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Research Paper

Participatory analysis of sustainable land and water management practices for integrated rural development in Myanmar

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ABSTRACT

Besides providing reliable water resources for agricultural production, rural development efforts in Myanmar should target rural water security in terms of safe water supply and sanitation, and by mitigating water-related hazards. However, very few studies are available over the status of water-related development in rural areas of the country, and consequently on suitable practical solutions. The present paper describes a participatory workshop undertaken involving 45 rural development officers of the Department of Rural Development (DRD) of the Ministry of Agriculture, Livestock and Irrigation (MOALI), aimed at identifying suitable sustainable land and water management (SLWM) practices to be developed in rural areas of the country. Adoption of water safety plans (WSP), water harvesting, and soil and water bioengineering were strongly supported, while the need for improving water sanitation, especially in the poorest areas, was made evident. Insights of the participatory process confirmed that the poorest regions of Myanmar have also the worst water management structures. The results of the present work can represent baseline information and a needs assessment for future development projects in the country. However, there is a strong need for more studies and reports targeting marginalized rural contexts of Myanmar, to support equitable development.

Key words | erosion, expert participation, public engagement, soil and water bioengineering, water harvesting, Water Safety Plans

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HIGHLIGHTS

- Research on water supply and sanitation and water-related hazards is lacking in rural Myanmar.
- We realized an expert participatory process to identify suitable Sustainable Land and Water Management practices.
- Water harvesting, Water Safety Plan and Soil Bioengineering were recommended.
- Poorest regions have the worst water management infrastructures.
- The study can inform future development projects in rural Myanmar.

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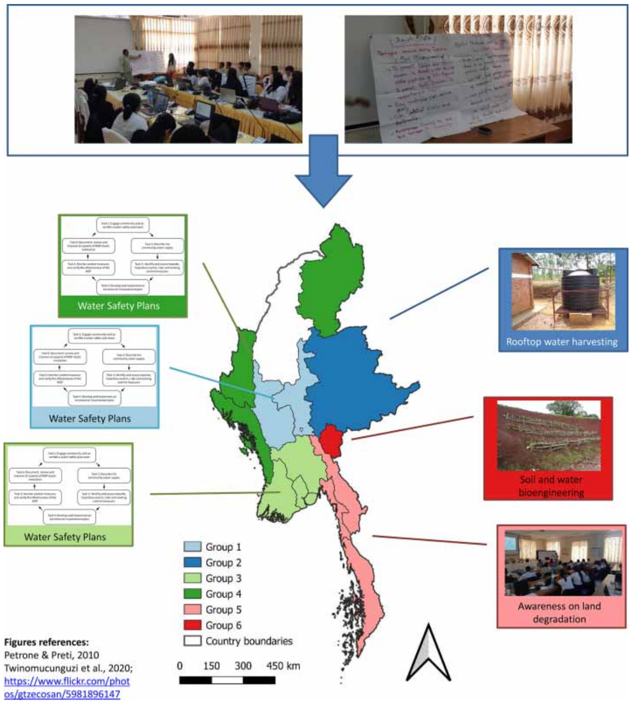
GRAPHICAL ABSTRACT



INTRODUCTION

Myanmar is rich in natural resources that can support human development and environmental health (World Bank 2019a). Water resources are abundant, but unevenly distributed due to variation in time (with 80% of rain falling in the rainy season) and space (FAO 2016; Taft & Evers 2016; Re *et al.* 2018). The country is still undergoing rapid political change; it was ruled by a military junta for three decades, until free elections of 2015 (World Bank 2019a). In this situation, the establishment of effective integrated water resources management (IWRM) is vital for the development of the country (Foran *et al.* 2019), and especially in rural areas, which accounts for 70% of the total population (UNFPA 2014). In this framework, according to the 'National Strategy for Rural Water Supply, Sanitation and Hygiene' (UNICEF 2016), some unsolved key issues in rural areas include the need for increasing water sanitation technologies for poorer households and in remote areas; management issues related to environmental impacts of water uses; and the structural weakness of monitoring and management information systems related to the water sector. These issues can be related to IWRM, since this approach makes claims for the integration of multiple uses of water, including the environment, and is also requesting the integration of data and approaches. The recent National Water Policy (National Water Resources Committee (NWRC) 2015) is further stressing an IWRM approach to water supply and sanitation, with a specific focus in rural areas, recognizing also the need for adequate capacity building and the setting up of adequate database and information systems.

However, while, especially at the level of small rural settlements, water management issues are jeopardizing the population's health and livelihoods, the water resources development focus in the country is still linked with large infrastructure development, aiming at tackling country-scale challenges (Taft & Evers 2016; Foran *et al.* 2019). On the other hand, in the latest years, UNESCO and UN Water have stressed the importance to reach also the day-to-day realities of vulnerable groups and small communities with adequate water resources planning and management, as stated in the 2019 World Water Development Report 'Leaving no one behind' (WWAP (UNESCO World Water Assessment Programme) 2019). In coordination with large infrastructures, small-scale water development efforts are then needed to secure the results of SDG 6, at the global scale as well as in Myanmar. Along with freshwater management issues, erosion and land degradation represent a major threat to rural livelihoods in the country, also considering that Myanmar has the highest erosion hazard of South Asia (Htwe *et al.* 2015).

In the framework of water resources development, especially within international cooperation projects and in rural development actions localized in small areas, the involvement of local stakeholders has proven to be fundamental to ensure good project outcomes, for the implementation of sustainable technological solutions, and for reducing inequalities (Alfredo *et al.* 2016; Castelli *et al.* 2018). However, if on the one hand, well-addressed stakeholders' participation can provide the identification of general basic needs, on the other, expert participation has been proven to be also fundamental. The latter is particularly useful for balancing population needs with feasible solutions, as well as for choosing technological options that local authorities can really manage even after the completion of international development projects (van Ast & Gerrits 2016).

This paper presents the results of a participatory process aiming at selecting sustainable land and water management (SLWM) practices for integrated rural development in Myanmar. The process was realized in two days, involving rural development officers of Myanmar Department of Rural Development (DRD), falling under the Ministry of Agriculture, Livestock and Irrigation (MOALI), devoted to the implementation of water access and sanitation in rural areas. The aim of this research work, is then, to present some useful options for small-scale rural land and water development in the country, focusing on rural water access and sanitation, and on water- and land-related hazards that threaten the environmental health of rural settlements (e.g., erosion, landslides and pollution). Issues related to water for food production were purposely not considered in order to have a narrower focus on the above-mentioned subjects and since a large body of literature is present about the topic for Myanmar (Matsuno *et al.* 2013; Rowell & Soe 2015; Than 2018). Moreover, according to Myanmar's administrative structure, the responsibilities of irrigation management are not held by DRD, but by the so-called Irrigation and Water Utilization Management Department. Given this premise, the present participatory process focuses on DRD topics of interest.

The scale of the present work is limited to the participatory process undertaken, but very few literature papers or studies have addressed possible small-scale water development options in Myanmar. Therefore, the paper can represent a baseline assessment useful for decision-making on investments in both future development cooperation projects and national development plans. The work provides an initial needs assessment and some suggestions regarding sustainable and feasible technical solutions for SLWM in Myanmar. Moreover, the methodology presented can be replicated in many similar contexts, providing a standard approach for a rapid – but still informed – assessment of water development needs in marginalized rural areas. Results can be considered for matching the objectives set by SDGs 6 'Clean Water and Sanitation', 11 'Sustainable Cities and Communities', and 15 'Life on Land'.

MYANMAR WATER RESOURCES AND RURAL DEVELOPMENT CONTEXT

Myanmar (Republic of Union of Myanmar) is located in South East Asia, approximately from 9°55′–28°15′N and 92°10′–101°11′E, with a maximum north–south extent of about 2,500 km and a maximum west–east extent of about 900 km. The country has mountain ranges in the north and in the west, while it is dominated by alluvial floodplains in the center. It is divided into 22 sub-national administrations including States, Regions, Union Territories, Self-Administered Zones and Self-Administered Divisions. The capital is Naypyidaw.

The major rivers of the country are the Ayeyarwady (Irrawaddy), the Salween, the Chindwin, and the Sittaung, where the first one is by far the largest and the most important one for the country, with a length of about 2,170 km. At the same time, part of the country relies on groundwater resources (some of them of alluvial origin), which are often affected by contamination issues and at risk of depletion due to increasing water demand (Pavelic *et al.* 2015). The monsoon season starts around the end of May and the beginning of June, lasting to September (Sen Roy & Kaur 2000). The annual rainfall amount has great variation, ranging from 500 to 1,000 mm in the central dry zone, to 4,000–6,000 mm on the western coast (FAO 2016). Rainy season diurnal temperatures can vary from 21 to 34 °C, while they drop to 11 to 23 °C in the cold season (Taft & Evers 2016). The country is still one of the most affected by climatic hazards, including floods, cyclones, and droughts (Kreft & Eckstein 2014).

According to the Myanmar Living Conditions Survey 2017 (Central Statistical Organization of the Ministry of Planning & Finance 2017), water access in rural areas has improved since 2015, first thanks to the private sector investment, and then with an increasing effort of DRD and its partner which have implemented around 5,000 water supply facilities per year around Myanmar. In these areas, many households must transport water from the source to the consumption point, increasing the risk of contamination by the use of dirty containers and storage systems. The worst situation in terms of access to improved water sources is in Rakhine State (Central Statistical Organization of the Ministry of Planning & Finance 2017). According to UNICEF (2020), one-third of rural houses lack improved water supplies, while the ratio of rural settlements with improved sanitation facilities is still not clear.

In this framework, it should be noticed that the need of higher control on water-related and environmental hazards is reported as a key challenge for safeguarding rural livelihoods (UNICEF 2016). It is evident how intense rainfall causes major floods and landslides in the country every year (Mon *et al.* 2018), further exacerbated by climate change (Herridge *et al.* 2019). The literature shows that in other similar rural contexts investing in erosion control and land management practices promoted the revitalization of marginal territories and the transformation of rural livelihoods (Yurui *et al.* 2019), and that on the other hand, landslides and severe soil erosion may hamper rural dwellers' well-being (Sudmeier-Rieux *et al.* 2013). Similar studies are absent for Myanmar, probably due to a lack of scientific analyses in rural areas. However, the landslide- and erosion-rural livelihood nexus was made evident by the personal communications given by the DRD officers involved in the participatory process.

METHODS

Training course and selected topics

Before undertaking the participatory selection of SLWM techniques and approaches, DRD officers were trained with a course of around 60 hours on 'Water Management and Disaster Risk Reduction'. The course represented the second edition of an action developed by 'GREAT – Management of Economic, Environmental and Land Resources in the Municipalities of Magway and Natmauk' project. In 2019, the first edition of the course was carried out within DRD, but with different participants. Based on the topics and on the final evaluation of the first edition, a renewed list of topics was suggested to DRD administration by the experts of Fondazione LINKS – Leading Innovation & Knowledge for Society and Università degli Studi di Firenze (Italy) to be cross-checked and confirmed, with specific regards to the practical needs of DRD field officers. After the feedback of DRD, the final program (Table 1) was confirmed.

The training lasted from 28/01/2020 to 07/02/2020 and was conducted by two Italian natural resources management experts. To facilitate information sharing with DRD officers, the course was fully translated by translators with expertise on GREAT project topics and objectives. An expert member of the central DRD administration also helped the coordination between the project team and course attendants. A total of 45 DRD officers trained and actively contributed to the subsequent participatory process, being selected under geographical and gender-equality criteria. The topics of the course, which also included practical training, are presented in Table 1.

Participatory selection of best SLWM practices

The participatory selection of best SLWM practices took place in the last 2 days of the course, in two sessions of

Table 1 | Topics selected for the training course undertaken before the participatory process

Lesson	Topics and main references
1	Driving forces, pressures, state, impacts and responses (DPSIR) framework (European Environmental Agency 1999); Ecosystem services (Costanza *et al.* 2017)
2	Introduction to sustainable water management; Integrated Water Resources Management (IWRM) (Global Water Partnership 2018)
3	Overview of climate change in Myanmar (Kreft & Eckstein 2014)
4	Sustainable groundwater development and management (IWMI 2015); DRASTIC methodology (US Environmental Protection Agency 1987)
5	Low cost supply methods for ground water development: Well protection and upgrading (Schneider 2014); Low cost pumping systems (Bresci *et al.* 2013)
6	Low cost supply methods for ground water development: sand dams (Maddrell & Neal 2013; Villani *et al.* 2018) and managed aquifer recharge (MAR) (Dillon *et al.* 2019)
7	Water safety plans (WSP) (WHO 2006; Rondi *et al.* 2015)
8	Low cost water and wastewater treatments (Collivignarelli *et al.* 2018)
9	Low cost rainwater harvesting technologies (Thomas & Martinson 2007; Mekdaschi Studer & Liniger 2013)
10	Soil and water conservation techniques (Liniger *et al.* 2007); Soil and water bioengineering (Petrone & Preti 2010)
11	Disaster risk reduction (UNISDR 2015)

2 hours each. To have a better geographic representation of the techniques to be considered, participants were divided in six groups of almost equal numerosity, based on their region of provenance (Figure 1).

Participants were asked to indicate the practices already applied in their respective regions, and SLWM techniques that could be put in place or that can respond to actual needs in their geographic area. For these latter ones, DRD officers were asked to identify the first, second, and third ones in order of priority, and to indicate which techniques could be implemented in the short term. Participants were then asked to present their findings by the means of a poster, that was presented and discussed with all courses' attendants and with the authors of the present paper.

RESULTS AND DISCUSSION

The practices selected with the participatory process are presented in Figure 2. The process made evident both the most urgent actions to be put in place and those at a piloting stage. A detailed description is provided in the following sub-sections.

Water safety plans and monitoring of water resources

Water safety plans represent community-based management strategies to ensure the safety of drinking water through the use of a risk assessment and management framework (WHO 2006). Plans can be implemented with a six-step iterative methodology, including: (1) the engagement of the community and the creation of a 'Water Safety Plan team'; (2) the description of the community water supply; (3) the identification of risks, including hazardous events and actual hazard evaluation, and the assessment of the existing control measures; (4) the development of an incremental improvement plan, including a detailed description of the actions to be put in place, responsibilities, and timing; (5) the monitoring of the implemented measures and of the effectiveness of the plan; (6) the documentation and the revision of all the aspects of the plan. WSP have been proven to represent flexible non-structural measures that can be implemented both in rural (Rondi *et al.* 2015; Twinomucunguzi *et al.* 2020) and in urban developed contexts (Sorlini *et al.* 2017). Application of WSP could be beneficial for rural water management in Myanmar, representing both a way to enhance rural water supply management and to develop local-scale monitoring networks and management committees. As a matter of fact, almost all groups indicated WSP as a priority measure that can be implemented in the short term.

Regarding the quality of basic water supply, groundwater, and in particular, well water has to be monitored. Some measures are in place, but the participatory workshop highlighted that common guidelines and procedures for wells' registering and monitoring are needed and should be implemented in all rural contexts of the country. The need is further justified given the fact that the quality of groundwater supply for drinking purposes is still uncertain in many regions (IWMI 2015).

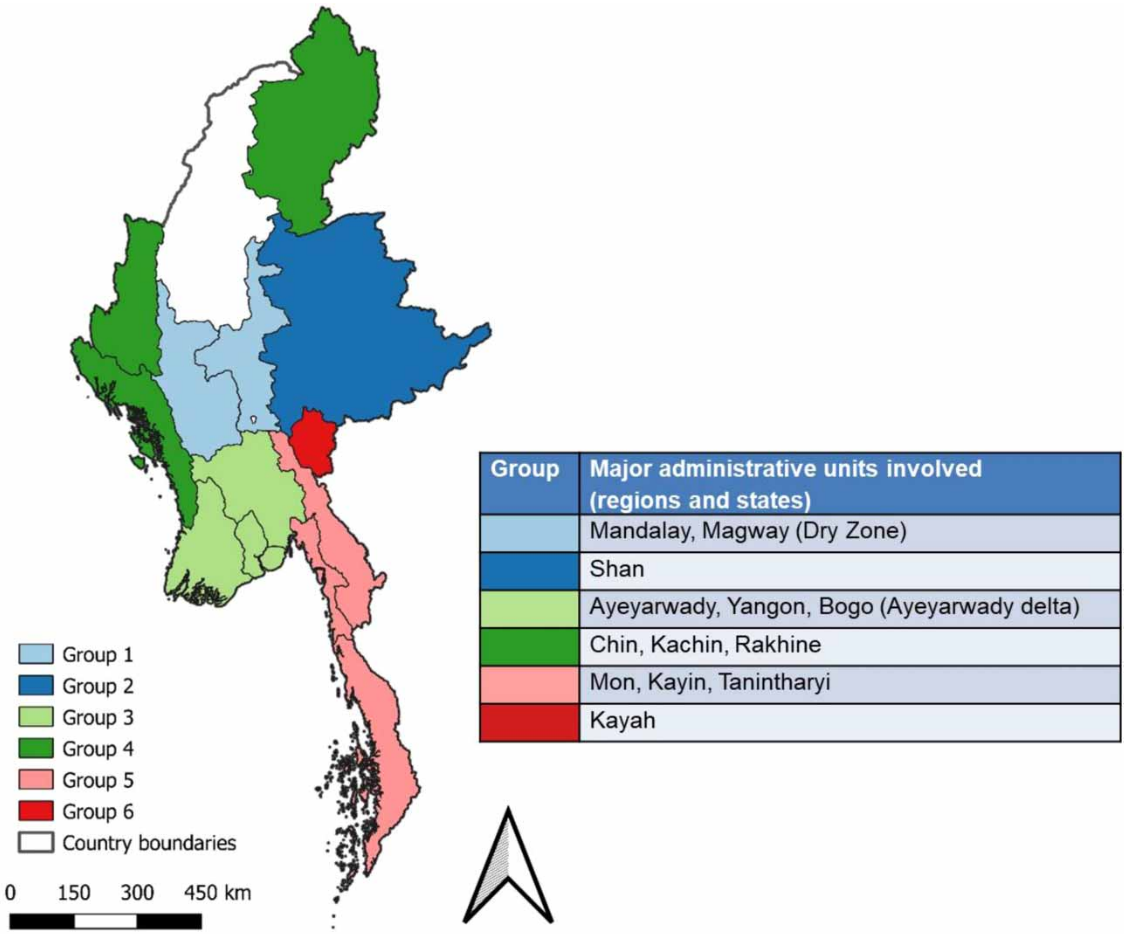


Figure 1 | Geographical localization of the groups created for the participatory process.

Sanitation and wastewater treatments

To the best of our knowledge, accurate data regarding water sanitation systems in rural areas are lacking for Myanmar. According to UNICEF (2016), despite a good coverage of basic sanitation systems, rural and the poorest households are facing some issues and may lack adequate sanitation systems. The urgency of working on improved sanitation facilities emerged for groups 1 and 4, and in particular, in the second one, including Chin, Kachin, and Rakhine States. It should be noted group 4 includes the two poorest areas of the country, since in Chin State almost six out of ten people are poor, while in Rakhine State about four out of ten are poor (World Bank 2019b). Here, a linkage between poverty conditions and the level of water management in rural areas is evident. It will, therefore, be crucial to invest in WASH planning for this latter area.

Water harvesting

Water harvesting techniques, namely, techniques that allow 'the process of concentrating precipitation through runoff and storing it for beneficial use' (Oweis & Hachum 2006) received great attention during the participatory process. The main interest of DRD officers was for rooftop water harvesting systems (Thomas & Martinson 2007), sand dams (Maddrell & Neal 2013), as well as small ponds (FAO 2010). Rooftop water harvesting was recognized as a key measure for securing water supply in rural areas. According to the Myanmar IWRM study (van Meel *et al.* 2014), in many

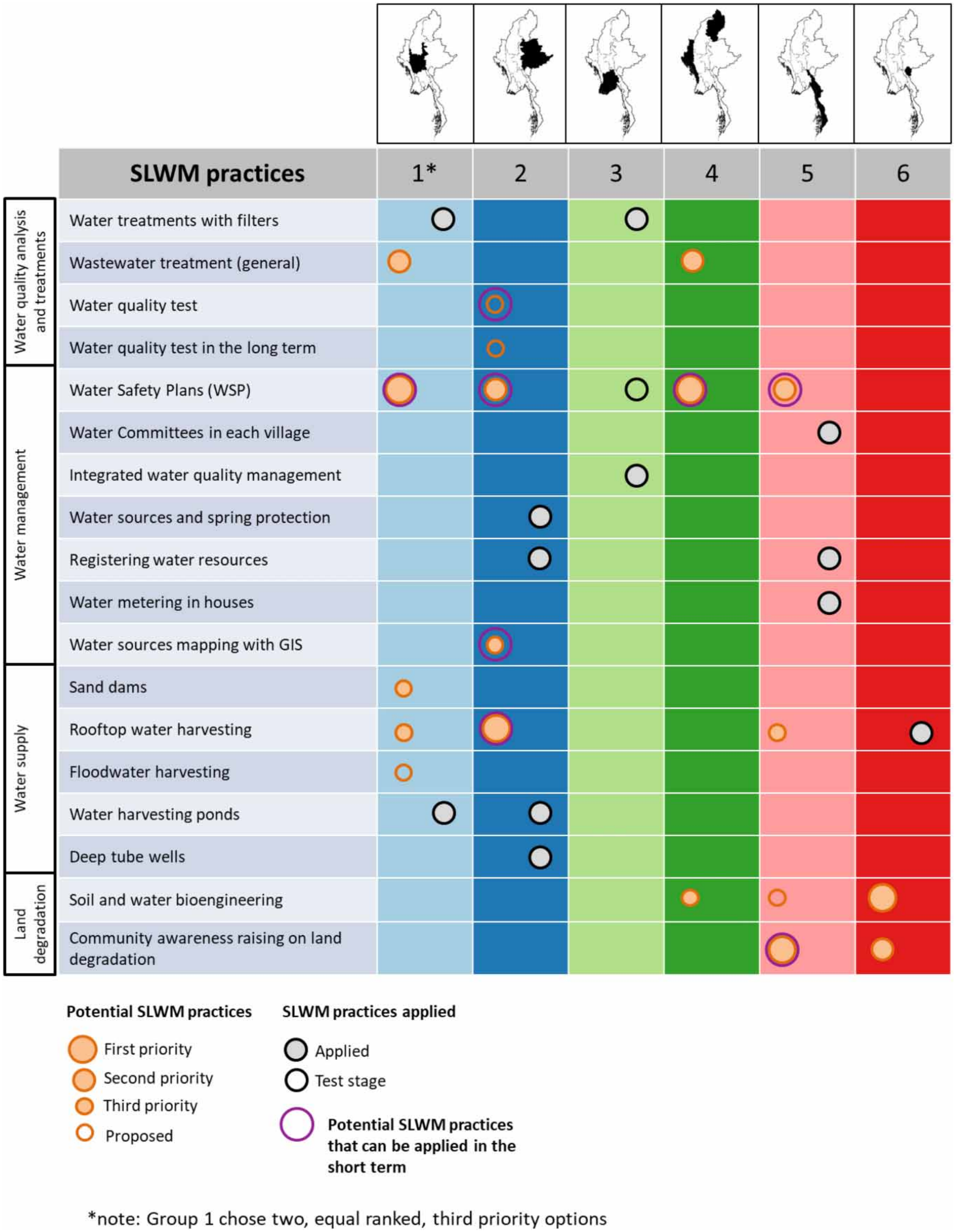


Figure 2 | Participatory selection of best SLWM practices for rural water management in different areas of Myanmar.

rural areas rooftop water harvesting, and water harvesting in general, are almost the sole source of water. Despite this, integrated country-scale plans for establishing a common design and management guidelines seems to be lacking. DRD officers' interest regarding water harvesting technologies encompassed also larger-scale solutions (sand dams and ponds/small dams). Even though DRD officers are not responsible for irrigation management, in some cases they follow the building of small civil infrastructures such as the ones mentioned. While sand dams have been seen as an innovative technology, it is necessary to further train the technical DRD personnel on their correct design and implementation. In addition to this, other studies referred to Myanmar as a hotspot for the potential increase of crop yields by water harvesting (Piemontese *et al.* 2020).

Soil and water bioengineering

Soil and water bioengineering is a civil engineering technique based on the use of live building material, alone or integrated with standard materials for applications such as landslide/riverbank stabilization, erosion control, and road protection (Petrone & Preti 2010; Rey *et al.* 2019). It received some attention during the participatory workshop as a means of reducing erosion hazards and protect key infrastructures in rural areas, such as streets, pipes, power and water treatment plants. Its potential was also highlighted as a control measure to be implemented in the development of rural WSP. Since soil and water bioengineering represent a cost-effective approach if labor cost is low (Petrone & Preti 2010), its application can be appropriate for Myanmar rural contexts. Its application, however, will require adequate preliminary studies to check to what extent local tree and shrub species can represent adequate building materials (Preti & Petrone 2013).

DISCUSSION AND CONCLUSIONS

The present paper describes the findings of a participatory process undertaken involving Myanmar DRD officers, in order to analyze and present SLWM practices to improve water and wastewater management in rural areas of the country. These areas, that will be key for an equitable development of the country after the end of the 30-year military government, have so far received little attention at the research level.

Key findings of the study were:

- WSP can represent a win-win measure to both improve the safety of rural water supply and to establish a ground-level monitoring network to check the status of water supply systems in the country. DRD has to be involved in their adoption, which should comply with WHO guidelines in every regional state.
- Detailed analysis and a national monitoring system may be needed with reference to the quality of groundwater sources, especially for wells. Well registering platforms should be extended to all rural areas in the country, as well as long-term groundwater quality monitoring.
- Information about the level of wastewater technologies present in rural areas should be gathered and systematized, while special attention should be given to retrieve funding for improving these infrastructures in the poorest areas, and for awareness-raising on water quality-related issues among rural communities.
- Water harvesting has the potential to supply part of the poor rural population with at least a stable source of water for domestic uses. Its application, however, should be further implemented with a national strategy.
- Soil and water bioengineering has the potential to be applied for erosion and landslide control measure, but further assessment on its suitability in the country are needed. The application of this latter technology may go beyond DRD's own task and will need to be planned also involving other departments of MOALI.

Despite the limited timeframe (2-day workshop) and the link with the technologies presented in the course, the present study represents a first structured attempt to highlight problems and potential solutions related to water supply, wastewater management, and water-related hazards in rural areas of Myanmar. The present findings can represent an initial step for future water development projects, both for international cooperation agencies and for national initiatives. However, for any further initiative, we also recommend the full integration of forthcoming project efforts with actions and strategies already put in place by the Myanmar government, such as the recent Rural Development Law.

Results also highlighted some evident nexus between rural poverty conditions and weak water systems management, that should be further investigated to highlight the multiple interlinkages between water and poverty in the country. Finally, the good participation of DRD staff and the outcomes of the process demonstrated that the proposed methodology can provide meaningful information and could, therefore, be upscaled and implemented in other contexts.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

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