MAY 2021 VOL. 2 ISSUE 1

# ADRiMP

*Association for Disaster Risk Management Professionals*

IN THIS ISSUE



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## Note from the President

At the time we face challenges due to COVID-19, it is important to focus and start thinking of Disaster Risk Reduction options at family and community levels. Hope everyone is following the health guidelines and staying safe. COVID-19 is a zoonotic disease and these new diseases are emerging at an alarming rate, driven by humanity's broken relationship with nature. Humans, animals and the environment are inextricably linked, therefore changes to land use planning settings are needed to minimize such interactions. As part of DRR, we need to minimize deforestation and loss of biodiversity to reduce the potential spread of new diseases from animals to humans. In that context, COVID-19 also provided us with an opportunity to rethink the way we live and how we can work intensively on principles of circular economy, sustainable agriculture systems, sustainable consumption and production and eco-friendly approaches contributing to enhanced Nature Based Solutions (NbS) and Ecosystem Based Disaster Risk Reduction (Eco-DRR) as highlighted in several articles in this issue. While wishing the members and readers a safer Sri Lanka, it is important that ADRiMP expand our role in DRR too. Kindly provide us with suggestions and information on this regard.

**Dr. Ananda Mallawatantri**
President of the Association of Disaster Risk Management Professionals (ADRiMP) Sri Lanka

MAY 2021 VOL. 2 ISSUE 1

# Mainstreaming Eco-DRR Towards Disaster Resilience

**ECOSYSTEM-BASED DISASTER RISK REDUCTION (ECO-DRR)**

"Sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience."

(PARTNERSHIP FOR ECO-DRR)

The overarching objective of mainstreaming Eco-DRR is to obtain disaster resilience while attracting economic gains in a given region or a community. At the same time, the implementation of Eco-DRR is expected to help achieve the objectives of large public investments in water supply and irrigation and resisting the forces of nature such as cyclones, and sea surges.

**NATURE-BASED SOLUTIONS (NBS)**

IUCN defines nature-based solutions (NbS) as "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

Often times Eco-DRR is associated with Nature-based Solutions (NbS). The fundamentals of NbS are derived from established practices such as forest landscape restoration, integrated water resource management, etc.

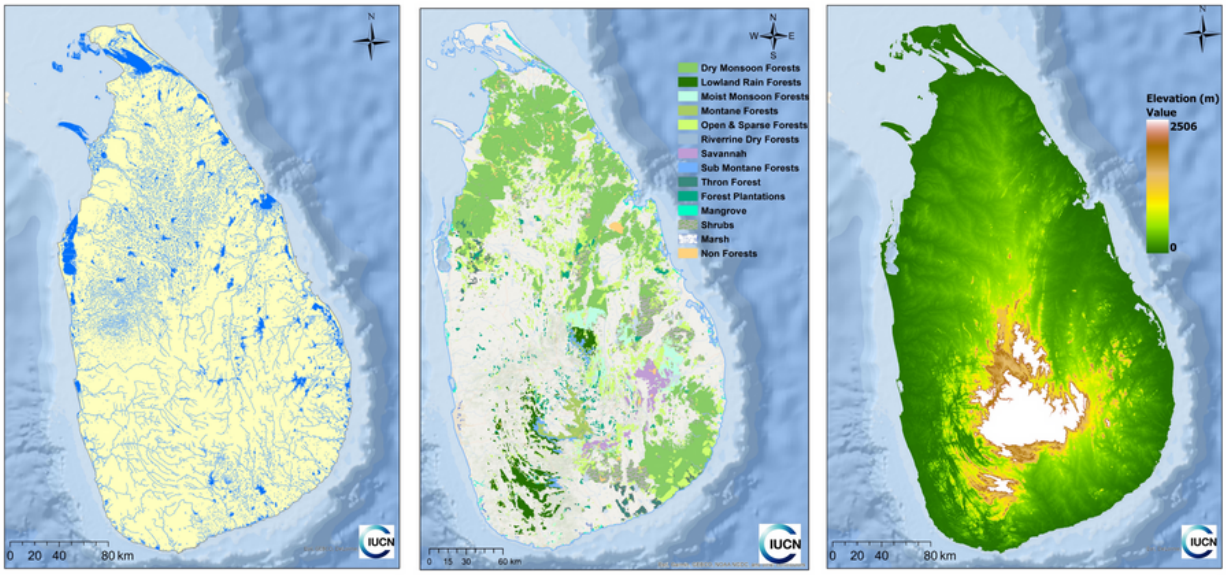
The NbS led Eco-DRR simultaneously work with Land, Water, Climate and Ocean depending on the type of natural disasters prevailing in each area. The empowerment of youth and communities consists of recognizing the context through data and maps; planning to retain much of the ecosystems in the interventions; restoring the lost ecosystems to generate economic and resilient benefits to communities; finding the resources through government, private and other green financing options; and reconnecting with all stakeholders to ensure that the plans are truly multi-sector and multi-stakeholder based.

In this context, the district and divisional level planning units and the associated Economic Development and Development Officers could play a key role along with youth from the area. To provide a comprehensive approach, Eco-DRR can be combined with multiple societal challenges in Eco-DRR planning.

In this newsletter, a few key areas crucial in mainstreaming Eco-DRR practices are identified.


Societal benefits by implementing NbS led Eco-DRR and EbA. Source (IUCN)

# 1. Ecosystems and Ecosystem Health



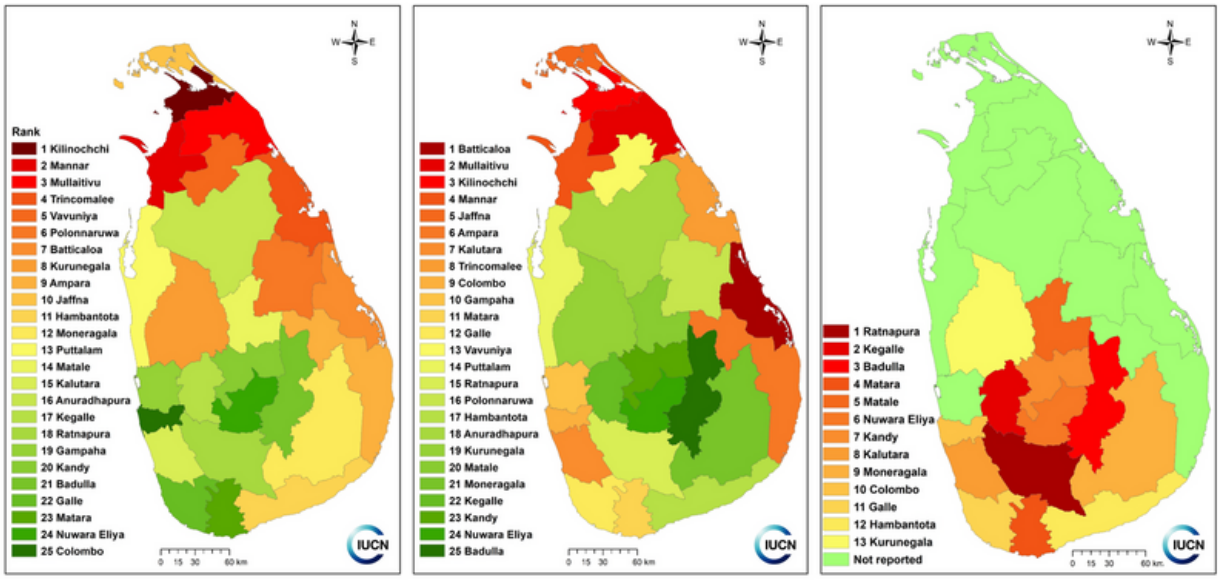

(L-R) Surface Water Bodies; Forests; and Slope Steepness

Sri Lanka is blessed with multiple ecosystems ranging from central hills to coastal marine. These systems are influenced by different climates and landscape variability. Human behaviour, land use patterns (urban, industrial, agriculture etc.) and climate change also affect the health of these ecosystems.

The "DisInventar" database managed by the Disaster Management Centre (DMC) provides historical information on disaster events, damages and losses etc. covering droughts, floods, landslides, animal attacks etc.

The climate related key disasters, namely, droughts, floods and landslides (sea level rise is yet to be seen) are distributed across the districts and the ranks of each district based on the disaster impacted populations between 2005 to 2015 period provides an opportunity to consider Eco-DRR measures based on district level.

The impact of disasters on people could be minimized by understanding their environment and improving the health of the ecosystem exposed to disaster challenges. Eco-DRR concepts help us to identify the elements and factors important in ecosystem health. Several key components describe the ecosystem health and each component is influenced by stressors mostly arising from human behaviours. Therefore, development programmes and Eco-DRR could focus on the components and plan to reduce the stressors.



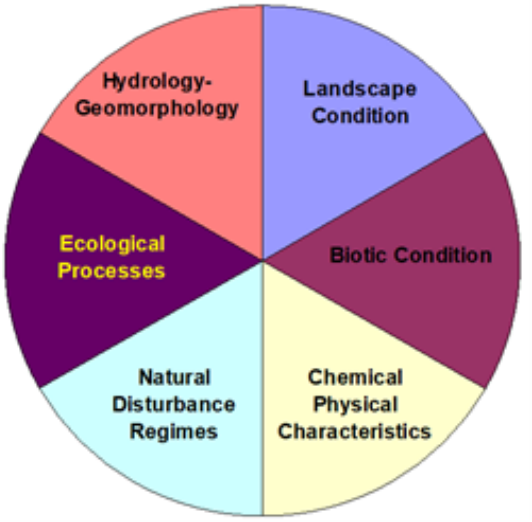

(L-R) Percentage of Population Affected by Droughts, Floods and Landslides by District

Hydrology and Geomorphology: Hydrology provides us with an idea of how the water flows within systems (soils) and geomorphology explains the origin and evolution of landscape features. Taken together, hydrology and geomorphology, provide information on the water movement and extent of land degradation. Modification of the hydrologic regime by development efforts such as roads, buildings, filling of wetlands, adding pavements and tar surfaces, aggravate disaster potential while reducing resilience capacity of the system. Further, the land use changes could modify the hydrology and impact the elements of the water cycle such as cloud capturing, infiltration of water to ground etc., reducing the water availability to tanks and reservoirs leading to droughts, among other socio-economic issues.

Landscape Conditions: This includes, mostly, unplanned human interventions (agriculture, construction etc.) induced degraded conditions. Landscape conditions may be explained by the richness of the vegetation, soil quality and extent of erosion and the quality of the landscape is directly connected with hydrology and water availability for multiple purposes. Therefore, the management of landscapes is considered a key aspect in Eco-DRR. Knowledge of the landscape condition decides the Eco-DRR measures required to rehabilitate the landscapes and an idea of the costs and technologies required.

Biotic Conditions: Biotic conditions allow us to understand how easy it is for an organism to survive and grow in each environment. These conditions are also influenced heavily by human actions.

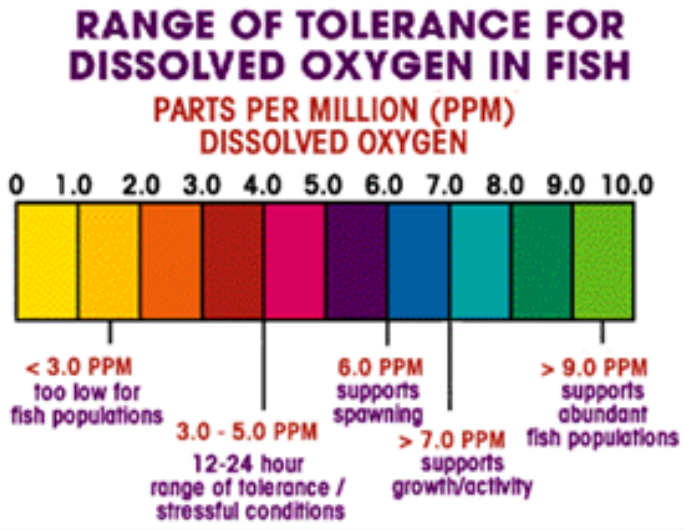
For example, bee populations supporting pollination are severely and negatively affected by excessive use of pesticides. Similarly, the fish in water may prefer better sunlight, high dissolved oxygen, and high availability of food. When the dissolved oxygen level in water reduces below 3 parts per million (ppm), life forms such as fish may not survive (Figure 6). The main stressors could be the eutrophic conditions in water bodies as a result of the excessive leaking of fertilizer nutrients or additions of waste rich with phosphorus and nitrogen.




Components of ecosystem health

Fragmentation of forest patches due to chena cultivation and cattle grazing in elephant feeding areas are stressors leading to human-elephant conflicts. Changes to the biotic conditions promote elephants to visit villages and paddy fields for food. Fragmentation of forest corridors also leads to leopard attacks in villages.

Climate induced temperature increases, sea level rise led intrusion of seawater to groundwater etc. may also change the biotic conditions. Unplanned urban developments and associated habitat changes will also change biodiversity, compounded by climate or human induced elevated temperatures, loss of wetlands etc.




Dissolved oxygen level and fish growth

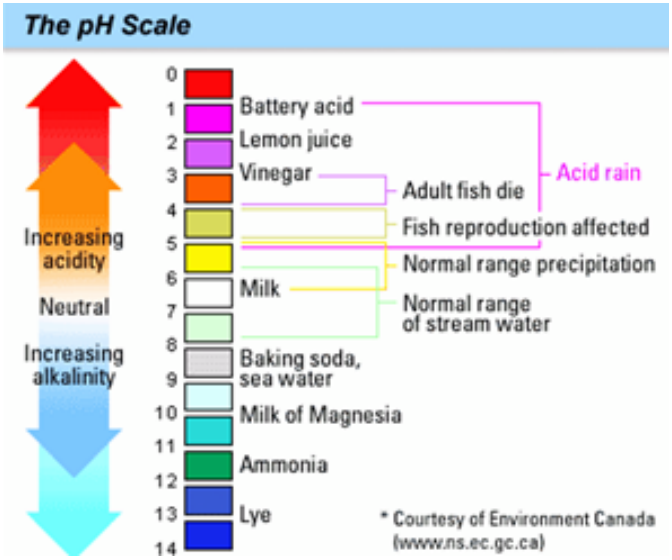
Chemical and Physical Characteristics: These actors indicate the conditions of the ecosystem and its ability to support lifeforms. Chemical characteristics related to air quality are expressed in terms of carbon monoxide, PM20, oxides of nitrogen in vehicle emissions etc. In water, the primary chemical characteristics include pH, dissolved oxygen, biochemical oxygen demand, pathogens, metals, and pollutants emerging from electronics, medicines, agriculture etc.

Physical characteristics include the shapes of elements. For example, a stream may have cobbles that allow the mixing of air in water—a physical condition that decides the dissolved oxygen amount in water. Acidity in water—a chemical condition may decide how healthy the water is for fish. For example, if industrial discharges increase the acidity levels below pH = 5 (lower the pH more acidic the water), the fish may die. The healthy streams should have neutral conditions indicated by pH = 6 to 8.

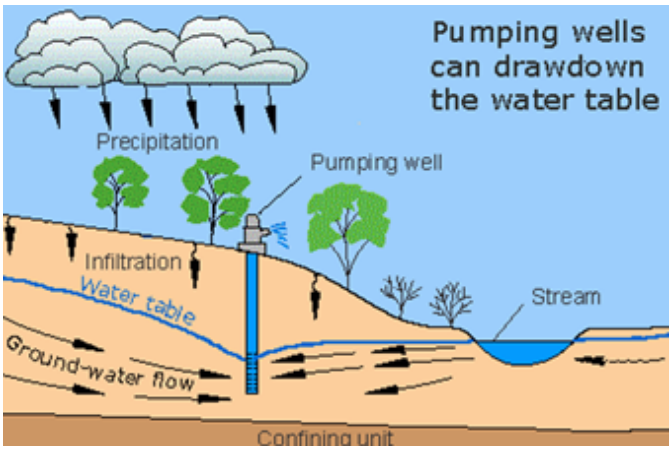
Natural Disturbances: Sometimes, natural disturbances also generate environmental stresses. For example, cyclones, floods, and landslides could cause changes to the environment significantly—permanently or reversible.

Further, human induced conditions could aggravate the impacts of natural disturbances. Removal of sand dunes are known to enhance tsunami damage. Similarly, over-pumping of groundwater could induce seawater intrusion into the groundwater system. Agriculture erosion in degraded soils and flash floods when the urban areas have more tar and paved surfaces could be considered as disturbances that can be controlled and managed via Eco-DRR.

Ecological Processes: There could be multiple ecological processes, and some are important for Eco-DRR mainstreaming. For example, the erosion from degraded slopes, water cycle, the advantage of green cover in reducing air temperature and capturing water from clouds, climate induced rainfall intensity on erosion etc. could be explained better using the ecology and ecological processes.




The pH Scale




Groundwater and stream water

Understanding the components of the water cycle (Figure 9) and how each component is being impacted by human actions and climate change could be one of the entry points in mainstreaming Eco-DRR.

This information could be combined with several ecosystem management tools at the landscape level such as Strategic Environment Assessments (SEAs), Restoration Opportunities Assessment Methodology (ROAM) etc. to arrive at policy decisions to ground level management decisions in Eco-DRR mainstreamed planning. Often times, these plans need to be supported by environmental measurements such as streamflow volumes, water quality parameters and bioindicators related to the health of the ecosystems.

# 2. Land Use Planning

Land use management to minimize wildlife threats and promote ecotourism (Picture: Sampath Goonathilake, IUCN)

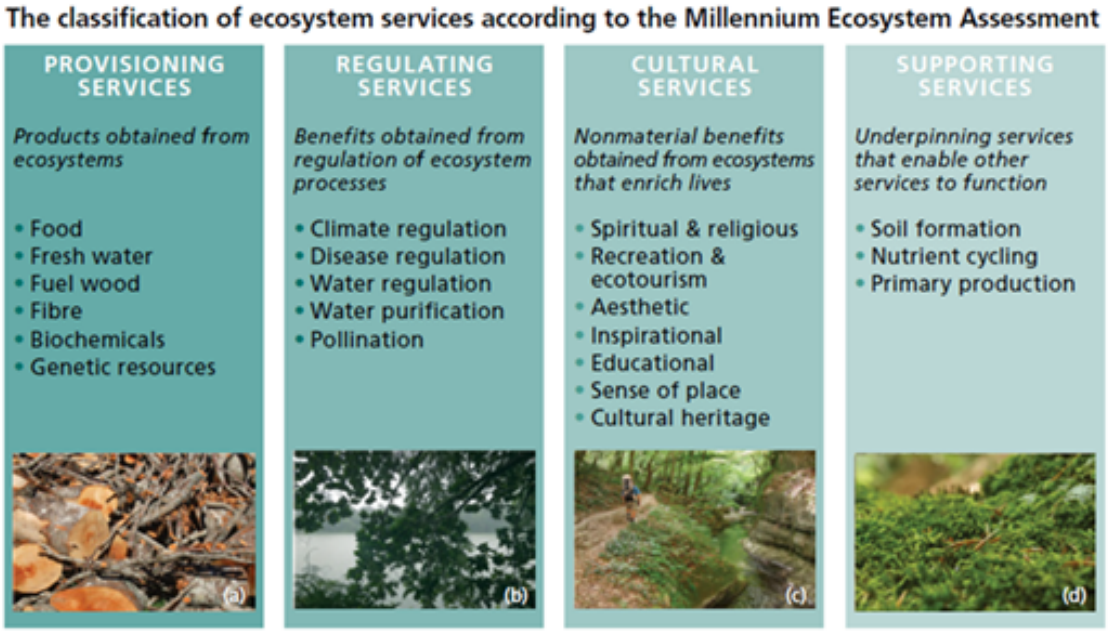
Sri Lanka as an island nation with rich biodiversity is dependent heavily on agriculture, supported by ecosystem services and tourism and other services linked to nature-culture-heritage. As such, the land use management in the country could use ecosystem approaches not only to reduce disasters but also to avoid land use conflicts leading to disasters such as human-animal conflicts.

The Millennium Ecosystem Assessment is a good guide to understand the ecosystem services that are vital for socio-economic development and resilience. Ensuring ecosystem services is one of the key objectives in land use planning and Eco-DRR in Sri Lanka.

Eco-DRR provides an opportunity to access the landscape for conservation and development or a mix of both. Scientific assessment using a multi-stakeholder and multi-sector group in line with a Strategic Environment Assessment (SEA) would help to mainstream Eco-DRR in landscape situations to harness the optimal benefits.

In the process, it is necessary to identify the most critical landscapes required to ensure ecosystem services and then use the other lands for agriculture, industrial and other production/development. The following scheme of land selection illustrates a sequence that can be used to isolate lands for development purposes while ensuring ecosystem services that are required for resilience. The lands could be identified and conserved in the following order to achieve the Eco-DRR objectives.

- High watershed area forests situated 5,000 feet above sea level
- Catchment areas of reservoirs, tanks, and other water sources
- Lands that are situated at slopes equal to or above 60 degrees
- Critical habitats including crucial biodiversity areas (point endemic, endemic, threatened and range-restricted species occur)
- All wet zone closed-canopy forests outside of protected areas



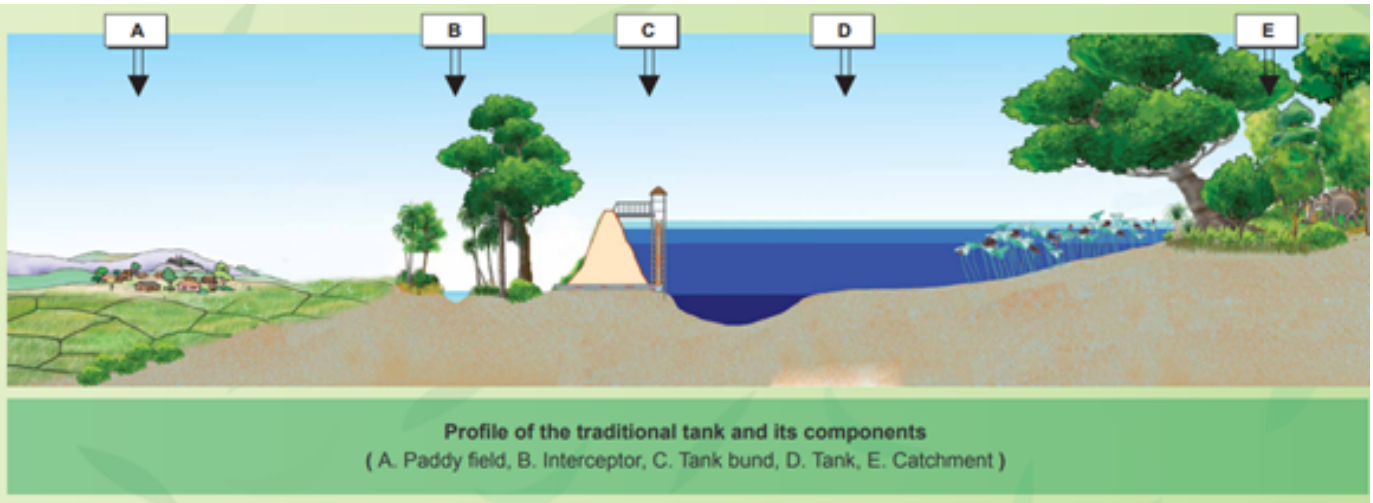

Classification of ecosystem service according to Millennium Ecosystem Assessment

# 3. Restoration of Small Tanks

Irrigation tank cascade systems in the dry zone of Sri Lanka, created over thousands of years ago by ancient kings, contributes to the economic, social, cultural, environmental aspects and community resilience, in the dry zone of Sri Lanka. However, the principles and science behind the tank systems are very much applicable in other areas including urban settings in the modern context as constructed wetlands or filter strips.

Tanks in the dry zone are designed to capture the rain primarily from the North-East Monsoon. They prevent floods and store water on the surface and ground, minimizing drought potential.

The role these tanks has in "climate adaptation" is extremely important to provide water for humans, animals and to maintain the ecosystem balance—a complete package of Eco-DRR.



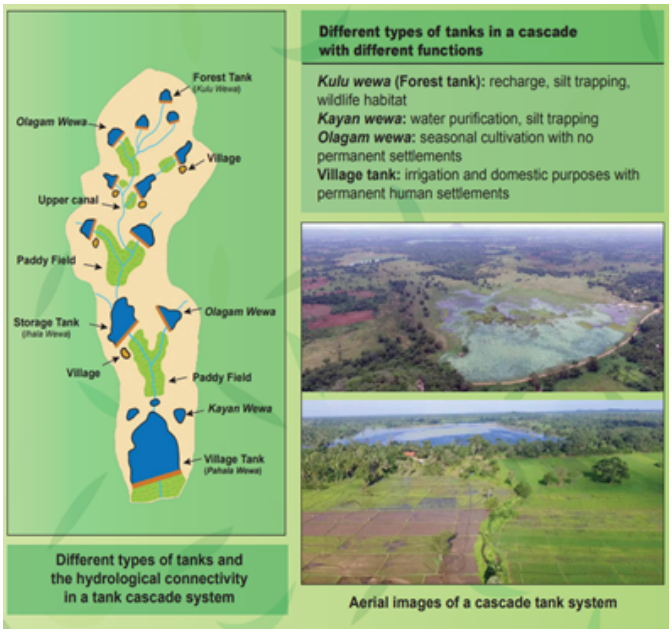

Tank, paddy fields and catchment

Tanks in the dry zone have been designed to provide the same water multiple times to paddy fields located in sequence, geographically. These systems are called tank cascades where water use efficiency is more than three times.

At the same time, within a cluster of a given tank system, there are smaller water holding areas to support the main village tank (Maha wewa) that provide most of the water for drinking, irrigation and household work, including bathing for humans and animals. Villages and catchments are positioned in the landscape to facilitate the functions of the entire system, although some small tanks have been levelled for agriculture due to the lack of system knowledge. Therefore, in Eco-DRR it is important to understand the functions of tank systems and act and plan accordingly, especially in land use planning and restoration of tank systems.

The Ihala Wewa or the tank upstream is a tank that holds additional water, which will eventually be used by the main tank.

Goda Wala is a water hole to be used by animals for drinking. In the landscape of the micro-catchment, the grass patches and other vegetation minimize the silt that is transported into the tank system through natural filtering.

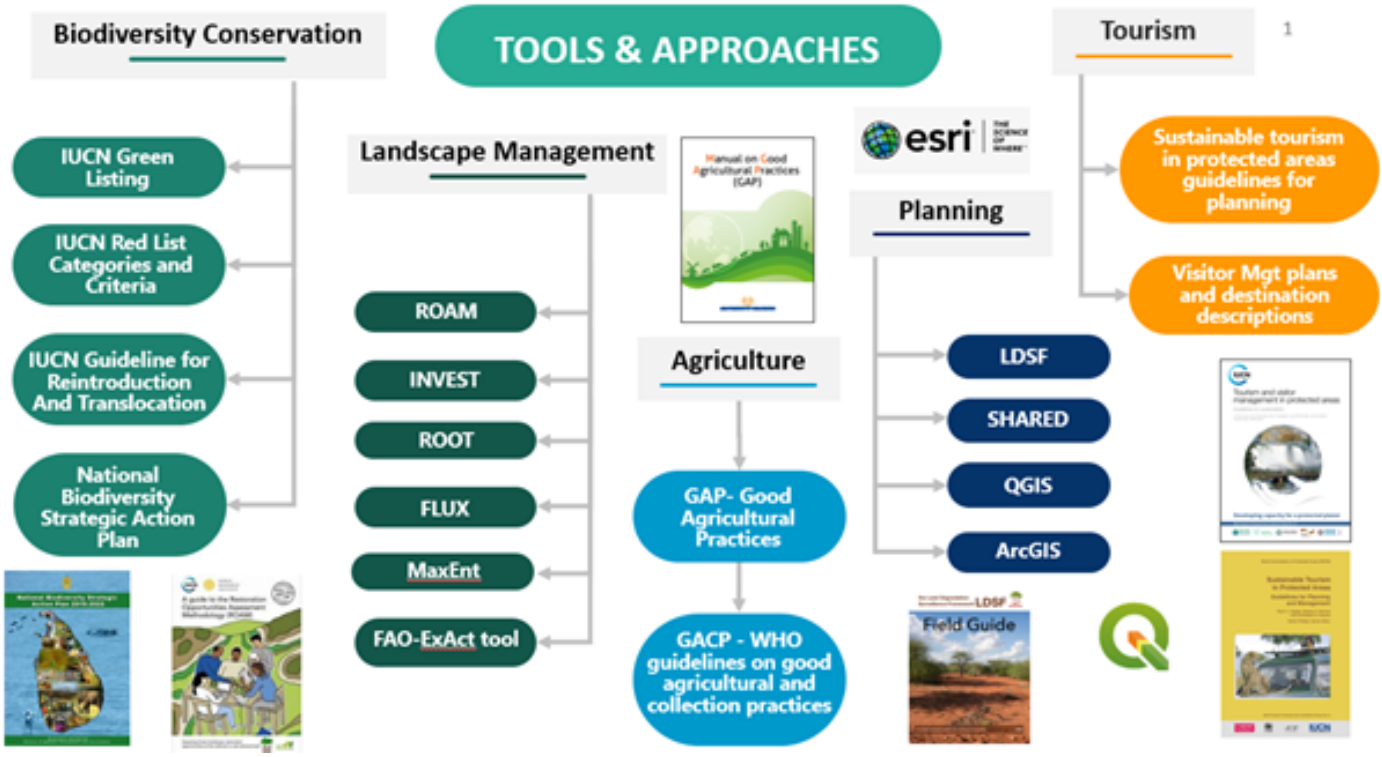



Elements in a tank system

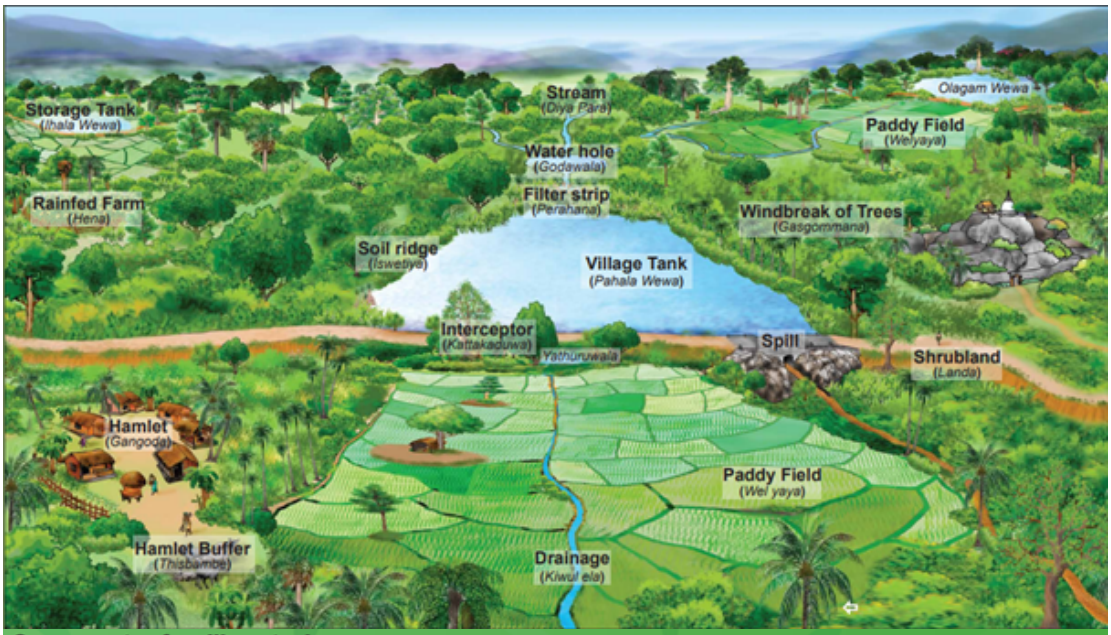
- Areas that cover unique ecosystems (Mangroves, Villus, thermal marshes, swamp forests, etc.)
- Animal migration paths including areas that connect two adjacent protected areas, elephant corridors and bird migration paths
- Migratory species' feeding grounds
- Archaeological monument sites and reserves
- Lands recognized for traditional, cultural and spiritual values
- Proposed protected areas identified by the DWC, FD, CC&CRM, CEA etc

Once this identification is performed, it is necessary to engage in a process of designing for the lands identified for development and to increase the ecosystem value in the lands identified for conservation. It is important to keep in mind that these lands with conservation potential also contributes to the economic development by way of ecotourism, sustainable forest products, pollination and timber benefits, water for hydropower, irrigation and drinking etc.

In this context, the land uses can be agreed upon among agencies and the communities so that the communities will understand and protect and protect the lands that are set up for conservation while enjoying the development benefits of other lands. In order to do so, the capacity of the agencies and the stakeholders needs to be developed on sustainable land management and fortunately, there are a number of local and global efforts that can be used to provide the needed capacity.




Selected local and global tools for sustainable land management capacity building




**Components of a village tank**

- *Diya-para* (stream); seasonal stream
- *Perahana* (filter): a strip of grass and reeds on the periphery of the water body that acts as filter to trap silt;
- *Godawala* (water hole): an upstream sediment trap;
- *Gasgommana* (windbreak of trees): an area planted with large trees that act as a windbreak to minimise evaporation from the surface of the tank;
- *Iswetiya* (soil ridge): an upstream bund to manage soil erosion and sedimentation;
- *Kattakaduwa* (interceptor): the stretch between the tank bund and paddy fields. This acts as a downstream wind barrier, reduces tank seepage, prevents sodium, magnesium and iron from entering the paddy land.
- *Wel yaya* (paddy field): developed for paddy cultivation; and
- *Kivul ela* (drainage): common drain of the irrigated area.

Several scientifically advanced ecosystem-based approaches are used to enhance and maintain the intended tank functions. These include wind barriers or "gasgommana" used to reduce the evaporation of water; salinity barriers or "kattakaduwa" used to remove salts before irrigating; and grass/green filters or "perahana" used to trap silt from upper catchment entering tanks, among other things.

"Gasgommana – windbreak of trees" is not only useful in reducing the evaporation in tanks but could also be replicated in urban areas to minimize temperature and evaporation of water in wetlands and water bodies. The idea of "Parehana" could be used in urban settings to filter the rainwater mixed with oil and other chemicals before they get into the groundwater and streams.

Due to the development and resettlement initiatives carried out without proper attention to ecosystem approaches used by ancient kings and poor understanding of tank functions, the effectiveness of these tank systems has been impacted.

Some tanks have been filled to claim the lands for agriculture. These land use practices have increased deforestation, erosion, water pollution, filling of tanks with sediment, loss of biodiversity and reduction of water quantity and quality, eutrophication due to nutrient accumulation and spread of invasive alien species. The overall quality of tanks and their supportive ecosystems has degraded thus reducing the ability to provide the "integrated socio-ecological system" contributions extremely valuable for disaster resilience and socio-economics.

Opportunity exists to use ecosystem knowledge effectively to restore these tanks towards improved food security and disaster risk reduction while meeting climate challenges. Optimal results for tank restoration can be achieved by combining the ecosystem knowledge to improve the tank functions with modern civil and other engineering advances combined with community participation.

# Introduction of Soil Bioengineering as a Non-Structural Slope Stabilization Measure

Soil bioengineering is the use of plant-based material, living or dead, to alleviate environmental problems such as shallow and rapid landslides, eroding slopes, stream banks, and cut- slopes. In bioengineering systems, plants are an essential structural component. Soil bioengineering most frequently mimics nature by using locally available materials and minimum heavy equipment. It can give an affordable path to resolve local environmental problems. These techniques may be utilized in combination with traditional engineering techniques like rock or concrete structures as a non-structural measure.

The application of soil bioengineering techniques depends on the type of abrasion and slope failure process. Topography, local geology, location of the landslide on the slope, steepness of the slope, the thickness of debris or soil, soil texture, biotic influences are mainly considered in designing landslide treatment. Environmental criteria like sensitiveness of the slope to erosion/mass movement, the potential for downstream damage, agricultural field, settlement, road and other infrastructure, and socioeconomic criteria-like demand of local people, the possibility of the participation of individuals, budget limitation, and extent of the impact on people's livelihood should be further considered for landslide treatment.

The main soil bioengineering techniques utilized in some countries are brush layering, palisades, live check dams, fascines, and vegetative stone pitching. Brush layers armour and reinforce the upper soil layers because the roots anchor and reinforce the soil to catch any additional debris

In this mechanism, hardwood cuttings are laid in lines across the slopes, usually following the contour. The formation of the cuttings protrudes just beyond the face of the slopes, where they grow buds and leaves that intercept rainfall, slow runoff and filter sediments. Palisades are generally used for the defence of deep, narrow V-shaped gullies.

The most successful disaster risk reduction method is mitigation, which consists of both structural and non-structural solutions. In structural mitigation measures, the artificial materials used are very costly, on the contrary, non-structural mitigation measures use cost-effective natural materials including living materials such as flora and fauna and non-living materials such as woody, rocky material etc. The introduction of non-structural mitigation measure is timely and useful because of the economic circumstances of developing countries like Sri Lanka.

Therefore, nature-based solutions should be implemented to shallow landslides and high hazard areas after properly studying soil science and bioengineering characteristics of the selected areas. In nature-based risk mitigation, plants play a vital role and are demonstrated in experiments conducted in other countries. Improving soil bioengineering decision-making skills is incredibly important for officials engaged in landslide mitigation work.

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MAY 2021 VOL. 2 ISSUE 1

# Making Hospitals Safe - Adapting WHO Safe Hospitals Initiative to Sri Lankan Hospitals

COVID-19 has demonstrated the importance of broadening hospital resilience beyond natural and man-made hazards to outbreaks. In parallel to the burden of the COVID-19 pandemic, hospitals had to face impacts of other natural and manmade hazards. For instance, an earthquake of 5.3 magnitudes caused the evacuation of several hospitals in the capital of Croatia (Čivljak et al., 2020). Recently a fire broke out due to an explosion of an oxygen tank in a hospital in Baghdad, Iraq which had killed 82 people (Tawfeeq, 2021). These synergized impacts of multiple hazards on healthcare facilities have severely threatened patients' and healthcare workers' safety. Foreseeing these impacts of disasters and emergencies on hospitals, the World Health Organization (WHO) and Pan American Health Organization (PAHO) launched the 'Safe Hospitals' initiative and the Hospital Safety Index (HSI), to strengthen the safety and preparedness of hospitals. A safe hospital has to continue its functions during a disaster without collapsing due to the impact of the disaster (WHO, 2015).

The 'Safe Hospitals' concept by the WHO was initially developed for Latin American countries where cyclones and earthquakes are identified as the predominant hazards (Raeisi et al., 2018). This initiative has brought remarkable benefits to several Latin American countries. For instance, fifty medical care units in Mexico collapsed in the earthquakes of September 1985. Over 1000 healthcare workers were found dead inside hospitals and more than 1200 beds were lost. Thirty-two years later, the earthquake that hit Mexico in September of 2017 caused no deaths inside healthcare facilities. Moreover, no structural collapses were reported in hospital buildings (PAHO, 2019).

Due to the dire need for safeguarding healthcare facilities from disasters, countries worldwide have launched the Safe Hospitals initiative after adapting the framework to better suit the context of their countries as recommended by the World Health Organization. The WHO has also identified the presence of a national safe hospital programme and its inclusion in the national disaster and emergency management mechanism as indicators of the 'Safe Hospital' initiative (WHO, 2015).

Elaborating on attempts taken in the South East Asia region, the Kathmandu Declaration on the protection of health facilities from disasters was adopted in 2009 committing member countries of the region to make health facilities resilient (World Health Organization, 2009).

***Launching 'Safe Hospitals' concept in Sri Lanka***


*Training on Safe Hospitals in Sri Lanka, 2014*

In Sri Lanka, the Disaster Preparedness and Response Division (DPRD) of the Ministry of Health identified the Safe Hospital Initiative as the strategy to integrate disaster risk reduction into the health sector. At the initial stages, the DPRD has assessed the capacities of hospitals on emergency preparedness and response with the support of the WHO. For instance, a 3-day training course on Safe Hospitals during emergencies and disasters was conducted in 2014 for health and health-related professionals in the country (Joson, 2014).

In 2017, the Ministry of Health, Sri Lanka (MOHSL) started adapting the 'Safe Hospitals'

initiative to Sri Lankan hospitals since damage to healthcare infrastructures from natural hazards is comparatively high in a situation where limited financial allocations are made for the health sector. The Disaster Preparedness and Response Division (DPRD) of the MOHSL have named this initiative one of their prioritized strategic areas ( DPRD, 2015; Amarasinghe et al., 2018; Hasalanka et al., 2019b).

Since Sri Lanka is a tropical country hydro-meteorological hazards such as floods, landslides, and high winds are predominant, which is a significantly different hazard profile when compared with the Latin American context. It has called for the need to evaluate the applicability of the Safe Hospitals Framework and the HSI within the Sri Lankan context and adapting them accordingly. Several research studies have been conducted by the Disaster Preparedness and Response Division (DPRD) of the MOHSL in collaboration with the Department of Civil Engineering, University of Moratuwa, Sri Lanka.

An initial study was conducted to evaluate the perception of a 'Safe Hospital' for Sri Lanka. The findings of the study revealed that a 'Safe Hospital' in Sri Lanka should have the capacity to function as a shelter for victims of a disaster in addition to being functional during the life cycle of a disaster (Kularatne et al., 2019). Furthermore, a pilot study was conducted in two hospitals; the District General Hospital (DGH) in Gampaha and the Teaching Hospital (TH) in Kegalle to evaluate the applicability of the HSI in the Sri Lankan context. This study reveals that the evaluation guide needs adaptations before applying to Sri Lankan hospitals due to several reasons. Non-engineered hospital buildings, the difference in hazard profile of Sri Lanka, and lack of documentation and engineering drawings are a few of those identified reasons.

Taking a step ahead, researchers from the Department of Civil Engineering, University of Moratuwa, and the Ministry of Health have developed a framework for Multi-Hazard maps to identify the natural hazards which affect the safety of Sri Lankan Hospitals (Hasalanka et al., 2019a).

In 2019, the Department of Civil Engineering, University of Moratuwa collaborated with researchers from the University College London (UCL) to start a project to strengthen the 'Safe Hospitals' project in Sri Lanka (HEART-SL). Under this project, pilot studies were carried out in six hospitals located on the Southern province of Sri Lanka. These hospitals were selected for the pilot study because of the exposure to tsunami hazards in the country (Harisuthan et al., 2020). As the first step of the project, the applicability of the Papathoma Tsunami Vulnerability Assessment (PTVA)-4 model in assessing the structural vulnerability of Sri Lankan hospitals against tsunamis was evaluated.

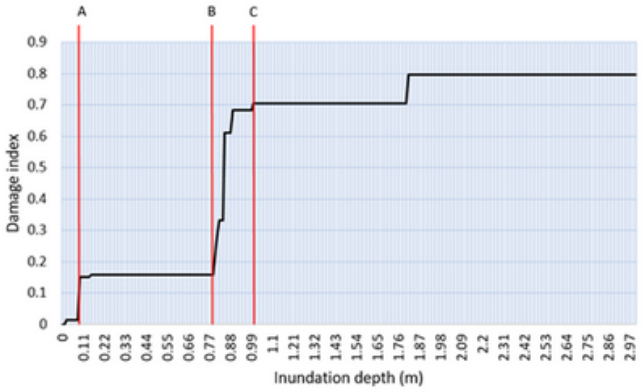
The findings revealed that the use of the PTVA-4 model alone is not adequate in the Sri Lankan context. Considering the outcomes of the pilot studies, researchers have developed a Multi-Hazard Structural Safety Toolkit (SSH-SL), which uses the Rapid Visual Screening Method to assess the structural vulnerability of Sri Lankan hospitals for natural hazards. Results of the study which applied the developed tool for hospitals on the Southern coast of Sri Lanka have highlighted that it is a better index compared to PTVA-4 in the Sri Lankan context since it has a wider range (Hasalanka et al., 2021).

Furthermore, the research team of the HEART-SL project has proposed a new Tsunami Relative Risk Index (TRRI) to quantify the impact of tsunamis on critical units. Through a case study conducted in three hospitals in the Southern Province of Sri Lanka, it has been shown that the TRRI can be used by authorities in improving the Figure 2: Dr. Chandana Siriwardana sharing the findings on Safe Hospitals Initiative (HEART-SL) in University College of London (UCL, UK) tsunami resilience of healthcare facilities (Baiguera et al., 2021).

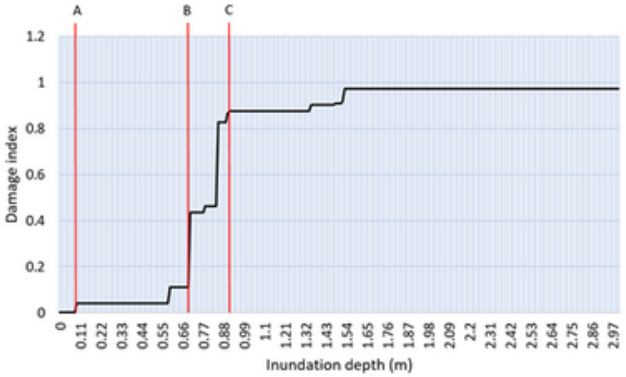

*Dr. Chandana Siriwardana sharing the findings on Safe Hospitals Initiative (HEART-SL) in University College of London (UCL, UK)*

Since it was revealed that the fire safety level of Sri Lankan hospitals does not meet the minimum acceptable, a comprehensive Fire Risk Management Framework for Hospitals has been developed under the 'Safe Hospitals' project in Sri Lanka (Kularatne et al., 2019). This fire risk management framework consists of a fire risk assessment tool and a post-disaster activity list for fires. Furthermore, since floods have caused the highest damage to the healthcare infrastructures in the country, a study has been conducted to develop a flood vulnerability assessment for Sri Lankan hospitals.

During this study, vulnerability curves were developed for critical units of the District General Hospital in Chilaw and the Teaching Hospital in Kurunegala using the concept of Depth Damage Functions (DFFs). During the study, three zones have been identified in the developed vulnerability curves: alert zone [O-A], action zone [A-B], and damage zone [B-C] (see Figures 3 and 4). These identified zones can be incorporated in the process of evacuation planning which is a consequential task for critical units as they contain the most expensive equipment and vulnerable patients (Koneshwaran et al., 2021).




*DDF for Premature Baby Unit in District General Hospital Chilaw (Koneshwaran et al., 2021)*




*DDF for Accident Service and ETU in District General Hospital Chilaw (Koneshwaran et al., 2021)*

***Outcomes of the research on the 'Safe Hospitals' initiative in Sri Lanka***

1. A framework to develop multi-hazard maps to identify the natural hazards which affect the safety of Sri Lankan hospitals (Hasalanka et al., 2019a)
2. A new Relative Risk Index for hospitals exposed to Tsunamis (Baiguera et al., 2021)
3. A structural robustness index against tsunamis for hospitals (Hasalanka et al., 2021)
4. A Multi-Hazard Structural Safety Toolkit (SSH-SL) (Hasalanka et al., 2018)
5. A flood vulnerability assessment framework for critical units of Sri Lankan hospitals (Koneshwaran et al., 2021)
6. A conceptual compilation of activity criteria during the post-disaster stage of a fire hazard in hospitals (Kularatne et al., 2021)
7. A Fire Safety Performance Assessment Framework

***Safe Hospitals initiative in the HOPE Curriculum in Sri Lanka***

Hospital Preparedness for Emergencies (HOPE) is part of the Programme for Enhancement of Emergency Response (PEER) initiated in 1998 by the US Agency of International Development's Office of the US Foreign Disaster Assistance. Currently, the Disaster Preparedness and Response Division (DPRD) of the Ministry of Health with the Asian Disaster Preparedness Centre (ADPC) and Disaster Management Centre (DMC) in Sri Lanka, have initiated a project in reviewing the HOPE curriculum before launching it in Sri Lanka. Findings of the pilot studies conducted under the Safe Hospitals initiative in Sri Lanka were incorporated in reviewing and adapting the curriculum to the Sri Lankan context. Lessons on Structural and Non-structural safety of Sri Lankan hospitals were especially reviewed and amended based on the findings of the research studies.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***Way forward***

Since the 'Safe Hospitals' project was initiated in Sri Lanka, under the guidance of the Disaster Preparedness and Response Division (DPRD) of MOHSL, a number of adaptations have been proposed for the HSI evaluation guide. As described above, these newly proposed assessment tools with required adaptations cover all four sections of the HSI. The outcomes of the proposed frameworks are vast and beneficial in strengthening the safety of Sri Lankan hospitals. Since these adapted frameworks are still at the initial stages, validations are needed through assessing more hospitals within the Sri Lankan context before including them in the policies of the country. The Ministry of Health, in collaboration with academia and other stakeholders, has taken necessary steps to continue this initiative with the vision of making Sri Lankan hospitals safe from disasters.

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