monitoring

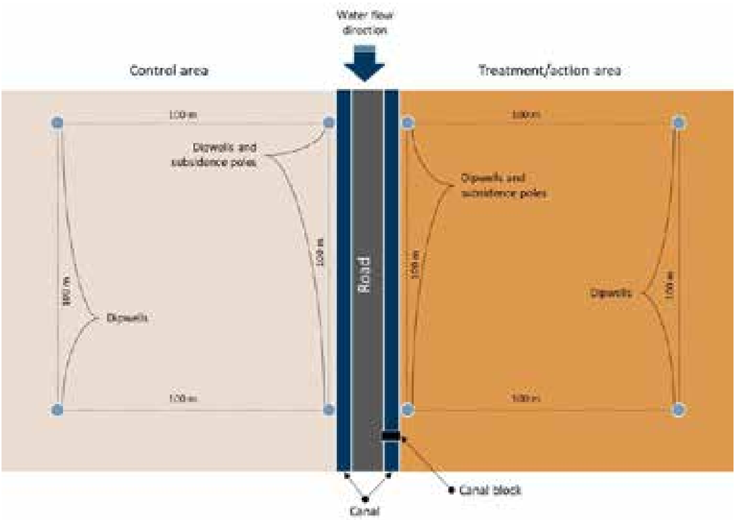


Figure 8. Dipwell and subsidence pole placement

2.4 Setting up peatland's groundwater level monitoring points

The placement of dipwells and subsidence poles is important for monitoring and understanding the effects of rewetting through canal blocking (Figure 8). Dipwells are installed in action/treatment areas where groundwater levels are affected by canal blocks, and in control areas where canal blocking is absent. It is important to select control and action/treatment areas with similar baseline conditions. As canal networks are often found along both sides of roads, dipwells can be positioned in a control area on one side, and in a treatment area on the other side where baseline conditions are almost identical. Four dipwells and two subsidence poles should be installed in each action/treatment and control area. Two dipwells should be placed alongside the canal at a distance of 100 m apart, and the other two at distances of 100 m from the canal.

2.5 Preparing and installing dipwells and subsidence poles

Dipwells are made from 3 inch-diameter polyvinyl chloride (PVC) pipes with lengths around 3 meters, or according to the groundwater depth in the monitoring site. The pipes are inserted into boreholes until around 20–25 cm are left to protrude above the peat surface. Before installation, small holes are drilled along the sides of tubes so water can infiltrate the dipwells. To prevent mud and litter entering and settling in the tubes, the holes are covered with mesh, and the top ends are sealed with tube caps. Dipwells can also be modified to incorporate floating small-diameter

PVC pipes marked with measurement scales to show water level depth and simplify the monitoring process. Such modifications will necessitate calibration to set the measurement scales and ensure they show groundwater levels correctly (Figure 9-11).

Figure 9. Dipwell pipe and floating measurement scale preparation

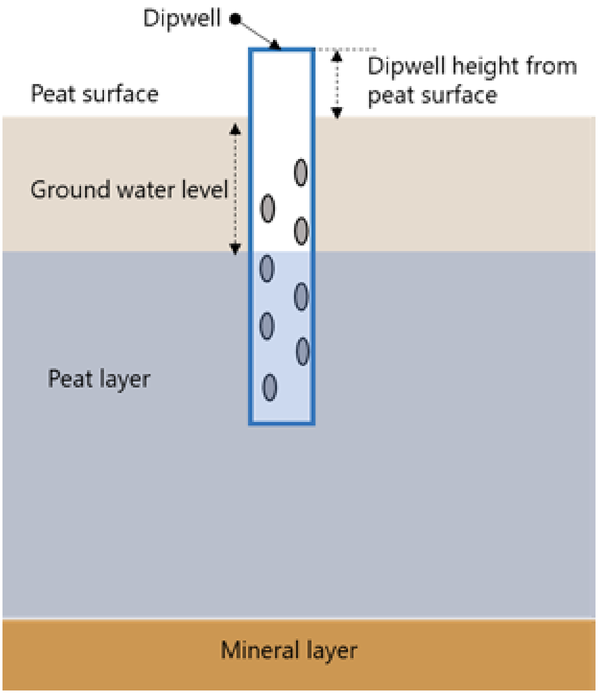


Figure 10. Dipwell installation design

Figure 11. Installing dipwells

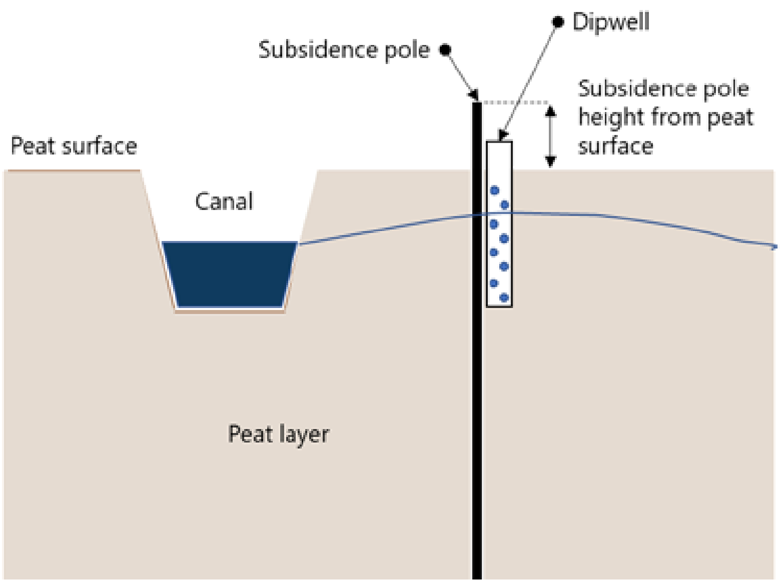


Figure 12. Subsidence pole installation design

Peat subsidence is measured periodically by using subsidence poles to determine the distance from the peat surface to the tip of the pole. Peat subsidence occurs as a result of carbon loss from peat compaction due to microbial decomposition, fire, or a combination of both. Subsidence poles are made from 13 mm threaded steel poles, the lengths of which can vary depending on the depth of the peat layer being measured. Where necessary, two or more poles can be welded together. Subsidence poles are installed beside dipwells, and should penetrate and pass through the peat layer to the mineral substrate below to ensure stability (Figure 12 and 13).

Figure 13. Installing subsidence poles

2.6 Collaborative planning and training

As community participation is the essence of all community-based processes including monitoring, monitoring plans must be developed collaboratively with all relevant stakeholders including the local communities involved. Local community members must be informed about what parameters are involved in the monitoring process and how to measure them. Plans for monitoring intervals and persons in charge should be discussed and agreed to ensure all stakeholders and persons involved understand their roles and responsibilities in the monitoring process. In peatland restoration monitoring, the local community is responsible for taking measurements and submitting measurement data to the server. Training, mentoring and evaluation are essential at the beginning of the monitoring phase to ensure all parameter measurement processes follow standard procedures. Evaluations should continue until the relevant community group or person in charge is considered capable of carrying out the monitoring process independently. Training and mentoring are essential for data quality assurance and ensuring data is collected correctly and meets required standards (Figure 14).

Appropriate monitoring intervals are important in determining changes in peatland condition dynamics, particularly hydrological conditions, and need to be agreed upon in every monitoring plan. Peatland hydrological parameters like groundwater level and soil moisture should be monitored at weekly intervals. Tree growth and peat subsidence, meanwhile, are gradual processes and do not necessarily need to be monitored so regularly. Six-monthly intervals are generally considered sufficient for determining tree growth and peat compaction dynamics. For reference, Minister of Environment and Forestry Regulation No. P.15/MENLHK/SETJEN/KUM.1/2/2017 stipulates a two-weekly monitoring interval for manual measurement of peat groundwater levels, and daily for sensor-based measurement.

Figure 14. Training and mentoring processes

2.7 Estimating emission reductions

Emission reductions in units of carbon dioxide equivalent (CO_2e) is a parameter commonly used in peatland restoration. The dashboard provides a feature for estimating emission reductions from rewetting and revegetation to gauge the impacts of peatland restoration. Avoided emissions from peat oxidation are estimated by comparing groundwater table data between areas where canal blocking has and has not been applied. Avoided carbon loss is calculated using the carbon loss and water table depth models from Hooijer et al. (2012).

For drained natural forest: (Hooijer et al. 2012) $CL = -98 * WD$

For deforested unproductive peatlands: (Hooijer et al. 2012) $CL = 9 - 84 * WD$

where:

CL = carbon loss, in tCO_2e ha−1 yr−1

WD = average water table depth below the peat surface (−metre; negative)

Carbon sequestration from revegetation is estimated from increments in aboveground biomass. Aboveground biomass values are calculated from tree growth parameters such as height and/or diameter using an allometric equation model (Figure 15). Stem diameter, measured as diameter at breast height (DBH), has a strong positive correlation with total aboveground biomass (Brown et al. 1991; Brown 1997; Chave et al. 2005). Where possible, the system uses species-specific allometric equations for estimating biomass. However, where such equations are unavailable, the system uses common allometric equations from Chave et al. (2014) and Kenzo et al. (2009), particularly during the seedling stage where only height data is available.

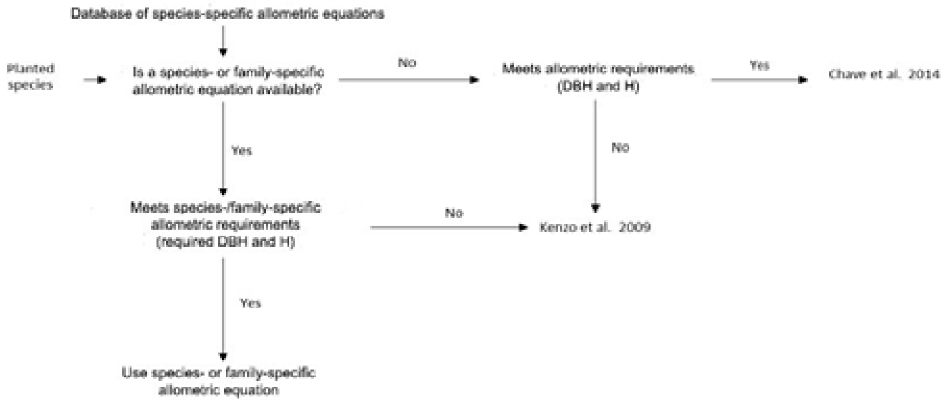


Figure 15. Selection of allometric equations

Allometric equation selection and biomass estimation are embedded in the background service and processed inside the database system before being published on the dashboard. Time series biomass increment data combined with survival rate information allow the system to estimate the carbon sequestration rate for each restoration plot, and show the impacts of revegetation in the dashboard.

$AGB = 0.0673(\rho D^2H)^{0.976}$ (Chave et al. 2014)

$AGB = 0.1525D + 2.34$ (Kenzo et al. 2009)

$AGB = 0.0558H + 2.53$ (Kenzo et al. 2009)

where:

AGB = Aboveground biomass (in kg)

D = Diameter at breast high (in cm)

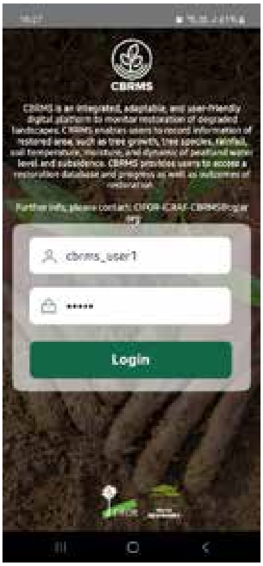
H = Height (in m)

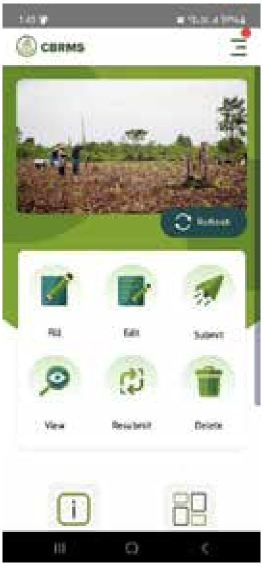
ρ = wood density (in g cm^{-3})

3 Preparing the Android device

3.1 Installation and general settings

- Download and install the CBRMS Android app from this link: https://data.cifor.org/cbrms/images/android/CBRMS_Dev_FinalRelease.apk
- Log in using the username and password of your **CBRMS account** to access the specified monitoring form. The system is designed so that each user only can access the specific monitoring form that connects to their username.
- Select the icon at the top right of the screen to access the **General Settings** tab, or to log out of the app.
- The **General Settings** tab consists of the user interface section, where you can select: **Theme, Language, Text Font Size,** and **Navigation**.
- Tap on the "**Language**" tab to change the default language, then tap on your preferred language to select it for your CBRMS app. The default language will follow your phone language setting.





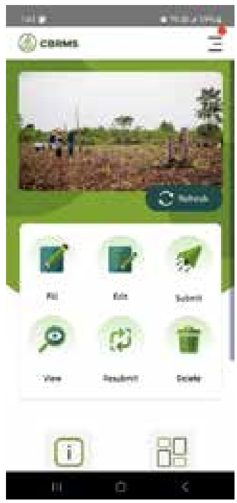
3.2 Home menu

- **Fill**: For opening a monitoring form as the first step for inputting data
- **Edit**: To edit monitoring records
- **Submit**: To submit monitoring records to the server
- **View**: To view submitted records
- **Resubmit**: To see a form that was submitted but rejected - the form must be edited before it can be resubmitted
- **Delete**: To delete monitoring records

4 Inputting measurement data

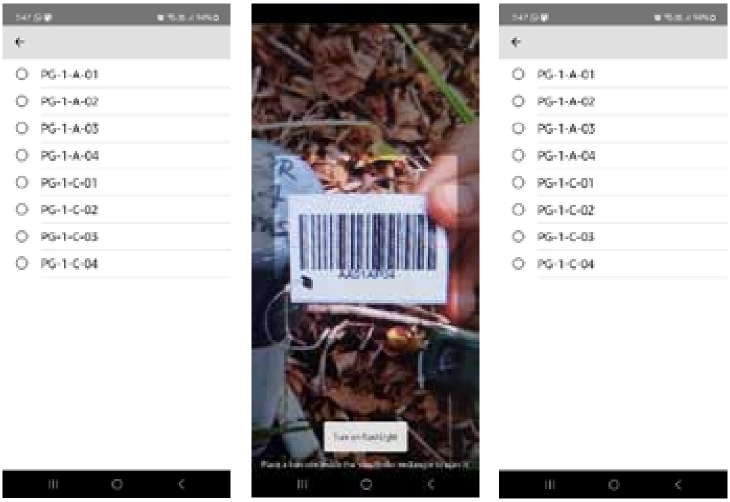
4.1 Peatland's groundwater level monitoring

1. On the home menu, tap on **Fill** and select the **Peat Monitoring** form to start data input.

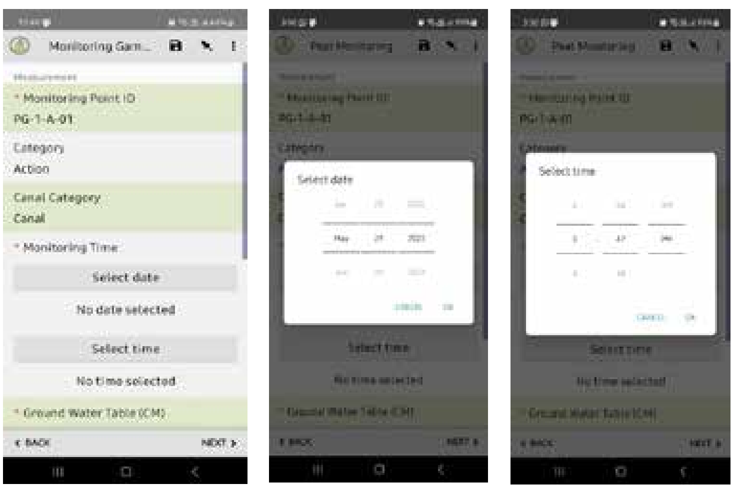


2. The first page is for identifying the monitoring point. First, select the **action arena** where the dipwell is located from the drop-down menu.

3. Check the label ID on the dipwell and fill in the **Dipwell ID** either by scanning the barcode or using the drop-down menu. Please note that when barcode scanning is successful, the select menu will disappear. Once completed, go to the next page by tapping the **Next** button.

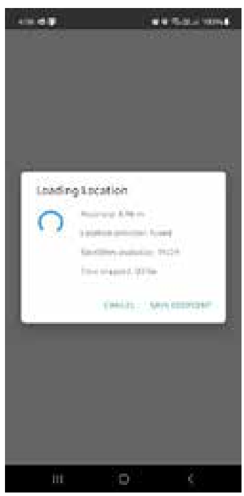


4. On this page, the **Dipwell ID** will automatically appear for cross-checking. Fill in the **Monitoring Time** by selecting the date and time. Default values refer to the device's date and time settings.

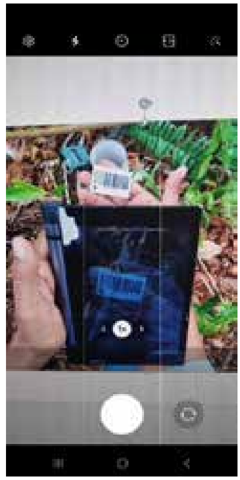


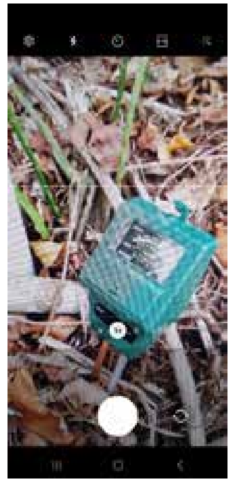
5. The bottom of the page contains queries on measurement. Measure **Ground Water Table** level, **Soil Moisture**, and **Height of Subsidence Pole** and fill out the form. Please refer to the default measurement units when filling out the form. Once complete, go to the next page by tapping the **Next** button.

6. This page is about measurement documentation. Assign the dipwell's geolocation by tapping the **Start GeoPoint** button. After the coordinates have been acquired, information on latitude, longitude and accuracy will appear.

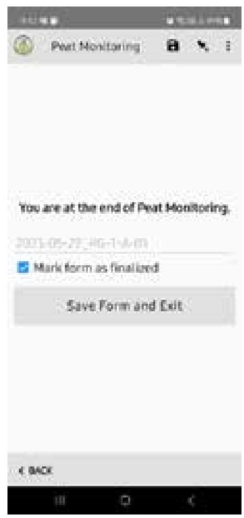


7. Attach pictures of the barcode tag and measurement process, either by tapping on the **Take Picture** button to capture images directly from the device's camera, or the **Choose Image** button to select images from the device's gallery. There is a **Notes** field for adding notes where necessary.



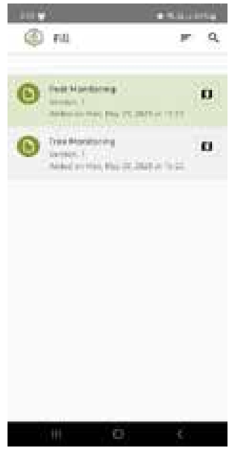


8. On the last page, check the displayed date and dipwell ID are correct, then tap on the **Save Form and Exit** button to finalize the measurement record.

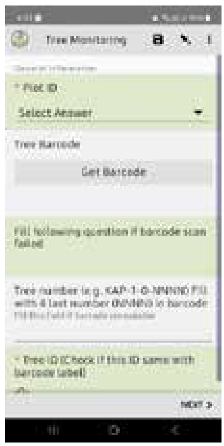


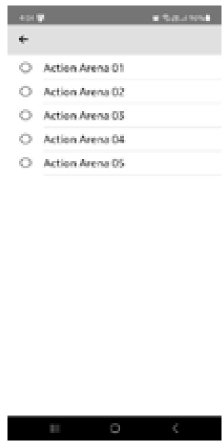
4.2 Tree monitoring

1. On the home menu, tap on **Fill** and select the **Tree Monitoring** form to start data input.



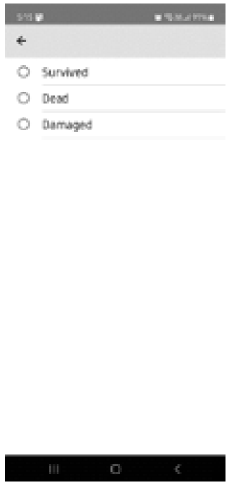
2. The first page is for identifying the plot and tree. First, select the action arena where the tree is located from the drop-down menu.

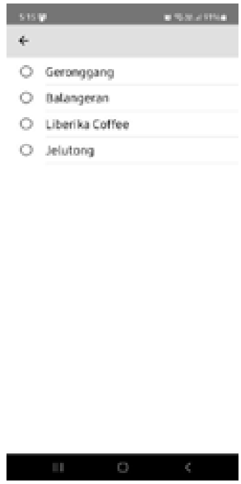




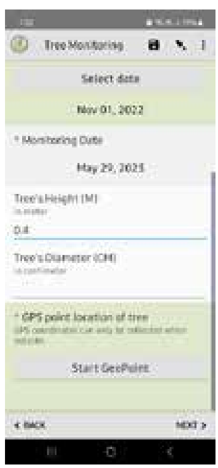
3. In the beginning of monitoring phase, the tree will be given a tree ID in form of barcode label. Attach the barcode tag to the tree and fill in the **Tree ID** either by scanning the barcode or using manual input if the device fails to scan the barcode. The scanned result of the **Tree ID** will appear for cross-checking. If the **Tree ID** scan result did not match with the label in the tag, the label can be re-scan again using **Replace Barcode** button. Once completed, go to the next page by tapping the **Next** button.

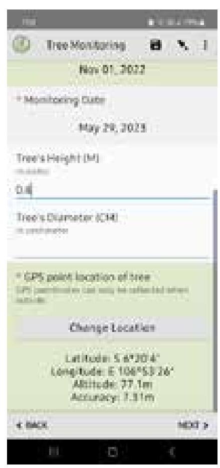
4. This page contains queries about tree condition, species, planting date and geolocation. The first queries are **Tree Condition** and **Tree Species**. When a tree is marked dead, no more queries will appear. The list in the drop-down menu under **Tree Species** can be set in the form setup.



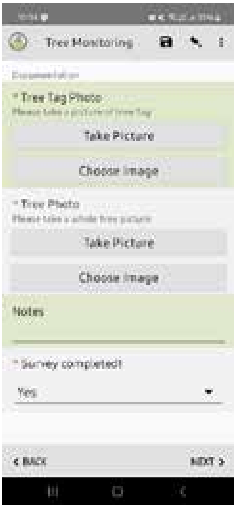


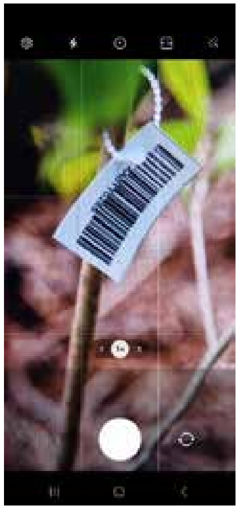
5. Default values for **Tree Planting Date** refer to the device's date and time settings. Measure the tree to determine its height and diameter, then enter values in the **Tree's Height** and **Tree's Diameter** fields. Only height values are needed until the tree reaches 1.5 m tall, after which diameter values are also required. Assign the tree's geolocation by tapping the **Start GeoPoint** button. After the coordinates have been acquired, information on latitude, longitude and accuracy will appear. Once completed, go to the next page by tapping the **Next** button.



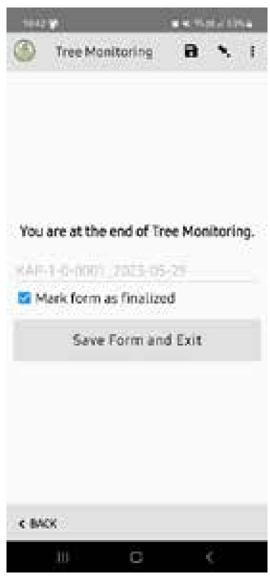


6. This page is about documentation. Attach pictures of the tree barcode tag and the tree itself either by tapping on the **Take Picture** button to capture images directly from the device's camera, or the **Choose Image** button to select images from the device's gallery. There is a **Notes** field for adding notes where necessary. When complete, select **Yes** on the **Survey completed!** tab and go to the last page.



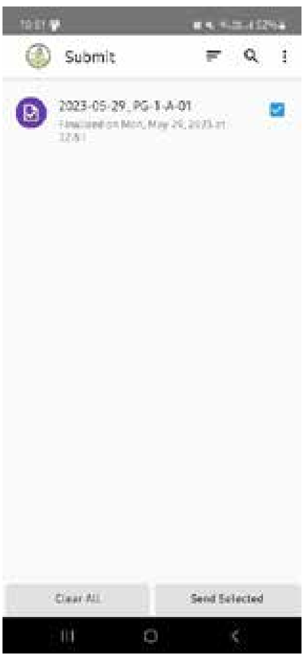


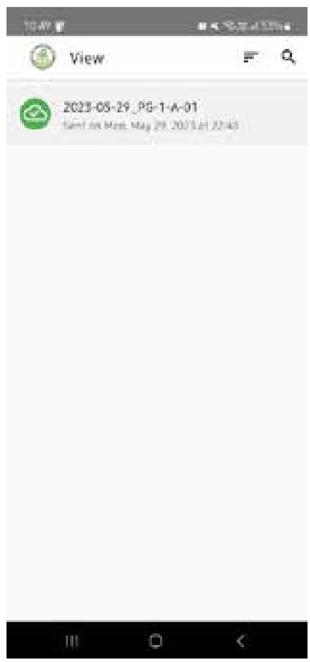
7. On the last page, check the displayed date and tree ID are correct, then tap on the **Save Form and Exit** button to finalize the measurement record.



5 Data editing and submission

- To edit saved information on the survey, select **Edit** and select the record you want to change. Identify the record from the listed name.
- After completing the edit, tap on **Save** to save the new information.
- To submit the form, select **Submit** to go to submit page. **Select** the record you want to submit, or you can check **Select All** to select all records, then tap on the **Send Selected** button. The submitted record(s) will then disappear from the **Submit** field and be displayed in the **View** field. Please note that data submission will require an active internet connection.





6 Data visualization

Data visualization and interpretation are helpful for summarizing the prevailing situation (Figure 16-18). A spatially explicit dashboard has been developed to provide information on restoration progress in the field. It displays information on site conditions, numbers of trees planted, species names, tree survival rates, peat subsidence, and peat hydrological conditions such as groundwater and peat moisture levels for each restoration site. The dashboard also provides calculations of carbon sequestration from revegetation and avoided emissions from rewetting. To provide additional information, the dashboard has API connections linked to PEATMAP for peat layer data, and FIRMS for data on fire alerts.

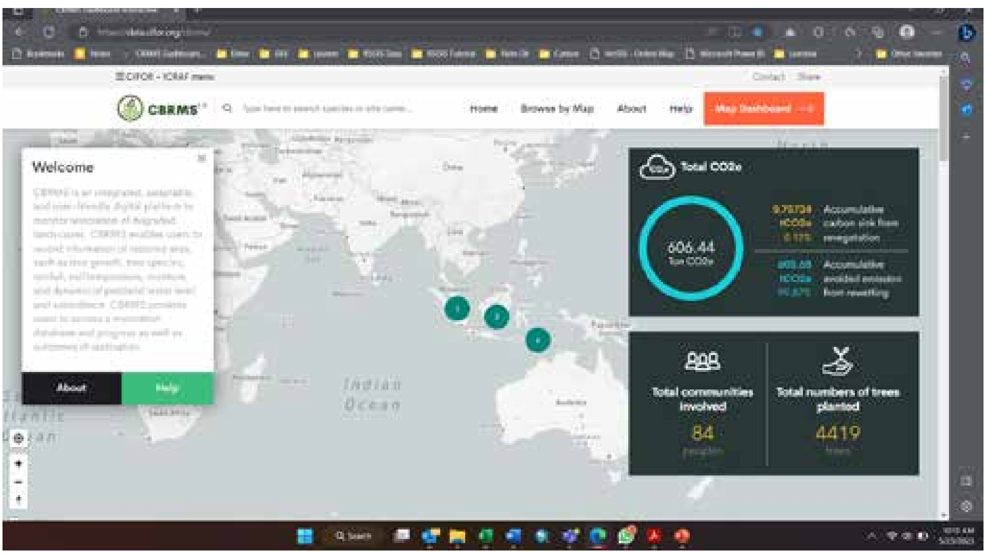


Figure 16. CBRMS dashboard home page: https://data.cifor.org/cbrms/

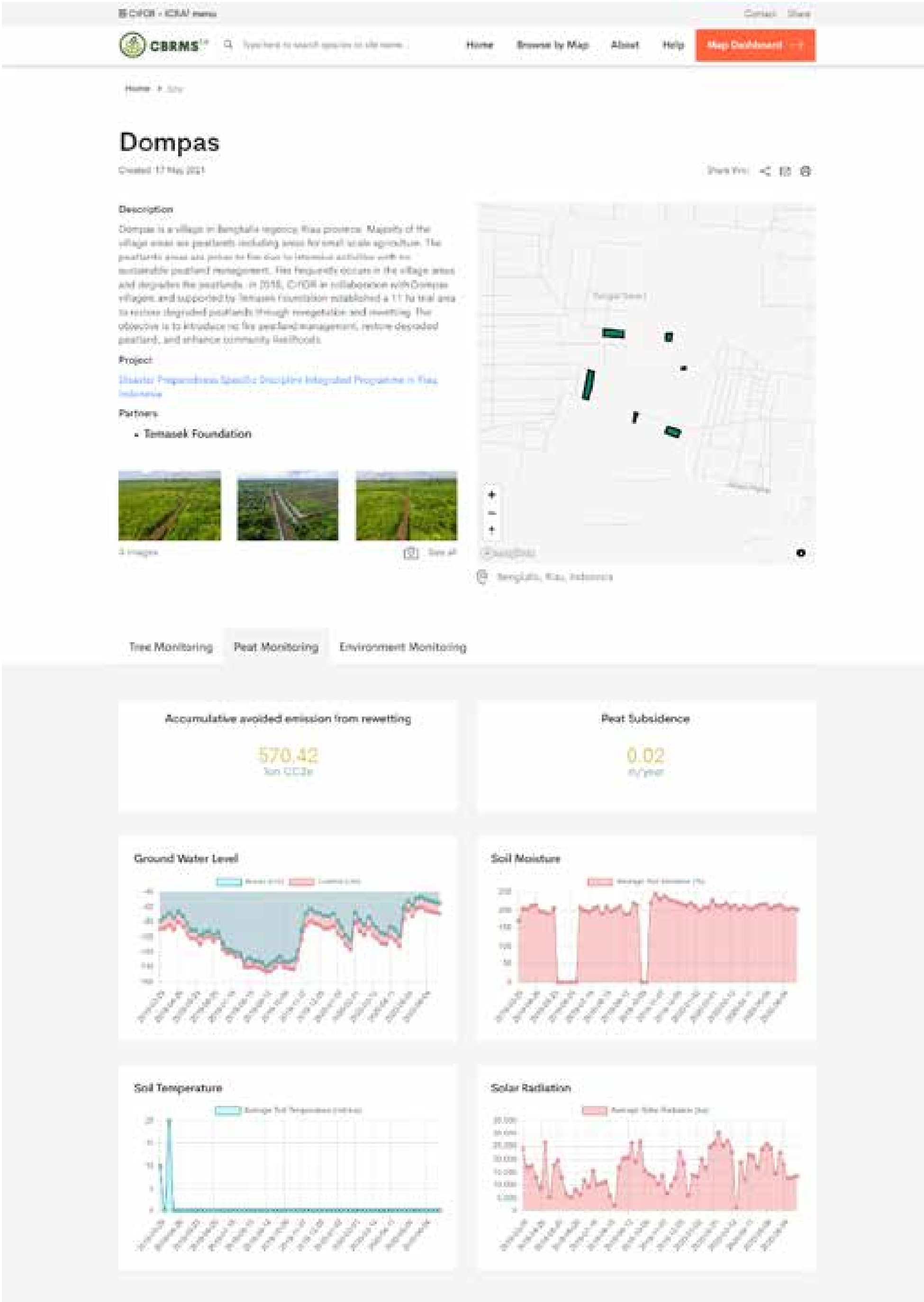


Figure 17. Peatland's groundwater level monitoring page for one of the restoration sites

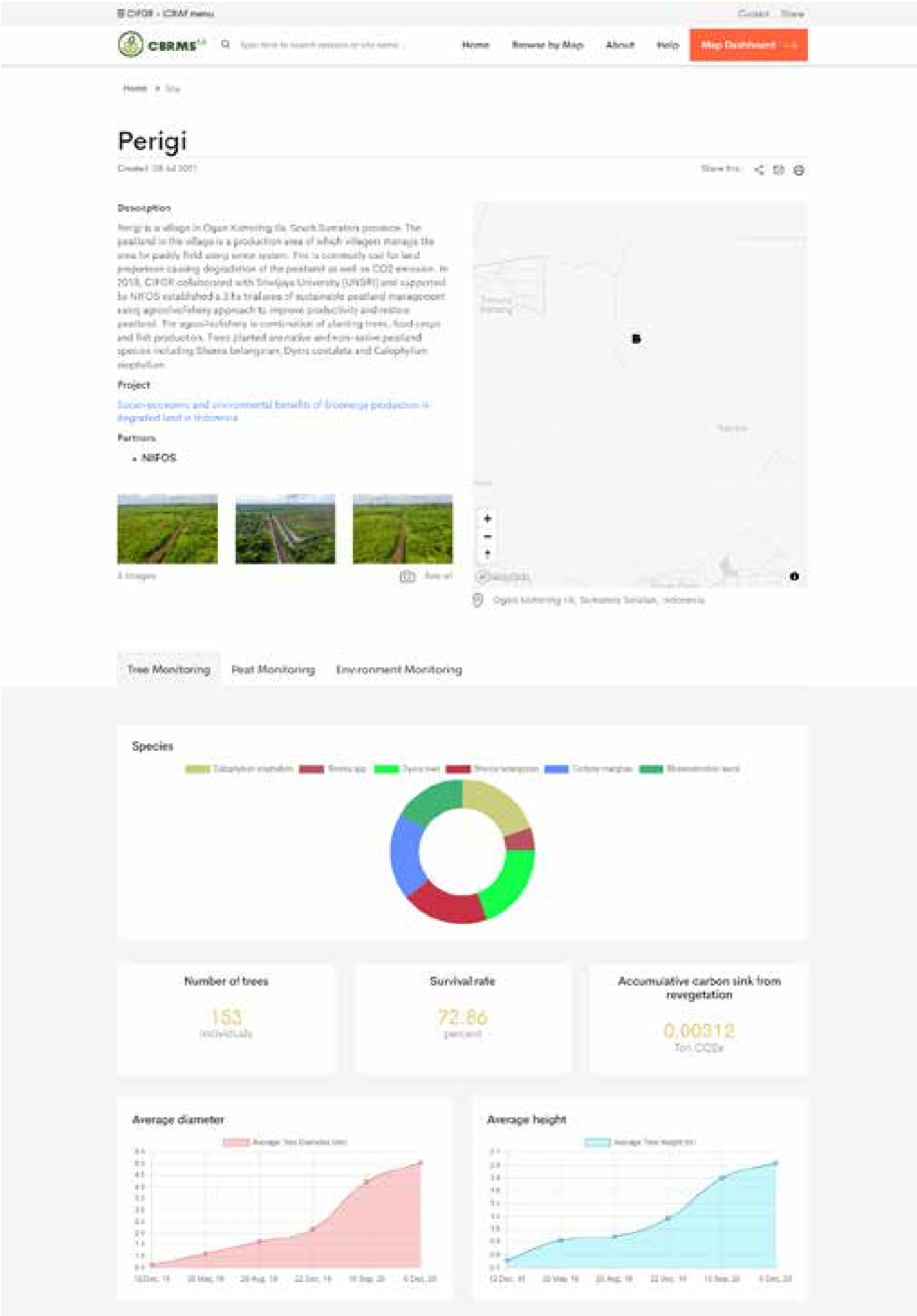


Figure 18. Tree monitoring page for one of the restoration sites

7 Quality assurance and quality control

Quality assurance (QA) and quality control (QC) are important for ensuring data integrity and minimizing errors. As a proactive process, quality assurance involves training (Figure 19); providing step-by-step guides and instructions in question forms; reviewing and writing monitoring data in logbooks as backup in the early stages of monitoring; providing pictorial documentation; and maintaining communications between data managers and community members responsible for collecting measurement data. It is a continuous process of preventing, detecting and correcting measurement errors to ensure the quality of the system's data.

Quality control, meanwhile, is a more reactive process incorporated into the system for detecting and preventing monitoring errors. It is applied through the use of barcodes for identifying objects of monitoring; defining types of data in forms; setting up accuracy tolerances for geolocation; applying mandatory fields for completion in forms; and applying data error ranges when forms are set up. Through quality control, the app can detect data inputting errors and prevent the user from proceeding to the next page in the form. Both of these processes were set up to prevent data loggers inputting erroneous monitoring data.

Figure 19. The community is trained to use CBRMS

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Monitoring is a crucial element of any peatland ecosystem restoration process, and well-designed monitoring programmes can improve the effectiveness of restoration efforts. Monitoring can measure progress toward restoration goals, and further improve the efficacy of the restoration process itself. Monitoring an ongoing project can also directly enhance restoration outcomes and improve future restoration decision making. Restoration monitoring does pose challenges and frequently faces constraints, including limited funds and human resources. Internet of Things (IoT)-based monitoring systems are available for doing so, but their coverage is limited, and they are unable to show restoration impacts on a local scale. Accordingly, we developed the Community-Based Restoration Monitoring System (CBRMS). This CIFOR-ICRAF flagship product offers the capacity to work offline, is compatible with more affordable smartphones, allows safe storage on cloud systems, is transparent and accessible, and facilitates local community involvement. It is designed as an organized system for collecting, processing and validating data necessary for measuring implementation progress and impacts, while empowering communities to participate in monitoring processes. The mobile application is designed to be user friendly and reliable, and offers high flexibility for modification to suit user requirements. This book outlines the monitoring system framework and provides guidelines for its application. We hope it can help practitioners and facilitators in monitoring progress made in restoration efforts on the ground.

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The Center for International Forestry Research (CIFOR) and World Agroforestry (ICRAF) envision a more equitable world where trees in all landscapes, from drylands to the humid tropics, enhance the environment and well-being for all. CIFOR and ICRAF are CGIAR Research Centers.

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