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Adoption of Community-based Monitoring to Peatland Restoration: Lesson from participatory action research in Riau, Indonesia

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Abstract

Restoration of degraded peatland ecosystems is fundamental to achieve sustainable development principally through those on climate change interventions, poverty eradication, food security, water regulation, and biodiversity conservation. Effective monitoring highly considers as an important stage for a successful restoration project allowing measurement of progress and identify corrective action or modification. Despite there are well-established peatland monitoring networks in Indonesia, the coverage area is still limited and not able to show restoration impact at a local scale. In this study, we demonstrate the value of community-based observations for monitoring peatland conditions under restoration activities as an alternative to broaden the coverage area. Learning from requirements, problems, limitations, and emerging new technology, we develop a Community Based Peatland Restoration Monitoring System (CO-PROMISE) to combine participatory measurement, science, and technology. The system offering an approach that adopting a method of technology that capable to works offline, compatible with cheap smartphones, affordable development cost, safe storage at cloud systems, transparent to monitor its result and local involvement. Community-based monitoring system implemented within a 13-ha community-based peatland restoration area in Bengkalis, Riau, Indonesia. An online dashboard was created to show groundwater level and soil moisture data as the impact of rewetting activities. Monitoring data helps develop insights into restoration activities progress and its impact within the study area. Despite there are challenges in encouraging the local community to keep monitoring activities after the project ended, community-based monitoring has been successfully collected temporal data of groundwater level, soil moisture, peat subsidence, and stored in a cloud database and published in the online dashboard. Moreover, a community-based monitoring system can be an alternative monitoring process during COVID pandemic situations, where travel can be limited for other stakeholders.

Keywords: Restoration, Peatland, Monitoring System, Participatory Action Research

Introduction

Indonesia has the largest tropical peatland (Page et al., 2011) and the latest study reveals total peatland extent in Indonesia is about 13.43 million hectares of peatland (Anda et al., 2021). Tropical peatland forest provides important ecological, climate and socio- economic benefits from the local to the global scale (Harrison, 2013; Harrison et al., 2020). Peatland ecosystem is habitat for threatened species (Posa et al., 2011) and essential carbon storage (Hergoualc'H and Verchot, 2011; Warren et al., 2017).

Peatland forest in Indonesia has been facing problems of deforestation, conversion to agriculture, drainage, and fire. The main drivers for peatland degradation in South-East Asia are logging, conversion to industrial plantations, drainage, and recurrent fires (Dohong et al., 2017; Miettinen et al., 2016). Degraded peatland and conversion to agriculture area make peatland are prone to fire and lead to environmental damages, health problems and economic loss (Huijnen et al., 2016).

Restoration of degraded peatland ecosystems is fundamental to achieve sustainable development principally through climate change interventions, poverty eradication, food security, water regulation and biodiversity conservation. Restoring hydrological functions of peatland is important to vegetation restoration and protection of remaining carbon stock (Page et al., 2009). Restoration of peat hydrology is considered as the key in overall tropical peatlands restoration. Raising the groundwater level with canal blocking can create the condition of more suitable for forest vegetation regeneration and prevent peat oxidation (Jaenicke et al., 2010; Jauhiainen et al., 2008)

An effective monitoring and evaluation system are essential part of restoration efforts. Monitoring allowing measurement of progress and helping identify corrective action and or modification to meet the objectives. Peatland restoration monitoring in Indonesia have advanced in recent years with integration of Internet of Things (IoT) and remote sensing technology (Bhomia and Murdiyarso, 2021). Collaborative action with local community involvement is recognize as one solution to sustainable environmental management (Khair et al., 2021) and can help to address local concern (Flores-Díaz et al., 2018). The rapid development of technology and internet provide opportunities for communities to be involved in data collection and uses. The application of technology in community based monitoring has been applied in various environment fields such as monitoring tropical forest crime and forest resources (Brofeldt et al., 2018), air quality (Elen et al., 2012), water management (Flores-Díaz et al., 2018), fish stock (Oviedo and Bursztyn, 2017), and wildlife harvest (Etiendem et al., 2020).

Despite there are well-established peatland monitoring networks in Indonesia, the coverage area is still limited and not able to show restoration impact at local scale. The study demonstrated the value of community-based observations for monitoring peatland restoration activities as an alternative to broaden the coverage area. This study aimed to see whether monitoring of groundwater level conducted by local people can contribute to monitoring peatland hydrology and restoration effort.

Methodology

This study was conducted in Dompas village, district of Bengkalis, Riau province, Indonesia as part of CIFOR's research project in fire prevention and peatland restoration. The monitoring focused on six sites of restoration activities where canal block was built for rewetting purpose. The restoration site is an ex-burned area during major peatland fire events in 2014-2016 period. The surrounding research site is dominated by smallholder's rubber tree plantation and directly adjacent to large scale oil palm and pulpwood plantation in the upper stream.

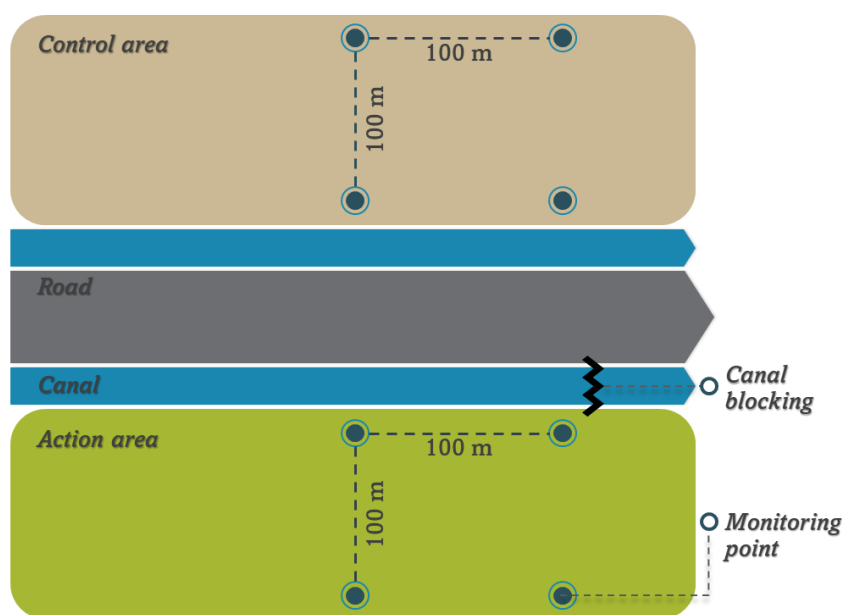


Fig. 1: Monitoring point placement across sites

The monitoring focuses on peat hydrological function and ground water level, soil moisture, and subsidence as parameters. Monitoring the groundwater level is important to understanding the peat hydrological conditions, evaluate effects of restoration and measure carbon dioxide emission from peat decomposition process. Draining of peatland results in peat drying out, and this leads to peat subsidence, oxidation and enhanced carbon emissions (Page et al., 2011; Basuki et al., 2021)

In this activity, ground water level is measured by using dipwell to see effect of canal blocking. The monitoring points are suggested to be placed in perpendicular transect to the blocked canal (Jaenicke et al., 2010). Dipwells were placed in the action area, where the groundwater level is affected by the canal block, and in the control area, where the groundwater level is not affected. In total, there are 48 monitoring dipwells across six observation sites and named Action Arena (AA). In each observation site, four of the dipwells were installed in each action and control area. Two dipwells were located next to the canal with 100-meter distance and the other two located 100 meters away from the canal as shown in Figure 1. Groundwater level depth was monitored by calculating the difference between measurement distance from ground water to the top of dipwell and measurement distance from top of dipwell to the peat surface using stick meter (Basuki et al., 2020). Monitoring point for soil moisture located in the same location with dipwell. Soil moisture were conducted in 3 level of depth 2 cm, 5 cm, and 15 cm from peat surface. We use analog hybrid soil moisture meter for measurement. Peat subsidence monitoring pole located in 24 monitoring

point across sites to keep connection between parameters. Subsidence is monitored by measuring the distance from the top of the pole to the peat surface and calculating the difference over time of monitoring. All measurement were planned in a weekly basis except for peat subsidence that was planned in less interval period of about one year.

To facilitate the data collection, we developed a system named Community Based Restoration Monitoring System (CO-PROMISE) to combine participatory measurement, science, and technology. The system offering an approach that adopting a method of technology that works offline, compatible with cheap smartphones, affordable development cost, safe storage on cloud environment, transparent to monitor its result and local involvement. CO-PROMISE was built on free and open-source application of Open Data Kit (ODK) and Microsoft Power-BI and running in Android ecosystem that familiar to many. Trained community members are doing the measurement in monitoring dipwell, input the data measurements, and submit it to the database once it connected to the internet. Once the measurement data being submitted, cloud database will be automatically sending data to monitoring dashboard and thus make monitoring data can be shown in near real time update manner.

Results



Fig. 2: Community measuring the ground water level and soil moisture

We found that the community members had made 11,319 entries of data on observed monitoring point in the system database between 29 March 2019 to 27 June 2020. There is total 68 observation date during the monitoring period. We found that not all soil moisture is recorded in all observation date. This happened because the soil moisture measurement tool was broken, and it took times to find the replacement. We also failed to monitor the peat subsidence due to subsidence pole damaged. Over three planned measurement, only ground water level measurement that have a complete series of measurement over monitoring period.

Table 1: Average measurement result within monitoring period

	Monitoring sites					
	AA01	AA02	AA03	AA04	AA05	AA06
Ground water level (cm)						
Action	-99.16	-82.98	-83.28	-100.83	-95.44	-84.05
Control	-111.71	-88.93	-96.22	-111.54	-101.25	-108.12
Soil moisture at 5 cm (%)						
Action	23.70	12.27	15.47	29.48	19.21	25.22
Control	23.85	18.01	13.25	16.76	16.36	26.75
Soil moisture at 10 cm (%)						
Action	94.27	81.07	89.08	96.65	95.94	95.78
Control	94.89	90.79	76.39	91.22	90.88	97.68
Soil moisture at 15 cm (%)						
Action	99.07	96.27	98.36	99.65	99.52	99.22
Control	99.65	98.03	92.81	98.22	98.99	99.61

The result from ground water level clearly shown the difference between action arena and control as impact of canal blocking site by site as shown in Figure 2. During the monitoring period, the canal blocking could increase the water level between 5.8 to 24.07 cm as shown in Table 1. The average ground water level in action arena is -90.96 cm and 102.96 cm in control which mean the increase is about 12 cm.

Ground Water Level Monitoring



Fig. 3: Ground water level monitoring dashboard

Source: <https://www2.cifor.org/fire-and-peatland-restoration/research/monitoring-of-the-action-arena/>

The moisture level at 5 cm depth in action arena is 20.89% slightly higher than control with 19.17%. In 10 cm depth, soil moisture level is 92.13 in action arena and 90.31 in control. While in 15 cm depth, the soil moisture level is 98.68 in action arena and 97.88 in control. In all sites average, soil moisture level in action arena is higher than control. However, for each site as shown in Table 1, the soil moisture result was varied across observation sites but consistent in each depth level. In AA03, AA04, and AA05 the soil moisture is higher in action arena than control while in AA01, AA02, and AA06 it was on the other way around.

Discussion

Compare to IoT based monitoring such as PRIMS (<https://prims.brg.go.id/>), community-based monitoring is having lower temporal resolution and required direct measurements. In this research we scheduled the monitoring interval for ground water level and peat soil moisture in a weekly basis based on discussion with the community group. As the member of community group also need to do their routine work, we find it would be difficult to do measurement in more dense time interval. Measurement interval can also be interrupted because of non-technical issue such as religious holiday or important event in the village.

Despite the low temporal resolution of data collection, results from community-based monitoring is able to shows the impact of rewetting by canal blocking particularly for ground water level. The data from measurement clearly show the impact of canal blocking in observation sites. However, the continuity of monitoring is very depending on project support, particularly financial support for operational cost. Even though, the cost for data collection is relatively low, of about USD 7 per week, without supporting fund the communities cannot afford the operational cost of monitoring. Monitoring activities should be connected with the available village funds and the village development plan.

The use of Android based application for data collection is crucial in maintaining the validity and deliver the measurement in near real time manner. Applying barcode for recording monitoring point's ID and setting range of error in data input are crucial to prevent mistakes in data collection. In the testing period, we found some cases that people who do the measurement making mistake in inputting the ID or measurement value. Applying data quality assurance as mentioned in methodology section has been proven to prevent mistakes in data input. Close engagement, direct supervision, and providing mentoring during early monitoring period also helping local community to do the measurement in a proper and efficient way.

Conclusions

The study has demonstrated how community-based monitoring can be used in monitoring the impact of peatland restoration particularly ground water level as impact of rewetting activities. Even though the community-based monitoring is less intense than IoT-based monitoring, the result of monitoring can show the impact of restoration that can be used by the stakeholders in evaluation process. This collaborative effort offers opportunities to gather information from the field in an efficient way and at low cost. Community-based monitoring effort combined with community

engagement and use of technology shown to be a promising collaborative platform for covering larger monitoring area and with current pandemic situation this approach can be an alternative, where travel can be limited for other stakeholders.

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