From
the People of Japan

DX4Resilience

CONNECT INNOVATE ACCELERATE

Digital Disaster Risk Reduction Maturity Model (DDRRMM)

White Paper | March 2022 | Version 4.0

Digital Disaster Risk Reduction Maturity Model (DDRRMM)

White Paper

Prepared By:
Disaster Risk Reduction and Recovery for Building Resilience Team (DRT)
Bangkok Regional Hub
United Nations Development Programme in Asia and the Pacific

CONTENTS

FIGURES

TABLES

ACRONYMS & ABBREVIATIONS

ADB	Asian Development Bank
AI	artificial intelligence
BPM	business process management
BRH	Bangkok Regional Hub
CBA	cost-benefit analysis
CMMI	Capability Maturity Model Integration
DBMS	database management system
DDRRMM	Digital Disaster Risk Reduction Maturity Model
DesInventar	DesInventar Disaster Inventory System
DR&T	digital resources and technologies
DRR	disaster risk reduction
DRRM	disaster risk reduction and management
DX4Resilience	Accelerating Disaster Risk Reduction and Enhancing Crisis Response through Digital Solutions
GIS	geographic information system
IoT	Internet of things
ISO	International Organization for Standardization
OCED	Organisation for Economic Cooperation and Development
ROI	return on investment
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
USAID	United States Agency for International Development
TLC	technology life cycle

1. INTRODUCTION

1.1 CONTEXT

With the COVID-19 pandemic and worsening vulnerabilities to natural hazards and climate change, institutions face complex and unprecedented problems. In countries where these shocks are happening simultaneously, cascading impacts regarding health, displacement, business discontinuity, disrupted government services, job and income losses, and the erosion of citizen trust and social cohesion require institutions to act decisively. Furthermore, these effects have profound immediate and long-term impacts on the most vulnerable people. There has been a marked increase in domestic violence and victimization of women and a lack of access for older people and those living with disabilities to life-saving services. There are immediate or permanent job losses for migrant workers and serious disruptions of education for children and youth. Within this context of worsening levels of vulnerability and inequality, the following developmental challenges have arisen.

DX4RESILIENCE OUTPUTS

1. Disaster data digitalized and integrated using cloud-based technologies to support disaster risk reduction and recovery in project countries.
2. Targeted digital solutions for increased preparedness and response of vulnerable groups developed and applied.
3. Strengthened capacities of national and subnational governments through partnerships for disaster risk-informed development planning.

1. Disaster and climate risks threaten the achievement of the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction (SFDRR).
2. Digitalization of disaster loss and damage data across countries is inadequate for risk-informed development.
3. COVID 19 has created multiple vulnerabilities and exposed the inadequacies of current approaches.
4. The private sector, which is key to digitalization and achieving the SFDRR and the SDGs, is insufficiently engaged in reducing and mitigating risks from disasters and pandemics.

"Accelerating Disaster Risk Reduction and Enhancing Crisis Response through Digital Solutions" (DX4Resilience)[1] is an initiative led by the UNDP Bangkok Regional Hub (BRH) to strengthen disaster risk reduction (DRR) and recovery efforts in the Asia Pacific region. Funded by the Japanese government, DX4Resilience aims to leverage UNDP's experiences related to DRR and recovery and ongoing efforts and partnerships in Indonesia, Nepal, Philippines, and Sri Lanka. The project focuses on the pressing need to change how disaster

[1] https://www.undp.org/asia-pacific/dx4resilience

data is managed where institutions cannot share, analyse, visualize, and use data for policymaking, programme planning, budgeting, and, more importantly, identifying who is most in need of these interventions. The project also aims to change the way vital information is disseminated and used by duty bearers and rights holders, especially those most vulnerable.

1.2 Relation to ongoing UN Initiatives

DX4Resilience – and hence the work related to the development and application of the **Digital Disaster Risk Reduction Maturity Model (DDRRMM)** presented here – is informed by, and aligned with, several significant initiatives, frameworks, and programmes of the United Nations.

In terms of broader impact, project outcomes address and support progress towards the targets set forth by the Sustainable Development Goals[2] and the Sendai Framework for Disaster Risk Reduction 2015–2030.[3] Furthermore, solutions offered through DX4Reslience, including DDRRMM, are steered by the three strategic directions for systemic change of the UNDP Strategic Plan 2022–2025[4]: structural transformation, leaving no one behind, and building resilience. They are likewise guided by the signature solutions prioritized by UNDP in its strategy, especially those related to supporting countries and communities in building resilience to diverse shocks and crises – including conflict, climate change, disasters, and epidemics. Finally, DX4Resilience is strongly aligned with the UNDP Crisis Offer and Crisis Bureau 2.0[5] and the response mechanisms it suggests to anticipate, prepare for, and prevent a crisis.

In terms of programmatic objectives and improving the role of digital technologies to reduce disaster risks and respond to crises, DX4Resilience's three outputs are directly informed by Pathway 1 of the UNDP Digital Strategy 2022–2025[6]. Pathway 1 focuses on empowering

[2] https://sdgs.un.org/goals
[3] https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030
[4] https://strategicplan.undp.org/
[5] The UNDP Crisis offer and Crisis Bureau 2.0 document was released internally within UNDP at the time of preparing this document. The offer entails eight response mechanisms to anticipate, prepare for, and prevent crisis, as well as to pursue pathways out of crisis and to build resilience. These mechanisms are: (1) enhanced data and analytics capacities to inform decision-making; (2) delivering multidisciplinary and integrated solutions with a risk and crisis lens; (3) offering an upgraded generation of integrated service offers on crisis and risk; (4) data, digital innovation and financing, supporting tailored solutions in crisis, high-risk and prevention contexts; (5) robust people-centered knowledge and learning systems; (6) enhanced thought leadership with more high visibility knowledge and advocacy products; (7) re-tooling internal capacities to ensure that the CB is fit for purpose for the new Strategic Plan; and (8) progressing the Women, Peace and Security agenda and advancing gender equality in crisis contexts.
[6] In 2019, UNDP launched its first Digital Strategy https://www.undp.org/asia-pacific/dx4resilience to foster new ways of collaborating with partners, creating environments and systems that drive and support innovation, and building new capabilities to develop and apply digital solutions that will enhance the quality, efficiency and effectiveness of UNDP's work. This strategy has been renewed for 2022–2025 to incorporate lessons learned and best practices based on UNDP's experience in implementing the earlier digital strategy, especially with the establishment of UNDP's Chief Digital Office, Data Governance Group, and Digital Governance Group, as well the launch of UNDP Data and IT strategies in 2020 and 2021 respectively.

digital ecosystems and developing digitally enabling programmes to solve development challenges. Digital transformation, in the context of disaster risk reduction and management (DRRM), refers to the transition in using digital technologies to create new — or modify existing — operational processes and an organizational culture to meet challenges arising from the complexity and interrelated factors that contribute to disaster risks. **The basic premise of digital transformation is to leverage digital technologies to create value**. **In the context of DRRM, this means accelerating progress towards meeting the SDGs and the Sendai Framework goals; developing proactive risk management; improving response, safety and resilience; minimizing impacts; and striving for more effective recovery from disasters.**

1.3 PURPOSE OF THE WHITE PAPER

Broad misconception limits digital transformation to the use of digital data. Digital transformation, however, is not only about data (which is indeed a critical element in the transformation process). It is also about the tools, computing infrastructure, people, processes, collaboration, information policies, and other features that together make up the digital ecosystem for DRRM. When a component is weak, the digital ecosystem becomes unable to deliver the full potential of digital transformation in DRRM. **When the various components of the digital ecosystem are intact and working in harmony, however, the digital ecosystem supports data-driven decisions, creates actionable information products, and streamlines collaboration and operations within the DRRM domain.**

- The challenge is in diagnosing the health of the digital ecosystem for DRRM and understanding how and where the digital transformation should intervene to improve the health of the digital ecosystem. **This paper discusses how the Digital Disaster Risk Reduction Maturity Model (DDRRMM) has been prepared to help UNDP country offices, and the governments they serve, conduct diagnostic assessments of the adequacy of digital resources and technologies (DR&T)[7] in the context of DRRM.** The overarching objectives follow.
- Provide intended users a vision of the optimal level that national, province/district, and local institutions can achieve by using DR&T to streamline DRRM operations, leave no one behind, and design and implement effective risk-informed development initiatives.
- Make DRRM managers, decision makers, and other stakeholders aware of where their institutions stand regarding the optimal utilization of DR&T, help them identify gaps,

[7] *Digital resources* can broadly be defined as available and/or potential means circulated and acted upon within the digital ecosystem environment. Tangible examples include data and various types of information in electronic form and software, apps, and hardware. Intangible examples of digital resources include people with digital literacy, training programmes, and financial resources/investments in digital transformation. Combined, these means (or resources) define the carrying capacity and the limits of the digital ecosystem; the more resources, the better the chances for the digital ecosystem to flourish and expand. *Digital technologies* refer to the tools, techniques, and devices (e.g., drones, cloud platforms, blockchain, algorithms) that process digital resources to transfer them from one form to another or to produce specific products such as statistics and maps, or to achieve certain goals such as effective response to disaster crisis).

and enhance their understanding of the strengths, weaknesses, opportunities, and threats they face in harnessing the full potential of advanced DR&T for DRRM.

- Inspire DRRM practitioners, managers, and decision makers to improve DR&T performance for DRRM by specifying the features and functions they currently lack, identifying best practices to adopt, and charting roadmaps to achieve the next level of maturity.

The white paper is part of a DDRRMM training bundle[8] under development to provide tools and recommendations on how to take an inventory and assess how DR&T is used to reduce and manage disaster risks. It also describes how to evaluate digital readiness and capacity at national, provincial/district, and local institutions to derive maximum benefit from available DR&T for DRRM. Assessment and analysis processes covered in the DDRRMM training programme aim to train staff at DRRM institutions on assessing where they stand in terms of realizing the full potential of DR&T, identifying a path for improvement, transitioning to the next steps, and measuring progress. Those completing the DDRRMM training will learn how to accomplish the following objectives.

OBJECTIVES OF DDRRMM

- Benchmarking progress towards realizing the full potential of DR&T for DRRM.
- Identifying areas for improvement in DR&T and how these align with improved DRRM capabilities and operations.
- Providing a standard for evaluating progress towards building the best-of-breed DR&T ecosystem for effective and integrated DRRM.

- Engage key stakeholders from all sectors (for instance, governmental, public, private, NGOs, community-based organizations) in understanding whether they are fully using available DR&T for DRRM and in envisioning and co-creating a mature DR&T ecosystem capable of supporting the implementation of holistic and proactive DRRM strategies.
- Suggest interventions that strengthen institutional and technical capacities in the use of DR&T for DRRM at all levels (national, provincial, and local).
- Set priorities for DR&T strategies to improve the return on the investment and enable full transition to a proactive DRRM paradigm.
- Integrate and streamline the expansion and refinement of DR&T as a fundamental component of the infrastructure a country needs to manage and reduce disaster risks effectively and mainstream DRRM into development and sectoral planning.
- Measure and monitor various stages of progression towards a mature DR&T ecosystem for DRRM and identify leverage points as well as bottlenecks and risk areas, taking corrective actions when necessary.

[8] A training programme on the use of DDRRMM is expected to be finalized and delivered by UNDP BRH during late 2022.

1.4 INTENDED USERS

The paper targets technical staff planning to perform DDRRMM assessments, including UN entities dealing with DRR, national and local government departments/agencies, multilateral and bilateral development agencies, NGOs/CSOs/CBOs, and national and international DRM practitioners and consultants engaged in designing and/or evaluating DT&R solutions for DRRM in specific countries/regions. Other potential users include donors, investment groups, and IT companies interested in better informing their strategic DR&T and DRRM missions.

1.5 ORGANIZATION OF THE WHITE PAPER

The white paper is organized into four chapters, in addition to appendices and reference materials.

- Chapter 1 contextualizes the paper and provides the rationale for developing DDRRMM in the DX4Resilience project.
- Chapter 2 presents the concept of maturity models and the matters that need to be considered when designing a maturity model. It then discusses the use of DR&T in the context of DRRM and what it means to reach a mature level in using DR&T for DRRM.
- Chapter 3 explains DDRRMM and its component, subcomponent, and element hierarchy.
- Chapter 4 showcases the applications and best practice examples for using DDRRMM.
- Appendices provide technical information on DDRRMM as well as materials explaining the methods used to drive the maturity model.

2. Building Maturity Models for Digital Technologies in Disaster Risk Reduction and Management

2.1 Maturity models

2.1.1 What is a maturity model?

In management and operational research, maturity is considered "a measure to evaluate the capabilities of an organization in regard to a certain discipline" [1]. A maturity model is essentially a classification scheme that places patterns in developing organizational capabilities under a certain capability stage, assuming linear progression from an existing mature state to a higher maturity level [2]. A typical maturity model represents stages of increased quantitative or qualitative capability changes of a maturing element to assess its advancement concerning a defined focus area [3]. Figure 1 is an example of a 5-stage maturity model for business process management (BPM) in an organization is shown in Figure 1.

Maturity models are frameworks that describe and attempt to measure progress made by organizations or institutions to develop and improve their capabilities in a specific domain.

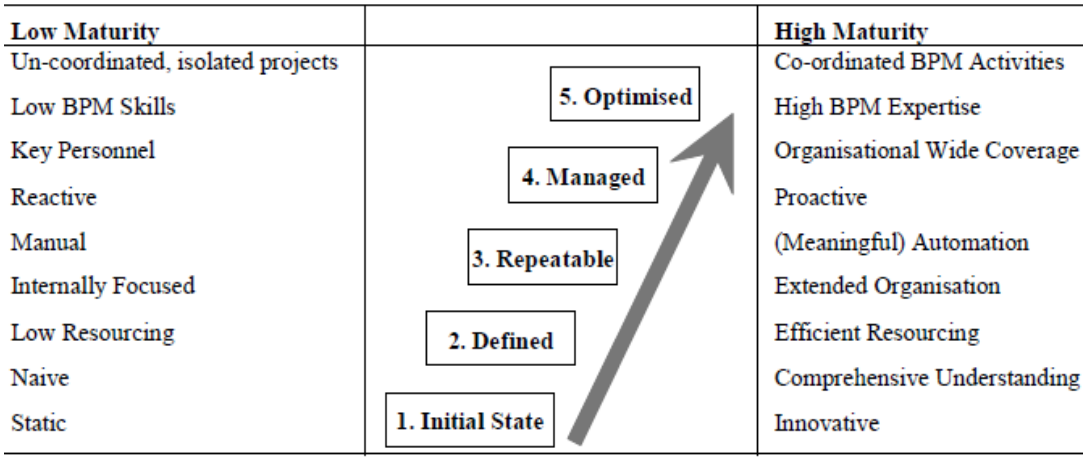


Figure 1: Comparison of low and high maturity levels spanning five maturity stages (Source [1]).

The word "maturing" indicates that a capability subject (BPM in Figure 1) has fulfilled all conditions required to get promoted from one stage to the next stage of capability. Requirements for promotion capture the various dimensions (i.e., maturing elements) that influence or impact the capability. In Figure 1, the capability subject is business process management, while work coordination, BPM skill, personnel, management style, level of automation and so forth represent the maturing elements or conditions that determine the BPM overall capability. Reaching a given stage of maturity implies fulfilling all requirements for the current and previous stages (e.g., in Figure 1, being in stage 3 means that the organizations fulfilled conditions for stages 3, 2, and 1).

2.1.2 History of maturity model applications

The development of maturity models goes back to the mid-1970s. In 1974, Gibson and Nolan [4] introduced a Four-Stage of Growth model that described the progression in adopting

computer-based applications in organizations (Figure 2). The model was refined in 1979 with four progressive stages: initiation, contagion, control, and integration [2].

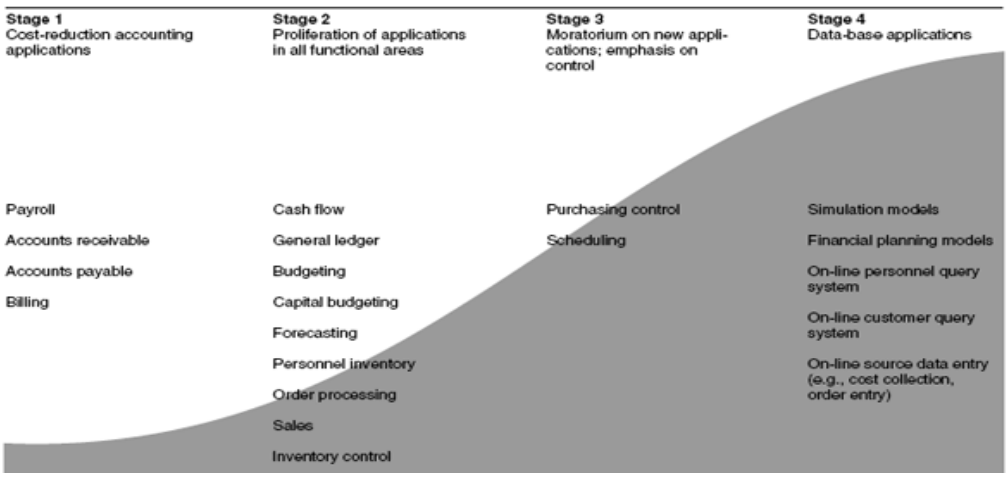


Figure 2: The Four-Stage of Growth Model proposed by Gibson and Nolan [4]

In 1987, Carnegie Mellon University in the United States was contracted by the Department of Defense to develop an evaluation system to assess the expertise and ability of contractors to deliver a software project. This evaluation system evolved into the Capability Maturity Model Integration (CMMI), which expanded beyond software engineering as a general model to help organizations assess their project and programme management practices. Between 1993 and 2010, CMMI had gone through several iterations of development to emerge as an integrated maturity model referred to as CMMI® V1.3 covering 22 areas of organization management practices or "process areas" such as project management, decision-making, monitoring, quality testing, procurement, and so forth (Figure 3). At present, CMMI® V2.0 covers a suite of models, including the original CMMI, CMMI Cyber Maturity Platform, Data Management Maturity, and People Capability Maturity. Each process area in CMMI is evaluated according to the 5-level maturity scale shown in Figure 4.

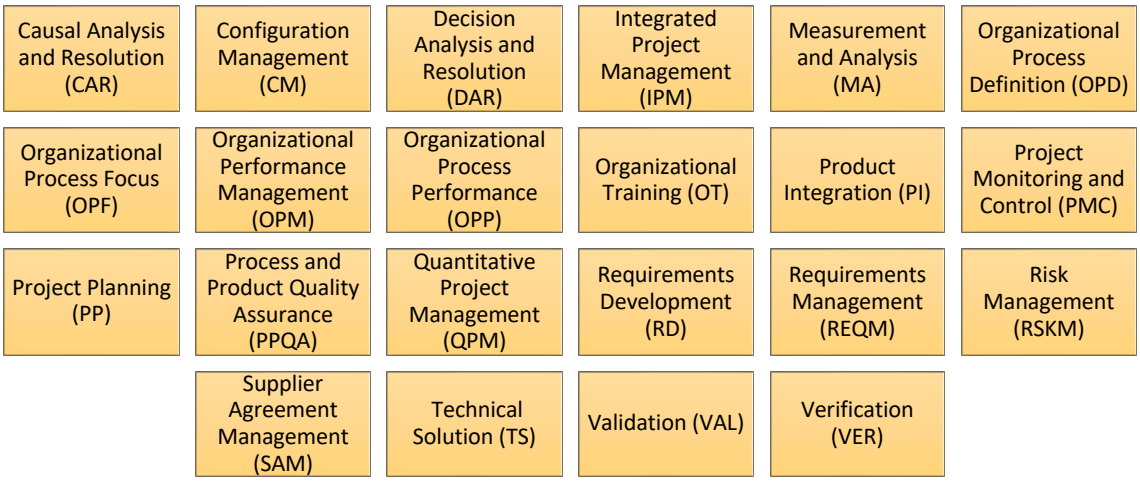


Figure 3: Process Areas of CMMI V. 1.3

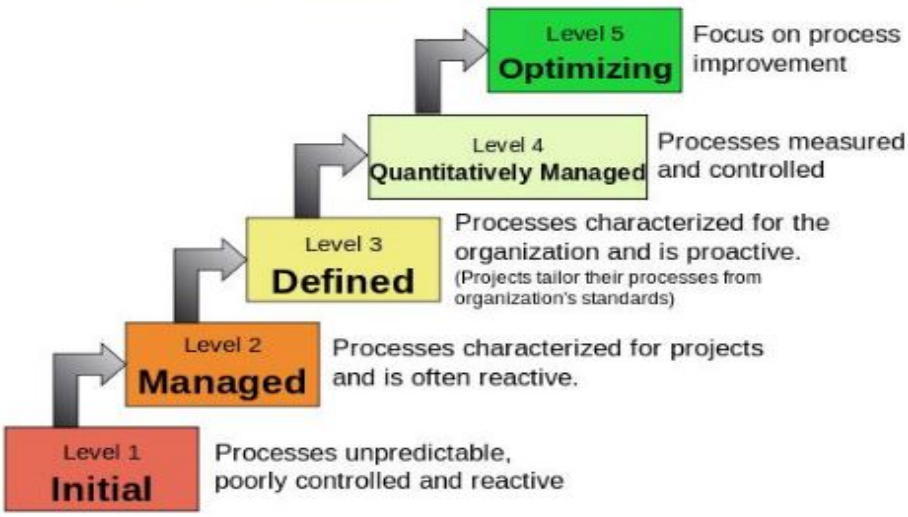


Figure 4: CMMI Maturity Levels (Source [5])

Maturity models have been developed for different domains and application areas. Besides their continuing use in assessing technological readiness in organizations, they are used to provide systematic assessments and guidance in governance and business process management [1, 6, 7], education [8], knowledge [3], transportation [9], societal development [10, 11], smart cities [12], and many others. Models vary in maturity levels, naming and meaning of the levels, dimensions and criteria for evaluating maturing elements, and maturity assessment instruments (Figure 5).

#	Model	Content						Methodology									
		Domain dimensions			Generic dimensions			Origin		Components			Application			Evaluation	
		Planning	Reporting	Consolidation	Services	Organization	Technology	Academic	Practice	Lightweight descript.	Questionnaire	Architecture	Self-assessment	Third-party	Certification body	Evaluated	Not transparent
1	Gluck et al. (1980)	■			■			■	■	■			■				■
2	Ansoff (1980, p. 132)	■			■			■		■			■				■
3	Gleich et al. (2006)	■			■	■		■	■	■			■				■
4	Marx et al. (2010)	■			■		■	■		■			■			■	
5	Weisberg (2007)		■		■	■	■		■		■	■		■			■
6	Wettstein and Kueng (2002)		■		■	■	■	■		■			■				
7	Arveson et al. (2010)	■	■		■	■			■	■			■				■
8	Thiruvenkatachari and Kartick (2009)	■	■		■	■	■		■		■	■		■			■
9	National-Audit-Office (2010)	■	■		■	■	■		■	■			■				■
10	McRoberts and Sloan (1998)	■	■		■	■	■		■	■			■				■
11	Ribaudo et al. (2010)			■		■	■		■	■			■				■
12	Kaplan (1990)			■	■			■		■			■				■
13	Aho (2009)		■				■	■	■	■	■		■				■
14	Rayner and Schlegel (2008)		■				■		■	■			■				■
		8	8	2	11	8	9	7	10	12	3	2	12	2	0	1	12

Figure 5: A comparison of maturity models in terms of their content, dimensions covered, and applications (Source [6])

For example, the smart city readiness scale [12] measures progress made by cities in using information and communications technology (ICT) in various domains (water, energy, buildings, etc.) to enhance liveability, workability, and sustainability. It uses four maturity levels: no progress, partial progress, over 50 per cent, and completed. Another example is the European Commission, which has adopted a nine-level maturity model covering technology readiness, societal readiness, organizational readiness, and legal readiness [10]. Technology readiness levels follow a measurement system organized by NASA to assess the maturity level of a particular technology, starting with observing and documenting a technology's basic principles (Level 1) to operational systems proven and ready for full commercial deployment (Level 9). Societal readiness levels assess the societal adaptation of ideas, products, processes and so forth starting from Level 1, where a problem is recognized, and ending with Level 9, where solutions are successfully implemented to solve the problem in society. Likewise, legal and organizational levels classify progress into respective areas along a nine-level scale.

TRIPARTITE GOALS

Maturity models are diverse and serve different applications. However, they all share tripartite goals.

- Describing the current capabilities of the maturing subject according to given criteria (i.e., a diagnostic goal).
- Providing a logical path for a desired evolutionary progress in the domain of interest through improvement in processes, performance, and/or systems (i.e., a perspective goal).
- Setting a standard for measuring, comparing, and assessing the achievement of maturity milestones along that path (i.e., benchmarking goal).

A third example is the Railway Management Maturity Model (also known as the Risk Management Maturity Model) adopted by the Office of Rail and Road in the United Kingdom [9]. This model has five levels (Ad Hoc, Managed, Standardized, Predictable, Excellence), each of which reflects the collective progress the agency is making across the domains of leadership, communication, employee competence, planning and implementing risk controls, and monitoring, audit and deployment of corrective actions.

Once a maturity model is adopted by a given community, reaching a certain maturity level becomes synonymous with a specific set of capabilities and performance one can expect from an organization (analogous to how an education level or work experience sets the expectations about a person's abilities). For example, some governmental bids in the United States, United Kingdom and Australia require bidders to hold at minimum a CMMI Level-3 certification to qualify. An organization with CMMI Level-3 implies operating at a "Defined" level of standard business operations covering 11 business process areas such as Decision Analysis and Resolution, Integrated Project Management, Employee Training, and Product Integration.

2.1.3 How is a maturity model constructed?

Several authors have discussed the design and construction of maturity models and provided guidance and underlying principles [1, 3, 6, 7]. These principles address the nature of the maturing subject and the dimensions (or elements) that a maturity model needs to cover to be deemed useful. They also deal with the model's stakeholders and the methods used in conducting assessments and determining areas and actions for improvement.

FOUR QUESTIONS

Essentially, there are four main questions the developer of a maturity model needs to answer.

(1) What is the maturing subject?
(2) What is the model used for?
(3) Who uses the model?
(4) How shall it be used?

2.1.3.1 Defining the maturing subject and dimensions

A prerequisite for constructing a new maturity model is to define its context (the domain of interest, and purpose), boundaries (what it does and does not cover), and the degree it overlaps with, and differs from, other maturity models. Once the rationale for a new model is justified, the first step is to define the main constructs of the model: maturity dimensions and maturation paths.

A *maturity dimension or component* represents a distinct capability or process area related to the domain of interest. Each dimension is further specified by elements (practices, objects, or activities) that can be measured quantitatively or assessed qualitatively through observable factors or criteria. The maturity model comprises a nested hierarchy of measures calculated from the bottom up, as shown in Figure 6. Since the bottom-level factors are likely to be measured differently, normalization techniques are applied to convert these measures into comparable numerical scores (e.g., 0 to 10 or 0 to 100). The scores assigned to a higher level in the hierarchy (e.g., dimensions) are calculated from the normalized scores from its immediate lower level (e.g., elements) based on an aggerate function (e.g., sum, average, etc.).

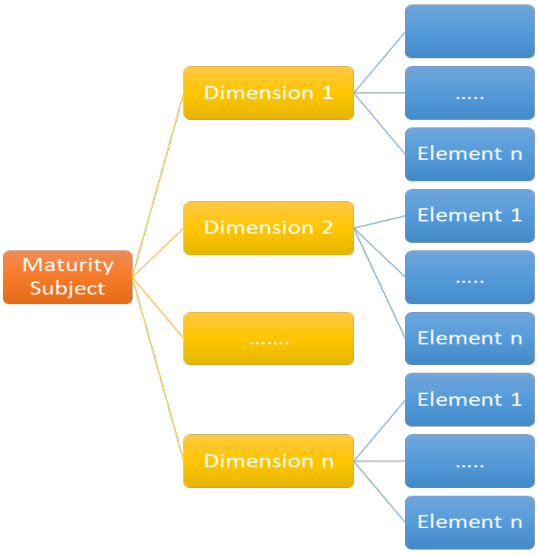


Figure 6: Maturity Model Hierarchy

The maturity subject, its dimensions/components, and their defining elements have their own maturation paths, but they are interrelated since the maturity path of higher levels in the model hierarchy is shaped by those of the lower levels. A *maturation path* is defined by maturity levels and granularity. One can think of the maturation path as a classification scheme of successive stages. Each stage or maturity level represents a "compound class" defined by a score range (e.g., from 0 to 20, or from 21 to 40). Each score range reflects characteristics that describe the state of maturity and the relationship with its predecessor and successor states. Granularity defines the stage intervals (number of levels) along the maturation path. The degree of granularity depends largely on the maturing subject and its life cycle and the use/application of the maturity model. For example, NASA's Technology Readiness Scale, originally developed in 1989, originally featured seven maturity levels for testing and validating space technologies before launch. The scale was further refined into nine levels in 1995 due to the need for additional validations required during the life cycle of technology development to reduce the risk of technological failure.

A maturation path is defined by maturity levels and granularity

The following considerations are suggested by Pöppelbuß and Röglinger [7] in defining the maturity model constructs related to maturity and maturation:

- maturity subject and dimensions of maturity;
- maturity levels and maturation paths;
- available levels of granularity of maturation;
- underpinning theoretical foundations concerning evolution and change; and
- definition of each of these constructs in the context of the application domain (i.e., maturing subject).

2.1.3.2 Stakeholders and uses of the maturity model

A critical task in developing a maturity model is identifying the model's stakeholders and how they intend to use it. Engagement of the right stakeholders at the right time during the model design steps discussed earlier is significant to its successful construction and adoption and ultimately will help accelerate progress towards higher maturity levels.

A maturity model's stakeholders include individuals or groups in an institution or a community who would use the model, contribute to its construction in the form of knowledge or support, and impact or be impacted by its application.

Effective stakeholder engagement goes beyond identifying and mapping potential model users or soliciting their inputs. Instead, **effective engagement rests on placing stakeholders at the centre of model construction through a co-creation process**. The goal of co-creation is to define the meaning of maturity levels collectively and identify improvement measures and interventions for each maturity level towards the successive state of maturity. The following considerations can help in the maturity model's co-creation process [7].

- Defining verifiable criteria for each maturity level and level of granularity
    - Solicit feedback on the adaptation and configuration of criteria.
    - Solicit feedback on the assessment instruments of criteria.
    - Capture expert knowledge and experience in related model dimensions.
- Defining improvement measures for each maturity level and level of granularity
    - Solicit feedback on the assessment of variables.
    - Solicit feedback on the adaption of the improvement measures.
    - Decision rules for selecting improvement measures/interventions
        - Clarification of relevant objectives
        - Description of relevant factors of influence

2.1.4 Limitations of maturity models

Any model of processes happening in the real world is just abstraction; maturity models are no exception. As a result, they have been criticized by several authors who have pointed to various limitations inherent in published models [7, 13, 14]. The major noted limitations follow.

- Maturity models are empirically driven and lack rigorous theoretical frameworks.
- The assumption of a fixed linear progression of maturity neglects the possible presence of other potential paths for improvement.
- Defining a "final state" of maturity can be dangerous as it can undermine a drive towards continuous improvement and is not realistic in today's fast-changing environment where what may be regarded as "mature" today might be old and outdated tomorrow.
- Maturity models can set the wrong motivation as they encourage the organization to celebrate achievement levels rather than focus on meaningful outcomes.
- Organizations may concentrate on areas with no importance for their operation but must achieve the next level of maturity.
- Maturity models are designed for large organizations, but they are not feasible for smaller organizations.
- Maturity models introduce bureaucracy in organizations as a portion of the effort is directed towards ensuring compliance with maturity requirements.

2.1.5 Addressing the limitations of maturity models

While the limitations noted in 2.1.4 hold some level of truth, a counterargument can also be presented. First, maturity models come in many forms and goals for different application areas. Therefore, it is misleading to criticize them as "one thing." For example, the critique concerning the lack of a theoretical framework undermines the fact that many of the models developed for project and management improvement are founded upon established theoretical models and frameworks in operational research.

Second, the idea that a final state of maturity is somehow dangerous stems from an incorrect assumption that targets and definitions of maturity levels are set in stone. CMMI has been updated regularly over the past twenty years to cope with the complex reality of operational environments in today's organizations. Many other maturity models, especially those related to the mature use of technology by organizations and certain domains, recognize that change is continuous and technology advances by the month, if not by the day. The suggested targets

are the best recommendations at the time of model construction, and many model authors recommend periodic revisions of model constructs (e.g., maturity level definitions) based on the state of the art.

Third, the idea that maturity models are limited because they encourage bureaucracies within organizations and set the wrong motive is flawed. The wrongness in applying a model does mean the model is limited. When adopting a model, organizations usually confuse *what to do* and *how to do it*. Most existing maturity models never prioritize one maturing dimension over another, nor do they suggest "how" organizations should operate to progress from one maturity level to another. Instead, maturity models only present the technical foundations and criteria for monitoring and evaluation capabilities within an organization. In other words, they just describe the "what" (not the "how") in terms of the capabilities an organization can reach.

Maturity models only present the technical foundations and criteria for monitoring and evaluation capabilities within an organization; they only describe the "what" (not the "how") in terms of the capabilities an organization can reach.

Finally, arguably many, if not all, of the noted limitations can indeed be addressed by (1) adhering to the design principles of model construction mentioned in the previous section and (2) complementing the maturity model with well-known methodological practices that guide organizations on how to progress along the maturation path. Examples include:

- IDEAL™ model (Initiating, Diagnosing, Establishing, Acting, and Learning) for planning process improvement in any given domain;
- PMI's Project Management Professional (PMP) methods for best practices and guidance in project management;
- Six Sigma methodology for defining, measuring, analysing, and optimizing resources and improved quality of operations;
- agile development methods for dividing any set of activities or improvement tasks into small releases towards completing bigger activities; and
- co-creation and participatory research methods for communication and building consensus and a shared organizational culture surrounding maturity goals.

2.2 The Case for Building a Maturity Model of DR&T for DRRM

2.2.1 The role of DR&T in DRRM

DRRM is an end-to-end process that includes technology and human behavior as well as the link between both. Technology covers data related to the various aspects of risks (such as hazard maps, elements at risk, damage assessments, exposure), tools, and applications (mapping tools, modeling natural phenomena, forecasting threats, and hazardous events), and technological support (i.e., information and technology infrastructure). Human behavior involves formulating policy, building partnerships, planning, public awareness, education, capacity-building, and response. The link between technology and human behavior aims to lessen disaster risks by using technology in decision-making, policy formulation, preparedness planning, warning systems, and in disseminating information about people in affected areas.

DRRM practitioners face numerous challenges in securing the necessary volume and type of information needed to perform their missions. Examples of these challenges include timeliness of the data required for proactive risk management, the presence of location and activity specific factors impacting the credibility of risk information (e.g., unvalidated volunteered/crowd data sources), and lack of integration of risk information into the daily activities and decision-making of other domains such as urban planning and economic development.

A first step in developing a mature DR&T for DRRM is to recognize that the maturity of DR&T is not just about data; it is also about the systems, people, and information required to support accurate, dependable, and coordinated risk reduction efforts, strengthen the operations of DRRM institutions towards the SDGs, and support ongoing monitoring, assessment, and adaptive management of disaster risks.

The relationship between the life cycle of risk information and its relation to DR&T and various DRRM activity areas is illustrated in Figure 7 below. The earlier phases of this life cycle (1 to 4) focus on collecting, transmitting, streaming, processing, fusing, and analysing raw data to produce reliable forecast models and predict or assess the impacts of disaster threats. Here the goal is to inform DRRM activities related to warning and response. Issues central to these earlier phases range from (1) the lack of shared data access and the quality and integrity of collected data to (2) the intense computational demands needed to provide site-specific real-time hazard forecasting to (3) the types of analytics and heuristic rules required to produce and disseminate credible information warnings and inform emergency operations.

Phase 5 of the life cycle is a turning point. It is where insights about disaster risks can be gained through DR&T tools such as risk and vulnerability assessment models, and data mining and knowledge discovery algorithms. Knowledge about differential vulnerability and risks within a community, the extent to which a community is resilient, and the cost-benefit ratio of mitigation measures are some of the questions these tools can answer.

The later phases of the disaster information life cycle (6 to 9) focus on translating the knowledge gained into actionable information to support a range of DRRM decision-making related to recovery, preparedness, mitigation, and informing policy. Examples of the tools used to fulfill this mission include data visualization, statistics, dashboards, and data reporting and dissemination services.

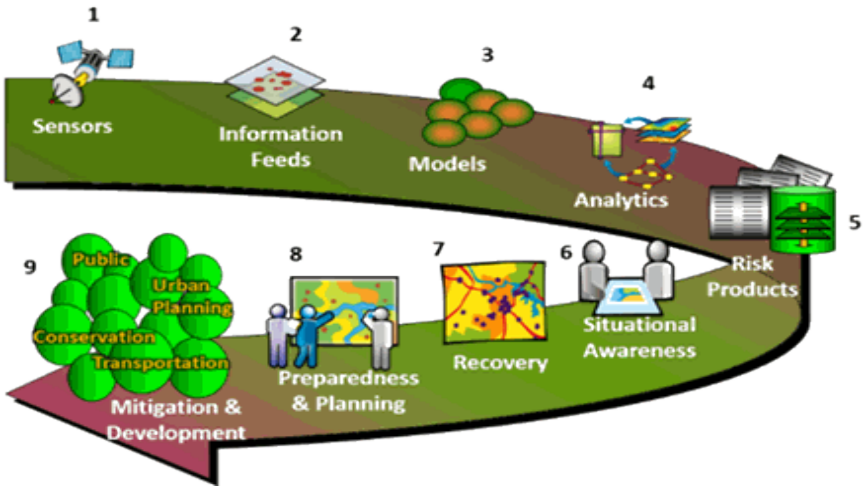


Figure 7: DR&T and the life cycle of disaster risk information

2.2.2 Barriers to maturity

The path to a mature utilization of DR&T for DRRM faces several obstacles and challenges in multiple contexts. Many of these barriers are rooted in hazard-specific traditional paradigms that tend to approach each phase in the DRRM cycle (preparedness, response, recovery, mitigation) as separate. This tendency has brought a "reactive approach" to managing disaster risks in which the only way to improve management practices and decisions is to wait for the next disaster and learn from it. Unfortunately, many DR&T solutions in DRRM follow the same pattern. A range of interrelated factors has contributed to this implementation pattern.

- **Fragmented and uncoordinated deployment**: Historically, DR&T solutions were deployed independently without coordination among DRRM stakeholders for many reasons such as financial constraints, isolated management and the need for tools to solve immediate problems. As a result, it is not uncommon to find redundancies in data and tools that duplicate expenses and are difficult to share among DRRM institutions and even among their internal units.

DR&T do not grant transformation to a fully integrated DRRM, but they are critical factors in bridging operational silos and improving coordination and collaboration

- **Not keeping pace with the state of the art**: Early DR&T solutions deployed for DRRM were a tradeoff between hardware constraints (higher costs, processing power, limited speed, and bandwidth) and the software features developed on such hardware. Advances in hardware and network infrastructure (Figure 8) have led to new types of software (e.g., object-relational databases, cloud, NoSQL systems) and development paradigms (e.g., agile vs. traditional waterfall) that have all improved the capabilities of DR&T at a rapid pace – making it possible to share resources and infrastructure in a way that was deemed difficult earlier. Yet, many DRRM institutions have not kept up with such advances and still operate based on deployment models and assumptions about technologies that have become obsolete.

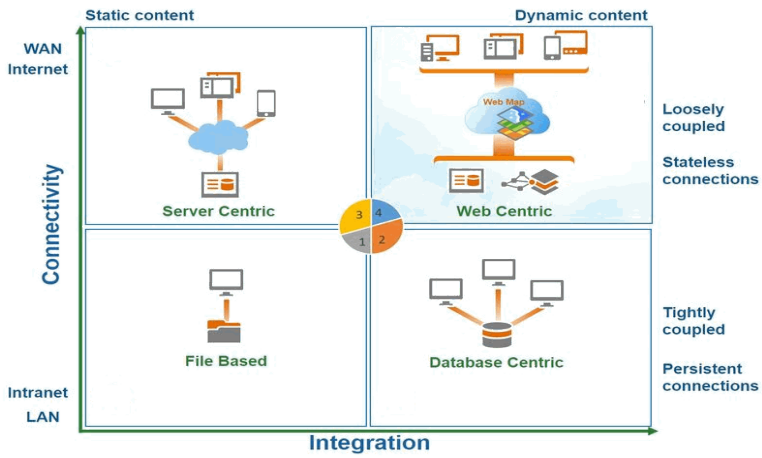


Figure 8: The evolving pattern of DR&T over time (Source http://wiki.gis.com/)

- **Lack of capacity:** Rapid advances in DR&T require DRRM institutions to have the budget, skills, and vision to push the state of the art. A mature DR&R for DRRM injects technological

resources into most, if not all, aspects of DRRM operations. DRRM institutions are at a disadvantage when they lack a skilled cadre at any level (technical, field, management, etc.) that grasps the full potential of DR&T and what is required for their deployment and operation.

- **Pilot trap:** A common saying in the IT world states "pilots never fail when they never scale." Some experts estimate that 84 per cent of piloted technology interventions fade away and never scale up [15]. Those who closely work in deploying DR&T solutions for DRRM observe how DRRM institutions easily fall into the "pilot trap" when pursuing technology innovation for their operations. A key reason is a lack of finances to support the scalability and durability of implemented pilots. In many developing countries, especially donor-driven economies, DR&T pilots, or even fully deployable solutions, are funded by external donors or grant mechanisms. The assumption is that once the institutions experience the benefits brought about by the pilot, they will find the financial resources to scale it up into a full operational solution. Unfortunately, this assumption often proves false due to the lack both of capital and a financial model to sustain and scale up the pilot, as well as the absence of commitment from high-level management to invest resources. The result is a reversion to business as usual once external funding ends.

  Yet, finances are not the only reason DRRM institutions fall into this trap. Other common pitfalls include:

  - *Wrong sizing*: The proposed DR&T pilot intervention does not fit the scale of the addressed problem.
  - *Kitchen sink*: The proposed DR&T pilot does not work well with existing systems to advance the common goal.
  - *Rigid mindsets*: The pilot is implemented without taking the institutional context and culture into account. For example, it is not coupled with proper training and lack of awareness.

DESINVENTAR

UNDP and UNDRR have promoted the development and use of a Disaster Inventory System (DesInventar) for over two decades. DesInventar is presented as a conceptual and methodological tool for the generation of national disaster inventories and the construction of databases for damage, losses, and other effects of disasters. As of 2020, its user base has grown to cover 112 countries.

A recent stakeholder needs assessment conducted by UNDRR [16] revealed some challenges regarding country buy-in of the system at the institutional level. Technical concerns do not drive such challenges; instead, the real issues relate to lack of capacity and institutionalization.

The assessment highlights the need for systems thinking and information governance approaches to strengthen the institutionalization of DesInventar beyond technology.

- **Disconnect with DR&T holistic thinking:** A mature DR&T for DRRM implies an ecosystem of standards, policies, data, procedures, technology, and capable people and institutions to support the effective coordination and dissemination of DR&T solutions across the DRRM community. It requires a system-wide and integrated view within and among

institutions of all aspects impacting, and impacted by, technologies. If the operational ecosystem (i.e., the DRRM problem domains that DR&T solutions are meant to address) lacks this view, one cannot expect progress on the DR&T maturation path. Unfortunately, many DRRM institutions worldwide are far from realizing this vision.

In this field, there is a preoccupation with building data assets. Certainly, these assets are essential for developing mature DR&R in DRRM. Nevertheless, data on its own does not guarantee a mature DR&T ecosystem or effective DRRM operations. Data assets contribute to DR&R maturation only when the community of agency stakeholders comprising DRRM can translate these assets into actionable information that results in tangible DRR interventions and effective management of disaster risks. In many countries, that is not the case. It seems many DRRM stakeholders have become so involved in data collection that they forget why they are doing so in the first place. Many observations reinforce this assertion – from the sole focus on gathering data about historical events and post-disaster damage statistics (while neglecting equally important data assets such as community assets, awareness, the performance of implemented interventions) to the lack of standards, capacities, and technological tools that operate on these data to derive knowledge and actions for effective DRRM.

A first step in developing a fully developed DR&T for DRRM is to recognize that the maturity of DR&T is not just about data; it is also about the systems, people, and information required to support accurate, dependable, and coordinated risk reduction efforts, strengthen the operations of DRRM institutions towards SDGs, and support ongoing monitoring, assessment, and adaptive management of disaster risks.

2.2.3 What does a mature DR&T ecosystem for DRRM mean?

As discussed earlier in this module, maturity implies progress towards completeness and perfection. In technology, completeness means that technology has realized its full potential for the application domain it serves and is on a path of continuous improvement to adapt and integrate with new innovations as they emerge. Mature status implies that the features offered by technologies and the business processes enabled by them are performing perfectly. It likewise suggests, however, that there is an enabling ecosystem where this perfection is manifested and measured. As such, we can think of maturity or perfection in terms of the following formula:

A mature DR&T for DRRM implies (1) a perfect performance in the use of technology resources and technologies and of the business processes to which these resources are applied, and (2) an enabling environment where this perfection is manifested and measured.

$$maturity = f(technology\ features, business\ processes, enabling\ environment)$$

The maturity formula suggests that perfection is a function of three parameters: technology features, business processes, and an enabling environment. The first two parameters represent the lower levels of the maturity model hierarchy illustrated earlier in Figure 6 (elements and sub-elements), while the third parameter, "enabling environment," represents aspects related to the higher level (dimensions).

In CMMI, reaching level 5 maturity implies top performance across 22 process areas impacting technology adaption (shown previously in Figure 3). However, the top performance status needs to be confirmed with robust measures. Lean Six Sigma [16] provides tools and a statistical concept for measuring the degree of perfection in CMMI process areas. Lean Six Sigma is backed by standards published by the International Organization for Standardization (ISO), including *ISO 13053-1: Quantitative methods in process improvement - Six Sigma Part 1: DMAIC methodology*; *ISO 13053-2: Quantitative methods in process improvement - Six Sigma Part 1: Tools and Techniques*, and *ISO 18404: 2015: Quantitative methods in process improvement - Six Sigma — Competencies for key personnel and their organizations with Six Sigma and Lean implementation*. These standards offer tools such as the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology to optimize and stabilize the business process. Such tools can be adapted to perfect the application of DR&T features in various DRRM processes, eliminate redundancy, and streamline operations.

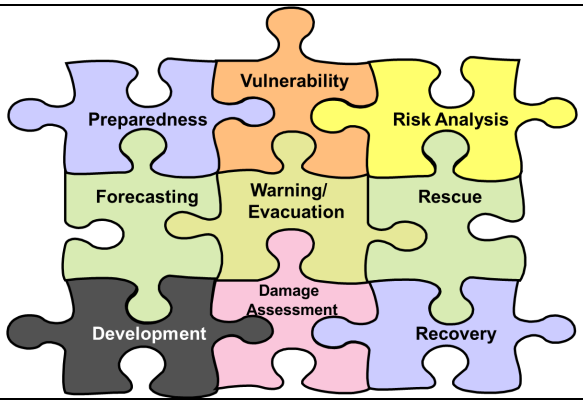
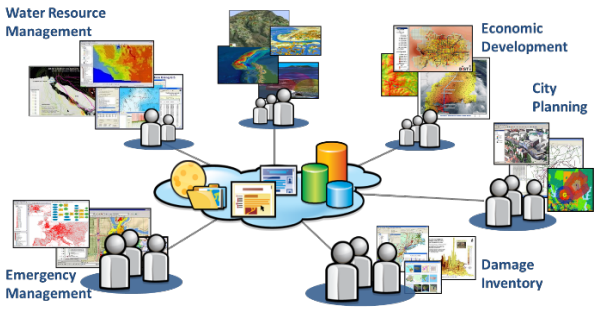
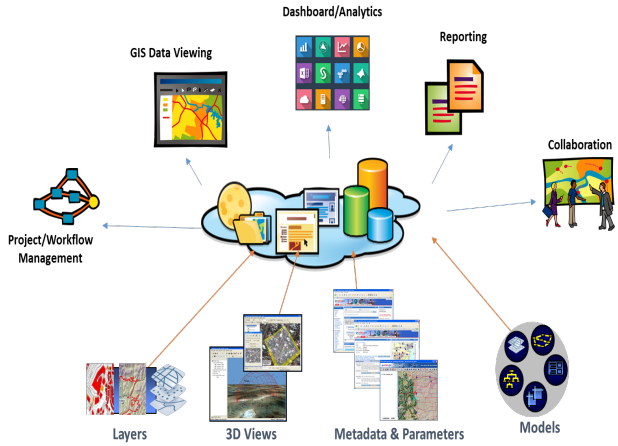
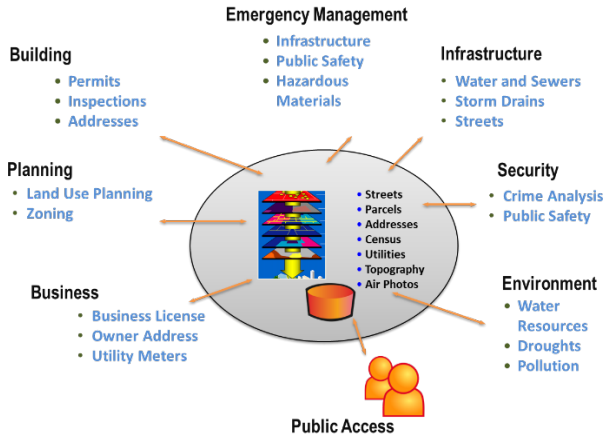
THE PERFECT PROCESS

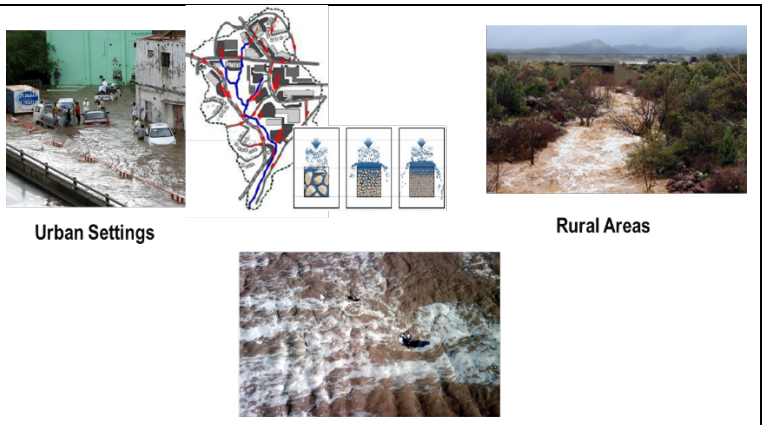
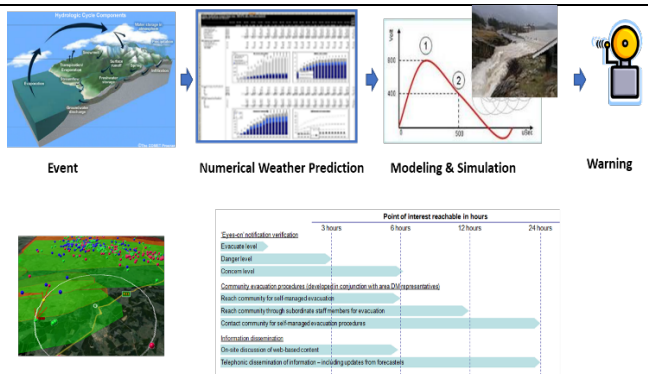
Lean Six Sigma [17] refers to management practices that provide tools and a statistical concept for measuring the degree of perfection in a process. This statistical concept is referred to by six sigma (6σ), which is the statistical presentation of a "perfect process" that yields no more than 3.4 defects per million operations. That means the process will produce 99.99966% of products with no waste or defects.

For example, if we were to assess the compliance of digital disaster datasets with international standards, we would expect 99.99966% of inspected data items to be in full compliance.

The attainment of maturity of DR&T in DRRM also requires an enabling environment that encompasses both established technologies in the field – such as geographic information systems (GIS), database management systems (DBMS), and surveying tools – and recent innovations in disruptive technologies such as artificial intelligence (AI), the Internet of things (IoT), and big data. A mature DR&T ecosystem extends well beyond supporting DRRM operations to inform risk-based planning and development by supplementing daily decision-making across various development sectors with sufficient risk knowledge to promote resilience. Table 1 summarizes the characteristics of such an ecosystem.

Table 1: Characteristics of a mature DR&T ecosystem for DRRM

Full support to DRRM: Streamline risk information sharing and auditing, as well as collaboration among a community of information "producers" and "consumers" across all areas of the disaster management continuum	
A platform for development: Risk knowledge products are consumed but also created by a community of users in all sectors in support of mitigation planning and risk reduction	
Scalability: Offer countless ways to interact with risk data, including APIs and services to create apps and added value information	
Shared geospatial infrastructure: Supported by an updated spatial data infrastructure, effectively governed, and adhering to common standards.	

Adaptability: Capable of supporting operations at various scales and contexts.	
Creditable: Offering built-in emergent behavior as well as automation and intelligent analytics.	

3. Introducing the Digital Disaster Risk Reduction Maturity Model

DDRRMM, as mentioned earlier, aims to provide a systematic way to capture the maturity status in using DR&T to enhance DRRM operations and improve disaster resilience and liveability in each context. It does so by looking at seven dimensions (i.e., maturity components) that either accelerate or hinder DRRM operations depending on their maturity status. Before discussing these dimensions Section 3.3 below, it is useful to look at what necessitated the construction of DDRRMM in the first place, what value it offers, and the guiding frameworks and approaches it is meant to synergize.

3.1 Drivers

3.1.1 Need for a holistic approach to address DR&T in DRRM

The rationale for developing a maturity model for DR&T in DRRM reflects a complex web of interrelated multiscale factors and dynamics that define today's world and impact our understanding of DRRM and DR&T realities and their interrelations. The world has changed radically in recent decades with globalization, information technology, and the unfolding environmental crisis. Many frameworks and models are being introduced to understand our quickly evolving world. Many such frameworks, however, are piecemeal, taking just one dimension of reality and breaking it down to develop an in-depth understanding of the issues with which they engage.

DDRRMM offers a synergetic mode of reasoning about DR&T maturity in DRRM by considering all related issues at once rather than taking them apart.

This reductionist approach works well when there is a weak interdependency among the components of the phenomenon we are trying to understand. This is certainly not the case with DR&T utilization for DRRM, where the issues and factors in question have a high level of interconnectivity and interdependency. As discussed earlier in section 2.2.2 on barriers to maturity, it is crucial to consider issues related to disaster data without first understanding the tools used to collect these data, the technologies available to process them, policies in place to govern data sharing, competencies of the user who handles the data and so forth. Addressing these issues simultaneously requires a synergistic mode of reasoning that puts all these things together rather than teases them apart. DDRRMM rests on a systems-based approach that provides a dynamic and holistic way to evaluate DR&T maturity in the context of DRRM.

3.1.2 Increased systemic risks

The increased non-linear interconnectivity between the various elements defining today's digital technologies creates conditions for increased dynamic systemic risks, defined roughly in terms of potential dangers that threaten a breakdown of the whole system (not simply the failure of some parts). In that sense, systemic risks are emergent phenomena that impact the entire system's integrity. When it comes to DR&T maturity for DRRM, systemic risks can be

understood in terms of the threats that make DR&T incapable of informing and supporting DRRM operations. DDRRMM is needed to address both risks and obstacles that threaten the maturation path of individual DR&T elements and the potential failures (for example, due to cyberattacks) across the whole landscape of related technologies and infrastructure that are supposed to work together in harmony to streamline DRRM.

3.1.3 Rapid technology changes

An important driver in making a case for the development of the DDRRMM is the revolutionary, rapid progress in DR&T, coupled with increased availability of technology options and relatively declining costs of implementation. The earlier model of "digitizing data" and making it available on a local server or a web portal for users to download and consume through desktop applications with limited processing power will soon vanish. Instead, three major technological trends are taking over.

DIGITIZATION VS. DIGITALIZATION VS. DATAFICATION

Digitization refers to the conversion of analog information into a digital format for transmission and manipulation by computers.

Digitalization is essentially about the process of digital transformation (e.g., how to convert business processes and operations) – also see footnote 3 above for the difference between digital resources and digital technologies.

Datafication refers to how data are generated digital-ready (e.g., through sensors, mobile devices, social media, internet transactions and so forth), moved to the cloud, and processed and compared with data collected from other sources.

The first technological trend is "datafication," a term associated with the rise of big data and related digital technologies. Datafication is defined by how subjects, objects, and practices are transformed into digital, machine-readable, and quantifiable data for aggregation and analysis [17]. Big data refers to the huge volume and high velocity by which this process occurs and the diverse nature of data it generates. Data collected by drones, satellites, ground sensors, mobile apps, crowdsourcing, etc., are examples of big data collected via datafication to inform critical DRRM operations such as early warning, response, rapid loss assessment, recovery, and intervention impact monitoring.

The second technological trend is related to cloud technologies. While the earlier wave of the information revolution was centred on acquiring hardware resources that were expensive yet offered limited processing power, we have come to an era where supercomputing infrastructure is available on-demand to any DRRM institution at a fraction of the cost. Cloud technologies represent a "platform thinking" paradigm that is very different from the "web portal" approach. The former is for making the data available for navigation and download. The latter is for building a community of DR&T consumers and producers and converting the old, centralized closed organizational server model into large open networks of computation resources. Many DRRM institutions have mastered the web portal model. However, they have yet to understand and reap the potential of the emerging cloud paradigm in the context of DRRM operations.

The third technological trend is the rise of algorithms and complex data analytics. The shift towards datafication and cloud computing is accompanied by an algorithmic revolution in AI and machine learning algorithms capable of fluidly consuming large amounts of structured and unstructured data to drive insights and reveal hidden patterns. DRRM operators and analysts are no longer limited to the information they store on their computers. They can now readily access larger and more complex datasets stored elsewhere. Even the traditional model of structured relational databases is gradually moving towards a NoSQL database model that provides a mechanism for storing and retrieving data not through relational rules but via ETL (extract, transfer, load) algorithms and other means.

"It took me a while, but I start to realize that the cloud is the biggest computing platform humanity has ever created"

Fei-Fei Li,
former Vice President, Google

The implications of these emerging technological trends in the DRRM domain are vast and involve major shifts in knowledge production and traditional decision-making processes. DDRRMM has been developed to inform the gradual transition of DRRM institutions to the emerging technological trends discussed above. DDRRMM helps re-set those institutions worldwide that are still struggling to optimize their DR&T practices based on the old information paradigm.

DDRRMM APPLICATIONS

Strengthen institutional and technical capacities for the use and application of digital technology for DRRM at various scales (national to local).

Better align technologies with various operations and activities pertaining to the DRRM cycle.

Employ the power of digital technologies in operationalizing a paradigm shift from reactive emergency relief to proactive and integrated DRRM.

Mainstream DRRM into development and sectoral planning.

3.1.4 Need for evidence-based investments

When faced with investing questions (including technology investments), organizations calculate the return of investment (ROI) or cost-benefit analysis (CBA) to decide whether the investment is worth pursuing. ROI calculates the tangible financial gains an organization can expect from investing in technology based on the following simple equation:

$$ROI = \frac{(total\ benefits - technology\ \&\ operational\ costs)}{total\ cost}$$

For example, if investing in a digital mapping technology costs $50,000, the mapping operations cost $50,000, and the projected returns from the digital maps are $150,000, then the net benefits would be $50,000, and ROI is 50 per cent.

CBA attempts to quantify both the tangible and intangible measures of the costs and benefits of the investment using a simple cost-benefit ratio. The tangible measures cover aspects directly expressed in, or easily converted to, monetary terms such as finances, time and resources saved, and doing things faster. The intangible measures

cover aspects that are more difficult to express in monetary terms, such as saving lives and improving livelihoods.

A recent study conducted by USAID's Center for Global Development shows a CBA ratio of 17 to 1 (i.e., $17 in social benefit for each dollar invested) for digital innovations [18]. However, a 2019 survey to collect evidence on digital investments shows that 90 per cent of organizations do not realize their technology benefit [19]. The discrepancy between the two statistics is shocking and suggests a random or ad hoc approach on the part of many organizations regarding technology investments. DRRM institutions are not an exception, and this is evident in the absence of sufficient studies that provide quantitative ROI and CBA for DR&T investments in DRRM.

A recent report by the Asian Development Bank (ADB) and the Organization for Economic Co-operation and Development (OECD) [20] provides a conceptual model for how emerging trends in DR&T can both streamline DRRM operations and generate financial gain (Figure 9). However, this model is yet to be implemented to measure both tangible and intangible benefits. DDRRMM is a step in this direction as it facilitates the collection of evidence and baseline measures for prioritizing and quantifying the costs and impacts of technology investments across seven dimensions that comprise the model.

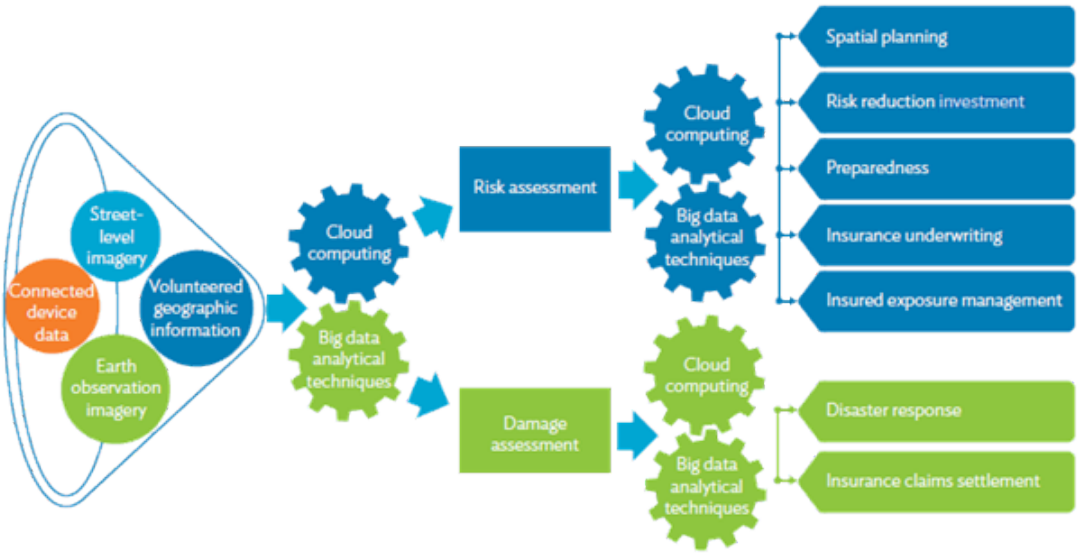


Figure 9: Applications of Emerging DR&T to DRRM and Financing (Source [20])

3.2 GUIDING FRAMEWORKS

Several emerging frameworks in both DRRM and DR&T inform the development of DDRRMM (Figure 10). The following frameworks correspond to at least one DDRRMM core component/dimension:

1. Sendai Framework for Disaster Risk Reduction 2015–2030 [21]
2. A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action [22]
3. Leaving No One Behind: Equality and Non-Discrimination at the Heart of Sustainable Development [23]
4. The Case for a Digital Ecosystem for the Environment: Bringing together data, algorithms, and insights for sustainable development [24]

5. The Role of Platforms and Platform Thinking in Open Innovation Networks [25]
6. Risk-Informed Development: From crisis to resilience [26]
7. An operational guide to Local Value Chain Development [27]

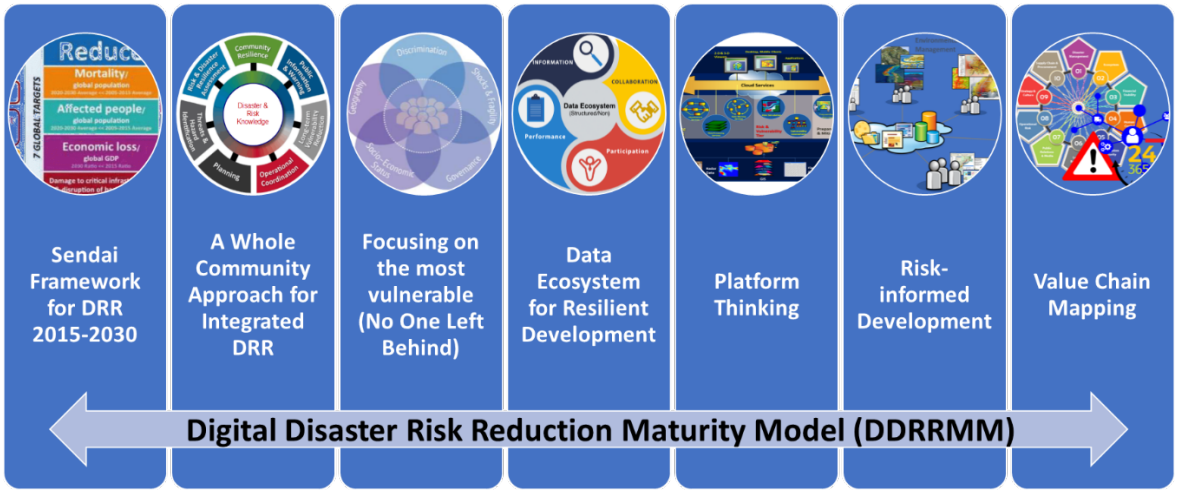


Figure 10: DDRRMM Guiding Frameworks

3.3 DDRRMM EXPLAINED

3.3.1 DDRRMM components/enablers

The DDRRMM framework revolves around seven main core components/enablers (Figure 11) deemed equally critical for the maturation of DR&T in DRRM. Each component represents an area of digital technology that influences the performance of DRRM operations.

DDRRMM components cover process areas, goals, practices, and informative material on the maturity of DR&T utilization by a DRRM institution.

- **Shared Data Resources and Access** is a maturation path leading to streamlined access to timely and quality datasets. This component encompasses a range of subcomponents and underlying elements concerning compliance with international and national standards of data specifications, management, quality, metadata, and the transition towards the full adoption of big data supporting DRRM.
- **Digital Applications and Services** is the maturation path a DRRM institute would undertake in adopting and harnessing the benefits of software applications, tools, analytics, services to increase productivity, automate and integrate workflows and operations, optimize performance, and inform decision-making.
- **ICT Infrastructure** is a maturation path to build, operate, and maintain a robust technology infrastructure that can support business continuity, high-level performance, speedy access, and timely decision-making and is scalable to accommodate the increased computation requirements of technology applications and protect the DRRM institution's assets and operations.

- **Institutionalization and Partnership Programmes** is the maturation path a DRRM institution undertakes to create an enabling environment and culture for promoting DR&T innovation such as investment, partnership and management of technology resources.
- **User Competencies** component addresses the maturation of the skills and knowledge of human capital and talents needed for operating and using DR&T effectively.
- **Governance (Policies, Standards, Guidelines, and Best Practices)** is a maturation path covering various legal and operational regulations and practices impacting access to DR&T, availability, data ownership, stewardship and privacy.
- **DRRM Coordination and Collaboration** component looks for evidence to assess the return on investment and social benefits of DR&T utilization in DRRM regarding enhanced operations and improved performance such as increased response, reduced fatalities, increased resilience, and improved risk-informed decisions.

Figure 11: DDRRMM Seven Core Components/Enablers

3.3.2 DDRRMM maturity hierarchy

As Figure 11 indicates, the DDRRMM Framework is a collection of seven core components covering the entire ecosystem of DR&T maturation in DRRM according to the maturity formula presented in section 2.2.3. The formula includes factors related to DR&T, DRRM operations, and the operational environment within a DRRM institution. In addition, to facilitate appraisal of maturity and provide a methodology for a systematic investigation leading to quantifiable measures, each

"WHAT GETS MEASURED GETS DONE."

Tom Peters, Business Management Consultant and Author of "In Search of Excellence"

of the DDRRMM components is further split into a hierarchical structure of subcomponents, elements, and indicators and measures, as shown in Figure 12.

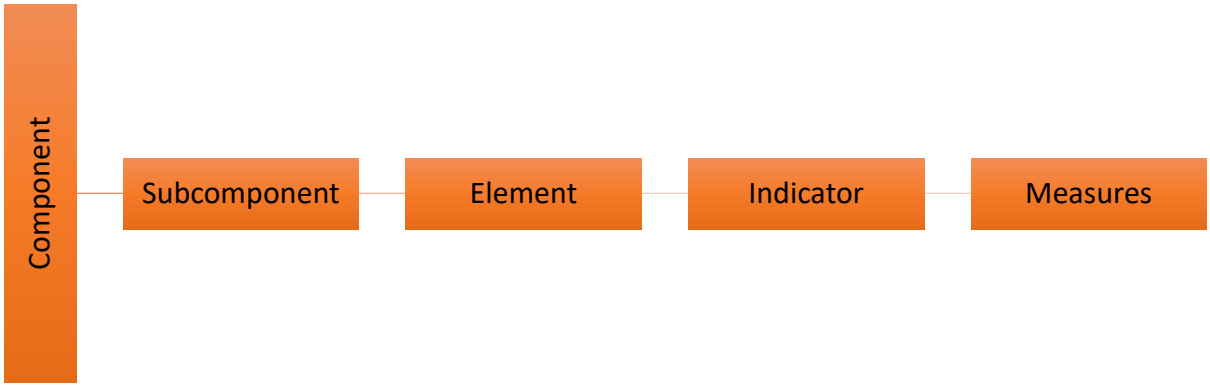


Figure 12: DDRRMM Model Hierarchy

- **Component**
  - This represents the highest level of the hierarchy in DDRRMM and refers to one of seven distinct areas; each covers a unique dimension influencing the state of the art in utilizing DR&T for DRRM.
  - All seven DDRRMM components are assumed to be equally important in DDRRMM and carry the same weight.
  - The maturity appraisal of the component is not assessed directly. Rather, it is derived through normalizing the quantitative scores assigned to its subcomponents.
- **Subcomponent**
  - The scope of a given DDRRMM component is determined by, or encompassing, specific DR&T areas that make up its scope. For example, DDRRMM Component 1 concerning "Data Access and Sharing" has five subcomponents: data frameworks, data availability and quality, data management, data governance, and big data capability.
  - Subcomponents do not carry the same weight; some may be deemed more critical for the maturity of the parent component than others. The importance of a subcomponent relative to its parent component may also change over time as the technology matures and practices evolve. Weights assigned to subcomponents should be decided periodically by experts in respective areas.
  - As with components, the maturity appraisal of subcomponents is not assessed directly. Rather, it is derived through normalized quantitative scores assigned to its elements, representing the next level down in the hierarchy.
- **Element**
  - Each subcomponent is further divided into elements. Each element represents an aspect of the subcomponent defined precisely and can be appraised and assigned a maturity score, directly or indirectly. For example, the status of "Fundamental data model specifications" represents an element in "Data Framework," which is a subcomponent of the "Data Access and Sharing" core

DDRRMM component. Fundamental data model specifications refer to the presence and maintenance of a data model/product framework that supports the DRRM institution's operational needs and complies with international standards.

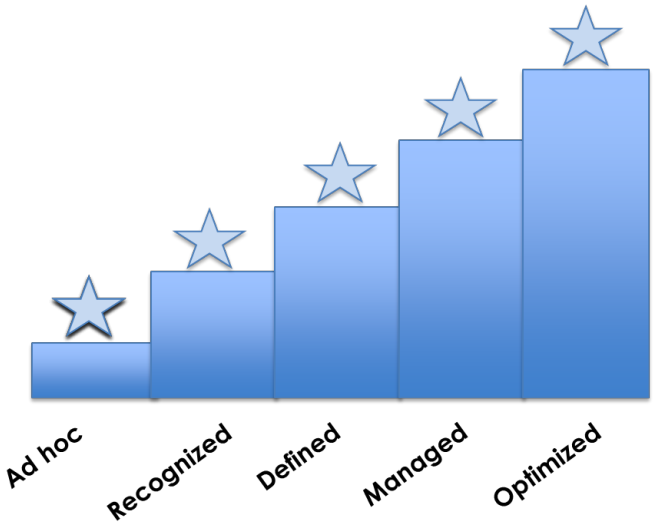
- Elements are assigned different weights according to their degree of importance to the overall maturity of the parent subcomponent. Element weights in DDRRMM are driven by experts from the DRRM community using a methodology described in Appendix B of this white paper. Users of DDRRMM are advised to revisit these weights periodically as the relative importance of various elements may change over time.
- The maturation score of an element is either measured directly or calculated from its indicators based on the level of DDRRMM assessment conducted (coarse assessment or detailed assessment).
  - In *coarse assessment*, elements represent the lowest level of the maturity assessment; therefore, the maturation scores are assigned to the element directly (i.e., through observation, surveys, stakeholder' interviews).
  - In the *detailed assessment*, maturation scores of elements are calculated through average scoring of quantitative measures assigned to its indicators.

- **Indicators and Measures**
  - When a detailed, quantitative assessment of DDRRMM is required, elements are split further into indicators and measures.
  - An *indicator* refers to the condition of something related to the element.

    A *measure* refers to the quantitative value assigned to this condition to express the indicator status. For example, "Core GIS Data" represents an element of the "Data Availability and Quality" subcomponent of the "Data Access and Sharing" core DDRRMM component. Indicators that are related to this element, Core GIS Data, include Completeness; Custodianship; Thematic Content; Data Format (vector, raster, grids, topology, etc.); Scale; Positional Accuracy; Attribute Accuracy; Temporal Scale; Currency; Tabular and Spatial Relationships; the Presence of Metadata; Map Projections; and Datums. Each indicator can be measured through quantitative means that reflect its condition and contributes to the maturity score assigned to the Core GIS Data element.

3.3.3 DDRRMM maturity levels and scoring

In DDRRMM, the maturation of DR&T for DRRM is described based on five levels as shown in Figure 13.



Ad hoc

- DR&T utilization for DRRM is random and undocumented.
- Resources are not available.
- DR&T tend to be implemented in an ad hoc, uncontrolled and reactive manner by users and events.

Recognized

- Importance of DR&T for DRRM is recognized.
- Silo implementation and cases of repetitive users are unlikely rigorous.
- Insufficient resources.
- No standard operational procedures.

Defined

- Some consistency in using DR&T for DRRM.
- Resources are available but not sufficient for optimal operations.
- Full integration across the organization is lacking and impacts performance.

Managed

- DR&T capabilities are well established and enhancing DRRM operations.
- Resources are sufficient in general.
- KPIs for managing and maintaining performance are present.

Optimized

- DR&T utilization for DRRM reflects the state of the art.
- Full implementation and integration across the DRRM institute and with the digital ecosystem are realized.
- KPIs and performance levels are at or near targets.

Figure 13: DDRRMM Maturity Levels

The granularity of DDRRMM (i.e., splitting maturity levels into five) reflects the technology life cycle (TLC) model [28]. The TLC depicts the role of technology as a driver of competitive advantage and innovation in business based on four stages derived from empirical evidence. The TLC assesses the costs and profits of commercial products from technological development to market maturity and ultimately decline. Its stages reflect how organizations

embrace technologies and the risk of becoming outdated if they do not keep up with evolving technology trends.

The assignment of a maturity level is based on a percentage score (Table 2) calculated as the average of all scores assigned to each DDRRMM component.

Table 2: DDRRMM Index Interpretation

MATURITY LEVEL	SCORE RANGE	SCORE RANGE %
Ad hoc	0 – 1	0 to 20
Recognized	1 – 2	> 20 to 40
Defined	2 – 3	> 40 to 60
Managed	3 – 4	> 60 to 80
Optimized	4 – 5	> 80 to 100

Component scoring will range between 0 and 5 for each component and is derived from their subcomponents, elements, and indicators as described in section 3.3.2. In coarse assessment, where maturity assessments start at the element level, scoring at the element level is based on a qualitative scale shown in Table 3.

Table 3: Qualitative description and assigned scores for maturity elements (coarse assessment)

MATURITY LEVEL	DESCRIPTION	SCORE
N/A	Not applicable (explanation required)	0
Ad Hoc	Desired, but is not planned	1
Recognized	Planned but with no resources available to achieve the capability	2
Defined	Planned and with resources available to achieve the capability	3
Managed	In progress/partially implemented – OR fully implemented but lacking performance assessment and compliance with international standards	4
Optimized	Fully implemented AND performance in full compliance with standards, continuous improvement on an ongoing basis based on quantified performance goal	5

Component 1 - Data Access and Sharing - Element Level Specifications

Subcompone	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score
1.1 Data Framework	1.1.1 Fundamental data model specifications	Presence and maintenance of a data model/product framework for a GIS basemap, imagery, and fundamental datasets that meets the DRRM institution's operational needs and complies with ISO 19131:2007 (Geographic information — Data product specifications) and ISO/TS 19129:2009 (Geographic information — Imagery, gridded and coverage data framework)							0
	1.1.2 Data/domain business alignment	Datasets and data management practices are aligned with the institution's DRRM operational domain and business strategy and free of any gaps (missing data), redundancies, or duplications, and comply with ISO/TR 19169 standard (Geographic Information — Gap-analysis)							0
	1.1.3 Domain data model specifications	Presence and maintenance of an application-/domain-specific schema for domain-specific GIS as well as non-GIS data (documents, tables, databases) that meets the DRRM institution's operational needs and comply with ISO 19131:2007 (Geographic information — Data product specifications) and ISO 19109:2015 (Geographic information — Rules for application schema)							0
	1.1.4 Visualization and portrayal framework	The DRRM institution implements a conceptual scheme visualization that describes symbols, portrayal functions that map geospatial features to symbols, support the collection of symbols and portrayal functions into portrayal catalogs system, and complies with ISO 19117:2012.							0

Figure 14: Example of a maturity assessment matrix at the DDRRMM element level

3.3.4 DDRRMM assessment

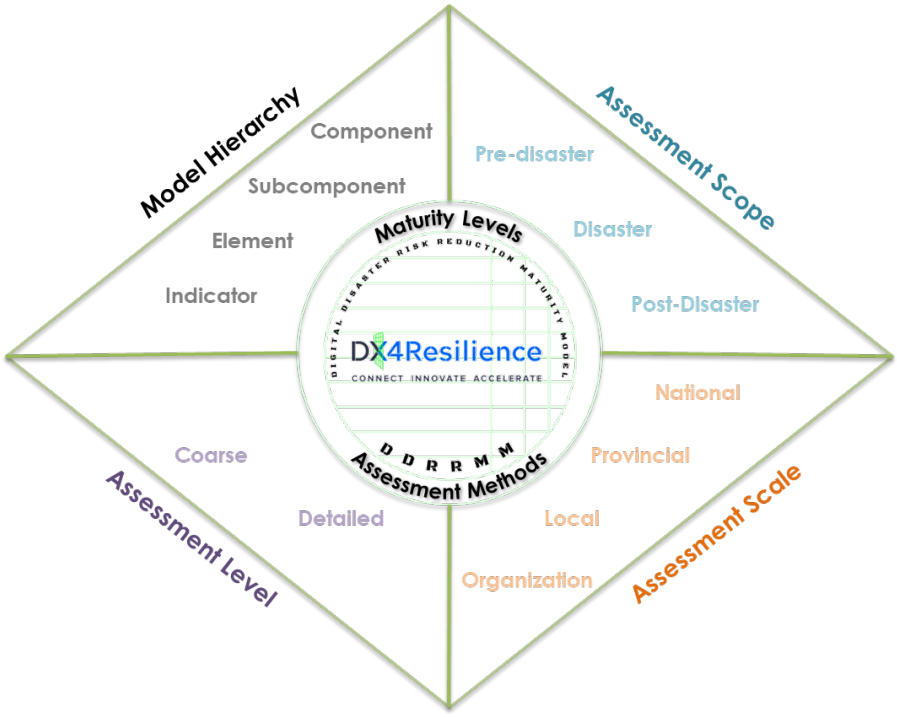


Figure 15: Aspects to consider when conducting DDRRMM Assessment

Figure 15 summarizes the following six aspects to consider when conducting a DDRRMM assessment.

1. DDRRMM Model Hierarchy, which dictates the level of maturity assessment as described in section 3.3.2.
2. DDRRMM Maturity Levels used to assign maturity scores and interpret maturity level as defined in section 3.3.3.
3. Assessment scale refers to the geographic/administrative assessment scale (national, provincial, or local).
4. Assessment level refers to how deep in the model hierarchy the assessment will go. DDRRMM assessment could be either coarse (element level) or detailed (indicator level), as shown in Figure 16.

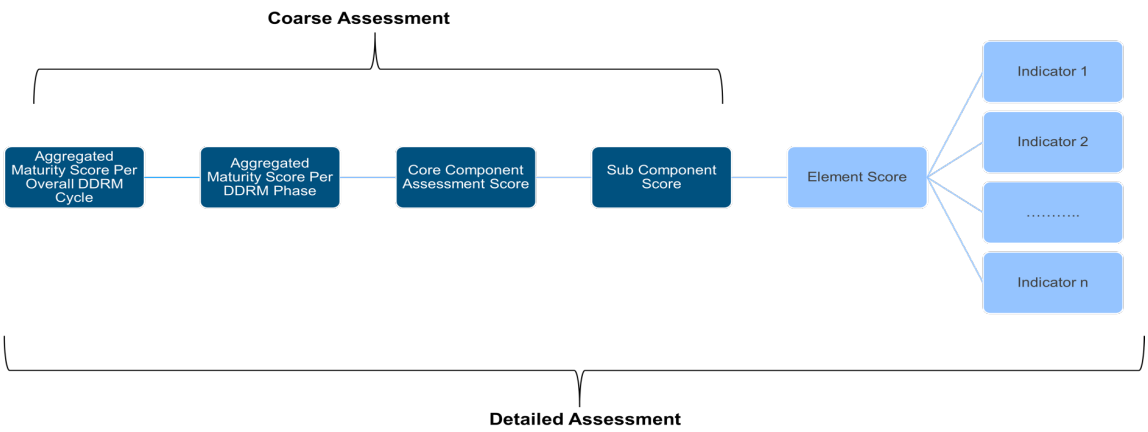
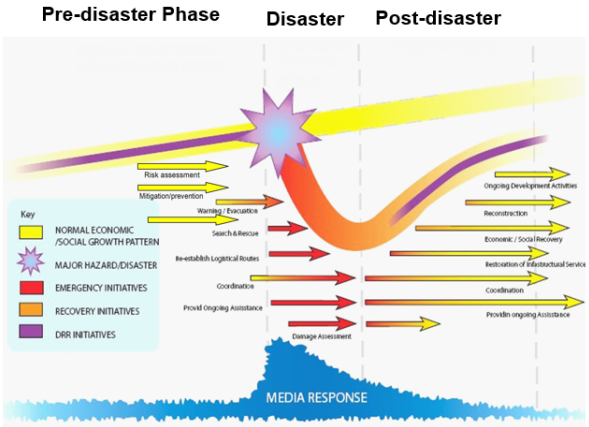


Figure 16: DDRRMM Different Levels of Assessment

5. Assessment method, which refers to how the maturity scores are assigned. Assessment methods are associated with assessment level and can be qualitative (for element level, course assessment) or quantitative (for the indicator level, detailed assessment).
6. Assessment scope refers to the coverage of DRRM activity and operations (Figure 17).



- **Pre-disaster Phase**
  - DR&T use in disaster risk assessment
  - DR&T use in Disaster risk management, planning and monitoring
  - DR&T use in Disaster mitigation and prevention
  - DR&T use in Mainstreaming DRM into development planning
  - DR&T use in Awareness raising and dissemination of risk information
  - Performance of early warning systems
  - DR&T use in Preparedness (overall and sector specific)
- **Disaster Phase**
  - DR&T use in supporting immediate response and/or relief assistance
  - DR&T use in damage and loss assessment
- **Post-disaster**
  - DR&T use in recovery of services and infrastructure
  - DR&T use in reconstruction
  - DR&T use in Rehabilitation, and economic and social recovery

Figure 17: DDRRMM Assessment Scope (Adapted from [29])

A mix of different aspects would yield different outcomes of the DDRRMM assessment, thus offering flexibility to assess maturity according to available resources, time frame, and goals. For example, a coarse assessment could be conducted at the national scale covering the entire scope of DRRM operations, complemented with a detailed assessment for one of the disaster phases. Additional examples are presented in the next chapter.

4. DDRRMM in Practice: Applications and Case Studies

This final chapter highlights some of the best practices for applying DDRRMM. These examples are not meant to provide a complete, step-by-step guide to using DDRRMM (a DDRRMM assessment guide and training package is planned for release in the summer of 2022). Rather, the goal is to help readers appreciate the utility of DDRRMM. The examples shown here reflect lessons learned from two project implementations of the DDRRMM. The first example was a rapid/coarse assessment performed by UNDRR/UNDP[9] to assess the status of national disaster data and databases and derive lessons to guide the next generation of disaster data systems. The assessment targeted thirteen countries from five regions (Arab States, South Asia, Africa, Europe and Central Asia, and South America) and was conducted at the DDRRMM's subcomponent level, pursuing only the lead disaster management institution in each country.

The second assessment is from DX4Resilience project implementation in Indonesia, Nepal, Philippines, and Sri Lanka where detailed national-level digital diagnostic and digital readiness studies were conducted[10] at the DDRRMM's element level and involved a diverse range of national institutions in each country.

The best practices cover four areas of DDRRMM application (Figure 18):

1. How to prepare for DDRRMM assessments at a national level.
2. How to conduct DDRRMM assessments.
3. How to tabulate and analyse the DDRRMM assessment results.
4. How to interpret and use DDRRMM assessment results to drive strategic recommendations for digital transformation interventions.

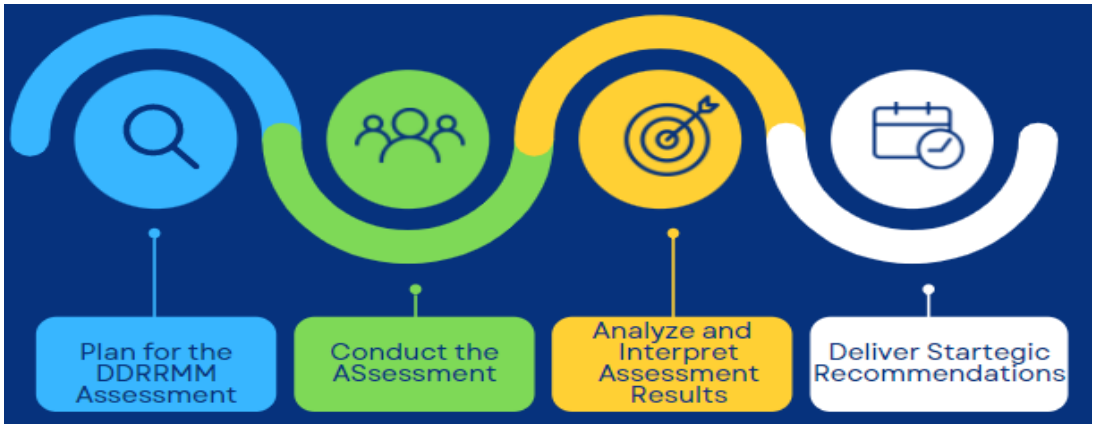


Figure 18: A Typical Workflow for Performing DDRRMM Assessment

[9] The UNDRR/UNDP DDRRMM rapid assessment was performed in summer 2021 and covered 13 countries: Philippines, Indonesia, Nepal, Jordan, Lebanon, Sudan, Niger, Malawi, Mauritius, Portugal, Armenia, Costa Rica, and Colombia.

[10] Digital Diagnostic Assessment and Digital Readiness studies in the DX4Resilience project countries started around July 2021 and concluded in February 2022.

4.1 Planning for a DDRRMM assessment

Figure 19 shows the key steps that required by the assessment team to plan for the DDRRMM assessment. To assess properly, provide sufficient time for each step.

Figure 19: An Infographic for DDRRMM Planning Steps

4.1.1 Desk study and literature review

DDRRMM assessment can be performed by internal members in DDRRMM institutions (self-assessment) or through external personnel such as consultants and evaluators. The following activities are recommended to prepare for assessment.

4.1.1.1 Study the status of disaster risks in the study area

A prerequisite to the DDRRMM assessment is to ensure a solid understanding of the status of disaster risks as appropriate to the assessment scale (national, provisional, local).[11] The assessment team should conduct a desk study and review hazard profiles and existing documentation of vulnerabilities and risks associated with these hazards such as risk assessment and vulnerability maps. Equally important is the collection of background information on existing DRRM institutions operating at the scale targeted by the assessment: their structures, mandates, policies, laws and disaster codes, and any related projects or studies. The latter may include studies on the socioeconomic, cultural, and community-based

[11] See https://www.undrr.org/ for a useful entry point to understand the status of hazards and profiles in various countries at the national level.

institutional systems prevalent in vulnerable areas, including information on disaster risk coping strategies.

The following is a general checklist of tools and methods that can be used in performing the desk study (the appropriateness of a given tool depends on the scale of the DDRRMM assessment).

- **Timeline and history of hazards/disasters**: frequency of shocks and coping mechanisms
- **Vulnerability context**: proportion and nature of households affected by disasters
- **Disaster risk assessment**: nature, scope, and magnitude of negative impacts of hazards on a community and its households within a particular period
- **Hazard and resource map** allows the community to identify graphically the vulnerable members of the community, especially youth, older people and those living with disabilities who are put at special risk by hazards
- **Seasonal calendar**: seasonal changes and related hazards, diseases, community events, and other risks related to specific months of a year
- **Ranking**: analysing problems to learn community priorities and significant problems
- **Transect**: walking in the geographical area belonging to a community to get an idea of the vulnerability of the community and the resources that are available or may be available for disaster risk management
- **Historical transect graphic presentation** of the history of disasters and development in the community (done by recall)
- **Matrix ranking**: ranking tools used to prioritize hazards or disaster risks, needs, or options
- **Household composition**: human capital, labour force, migration, education, dependency status of various socioeconomic groups
- **Resource ranking**: typical characteristics of resources and capabilities in community institutions

4.1.1.2 Create an inventory of DRRM institutions and organizations of interest

The DDRRMM assessment is conducted for DRRM institutions to assess the degree to which they are mature in using DR&T in their operations and how the technology helps them fulfill their institutional mandates. Therefore, it is important at the outset to identify the relevant institutions and focal points within each one. The activity in 4.1.1.1 may help guide the selection of institutions. In addition, the following are some questions that can be used to determine the relevance of an institution to DDRRMM assessment.

- What is the institution's type (governmental, NGO, community-level)?
- How are the scope, purpose, scale, and specific mission of the institution related to DRRM? The target institution should play a pivotal role in DRRM within the study area such as developing a policy framework, conducting specific operations, providing critical data, and conducting relief.

- Does the institution have a specific hazard focus like flood management or seismic hazards mitigation?
- Does the institution focus on certain disaster risk management phases including preparedness, mitigation, relief, reconstruction and rehabilitation?
- Which institutions have the mandates and/or responsibility for implementing disaster risk reduction interventions, including overall coordination and sectoral responsibilities?
- Which ministries/institutions and technical agencies are designated as national focal points for aspects of DRM-related activities? How do they coordinate with institutions operating at the provisional and local levels?

4.1.1.3 Ensure a thorough understanding of DDRRMM

The study team needs to be familiar with DDRRMM, its model hierarchy, and the meaning and goal of each subcomponent and element. A team member should be prepared to answer technical questions or explain the purpose of the assessment to target stakeholders in an easy-to-understand manner.

4.1.2 Identification of key participants

Institutions are the medium through which one can assess the state of the art in using DR&T for DRRM in any context (local community, province, country, regional or continental). They are the driving forces who plan, implement, monitor, and evaluate digital transformation interventions, hence improving the maturity of DR&T for DRRM.

Identifying the key institutions (as presented in 4.1.1) is critical, but equally vital is recognition of the importance of these institutions for DRRM processes and the formal and informal links both among them and with other agencies. This process is known as *stakeholder mapping* and refers to mapping out the different organizations that have a stake or interest in a project or system (in this case, the use of DR&T for DRRM). Stakeholder mapping[12] is the process of mapping out these various stakeholders, and it typically involves the following steps.

1. Create a list of stakeholders such as DRRM institutions and agencies with a stake in DR&T use for DRRM in the context of the analysis.
2. Determine the influence of the stakeholders (i.e., which agencies play a critical role in the digital transformation for DRRM). The relative importance (also known as stakeholder power or weight) can be determined according to different dimensions of influence like resources, decision-making and leadership.
3. Place stakeholders on the map, scaling them according to their level of importance (typically, using these three tiers: primary, secondary, and tertiary).

[12] Stakeholder mapping can be done for a geographic context (country or community level for example) as well as for an organizational context (in this case the focus is on individuals and departments/units within this organization).

4. Finally, map out the flows between them such as financial, physical goods, communication, trust, and influence.

In an ideal case, all stakeholders should be evaluated. Often this is not possible, however, due to constraints in time or resources. If this is the case, the priority of the assessment is given to those stakeholders of higher importance.

Below are several examples of tools and methods for stakeholder mapping [29].

- **Venn diagram**: Create a Venn diagram and/or 'mental map' of DRRM institutions, their relative importance, and linkages with higher-level institutions.
- **Colour card exercise**: Identify relationships and linkages between institutions that can be mapped by writing key factors on cards, sticking the cards onto a wall in a pattern, and drawing lines between cards to show lines of influence. Colored cards can then be used to represent different sectors and their DRRM-related activities.
- **Group exercise**: Divide stakeholders into a few groups based on their organizational mission. For each group, brainstorm the key linkages within and between the institutions and then repeat the same exercise at the group level.
- **Institutional environment mapping** is a form of stakeholder analysis that illustrates the relationships between actors at a micro-level (local) and the relationships between actors in a particular sector or at higher levels (province or national).
- **Sectoral institutional assessment**: In a sectoral institutional assessment, data are gathered and examined in a tiered analysis at the political-structural level, the administrative-systems level, and the technical-sectoral level, paying particular attention to institutional dynamics and linkages among sectoral agencies.

Best Practice: Identification of Key DRRM Institutions in Sri Lanka

The selection of stakeholder agencies involved in the DRRM functions was a critical factor for DX4Resilience project countries as the final consolidated score represented the maturity level of the country. For example, in Sri Lanka, the Disaster Management Act #13 of 2005 lists 20 areas or core subjects that need to be presented in the National Council. The preliminary stakeholder evaluation considered 15 ministries and government agencies responsible for these subjects. Unfortunately, not all agencies could be approached for DDRRMM assessment because of COVID-19 and project time constraints. Therefore, the *relative importance of agencies was evaluated against four criteria*:

1. institutional relation to the national mandate for DRRM functions in Sri Lanka;
2. whether the operations and the business process of the institution was directly related to DRRM functions such as risk assessments, early warning, mitigation, adaptation, response, and resettlement planning;
3. the presence of an enabling environment for data governance, institutional setup, policy, and data sharing arrangements; and
4. demonstrated ability in technology applications (digital data ICT tools and systems for DRRM).

A total of *21 indicators* were used to measure the performance of the fifteen agencies with equal weights given for the above four main criteria as follows.

- **Criterion 1 (relevance to the national mandate)**: (1) focal agency for coordination of DRR; (2) focal agency for hazard risk management; (3) coordinating relief and response activities; (4) post-disaster recovery interventions; (5) island wide coverage
- **Criterion 2 (institutional operations)**: (6) hazard zonation mapping and risk assessment; (7) early warning (formulation and dissemination); (8) hazard risk mitigation/prevention; (9) relief distribution; (10) preparedness planning; (11) disaster response; (12) recovery activities; (13) resettlement planning
- **Criterion 3 (DRRM Data)**: (14) assessment of access to data; (15) implementation of provisions in Disaster Management Act or any other legislation to set up and maintain databases facilitating DRRM functions; (16) past event databases (such as DesInventar database, landslide inventory, national health and diseases database; (17) policies, circulars, and guidelines to make DM-related data available to any user; (18) an officer appointed to facilitate the data/information management
- **Criterion 4 (technology applications)**: (19) database containing hazard maps/zonation maps (1:50,000, 1:10,000, 1:5000,1:2000 scales); (20) databases that facilitate overlay and combined analysis – for example rainfall data generators (digital data and analogue), typography /bathymetry data generators; (21) database containing exposure data (rivers network, admin boundaries, road networks, lifeline facilities)

The following institutions with the top five scores were selected to conduct the DDRRMM assessment.

1. Disaster Management Centre (DMC)
2. Department of Irrigation (DoI)
3. National Building Research Organisation (NBRO)
4. National Disaster Relief Services Center (NDRSC)
5. Department of Meteorology (DoM)

4.1.3 Inception meeting with stakeholders

Once the key stakeholder institutions are identified, inception meetings with focal points at each institution need to be planned to identify those who should participate in the DDRRMM assessment. Ideally, each institution will provide representatives capable of answering

questions related to the seven main components of DDRRMM: Data, Tools, Technology Infrastructure, Capacity Building, Governance, Institutionalization, and Alignment with DRRM and Organizational Mission. The purpose of the inception meeting is to obtain support and commitment at the institution's senior decision-making level to conduct the DDRRMM assessment and present the purpose, main agenda, and guidance for the assessment.

The inception meeting should explicitly present the goal and the key features of DDRRMM to help each institution understand the goal of the DDRRMM assessment. Furthermore, as the inception meeting proceeds, it would be advisable for the chair/facilitator to set up one or more smaller technical group meetings on specific DDRRMM components that entail technical aspects (data, tools, and ICT infrastructure) to allow nontechnical topics to advance on the main agenda.

Best Practice: Example of an Inception Meeting Agenda

Background: UNDRR and UNDP are engaged in a joint mission to analyse national disaster loss databases (DLDs) in selected countries with the goal of developing recommendations for the next generation of DesInventar. The analysis targets governmental stakeholders of DLDs in Armenia, Serbia, Tajikistan, Lebanon, Jordan, Sudan, Mauritius, Niger, Malawi, South Sudan, Indonesia, Philippines, Nepal, Fiji, Solomon Islands, and Tonga.

Purpose and format: UNDRR/UNDP will perform one-on-one semi-structured interviews with government stakeholders to capture their experiences with DLD systems, prioritize challenges, and create strategic pointers for future improvements. The interviews will be informal, in-depth conservations around the seven components of UNDP's DDRRMM covering data, applications, ICT infrastructure, user competencies, institutionalization, governance, and alignment with DRR&M operations.

Participants: Government affiliate(s) in each country, UNDP and UNDRR representatives (observers), and a consultant/moderator

Duration: 90 minutes

Organization

Duration (minutes)	Topic
5 minutes	Participant introductions Purpose of the meeting Interview format
10 minutes	Overview of the current situation/context of national DLD tools Role of agency participating in the meeting The landscape of disaster loss data handling (other stakeholders, data custodianship ...)
35 minutes	Introducing DDRRMM and its Assessment Areas
35 minutes	Agency's North Star Requirement for immediate and short-term action for each DDRRMM assessment area
5 minutes	Discussion of next steps (ranking webinar) and whether the agency is willing to participate in UNDRR piloting of the solution

4.2 CONDUCTING DDRRMM ASSESSMENT

The following steps for conducting a DDRRMM assessment with DRRM institutions should be amended or sequenced according to specific situations.

- Prepare a semi-structured interview questionnaire covering all aspects of the DDRRMM components, subcomponents, and elements.
- Organize one or more interview sessions with the representatives of the target DRRM institution to review the questionnaire. Questions should be designed to gain a deeper understanding of the elements and not be posed in a multiple-choice format.
- Record the responses in the DDRRMM Calculator (V3.0), a tool developed by DX4Resilience to record answers to various questions and estimate maturity levels (see Appendix C).
- If separate meetings take place representatives from the main institution, a final cross-checking discussion should be organized to resolve any conflicts over perceived facts and widely divergent viewpoints.
- Throughout the process, cross-check or clarify facts and recommendations found in key publications such as IT strategy documents, annual reports, and sample data.

Some of the useful methods/tools for conducting assessments include:

- Participatory design/co-design
  - Purpose
    - Engage real-world users in design activities to uncover new ideas, priorities, and flows.
    - Challenge our assumptions about feature development and the value proposition of our products.
  - Outcome
    - Generate new ideas based on direct input from our target audience.
    - Gain more certainty that our products meet the needs of their target audience.
- Contextual Inquiry
  - Purpose
    - Understand behaviors in the context of where people perform the activities we want to solve.
    - When solving for complex systems and behaviors, contextual inquiry can bring us into the life of the users as an observer. For example, the term “digital innovation” may be understood differently if two individuals come from different backgrounds and have varying levels of mastery and awareness of digital technologies. Contextual inquiry removes those personal translations we make in interviews, so it is clear what these terms mean.
  - Outcome
    - Empathy and real life understanding of user situations lead to a better understanding of the problem and how to solve reactive implementation of DR&T.

Best Practice: Example of a Semi-Structured Interview Agenda - Nepal

Questionnaire: Digital Diagnostic Assessment for Disaster Risk Reduction and Recovery for Nepal

Youth Innovation Lab (YI-Lab) highly acknowledges your co-operation and support for the research entitled "Digital Diagnostic Assessment for Disaster Risk Reduction and Recovery for Nepal". YI-Lab is conducting this assessment to diagnose the digital disaster maturity level in collaboration with United Nations Development Programme (UNDP) and National Disaster Risk Reduction Management Authority (NDRRMA).

This assessment will be an opportunity to test and operationalize the Digital Disaster Risk Reduction Maturity Model (DDRRMM) adopted by UNDP. The output will support institutions involved in digital resources and technology, NDRRMA, the Government of Nepal (GoN), UNDP and other donors, in identifying the enabling factors, policy landscape, and barriers to digital and technological solutions. The goal of this assessment is to identify the intervention areas to strengthen digital practices in disaster risk reduction, management and recovery.

Part A of the questionnaire comprises semi-structured questions for testing the DDRRMM model.

Part B of the questionnaire comprises open-ended questions for user requirement assessment.

Digital maturity will be assessed across seven components:

1. Data access and sharing
2. Digital application and services
3. ICT infrastructure
4. Alignment with DRR coordination and collaboration
5. Staff competencies
6. Institutionalization and partnership
7. Governance.

Based on this survey questionnaire, the maturity level will be assigned across five levels: ad hoc, recognized, defined, managed, optimized. Details are presented in the table below.

Digital Disaster Risk Reduction Maturity Model (DDRRMM) hierarchy level tool for assessment

	AD HOC	RECOGNIZED	DEFINED	MANAGED	OPTIMIZED
	1	2	3	4	5
Process	Process is unpredictable, poorly controlled and reactive. Few processes are defined but are occasionally in a state of complete confusion and disorder.	Process characterized for the project, often reactive The necessary process discipline is in place to repeat earlier successes on projects with similar applications.	Process characterized for the project, proactive Process is documented, standardized, and integrated into all processes.	Process is measured and controlled. Process and products are quantitatively understood and controlled.	Focus on process improvement Continuous process improvement is enabled by quantitative feedback from the process and from piloting innovative ideas and technologies.

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Details of key Informant Interview:

Date…… Name……
Designation…… Organization……
Contact Information…….

_____

COMPONENT 1: DATA ACCESS AND SHARING

Subcomponent 1.1 Data Framework

S.N	Element	Questions	Target	Method	Marking tool
1.1.1	Fundamental data model specifications	Does your digital system have data models or a product framework for disaster related data (GIS/imagery or other type of data)? If yes, does it align with National or International standards (ISO 19131:2007, ISO/TS 19129:2009)?	IT	one-on-one	Scale of Standardization
1.1.2	Data/domain business alignment	Are the data management practices in your organization as per the organization's operational needs for DRRM? (Please answer on a scale of 0 to 5)	IT	one-on-one	Scale of Standardization
1.1.3	Domain data model specifications	Do you maintain domain specific schema for GIS and NON-GIS data? If yes, does is align well with national or international standards?	IT	one-on-one	Scale of Standardization
1.1.4	Visualization and portrayal framework	Do you have a visualization and portrayal framework for geospatial data? If yes, does your framework comply with national or international standards (ISO 19115:2019)?	IT	one-on-one	Scale of Standardization
1.1.5	Data catalog & discovery framework	Does your organization have an inventory of data (data catalogue), data concept dictionaries and complete and up-to-date metadata? Does it align with international standards?	IT	one-on-one	Scale of Standardization
1.1.6	Data maintenance framework	Does your organization maintain and update data regularly? Do you have data maintenance standards? Does it align with international maintenance frameworks?	IT	one-on-one	Scale of Standardization

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Subcomponent 1.2 Data Availability and Capability

S.N	Element	Questions	Target	Method	Marking criteria
1.2.1	Core and business GIS data	Is the GIS data complete? If yes, is it thematically relevant to a disaster context? Does it have necessary data formats (vectors, raster etc.), scale, position accuracy, presence of metadata, and map projections?	IT/data manager	one-on-one	Project management
1.2.2	Non-GIS data (structured)	Regarding the non-GIS data, is it complete, fit for use, accurate, and in accordance with integrity rules?	IT/data manager	one-on-one	Project management
1.2.3	Other business data (unstructured)	Do you also use unstructured data (documents, pdfs, social media posts etc.) to carry out the organization's operations? If yes, are they geotagged, integrated with structured data and support entity recognition?	IT/data manager	one-on-one	Project management

Subcomponent 1.3 Data Management

S.N	Element	Questions	Target	Method	Marking criteria
1.3.1	DBMS /data warehouse	Does the data reside in a secure database management system that has good management support? If yes, does it have different user privilege mechanisms?	IT/data manager	one-on-one	Project management
1.3.2	QA/QC	Are you aware of principles required for maintaining quality data? Do you apply measures for evaluating and reporting the quality of the data? Do you also meet the ISO 19157:2013 standard?	IT/data manager	one-on-one	Standardization measure
1.3.3	Data update/audit cycle	Are the data available well-maintained and updated on a predetermined and scientific basis?	IT/data manager	one-on-one	Process
1.3.4	Metadata	Are metadata available and updates for all types of data? If yes, does it meet all requirements set forth by guiding metadata standards?	IT/data manager	one-on-one	Standardization measures
1.3.5	Backup and recovery	Do you have in place a backup, archival and recovery system for data?	IT/data manager	one-on-one	Project management

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Subcomponent 1.4 Data Governance

S.N	Element	Questions	Target	Method	Marking criteria
1.4.1	Evidence of data interoperability	Are data easily accessible and in open data formats (GeoJSON, JSON, XML etc.)? Are they linked to the Semantic Web and are there HTTP URIs present as well as mechanisms to publish the data in RDF, JSON_LD, NT or TTL?	IT/data manager	one-on-one	Standardization measure
1.4.2	Evidence of data transfer protocols	Are there data transfer protocols in place that allow data access to various user groups?	IT/data manager	one-on-one	Standardization measure
1.4.3	Evidence of data policies	Are the data available well-maintained and updated on a predetermined and scientific basis?	IT/data manager	one-on-one	Project management

Subcomponent 1.5 Big Data Capability

S.N	Element	Questions	Target	Method	Marking tool
1.5.1	Big data readiness	Are you ready for, and realize, the value of big data? Do you implement big data projects?	IT/data manager	one-on-one	Process
1.5.2	Big data accessibility and infrastructure	If working with big data, are the data managed in master data management repos (Hadoop, Map Reduce etc.)?	IT/data manager	one-on-one	Process
1.5.3	Big data management	Is big data management integrated across the DRRM institution on a unified platform?	IT/data manager	one-on-one	Standardization measure

COMPONENT 2: DIGITAL APPLICATION AND SERVICES

Subcomponent 2.1 Application Portfolio

S.N	Element	Questions	Target	Method	Marking tool
2.1.1	Portfolio/business alignment framework	Do you have a portfolio of software applications/services as per an IT strategy to attain your organizational goals?	IT/mid-level manager/ high-level manager	one-on-one	Process
2.1.2	Portfolio management & maintenance	Do you manage your portfolio through routine maintenance?	IT/mid-level manager/ high-level manager	one-on-one	Process

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Subcomponent 2.2 Software

S.N	Element	Questions	Target	Method	Marking tool
2.2.1	Procurement	Do you have a software procurement strategy in place? If yes, are the processes designed to get best value for acquired supplies and services?	IT/mid-level manager/high-level manager	one-on-one	Process
2.2.2	Product scalability and integration	Does the organization implement design and strategy for product integration and scalability (for e.g., Zachman framework)?	IT/mid-level manager/high-level manager	one-on-one	Process
2.2.3	Management, maintenance, updates	Are there effective procedures and best practices in place to manage and maintain the software application to ensure continuity of its operations? Do you undergo software audits?	IT/mid-level manager/high-level manager	one-on-one	Process
2.2.4	Budget and finances	Do you have adequate budget for the procurement, operation, and regular maintenance and update of software?	IT/mid-level manager/high-level manager	one-on-one	Process

Subcomponent 2.3 Tools for Workflow Optimization

S.N	Element	Questions	Target	Method	Marking tool
2.3.1	Automation	Do you implement automated software tools to carry out your business processes? (budget approval process, engineering change process, procurement process etc.)	IT/mid-level manager/high-level manager	one-on-one	Process
2.3.2	Application Programme Interfaces (APIs)	Is the IT strategy API driven? If yes, does the API support discovery and provide self-documenting protocols?	IT/mid-level manager	one-on-one	Process
2.3.3	Performance Tracking and Process Improvement	For performance tracking and improvement, does your organization use applications and tools (e.g., quality control, quality assurance) for operating, managing, and documenting processes?	mid-level manager	one-on-one	Process
2.3.4	Field Support	Do you use the latest tech to support field tasks like surveys, GIS field mapping etc.? Does it facilitate real-time data gathering and reporting, maximize the allocation of resources, support effective communication between the field and offices? Does it improve accountability and productivity of field personnel?	mid-level manager	one-on-one	Process

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Subcomponent 2.4 Analytics

S.N	Element	Questions	Target	Method	Marking tool
2.4.1	Digital Platform	Do you have a common platform that allows employees to use all digital resources from a managed and end-to-end process?	IT/mid-level manager	one-on-one	Scale of standardization
2.4.2	GIS and data science Analytics	Do you have analytical capability – such as GIS and data science – to serve all needs related to analysing historical data, finding patterns, creating forecasts, optimization and decision-making?	IT/mid-level manager	one-on-one	Scale of standardization
2.4.3	Big data analytical capabilities	Do you have big data analytical capabilities? Are they automated or integrated with the business process and operation and can incorporate all kinds of data (structured, unstructured, real-time data, etc.) in decision-making processes?	IT/mid-level manager	one-on-one	Process

COMPONENT 3 ICT INFRASTRUCTURES

Subcomponent 3.1 Computing Infrastructure

S.N	Element	Questions	Target	Method	Marking tool
3.1.1	Architecture specifications	Does your institution maintain and operate computing hardware and software (network components, GIS)? Are they kept current with technological trends?	mid-level manager	one-on-one	Project management
3.1.2	Sizing and capacity	Are these infrastructures timely maintained and updated?	mid-level manager	one-on-one	Project management
3.1.3	Procurement	Is the procurement of ICT infrastructure driven by the institution's strategy and reflect best value for acquired equipment?	mid-level manager	one-on-one	Project management
3.1.4	Asset inventory and maintenance	Do you have an up-to-date inventory of currently available ICT infrastructure including technical specifications?	manager	one-on-one	Scale of standardization
3.1.5	Management of infrastructure	Do you have any framework or standardized practice for managing ICT Infrastructure (hardware/software)?	mid-level manager	one-on-one	Scale of standardization
3.1.6	Budget	Does your institution have adequate budget and funding for the procurement, upgrade, operation, and maintenance of its computing infrastructure?	mid-level manager	one-on-one	Project management

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

3.2 Network Infrastructure

S.N	Element	Questions	Target	Method	Marking tool
3.2.1	Design and carrying capacity	Do you have a standardized practice for design, development and deployment of networks?	IT/mid-level manager	one-on-one	Scale of standardization
3.2.2	Performance and downtime	Do you have a fast network with adequate bandwidth, security and availability to meet increasing data needs?	IT/mid-level manager	one-on-one	Scale of standardization

3.3 Risk Management

S.N	Element	Questions	Target	Method	Marking tool
3.3.1	Disaster recovery	Do you have a backup for hardware failure and data loss (multiple servers)?	IT/mid-level manager	one-on-one	Standardization measure
3.3.2	Firewalls and security breaches	Do you have cyber security in place?	IT/mid-level manager	one-on-one	Standardization measure

3.4 Computing Infrastructure for big data processing

S.N	Element	Questions	Target	Method	Marking tool
3.4.1	Storage Solutions	Do you have data storage options (hardware/cloud-based) for big data storage, access and retrieval?	IT/mid-level manager	one-on-one	Standardization measure
3.4.2	Processing power	Do you have data processing options (hardware/cloud-based) for big data analysis?	IT/mid-level manager	one-on-one	Standardization measure
3.4.3	Networking hardware	Do you have robust networking hardware for the fast transfer of big data?	IT/midlevel manager	one-on-one	Standardization measure

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

COMPONENT 4: ALIGNMENT WITH DRR CO-ORDINATION AND COLLABORATION
Subcomponent 4.1: Pre-disaster Phase
Q 4.1: Does your institution use its DR & T for the pre-disaster stage? (Risk assessment, mitigation, preparedness, planning). If no, skip section 4.1.

S.N	Element	Questions	Target	Method	Marking tool
4.1.1	DR&T use in disaster risk assessment	Does your institution have/disseminate: • Published guidelines for risk assessment? • DRR tool kit for risk assessment? • Standard procedure for consolidating resulting risk information? • Assessment tool to identify the usefulness of the resulting risk product?	mid-level manager/high-level manager	one-on-one	Process
4.1.2	DR&T use in disaster risk management, planning, and monitoring	Does your institution produce/disseminate: • Risk information covering subnational level? • Vulnerability maps? • Indicator for monitoring the effectiveness of its DRRM plans (early warning, risk prevention, etc.)?	mid-level manager/high-level manager	one-on-one	Process
4.1.3	Disaster mitigation and prevention	Does your institution • Support mitigation intervention? • Track the experience of mitigation intervention impact? • Does DR & T support data-driven decision making? How?	mid-level manager/high-level manager	one-on-one	Process
4.1.4	Supporting risk-informed planning and development	• Are the information products by your DR&T included in ongoing development programmes and sector action plans? • Is there evidence of this? • Does the DR&T of your institution offer intelligence and prediction via simulation, AI and machine learning?	mid-level manager/high-level manager	one-on-one	Process
4.1.5	Awareness-raising and dissemination of risk information	Does your institution have mechanisms for the production and rapid communication of a risk information product?	mid-level manager/high-level manager	one-on-one	Process

Best Practice: Example of a Mid-level Interview Agenda – Nepal – *continued*

4.1.6	Performance of early warning systems	Does your DR&T • Link with an early warning system to ensure rapid dissemination of early warning? • Produce hazard impact information? • Suggest actions for risk management such as evacuation?	mid-level manager/high-level manager	one-on-one	Process
4.1.7	Preparedness (overall and sector-specific)	Does your DR&T inform preparedness for response activities at national level/sector level (relief decisions, response decisions)?	mid-level manager/high-level manager	one-on-one	Process

Subcomponent 4.2: Disaster Phase
Q 4.2: Does your institution use its DR&T in the disaster phase to support immediate response, damage and loss assessment? If no, skip section 4.2.

S.N	Element	Questions	Target	Method	Marking tool
4.2.1	Supporting immediate response and/or relief assistance	Does your DR&T • Inform emergency response? • Offer a platform to manage and coordinate logistics? • Monitor the performance of relief distributed?	mid-level manager/ high-level manager	one-on-one	process
4.2.2	Damage and loss assessment	Does your DR&T • Have a standard mechanism for damage and loss assessment and needs assessment? • Have predicted analytics to inform early recovery?	mid-level manager/high-level manager	one-on-one	Process/Scale of Standardization

Subcomponent 4.3: Post-disaster Phase
Q 4.3: Does your institution use its DR&T for Post-disaster phase? (Recovery and Rehabilitation). If no, skip this section 4.3.

S.N	Element	Questions	Target	Method	Marking tool
4.3.1	Recovery of services and infrastructure	Does your DR&T • Offer tools and analytics to inform early recovery and priorities? • Offer indicators to monitor the performance of response? • Offer criteria for compensation?	mid-level manager/High-level manager	one-on-one	Process
4.3.2	Rehabilitation and economic and social recovery	Does your DR&T • Inform rehabilitation plans? • Support financial planning? • Assess performance and extract lessons learned?	mid-level manager/high-level manager	one-on-one	Process

Best Practice: Example of a Semi-structured Interview Agenda – Nepal – *continued*

COMPONENT 5: STAFF COMPETENCIES.

Subcomponent 5.1 Competency Framework

S.N	Element	Questions	Target	Method	Marking tool
5.1.1	Data acquisition	Do you have • a standardization measure for data collection? • Any other standardization measure for data quality?	mid-level staff	FGD/one-on-one	Standardization measures
5.1.2	Analysis and modeling	• How many on staff are capable of data analysis? • Does the institution analyse geospatial data through models/software/conceptual framework?	mid-level staff	FGD/one-on-one	Project management
5.1.3	Programming and development	• Do you design/create GIS software/applications? • Add value to remotely sensed data /customize end user products?	mid-level staff	FGD/one-on-one	Project management
5.1.4	Management	• How many technical/data managers do you have? What are their qualifications?	mid-level staff	FGD/one-on-one	
5.1.5	Big data competencies	• Do you understand big data? • Do you use big data for analysis?	mid-level staff	FGD/one-on-one	Scale of standardization

Subcomponent 5.2 Training portfolio

S.N	Element	Questions	Target	Method	Marking tool
5.2.1	Roles and skills alignment with domain	• How many staff members do you have? How many are experts on data? How many are disaster experts?	mid-level staff	FGD/one-on-one	
5.2.2	Training plans	• How often are staff trained? What kind of training?	mid-level staff	FGD/one-on-one	Standardization measures
5.2.3	Training utilization/performance assessment	• Are staff members assessed on their skills regularly? Are their skills assessed after they receive trainings?	mid-level staff	FGD/one-on-one	process
5.2.4	Budget	• Has the institution allocated budget for staff development and training, especially in digital technology? • How much and is it sufficient?	mid-level /high-level staff	FGD/one-on-one	

Best Practice: Example of a Semi-Structured Interview Agenda – Nepal – *continued*

Subcomponent 5.3 Decision making support

S.N	Element	Questions	Target	Method	Marking tool
5.3.1	Evidence-based decisions	• Does your institution use its digital data for decision-making?	mid-level /high-level staff	one-on-one	Standardization measure
5.3.2	Technology transformation	• Does top management value digital innovation in DDRM on a scale of 0 to 5?	mid-level /high-level staff	one-on-one	Standardization measure

COMPONENT6: INSTITUTIONALIZATION AND PARTNERSHIP PROGRAMME
Subcomponent 6.1: Stakeholder management and collaboration

S.N	Element	Questions	Target	Method	Marking tool
6.1.1	Internal coordination /collaboration function	• Does the institution have a committee to design a framework, access and maintain digital resources and technology?	mid-level /high-level staff	one-on-one	Scale of standardization
6.1.2	External stakeholder framework	• Does the organization have a formal protocol for partnership in DR&T with external partners?	mid-level /high-level staff	one-on-one	Scale of standardization
6.1.3	Stakeholder engagement	• Does the organization have key performance indicators for improving collaborations?	mid-level /high-level staff	one-on-one	Scale of standardization
6.1.4	Protocols and agreements	Does the institution have • Protocols for data sharing, interoperability, license sharing? • Collaboration agreement meant to maintain effectiveness and minimize cost and redundant functions?	mid-level /high-level staff	one-on-one	Scale of standardization

Best Practice: Example of a Semi-Structure Interview Agenda – Nepal – *continued*

Subcomponent 6.2 Communication

S.N	Element	Questions	Target	Method	Marking tool
6.2.1	Communication Plan	• Does the institution have a formal communication plan including the evaluation of its communication concerning its operational and organizational goal?	mid-level /high-level staff	one-on-one	Scale of standardization
6.2.2	Communication Performance	• Is communication a part of key performance indicators of the organization? • How active is the organization in digital media, including social networks?	mid-level /high-level staff	one-on-one	Scale of standardization

COMPONENT 7: GOVERNANCE (Policies, standards, guidelines, best practices)

Subcomponent 7.1: Governance Frameworks

S.N	Element	Questions	Target	Method	Marking tool
7.1.1	Legal regulations and policies	Does your institution have a legal framework/regulations and policies for: • Data ownership? • Data access? • Data exchange/sharing?	mid-level /high level staff	one-on-one	Scale of standardization
7.1.2	Resource allocation framework	Does your institution • Embrace collaboration as an organizational culture? • Have a formal framework for partnership in the operation?	mid-level /high level staff	one-on-one	Scale of standardization
7.1.3	Technology alignment framework	• Does the institution have a business strategy/operational projects that align and support digital resources and technology and does it help identify gaps?	mid-level /high level staff	one-on-one	Scale of standardization
7.1.4	Governance framework	Does your DRRM institution have the following for DR&T: • Legal framework? • Resource allocation framework? • Technological framework? • Mechanism for execution? • Mechanisms or monitoring and evaluation?	mid-level /high level staff	one-on-one	Scale of standardization

Best Practice: Example of a Semi-Structure Interview Agenda – Nepal – *continued*

Subcomponent 7.2: Governance Best Practices

S.N	Element	Questions	Targeted personnel	Method	Marking tool
7.2.1	SOPs for technology operations	Does your institution have • SOPs on governance, asset management, training? • Feedback mechanism to improve the efficiency?	mid-level/ high-level staff	one-on-one	Process/scale of standardization
7.2.2	D&RT management support	Does the institution have management standards to implement, measure and improve project management?	mid-level/ high-level staff	one-on-one	Process/scale of standardization

4.3 Tabulation and Interpretation of DDRRMM Assessment Results

The third phase in performing the DDRRMM assessment (see Figure 18 for the DDRRMM assessment's workflow) is to analyse, synthesize and interpret the information collected during the assessment. The goals of this phase are to 1. present the information in an accessible form for stakeholders (i.e., a digital maturity status) and 2. validate with the stakeholders the collected data and the status quo of DR&T in their institutions.

4.3.1 Translating DDRRMM assessment results into a maturity status

As explained in the second chapter, the maturity model is a classification scheme revolving around a specific subject – the use of DR&T for DRRM. It sets criteria (expressed in the DDRRMM elements and subcomponents) that enable us to place a specific entity (DRRM institutions) into a maturity level (Ad hoc, Recognized, Defined, Managed, Optimized).

When conducting the DDRRMM assessment, we assign a specific grade (called a maturity level) to DRRM institutions, implying how effectively they use digital resources and technologies to achieve their operational mission. Therefore, it is critical for those conducting the DDRRMM assessment to ensure that technical personnel and decision makers in stakeholder institutions understand the meaning of each maturity level, its score range, and where it stands on the maturation path towards optimal utilization of DR&T in DRRM.

The DDRRMM Calculator (see Appendix C) is useful for communicating DDRRMM assessment results to stakeholders both quantitatively and qualitatively. A maturity score is calculated for each DDRRMM component starting with the elements. The elements within a specific subcomponent (see DDRRMM model hierarchy presented in Chapter 3) are given a numerical score from 0 to 5 based on the self-assessment of stakeholders and according to the criteria explained in the DDRRMM calculator. The elements are weighted for their relative importance to the parent subcomponent (see Appendix B for how weights were derived),

such that the score assigned to the subcomponent is weighted from 0 to 5. The maturity score assigned to each DDRRMM component is an average score of the subcomponents (assuming all subcomponents are equally important), expressed as a percentage from 0 to 100. Finally, the institution's overall maturity score is calculated as the average of the maturity score percentages of all seven components.

When communicating results with end users, it is therefore recommended not only to show the scores but also to explain how the institution stands regarding overall maturity so that they know the areas to focus on to improve maturity. Visualization aids such as radar charts and dashboards can greatly help communicate the findings.

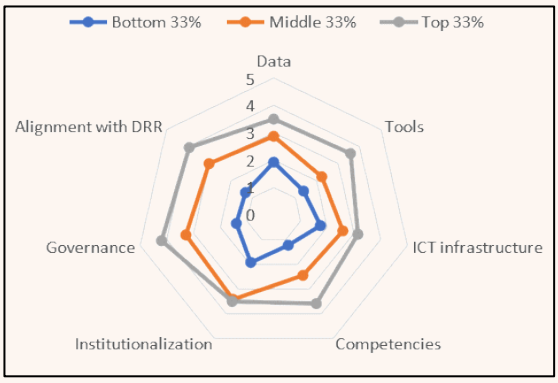
Best Practice: Example of Reporting DDRRMM Assessment Results

Countries were grouped into one of three maturity clusters based on their overall DDRRMM score as based on inputs provided by government stakeholders. The average scores (0 min to 5 max) assigned to each cluster for every DDRRMM component were provided as a table summary and a radar chart. In addition, analysis of variance in maturity scores within and among the clusters was reported to the stakeholders.

DDRRMM component scores assigned to the three maturity clusters

AVERAGE NORMALIZED SCORES (MIN 1- MAX 5) PER DDRRMM DIMENSIONS							
CLUSTER	Data	Tools	ICT infrastructure	Competencies	Institutionalization	Governance	Alignment with DRR
Bottom 33%	1.93	1.40	1.75	1.23	1.93	1.40	1.31
Middle 33%	2.87	2.24	2.59	2.45	3.42	3.29	3.01
Top 33%	3.50	3.59	3.15	3.59	3.50	4.20	3.94

Best Practice: Example of Reporting DDRRMM Assessment Results, *continued*



A radar chart showing the average scoring of DDRRMM scores per maturity cluster

Analysis of variance (ANOVA) in DDRRMM maturity scores calculated for the three maturity clusters

SUMMARY						
Groups	*Variance*					
Cluster 1	0.087865					
Cluster 2	0.323167					
Cluster 3	0.114479					
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Clusters	15.51815	2	7.759077	44.29452	1.11697E-07	3.554557
Within Clusters	3.153063	18	0.17517			

The key points in Table 1 and Figures 2 and 3 include the following.

1. The average scores assigned for DDRRMM components in each cluster tend to mostly fall under the same percentile group as their corresponding maturity clusters. The scores show that countries doing well with their national DDS solutions (hence scoring high in maturity) tend to do so by balancing progress in all digital transformation aspects (i.e., the seven DDRR components).

2. Calculated variance (a measure of variability) for the three clusters reveals how institutions and countries progress along the DDS maturation path. Cluster 1 exhibits the smallest variance among maturity scores calculated for the DDRRMM components because cluster 1 represents countries at the early stage of setting up a DDS solution. Cluster 2 has the highest variance, reflecting different degrees of progression in maturity among the components. Cluster 2 represents “institutions in transition" that experience unbalanced progress in digital transition with maturation thus advancing in some areas faster than others. In the countries sampled, institutions under cluster 2 emphasize the institutionalization and governance of DDS solutions over data, tools, or building capacity. Transition management is key for such countries to move forward; otherwise, they risk potential setbacks. Finally, cluster 3 variance shows a value between clusters 1 and 2, though leaning more towards small variability. These countries have reached a reasonable maturity status across all DDRRMM components and are now more concerned about maintaining and improving the ecosystem surrounding DDS operations.

Best Practice: Example of Reporting DDRRMM Assessment Results, *continued*

3. The results from running the analysis of variance (ANOVA) in and between the three clusters show that the source of variation between clusters is statistically significantly higher (i.e., very small P-value) than within the clusters. This suggests that observed variation in maturity scores among DDRRMM components are directly attributable to digital transformation interventions and their suitability to the specific country context. Thus, while countries are encouraged to replicate best practices, they also need to ensure that adopted interventions are context-sensitive because what works for country A may not yield the same results in country B.

4. Overall, the maturity scores show that to truly capture the status of a national DDS in a country, a holistic look at all aspects of digital transformation (i.e., data, tools, ICT, competencies, institutionalization, governance, and alignment with DRR activities) is needed. Focus on just one or two aspects of digital transformation may yield a false interpretation of progress and possibly lead to the wrong prioritization of the kinds of investments needed to improve the DDS solution performance.

4.3.2 Validating the DDRRMM assessment results

Certainly, assessment results require validation by stakeholders before making conclusions and delivering recommendations. The challenge, however, is that the stakeholders may be too overwhelmed by the volume of assessment results and technical details. Therefore, it is critical to ensure that the earlier step (communicating the results) is done properly before switching to the validation exercise. In doing the validation exercise, it is important to keep in mind the following:

- be clear in communicating the goal of the validation and why it is important;
- explain what needs to be validated and the method of validation;
- ensure the validation is done through a participatory process inclusive of all required technical and decision-making personnel; and
- provide them with the means to study the results that need to be validated and a way to communicate their feedback in a structured manner.

Best Practice: Validating the DDRRMM Assessment Results

The stakeholder validation process typically employs several methodologies to ensure proper validation. One of the most common methods is to conduct a participatory workshop and use the stakeholder walkthrough exercise to review assessment results and provide feedback.

Another method is to administer a survey (online or in-person) to solicit feedback. In this scenario, stakeholders need easy access to assessment results and the ability to shift back and forth between the survey questions and the results. In this case, the provision of a dashboard is useful. Below is a screenshot of a DDRRMM assessment dashboard developed for the Philippines (https://datastudio.google.com/reporting/95ef3a74-86c0-4f74-aeec-741e17c23563/page/p_25lup6q0pc).

Best Practice: Validating the DDRRMM Assessment Results, *continued.*

DDRRMM Dashboard

README Overview Agency-level

Digital Disaster Risk Reduction Maturity Model Dashboard

The Digital Disaster Risk Reduction Maturity Model (DDRRMM) provides a systematic way to capture the maturity status in utilizing Digital Resources & Technologies (DR&T) to enhance DRRM operations.

The DDRRMM framework revolves around seven core components, with each representing a distinct area for digital technology that influences the performance of DRRM operations.

7 Components
- Data Access and Sharing
- Applications and Services
- ICT Infrastructure
- User Competencies
- Institutionalization
- Governance
- Alignment with DRRM

↓

23 Subcomponents

↓

80 Elements

A component represents the highest level in the DDRRMM hierarchy, which can be broken down to its sub-components. As such, the maturity of a component is an aggregation of the maturities of its sub-components.

A subcomponent refers to a set of processes or areas that comprise a component, and is further broken down to its elements - the most granular level.

An element represents the most granular aspect of a subcomponent, and is the one that is assigned/given a maturity score from the DDRRMM survey.

Maturity Level	Score	Range	Description
Not Applicable	0	-	Not applicable (explanation required)
Ad Hoc	1	0 to 20	Desired, but not planned.
Recognized	2	> 20 to 40	Planned but with no resources available to achieve the capability.
Defined	3	> 40 to 60	Planned and with resources available to achieve the capability.
Managed	4	> 60 to 80	In progress/partially implemented - OR fully implemented but lacking performance assessment and compliance with international standards
Optimized	5	> 80 to 100	Fully implemented AND performance, full compliance with standards, continuous improvement is done on an ongoing basis based on quantified performance goals.

In the DDRRMM framework, assessment starts at the element level, whose score is based on the response scale shown above. A subcomponent score is then derived from its elements, and a component score is derived from its subcomponents.

Percentage scores (0 to 100) are calculated for the components and subcomponents, and depending on what range they fall into, they are assigned a maturity level.

The overall score of an agency would be the average of all the component scores, and the national average score would be the average of the overall scores of the agencies.

DDRRMM Dashboard

README Overview Agency-level

Digital Disaster Risk Reduction Maturity Model Dashboard

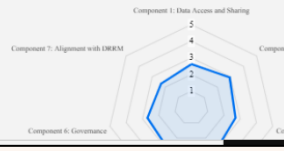
- Select "All Agencies" to see scores for all agencies.
- Click on 'Only' beside agency to view scores for only that agency.
- Check the boxes to select multiple agencies.

Agency: All Agencies (1)

Overall DDRRMM Index
2.76
0 5

The Philippines scores **2.76** in its Overall DDRRMM Index, falling into the **Defined** level in terms of digital maturity:

Consistency in using technology for DRRM is consistent in some areas, with defined SPOs; resources are available but not sufficient for optimal operations, full integration is lacking impacting performance.



Agency Maturity Distribution per Component

Number of agencies in each maturity level for each component

DDRRMM Dashboard

README Overview Agency-level

Digital Disaster Risk Reduction Maturity Model Dashboard

Component Maturity Across Agencies

- Click the column header to sort rows

DDRRMM Index Legend: Ad hoc, Recognized, Defined, Managed, Optimized

	Agency	Overall DDRRMM Index	Data Access and Sharing Component 1	Applications and Services Component 2	ICT Infrastructure Component 3	User Competencies Component 4	Institutionalization Component 5	Governance Component 6	Alignment with DRRM Component 7
	Component Averages	2.76	2.62	2.94	2.71	3.08	2.94	2.70	2.32
1.	PDC	5	5	5	5	5	5	5	5
2.	DENR-NAMRIA	4.55	4.39	4.15	4.15	4.9	5	5	4.28
3.	DOST-PAGASA	4.01	3.37	4.48	3.61	4.67	4.25	4.87	2.82
4.	DILG-CODIX	4	4	4	4	4	4	4	4
5.	GSIS	3.97	3.71	3.79	4.45	4	4	4	3.82
6.	DOST-PHIVOLCS	3.74	3.1	4.22	3.22	4.85	4.63	2	4.14
7.	OCD	3.17	3.45	3.33	3.43	3.77	3.38	2.82	2
8.	UPRI	2.77	3.62	3.68	2.16	3.69	2.25	2	2
9.	All Agencies	2.76	2.62	2.94	2.71	3.08	2.94	2.7	2.32
10.	DPWH	2.73	3.05	3	3	2.44	2.88	2.38	2.37

4.4 Delivering Interventions Recommendation

As communicated through this white paper, DDRRMM objectives extend beyond assessing the current maturity status in DR&T for DRRM to facilitating intervention recommendations and measuring their impacts once implemented. With maturity scores assigned to 80 elements comprising the entire digital ecosystem of DRRM, the DDRRMM assessment generates a rich set of baseline indicators to inform decision-making related to the interventions and pathways needed to improve digital maturity. Ideally, a DRRM institution would reach an optimal state in each of these elements to reach full maturity. In practice, however, this is not easy to achieve at once for the following reasons.

1. Interventions require investments in monetary terms, efforts, and resources. With different interventions needed to improve the maturity status of a single element, a DDRRMM institution requires an abundance of resources to address the maturity needs of all 80 elements at once, which is not often possible most organizations.
2. The process of improving maturity is gradual. An institution cannot jump directly from an Ad hoc maturity level (maturity score range of 0 to 1) to an Optimal maturity level (maturity score range of 4 to 5). Instead, it must pass through the intermediate maturity levels of Defined, Recognized, and Managed. This gradual improvement in maturation needs time and multiple interventions designed for each level of maturity. The process should also reflect experiences gained and lessons learned specific to the DRRM institution context.
3. The 80 elements constituting the DDRRMM assessment refer to interrelated and interconnected entities in the DRRM digital ecosystem. Therefore, an intervention for one element will likely impact many other elements. Consequently, it is important to invest time in studying alternative interventions to avoid any side effects that could lead to adverse results on the overall maturity status of the institution (Figure 20).

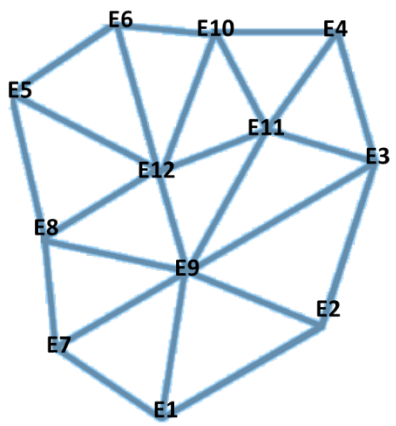


Figure 20: Conceptual Illustration of DDRRMM Elements Connectivity

Given the factors above, it is critical that strategic plans (and roadmaps for implementing these strategies) align with DDRRMM assessment results and use them to identify leverage points for interventions. To this end, there are **three important tips for delivering digital transformation interventions based on DDRRMM**.

The first is related to the concept of "Leverage Points" or those specific elements within DDRRMM where interventions can significantly impact the overall maturity level of an organization. For example, as shown in Figure 21, interventions that target element E12 are likely to have a more profound impact on the overall maturity status than those targeting elements E1 or E2.

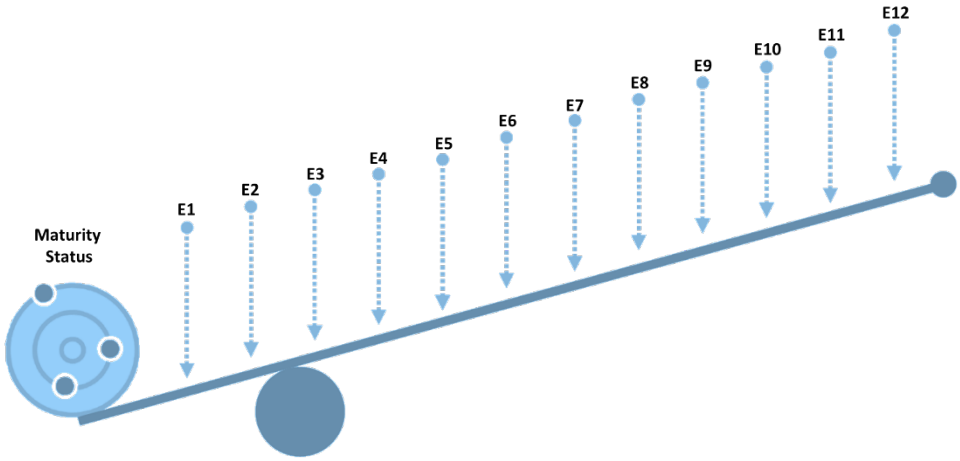


Figure 21: Conceptual Illustration of Leverage Points for Interventions

2. While the maturation path of digital maturity is linear, intervention impacts are not because the DDRRMM elements targeted by interventions are interconnected (Figure 20). Therefore, the more the element is found at the heart of the connection web, the greater its influence on the overall maturity status.
3. There is no one-size-fits-all solution when recommending interventions. Interventions are both scale and context specific. For example, two DRRM institutions with the same maturity status will likely require different digital transformation interventions because of the DRRM mission they serve, their organizational hierarchy, size of operation, and so forth. Thus, interventions need to be tailored to the contexts they target.

With the above tips in mind, the following are practical steps on how to identify leverage points and propose interventions based on the DDRRMM assessment results.

- Perform a SWOT[13] analysis for each of the DDRRMM elements to understand why this element received a given score.
- Consolidate the element-level SWOT analysis to the subcomponent level, focusing mainly on cross-cutting issues among all elements belonging to the subcomponent (i.e., common strengths, weaknesses, opportunities, and threats).
- Consolidate the subcomponent-level SWOT analysis with the DDRRMM component level thus focusing mainly on cross-cutting issues among the subcomponents (i.e., common strengths, weaknesses, opportunities, and threats).

[13] SWOT analysis refers to strengths, weaknesses, opportunities and threats.

- Propose interventions and solutions that address component-level SWOT findings. An intervention should reinforce identified strengths, eliminate weaknesses, leverage opportunities, and address threats.
- Contrast the proposed interventions against the various elements and assess the degree to which a particular intervention impacts the element and the level of improvement in maturity for that element.
- Rank the interventions in terms of the elements they address and the impacts they produce – those with the highest rank present leverage opportunities.
- Evaluate the leverage points regarding their cost-effectiveness, return on investment, and duration.
- For the final set of proposed interventions, identify key performance indicators that help validate the impact of each intervention on overall maturity.
- Map selected interventions in terms of implementation priority and interdependencies to produce an intervention roadmap.
- Align the intervention roadmap with the DRRM institution's mission and strategic direction to produce a final digital transformation strategy to improve the digital maturity status.
- Conduct periodic DDRRMM assessment to monitor the impact of implemented interventions.

Best Practice: Example of SWOT Analysis Conducted at the DDRRMM Component Level for Indonesia

DX4Resilience
CONNECT INNOVATE ACCELERATE

1. Data Access & Sharing

S

- Indonesia has initiated several major reforms to improve the state of data governance in the public sector (one data, one map policy).
- Availability of data at the national scale is managed well by central government organizations.
- Data on earthquakes is better in terms of availability and quality compared with other disasters.
- The BSN have adopted many of the ISO standards.

W

- Full data integration is still lagging.
- Barriers to data sharing, particularly related to interoperability, are still high.
- Detailed data to support policymaking and actions at the local level are severely lacking.
- The practice of using *SNI to assure quality is still lacking in Indonesia.
- Agencies and ministries at various levels do not have a single, common format for cataloging digital data.

O

- Bilateral cooperation agreements must be established and extended regularly among institutions.
- Proper regulation framework regarding the protection of personal data and security might enhance cooperation.
- Implementations of SNIs must be enforced through incentives, rewards, or punishments.

T

- Complexity of public administration in Indonesia is a threat to data unifying efforts.
- Many organizations have built their own hotspot data and each of the organizations has its own threshold, method of measurement, parameters, and modeling.
- Having many cooperation agreements for data sharing also does not guarantee the strengthening of protection of data privacy when the security aspects of the data transfer process and utilization are not built and managed well.

*SNI=Indonesia National Standard

Best Practice: Example of SWOT Analysis Conducted at the DDRRMM Component Level for Indonesia, *Continued*

DX4Resilience
CONNECT INNOVATE ACCELERATE

2. Applications & Services

S

- Subcomponents such as application portfolio, software, and analytics are already at the managed level.
- In general, each organization already has a specific unit, division, or directorate responsible for managing data and systems.
- Indonesian Government has recently moved toward *API-driven applications to support interoperability.

W

- Tools for workflow optimization still need improvement.
- Applications are often designed in a siloed manner with low consideration for integration.
- Lack of quality assurance and control leads to the poor quality of the applications.
- Many applications are developed due to training requirements and not necessarily the needs of the organization or for the benefit of the public.

O

- Data platform integration will result in a decrease in workload and the likelihood of making errors.
- Collaboration among organizations will lead to resource and budget optimization.

T

- Organizations at the national and subnational levels tend to have their own applications even though they may be redundant or overlapping.
- Many still siloed applications and data platforms are a threat to the formation of one integrated data network.
- Applications are often not developed with user orientation in mind as indicated by multiple disconnected applications with redundant data entries.

*Application Programming Interface

DX4Resilience
CONNECT INNOVATE ACCELERATE

3. ICT Infrastructure

S

- Since 2015, the Government of Indonesia (GoI) has implemented an aggressive plan to accelerate the development of ICT infrastructure all over Indonesia, particularly in remote areas.
- The GoI allocated 26 trillion IDR for ICT infrastructure development this year.
- Indonesia is on track to achieve its Government 4.0 goal by strengthening the basic ICT infrastructure across the country.

W

- Among the subcomponents related to ICT Infrastructure, however, risk management and computing infrastructure for big data received lower scores.
- The limitation in the budgeting and procurement approach – particularly to support the maintenance of infrastructure – hinders infrastructure development.

O

- Sustainable maintenance would require stable budget allocation that enables framework agreement with vendors.
- Risk management in disaster recovery related to firewalls and security breaches needs to be strengthened.
- The GoI is currently processing a bill on Personal Data Protection (RUU PDP) to serve as a single comprehensive law.

T

- The subcomponent *computing infrastructure for big data* received low scores and hence poses a serious threat to the advancement of ICT infrastructure efforts.
- Security issues and data breaches are also impeding the implementation of the full agenda for ICT infrastructure.

Best Practice: Example of SWOT Analysis Conducted at the DDRRMM Component Level for Indonesia, *Continued*

DX4Resilience
CONNECT INNOVATE ACCELERATE

4. Staff Competencies

S

- BNPB, for example, is deploying inAWARE, a web-based decision support system for use by disaster managers at national and provincial levels.
- BMKG is also quite active in providing a decision support system in the district and city levels, especially in the regional BMKG and BPPB offices (local disaster management agency), and even in the regent of governor office.

W

- The competency gap between national and local levels is significant.
- There is limited financial capacity in national and subnational level agencies to cover the staff required to promote and facilitate system adoption and utilization among potential users.
- Relatively high staff rotation also creates difficulty in developing expertise in certain competencies, particularly at the subnational level.

O

- Routine evaluation or assessment of training effectiveness and utilization needs to be strengthened.
- Aside from training for technical staff, executive training for leaders at the subnational level (governor, regent, mayor) also needs to be conducted annually.
- There is a need to identify the intended user of this data and information.

T

- The presence of multiple decision-making support systems is a threat to enhancing staff competencies.
- Not validating the utility of the data and information in decision making.

DX4Resilience
CONNECT INNOVATE ACCELERATE

5. Institutionalization & Partnership Program

S

- At the national level, there are already many collaborations with private and civil society organizations.
- DRR Forum has a potentially important role in identifying who is doing what and what resources could be used for collaboration.
- There are many potential partners willing to help and with sufficient funding.

W

- Leadership in pursuing and developing partnerships gaps is missing.

O

- Defined and well-established protocols and MoUs would help in enhancing the partnerships.

T

- Clear protocol and MoUs are not yet well-established.

Best Practice: Example of SWOT Analysis Conducted at the DDRRMM Component Level for Indonesia, *Continued*

DX4Resilience
CONNECT INNOVATE ACCELERATE

6. Governance

S

- Organizations already have the required regulations, policies, and SOPs for technology alignment and governance.
- the Government of Indonesia issued Presidential Regulation No. 95 Year 2018 concerning e-Government (SPBE/ Sistem Pemerintahan Berbasis Elektronik).
- Each organization at national and subnational levels shall have an independent and annual assessment on the state of SPBE in their respective organization.

W

- There exists no clearly defined, empowered, and active governance mechanism that considers an overall organizational approach to governance.
- Technology decisions are not guided by the organization's enterprise perspective and lack dedicated resources for their implementation.

O

- Clearly defined governance mechanisms should be devised at the national level.

T

- The absence of a clear chain of accountability that specifies roles and responsibilities across departments and includes enforcement threatens a fully functioning governance mechanism.
- The lack of a role for IT units to enforce interoperability and standards weakens governance capabilities.

DX4Resilience
CONNECT INNOVATE ACCELERATE

7. Alignment with DRR Coordination and Collaboration

S

- The use of DR&T during the emergency and disaster response phase is considered quite good by respondents.
- Risk assessment as well as awareness-raising during the pre-disaster phase are managed well

W

- There are several flaws in the disaster logistic and resource allocation mechanism and system.
- DRR coordination and collaboration during the post-disaster phase is very weak.

O

- Alignment in the pre-disaster phase, particularly in preparedness, and the post-disaster phase, particularly in rehabilitation and recovery, need further strengthening.
- Digital resources and technology could still be optimized to support preparedness such as for resource mobilization, monitoring of logistics and shelters, identifying vulnerable people, etc.

T

- Preparedness of the early warning system is not up to the "managed" maturity level in DDRRMM and could undermine DRR coordination and collaboration efforts.
- Improper and unmanaged recovery services and infrastructure could threaten DRR coordination and collaboration efforts.

APPENDIX A – DDRRMM HIERARCHY DESCRIPTION AT THE ELEMENT LEVEL

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V1.3		
Component 1 - Data Access and Sharing - Element Level Specifications		
Subcomponent	**Element**	**Description**
1.1 Data Framework	**1.1.1 Fundamental data model specifications**	Presence and maintenance of a data model/product framework for a GIS base map, imagery, and fundamental datasets that meets the DRRM institution's operational needs and complies with ISO 19131:2007 (Geographic information — Data product specifications) and ISO/TS 19129:2009 (Geographic information — Imagery, gridded and coverage data framework).
	1.1.2 Data/domain business alignment	Datasets and data management practices are aligned with the institution's DRRM operational domain and business strategy and free of any gaps (missing data), redundancies, or duplications, and comply with ISO/TR 19169 standard (Geographic Information — Gap-analysis).
	1.1.3 Domain data model specifications	Presence and maintenance of an application-/domain-specific schema for domain-specific GIS as well as non-GIS data (documents, tables, databases) that meets the DRRM institution's operational needs and comply with ISO 19131:2007 (Geographic information — Data product specifications) and ISO 19109:2015 (Geographic information — Rules for application schema).
	1.1.4 Visualization and portrayal framework	The DRRM institution implements a visualization conceptual scheme that describes symbols, portrayal functions that map geospatial features to symbols, supports the collection of symbols, organizes portrayal functions into portrayal catalogs system, and complies with ISO 19117:2012.
	1.1.5 Data catalog & discovery framework	The DRRM institution adopts a methodology or a system for cataloging its data, developing data concept dictionaries, and maintaining up-to-date metadata that complies with ISO 19110:2016 (Geographic information — Methodology for feature cataloging), ISO 19126:2021 (Geographic information — Feature concept dictionaries and registers), and ISO 19115:2014 & ISO 19115:2019 (Geographic Information – Metadata).
	1.1.6 Data maintenance framework	The DRRM institution ensures that data is always up-to-date and implements a comprehensive framework for data maintenance that describes data stewards, QA/QC practices, and data update triggers of every single data item.
1.2 Data Availability and Quality	**1.2.1 Core & Business GIS Data**	GIS data in a condition that meets the DRRM institution's operational needs in terms of Completeness; Custodianship; Thematic Content; Data Format (vector, raster, grids, topology, etc.); Scale; Positional Accuracy; Attribute Accuracy; Temporal Scale; Currency; Tabular and Spatial Relationships; the presence of Metadata; Map Projections; and Datums.
	1.2.2 Non-GIS Data (structured)	Tabular data and database tables meet the DRRM institution's operational needs in terms of the Completeness; Fitness for Use; Identifiers; Accuracy of Tabular Information; Complete Data Dictionaries; and Presence of Integrity Rules.

	1.2.3 Other business data (unstructured)	(*Applicable only if the DRRM operational needs require access to unstructured data).* Unstructured data (addresses, documents, PDFs, social media posts, etc.) are Geotagged/geo-enabled, integrated seamlessly with structured data, and support entity recognition.
1.3 Data Management	**1.3.1 DBMS/data warehouse**	All data of the DRRM institution resides in a database management system and/or a data warehouse (if applicable) that supports a secure integrated environment for accessing, managing, and versioning datasets; supports quick and easy data access; and ensures consistent quality data through validation rules and varying user privilege.
	1.3.2 QA/QC	The DRRM institution observes all principles required for maintaining quality data and applies measures for evaluating and reporting the quality of the data in compliance with ISO 19157:2013 (Geographic information — Data quality) and ISO/TS 19158:2012 (Geographic information — Quality assurance of data supply).
	1.3.3 Data update/audit cycle	Data within the DRRM institution is well-maintained and updated on predetermined frequencies consistent with the data maintenance framework and ensures data quality and currency.
	1.3.4 Metadata	Metadata is available and current for all types of data and meets all requirements set forth by guiding metadata standards in the data catalog & discovery framework.
	1.3.5 Backup and recovery	A backup, archival, and recovery system for data is in place and periodically tested to ensure reliable performance.
1.4 Data Governance	**1.4.1 Evidence of data interoperability**	Data is integrated and accessed in a technically appropriate and efficient manner across the DRRM institution; use of open data formats (XML, JASON, GeoGSN, etc.); published datasets are linked on the Semantic Web; the presence of HTTP URIs that identify and describe datasets; mechanisms to publish original datasets in RDF, JSON-LD, NT, or TTL.
	1.4.2 Evidence of data transfer protocols	Data is easily available and accessible to various user groups; evidence that the DRRM institution prioritizes interoperability (such as institutional framework, data governance officers, stewardship teams, using common classification and vocabularies, presence of semantic/ontology rules).
	1.4.3 Evidence of data policies	Data within the DRRM institution is well-maintained and updated on predetermined certain frequencies consistent with the data maintenance framework and data quality and currency are ensured.
1.5 Big Data Capability	**1.5.1 Big data readiness**	The DRRM institution realizes the value of big data; users depend on big data from various resources and are actively implementing big data projects throughout the institution.
	1.5.2 Big data accessibility and infrastructure	Data is organized and architected on a master data management repository (e.g., Hadoop, Map Reduce) to allow high volume and velocity data sharing between systems and across multiple users.
	1.5.3 Big data management	Big data management is integrated across the DRRM institution on a unified platform.
Component 2 - Digital Applications and Services- Element Level Specifications		
Subcomponent	**Element**	**Description**

2.1 Application portfolio	**2.1.1 Portfolio/business alignment framework**	The DRRM institution has a portfolio of software applications and software-based services (either custom or off-the-shelf), which it uses to attain its strategic goals or objectives and according to an IT strategy and/or common design and development framework.
	2.1.2 Portfolio management & maintenance	The DRRM institution's application portfolio is managed and kept viable through ongoing support and routine application maintenance.
2.2 Software	**2.2.1 Procurement**	Procurement and decisions of "make, buy, or reuse" software are informed by and aligned to the DRRM institution's strategy and drive the attainment of best value for acquired the supplies and services.
	2.2.2 Product scalability and integration	The DRRM institution implements an architecture design and a strategy for product integration and scalability that adhere to the Zachman Framework (or similar), with clear procedures, criteria, and performance verification.
	2.2.3 Management, maintenance, updates	The DRRM institution applies effective procedures and best practices to manage and maintain its software and application assets to ensure continuity of operations (i.e., keeps an up-to-date software asset inventory; has a well-defined software service-level agreement that keeps software assets up-to-date; implements a framework and action plans for system administration, database administration, network administration, system security, data backup, security, and restore processes, etc.).
	2.2.4 Budget and finances	The DRRM institution has an adequate budget for the procurement, operation, and regular maintenance and update of software.
2.3 Tools for Workflow optimization	**2.3.1 Automation**	The DRRM institution maintains a portfolio of platforms and tools to facilitate enterprise-wide automation of common business processes with defined targets and performance metrics (e.g., automated data extraction, computer-aided dispatch, automated tracking of field works, etc.).
	2.3.2 Application Programme Interfaces (APIs)	The IT strategy of the DRRM institution is API-driven (meaning that the diverse software programmes and applications it uses are seamlessly connected and talk to each other to provide a valuable digital experience to all users) and implemented APIs support discovery and provide self-documenting protocols.
	2.3.3. Performance tracking and process Improvement	The DRRM institution employs applications and tools (e.g., QA/QC applications) for operating, managing, and documenting processes and tasks and tracking performance to comply with ISO 18091:2019 (Quality management systems - Guidelines for the application of ISO 9001 in local government) and ISO/IEC/IEEE 90003:2018 (Guidelines for the application of ISO 9001:2015 to computer software).
	2.3.4 Field support	The DRRM institution uses the latest technologies in support of various field tasks (surveys, GIS field mapping, etc.) that provide instant access to reliable and updated data, facilitate real-time data gathering and reporting, maximize the allocation of resources, support effective communication between field and offices, and improve accountability and productivity of field personnel.

2.4 Analytics	**2.4.1 Digital platform**	Users at the DRRM institution access all digital resources and tools via a common platform managed in a cohesive (end-to-end) manner.
	2.4.2 GIS and data science analytics	The DRRM institution is equipped with a range of analytical capabilities (GIS, data science, etc.) that serve all its operation and business needs related to gathering and visualizing historical data, identifying patterns and dependencies, creating probable forecasts, providing an optimization option, and supporting decision making.
	2.4.3 Big data analytical capabilities	The DRRM institution is equipped with big data analytical capabilities (e.g., machine learning and AI) that are automated or integrated with its business process and operation and can incorporate all kinds of data (structured, unstructured, real-time data, etc.) in decision-making processes.

Component 3 - ICT Infrastructure - Element Level Specifications

Subcomponent	Element	Description
3.1 Computing Infrastructure	**3.1.1. Architecture specifications**	The DRRM institution maintains and operates a computing infrastructure informed by an architecture design of hardware (servers, storage, desktops, input, and output peripherals), network components, operating system, GIS, etc. that meets its business needs and reflects current technological trends.
	3.1.2 Sizing and capacity	The conditions and performance levels of computing infrastructure assets are well monitored and subject to scheduled maintenance and updates.
	3.1.3 Procurement	Procurement and hardware decisions are informed by and aligned to the DRRM institution's strategy and drive the best value for acquired equipment.
	3.1.4 Asset inventory and maintenance	The DRRM institution maintains an up-to-date infrastructure asset inventory with detailed technical specifications.
	3.1.5 Management of infrastructure	The DRRM institution's computing infrastructure is actively managed against standardized management practices that comply with ISO 13485:2016 (sections that cover process equipment – both hardware and software – and supporting services such as communication or information systems).
	3.1.6 Budget	The DRRM institution has adequate budget and funding for the procurement, upgrade, operation, and maintenance of its computing infrastructure.
3.2 Network Infrastructure	**3.2.1 Design and carrying capacity**	The design, development, and deployment of networks in DRRM institution comply with ISO/IEC 17568:2013 (Information technology - telecommunications and information exchange between systems).
	3.2.2 Performance and downtime	The DRRM institution's networking infrastructure (both wired and wireless) meets increasing user demand for bandwidth, speed, security, and availability.
3.3 Risk management	**3.3.1 Disaster recovery**	The DRRM institution implements a disaster recovery strategy for unplanned hardware failure and data loss and restores events.
	3.3.2 Firewalls and security breaches	The DRRM institution implements cybersecurity controls and techniques that comply with O-ISM3 (information security management maturity standard published by The Open Group) and/or ISO 14001 and enables automated security

		controls to protect the institution from inside and outside threats.
3.4 Computing infrastructure for big data processing	**3.4.1 Storage solutions**	The DRRM institution has an enabling computing environment (in-house or cloud-based) optimized for big data storage, access, and retrieval.
	3.4.2 Processing power	The DRRM institution has an enabling computing environment (in-house or cloud-based) that provides the increased processing power required to run big-data analytics and processing algorithms.
	3.4.3 Networking hardware	The DRRM institution has robust networking hardware and an enabling computing environment (in-house or cloud-based) that facilitates fast data transfer of big data volumes

Component 4 - Staff Competencies - Element Level Specifications

Subcomponent	Element	Description
4.1 Competency framework	**4.1.1 Data acquisition**	Data users within the DRRM institution have strong knowledge of the unique geometric and thematic properties of geospatial data, the factors that affect data quality, and data production technologies – including data collection, data capture methods, and technologies used to collect georeferenced observations and measurements.
	4.1.2 Analysis and modeling	Analysts within the DRRM institution have strong knowledge and experience with the application of the analytical functions ("exploratory" analyses as well as model-driven analyses) of geospatial and data software tools.
	4.1.3 Programming and development	Developers within the DRRM institution possess the knowledge and skills to design and develop software and applications, including GIS software products, applications for processing, analysis, or adding value to remotely sensed data, and applications to automate routine tasks and customize end-user interfaces.
	4.1.4 Management	Technical managers within the DRRM institution have the knowledge and skills of project management, database administration, etc.
	4.1.5 Big data competencies	Users within the DRRM institution at various levels understand the benefits of big data and are familiar with the various technical aspects relevant to the job they perform (i.e., analysts know how to run and interpret the results of big data analytics, technical administrators know how to manage big data, decisionmakers understand the value of data-driven decisions, etc.)
4.2 Training portfolio	**4.2.1 Roles and skills alignment with domain**	Digital solutions and analysis by the DRRM institution is managed and run by adequate staff with appropriate professional qualifications, experience, and credentials.
	4.2.2 Training plans	Staff have access to ongoing training to maintain and develop their technical and operational knowledge, skills, and abilities.
	4.2.3 Training utilization/performance assessment	The DRRM institution routinely executes performance appraisal to assess training effectiveness; decisions for tenure are based on clear criteria for work performance and acquired competencies.
	4.2.4 Budget	The DRRM institution has an adequate budget and funding to run and maintain a strong training portfolio for its staff in digital technologies.

4.3 Decision-making support	**4.3.1 Evidence-based decisions**	The DRRM institution uses evidence-based planning and operating, and its decision-making process relies heavily on products and data provided by digital technologies.
	4.3.2 Technology transformation	The highest levels of the organizational hierarchy at the DRRM institution embrace digital transformation and innovation in digital technology as a core values.

Component 5 - Institutionalization and Partnership Programmes - Element Level Specifications

Subcomponent	Element	Description
5.1 Stakeholder management and collaboration	**5.1.1 Internal coordination/collaboration function**	The DRRM institution has a DR&T coordination function and/or committee to oversee framework development and maintain DR&T assets.
	5.1.2 External stakeholder framework	The DRRM institution embraces collaboration as an organization-wide culture and has a formal framework or protocol for DR&T strategic partnerships and alliances as part of its operational model.
	5.1.3 Stakeholder engagement	The DRRM institution adopts standard processes and tools for stakeholder engagement (both internal and external) and different types of partnerships in DR&T; KPIs in place for assessing and improving how the DRRM institution manages collaboration opportunities with local, national, and regional partners in the development and operation of data, infrastructure, and applications to leverage benefits and return of investments in DR&T.
	5.1.4 Protocols and agreements	The DRRM institution executes different protocols for data sharing, interoperability, license sharing, and collaboration agreements to maintain effectiveness, minimize cost and eliminate redundancy.
5.2 Communication	**5.2.1 Communication plan**	The DRRM institution has a formal plan/framework for analysing, planning, implementing, measuring, and evaluating communication activities and communication value concerning its operation and organizational goals.
	5.2.2. Communication performance	Communication activities and efforts are linked to outcomes such as key performance indicators and impact measurements through qualitative and quantitative methods and the presence of digital trace evidence such as posts and interaction on social networks.

Component 6 - Governance (Policies, Standards, Guidelines, and Best Practices)

Subcomponent	Element	Description
6.1 Governance Frameworks	**6.1.1 Legal regulations and policies**	The DRRM institution has a legal framework with regulations and policies concerning the ownership and stewardship of its digital resources and technologies, alignment with standards, interoperability, when and how these resources can be used and accessed, privacy, etc.
	6.1.2 Resource allocation framework	The DRRM institution has a progressive resource and capability management process aimed at enabling organizations to optimally allocate & utilize the scarce resources available (human, finances, etc.).
	6.1.3 Technology alignment framework	The DRRM institution aligns DR&T with its business strategy such that the DR&T mission, objectives and plans are supported by business processes and operational projects with measures and indictors capturing the degree of alignment and possible gaps.

	6.1.4 Governance framework	The DRRM institution adopts a DR&T governance framework for overseeing the implementation of legal, resource allocation, and technology alignment frameworks and covering best practices in its structure (i.e., presence of a Chief Information Office, committees or workgroups overseeing different dimensions related to DR&T, etc.), published DR&T policies, dedicated resources, and mechanisms for execution and monitoring.
6.2 Governance Best Practices	**6.2.1 SOPs for technology operations**	The DRRM institution has formal standard operational procedures (SOPs) that cover all aspects related to DR&T (governance, asset management, training, etc.) with necessary diagnostic tools and feedback loops to continuously improve the efficiency and effectiveness of the processes through incremental and step-function improvements and innovations.
	6.2.2. D&RT management support	DR&T management complies with best practices (e.g., the 10 practice areas listed in the Project Management Body of Knowledge (PMBOK®) and management standards (i.e., ISO 21500:2012 - Guidance on project management) with mechanisms in place to measure project effectiveness, efficiency, and continuous improvement.

Component 7 - Alignment with DRR Coordination and Collaboration (National Level) - Element Level Specifications

Subcomponent	Element	Description
7.1 Pre-disaster Phase	**7.1.1 DR&T use in disaster risk assessment**	The DRRM institution has published guidelines for the use of DR&T in undertaking a disaster risk assessment; presence of a DR&T toolkit for disaster risk assessment; evidence of clear alignment of the data, tools, and analytics in the DR&T toolkit and disaster risk assessment methods and approaches adopted; measures to check the accuracy of risk assessment results produced by the DR&T toolkit; procedures for consolidation, classification, and analysis of resulting risk information products; assessment of the utility of resulting products for decision-making, risk reduction, and other development functions.
	7.1.2 DR&T use in disaster risk management, planning, and monitoring	DR&T play a significant role in the development of a comprehensive national DRRM plan, as evidenced by risk information products covering major national/sub-national disaster risk areas, vulnerability maps addressing single and multiple vulnerabilities, presence of up-to-date indicators for monitoring the implementation of the DRRM plan and assessing the effectiveness of its different components, and linkage to DR&T models for early warning, risk prevention, response and recovery, and disaster mitigation.
	7.1.3 Disaster mitigation and prevention	DR&T are effectively used in the assessments of past experiences of disaster mitigation through measures and standards used to track evidence of mitigation intervention impact; evidence of how the knowledge created through DR&T is made available for decision-making with the DRRM institution and partnering agencies in support of data-driven decision-making.

	7.1.4 Supporting risk-informed planning and development	Evidence that information products by DR&T are incorporated into ongoing development programmes and sectoral action plans; DR&T helps prioritize DRRM activities within development programmes and informs the allocation of adequate funding and human resources; DR&T offer intelligence and prediction (i.e., via simulation, AI, and machine learning) for scaling up good practices and lessons learned.
	7.1.5 Awareness-raising and dissemination of risk information	DR&T offer mechanisms for the production and rapid communication of risk information products to relevant ministries/departments, as well as the public through mass media and local alert systems, with support from specialized agencies and information networks.
	7.1.6 Performance of early warning systems	DR&T are effectively used to link with international early warning systems and sectoral ministries and emergency centres to ensure rapid dissemination of early warning information throughout the country at various levels; DR&T produce sector-specific impact warning systems, indicators, and alert criteria; DR&T provide intelligence and suggest actions for risk/disaster management (e.g., evacuation, shelter use, etc.).
	7.1.7 Preparedness (overall and sector-specific)	DR&T inform the development of both a national-level preparedness plan and section-specific preparedness plans; DR&T provide hazard-level evidence for suggested actions; DR&T are used to mobilize resources and relief assistance/technical support (national, international, regional, NGO agencies; DR&T keep track of the status and capacity of shelters and facilities used to protect lives and livelihood assets, and functionality of warehouses, volumes of relief materials (drinking water, foods tents, and blankets) and emergency food storage facilities; DR&T are used to plan logistics (mobilization of health teams and first responders, locations and enumeration of the most vulnerable people (children, elderly, disabled, women and people living in extreme poverty) and offer criteria to identify evacuation routes; DR&T used to plan and simulate rapid response exercises (evacuation, relief, etc.)
7.2 Disaster Phase	**7.2.1 Supporting immediate response and/or relief assistance**	DR&T provide a reliable alarm system to alert concerned officials and initiate an emergency response when needed; DR&T offer reliable means to inform relevant service providers and, if required, external relief agencies; DR&T offer a platform to manage and coordinate logistics and monitor the performance of relief/assistance operations to ensure aid reaches those in need.
	7.2.2 Damage and loss assessment	DR&T offer instruments and standards and streamlined processes for situation awareness and establishing a common picture of impact/damage/loss assessment and needs for food, shelter, water, medicines, hospitalization, etc., a platform for managing fieldwork logistics and personnel involved in the damage and loss assessment, tools for standardized reporting, and predictive analytics to inform early recovery efforts.

7.3 Post-disaster Phase	**7.3.1 Recovery of services and infrastructure**	DR&T offer tools and streamlined mechanisms for integrated response and recovery operations, including analytics to inform early recovery efforts and prioritize repair/reconstruction of infrastructure (e.g., roads, bridges wells, schools, and other key buildings) and services (e.g., health, education, agricultural extension, etc.); criteria for paying compensation and insurance; and standards and indicators to monitor the quality and performance of the emergency.
	7.3.2 Rehabilitation and economic and social recovery	DR&T predictive analytics, data mining, machine learning, and simulation are used to inform rehabilitation plans, provide the evidence needed for economic and livelihood recovery, estimate costs and support financial planning, and assess performance and extract lessons learned to build resilience to future hazards.

APPENDIX B – METHODOLOGY FOR CALCULATING ELEMENTS WEIGHTS

The weighting of DDRRMM elements is calculated based on input from the UNDP Country Offices in Nepal, Philippines, Sri Lanka, and Indonesia using the analytic hierarchy process (AHP) developed by Saaty [30]. The AHP approach allows one to assess the relative weight of multiple criteria through intuitive pairwise comparison. The fundamental input to the AHP is the decision maker's answers to a series of questions in this general format: 'How important is criterion A relative to criterion B?'. Responses are gathered in verbal form and subsequently codified on a nine-point intensity scale. Satty's basic method to identify the value of the weights depends on matrix algebra and calculates the weights as the elements in the eigenvector associated with the maximum eigenvalue of the matrix. Results include the weight of each element and a measure of inconsistency that informs users as to whether the preference assignment needs revision. The results below show the weight calculation and ranking results of the 78 DDRRMM elements spanning 23 subcomponents.

Component	1. Data Access and Sharing
Subcomponent	1.1 Data Framework

Rank	Element	Weight
1	1.1.2 Data/domain business alignment	26.7%
2	1.1.1 Fundamental data model specifications	24.6%
3	1.1.3 Domain data model specifications	22.5%
4	1.1.4 Visualization and portrayal framework	13.0%
5	1.1.5 Data catalog & discovery framework	6.6%
6	1.1.6 Data maintenance framework	6.6%
	Sum	100.0%

Number of comparisons	15
Consistency Ratio CR	3.3%
Principal eigenvalue	6.204

Component	1. Data Access and Sharing
Subcomponent	1.2 Data Availability and Quality

Rank	Element	Weight
1	1.2.1 Core & Business GIS Data	45.5%
2	1.2.2 Non-GIS Data (structured)	45.5%
3	1.2.3 Other business data (unstructured)	9.1%
	Sum	100.0%

Number of comparisons	3
Consistency Ratio CR	0.0%
Principal eigenvalue	3.000

Component	1. Data Access and Sharing

Subcomponent	1.3 Data Management

Rank	Element	Weight
1	1.3.3 Data update/audit cycle	42.8%
2	1.3.5 Backup and recovery	18.9%
3	1.3.2 QA/QC	13.5%
4	1.3.1 DBMS/Data Warehouse	12.4%
5	1.3.4 Metadata	12.4%

Sum 100.0%

Number of comparisons 10
Consistency Ratio CR 6.6%
Principal eigenvalue 5.295

Component	1. Data Access and Sharing
Subcomponent	1.4 Data Governance

Rank	Element	Weight
1	1.4.1 Evidence of data interoperability	45.5%
2	1.4.3 Evidence of data policies	45.5%
3	1.4.2 Evidence of data transfer protocols	9.1%

Sum 100.0%

Number of comparisons 3
Consistency Ratio CR 0.0%
Principal eigenvalue 3.000

Component	1. Data Access and Sharing
Subcomponent	1.5 Big data Capability

Rank	Element	Weight
1	1.5.1 Big data readiness	54.0%
2	1.5.2 Big data accessibility and infrastructure	29.7%
3	1.5.3 Big data management	16.3%

Sum 100.0%

Number of comparisons 3
Consistency Ratio CR 1.0%
Principal eigenvalue 3.009

Component	2. Digital Applications and Services
Subcomponent	2.1 Application portfolio

Rank	Element	Weight
1	2.1.1 Portfolio/business alignment framework	75.0%

2	2.1.2 Portfolio management & maintenance	25.0%

Sum 100.0%

Number of comparisons 1
Consistency Ratio CR 1.0%
Principal eigenvalue 2.000

Component	2. Digital Applications and Services
Subcomponent	2.2 Software

Rank	Element	Weight
1	2.2.4 Budget and finances	57.2%
2	2.2.2 Product scalability and integration	20.9%
3	2.2.1 Procurement	10.9%
4	2.2.3 Management, maintenance, updates	10.9%

Sum 100.0%

Number of comparisons 6
Consistency Ratio CR 0.2%
Principal eigenvalue 4.004

Component	2. Digital Applications and Services
Subcomponent	2.3 Tools for Workflow optimization

Rank	Element	Weight
1	2.3.2 Application programme interfaces (APIs)	30.5%
2	2.3.3. Performance tracking and process improvement	30.5%
3	2.3.1 Automation	27.7%
4	2.3.4 Field support	11.3%

Sum 100.0%

Number of comparisons 6
Consistency Ratio CR 0.8%
Principal eigenvalue 4.021

Component	2. Digital Applications and Services
Subcomponent	2.4 Analytics

Rank	Element	Weight
1	2.4.1 Digital platform	49.3%
2	2.4.2 GIS and data science analytics	31.1%
3	2.4.3 Big data analytical capabilities	19.6%

Sum 100.0%

Number of comparisons 3

Consistency Ratio CR 5.6%
Principal eigenvalue 3.054

Component	3. ICT Infrastructure
Subcomponent	3.1 Computing Infrastructure

Rank	Element	Weight
1	3.1.5 Management of infrastructure	20.6%
2	3.1.6 Budget	20.6%
3	3.1.4 Asset inventory and maintenance	20.3%
4	3.1.2 Sizing and capacity	18.4%
5	3.1.1. Architecture specifications	14.0%
6	3.1.3 Procurement	6.1%

Sum 100.0%

Number of comparisons 15
Consistency Ratio CR 1.7%
Principal eigenvalue 6.109

Component	3. ICT Infrastructure
Subcomponent	3.2 Network Infrastructure

Rank	Element	Weight
1	3.2.1 Design and carrying capacity	50.0%
2	3.2.2 Performance and downtime	50.0%

Sum 100.0%

Number of comparisons 1
Consistency Ratio CR 0.0%
Principal eigenvalue 2.000

Component	3. ICT Infrastructure
Subcomponent	3.3 Risk management

Rank	Element	Weight
1	3.3.1 Disaster recovery	75.0%
2	3.3.2 Firewalls and security breaches	25.0%

Sum 100.0%

Number of comparisons 1
Consistency Ratio CR 0.0%
Principal eigenvalue 2.000

Component	3. ICT Infrastructure
Subcomponent	3.4 Computing infrastructure for big data processing

Rank	Element	Weight
1	3.4.1 Storage solutions	33.3%
2	3.4.2 Processing power	33.3%
3	3.4.3 Networking hardware	33.3%

Sum 100.0%

Number of comparisons 3
Consistency Ratio CR 0.0%
Principal eigenvalue 3.000

Component	4 - Staff Competencies
Subcomponent	4.1 Competency framework

Rank	Element	Weight
1	4.1.1 Data acquisition	30.9%
2	4.1.2 Analysis and modeling	30.9%
3	4.1.4 Management	23.8%
4	4.1.5 Big data competencies	7.6%
5	4.1.3 Programming and development	6.8%

Sum 100.0%

Number of comparisons 10
Consistency Ratio CR 2.1%
Principal eigenvalue 5.096

Component	4 - Staff Competencies
Subcomponent	4.2 Training portfolio

Rank	Element	Weight
1	4.2.1 Roles and skills alignment with domain	30.5%
2	4.2.4 Budget	30.5%
3	4.2.2 Training plans	27.7%
4	4.2.3 Training utilization/performance assessment	11.3%

Sum 100.0%

Number of comparisons 6
Consistency Ratio CR 0.8%
Principal eigenvalue 4.021

Component	4 - Staff Competencies
Subcomponent	4.3 Decision making support

Rank	Element	Weight

1	4.3.1 Evidence-based decisions	66.7%
2	4.3.2 Technology transformation	33.3%

Sum 100.0%

Number of comparisons 1
Consistency Ratio CR 0.0%
Principal eigenvalue 2.000

Component	5 - Institutionalization and Partnership Programmes
Subcomponent	5.1 Stakeholder management and collaboration

Rank	Element	Weight
1	5.1.1 Internal coordination/collaboration function	25.0%
2	5.1.2 External stakeholder framework	25.0%
3	5.1.3 Stakeholder engagement	25.0%
4	5.1.4 Protocols and agreements	25.0%

Sum 100.0%

Number of comparisons 6
Consistency Ratio CR 0.0%
Principal eigenvalue 4

Component	5 - Institutionalization and Partnership Programmes
Subcomponent	5.2 Communication

Rank	Element	Weight
1	5.2.1 Communication plan	50.0%
2	5.2.2. Communication performance	50.0%

Sum 100.0%

Number of comparisons 1
Consistency Ratio CR 0.0%
Principal eigenvalue 2.000

Component	6 - Governance (Policies, Standards, Guidelines, and Best Practices)
Subcomponent	6.1 Governance Frameworks

Rank	Element	Weight
1	6.1.1 Legal regulations and policies	36.2%
2	6.1.2 Resource allocation framework	26.7%
3	6.1.4 Governance framework	23.5%
4	6.1.3 Technology alignment framework	13.6%

Sum 100.0%

Number of comparisons	6
Consistency Ratio CR	9.3%
Principal eigenvalue	4.425

Component	6 - Governance (Policies, Standards, Guidelines, and Best Practices)
Subcomponent	6.2 Governance Best Practices

Rank	Element	Weight
1	6.2.1 SOPs for technology operations	75.0%
2	6.2.2. D&RT management support	25.0%
	Sum	100.0%

Number of comparisons	1
Consistency Ratio CR	0.0%
Principal eigenvalue	2.000

Component	7 - Alignment with DRR Coordination and Collaboration (National Level)
Subcomponent	7.1 Pre-disaster Phase

Rank	Element	Weight
1	7.1.1 DR&T use in disaster risk assessment	14.3%
2	7.1.2 DR&T use in disaster risk management, planning, and monitoring	14.3%
3	7.1.3 Disaster mitigation and prevention	14.3%
4	7.1.4 Supporting risk-informed planning and development	14.3%
5	7.1.5 Awareness-raising and dissemination of risk information	14.3%
6	7.1.6 Performance of early warning systems	14.3%
7	7.1.7 Preparedness (overall and sector-specific)	14.3%
	Sum	100.0%

Number of comparisons	21
Consistency Ratio CR	0.0%
Principal eigenvalue	7

Component	7 - Alignment with DRR Coordination and Collaboration (National Level)
Subcomponent	7.2 Disaster Phase

Rank	Element	Weight
1	7.2.1 Supporting immediate response and/or relief assistance	50.0%
2	7.2.2 Damage and loss assessment	50.0%
	Sum	100.0%

Number of comparisons	1
Consistency Ratio CR	0.0%
Principal eigenvalue	2.000

Component	7 - Alignment with DRR Coordination and Collaboration (National Level)
Subcomponent	7.3 Post-disaster Phase

Rank	Element	Weight
1	7.3.1 Recovery of services and infrastructure	50.0%
2	7.3.2 Rehabilitation and economic and social recovery	50.0%
	Sum	100.0%

Number of comparisons	1
Consistency Ratio CR	0.0%
Principal eigenvalue	2.000

APPENDIX C – THE DDRRMM CALCULATOR

Below is a description of the DDRRMM calculator (available in Excel worksheet format) used to automatically calculate the DDRRMM maturity scores of an organization. Eight sheets comprise the Excel worksheet with the title of each sheet in red.

Sheet 1: DDRRMM Score and Description:

*This sheet is protected - DDRRMM values are automatically populated based on elements scoring

DRRMM Component	Score
Data Access and Sharing	#####
Digital Applications and Services	#####
ICT Infrastructure	#####
Staff Competencies	#####
Institutionalization and Partnerships	#####
Governance	#####
Alignment with DRR	#####

Overall DDRRMM Index **#VALUE!**

Interpretation of the overall DDRRMM Index

0-20%	Technology utilization for DRRM is random, undocumented; resources not available; tends to be driven in an ad-hoc uncontrolled and reactive manner by users or events
>20-40%	Role of technology for DRRM is recognized, silo implementation and cases of repetitive uses unlikely rigorous, insufficient resources, no SPOs in place
>40-80%	Consistency in using technology for DRM is consistent is some areas, with defined SPOs; resources are available but not sufficient for optimal operations, full integration is lacking impacting performance
>60-80%	Technology capabilities are established and enhancing DRRM; resources are sufficient in general; KPIs for managing and maintain the systems are in place, integration exists but not fully realized
>80-100%	Technology utilization for DRRM reflects the state of the art; full implementation and integration is realized; focus is on continually improving of performance and utilization of new innovations

DX4Resilience
CONNECT INNOVATE ACCELERATE

Sheet 2: Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0

Component 1 - Data Access and Sharing - Element Level Specifications

Subcomponen	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
1.2 Data Availability and Quality	1.2.1 Core & Business GIS Data	GIS data in a condition that meets the DRRM institution needs for operation in terms of **Completeness**; **Custodianship**; **Thematic Content**; **Data Format** (vector, raster, grids, topology, etc.); **Scale**; **Positional Accuracy**; **Attribute Accuracy**; **Temporal Scale**; **Currency**; Tabular and Spatial Relationships; presence of **Metadata**; **Map Projections**; and **Datums**.							######	45.5%
	1.2.2 Non-GIS Data (structured)	Tabular data and database tables meet the DRRM institution's needs for operation in terms of the **Completeness**; **Fitness for Use**; **Identifiers**; **Accuracy of tabular information**; **Complete Data Dictionaries**; and presence of **Integrity Rules**.							######	45.5%
	1.2.3 Other business data (unstructured)	*(Applicable only if the DRRM operational needs require access to unstructured data).* Unstructured data (addresses, documents, PDFs, social media posts, etc.) are **Geotagged/geo-enabled**, **integrated seamlessly with structured data**, and **support entity recognition.**							######	9.1%
								Subcomponent Total Score	######	
1.3 Data Management	1.3.1 DBMS/Data Warehouse	All data of the DRRM institution is residing in a database management system and/or a data warehouse (if applicable) that supports a secure integrated environment for accessing, managing, and versioning datasets; support quick and easy data access; and consistent quality data through validation rules and varying user privilege.							######	12.4%
	1.3.2 QA/QC	The DRRM institution observes all principles required for maintaining quality data and applies measures for evaluating and reporting the quality of the data that comply with ISO 19157:2013 (Geographic information — Data quality) and ISO/TS 19158:2012 (Geographic information — Quality assurance of data supply).							######	13.5%
	1.3.3 Data update/audit cycle	Data within the DRRM institution is well-maintained and updated on pre-determined certain frequencies consistent with the data maintenance framework and ensures data quality and currency.							######	42.8%
	1.3.4 Metadata	Metadata is available and current for all types of data and meets all requirements set forth by guiding metadata standards in the data catalog & discovery framework							######	12.4%
	1.3.5 Backup and recovery	A backup, archival, and recovery system for data is in place and is tested periodically to ensure periodically test reliability to ensure reliable performance							######	18.9%
								Subcomponent Total Score	######	
1.4 Data Governance	1.4.1 Evidence of Data interoperability	Data is integrated and accessed in a technically appropriate and efficient manner across the DRRM institution; use of open data formats (XML, JASON, GeoGSN, etc.); published datasets are linked on the semantic web; the presence of HTTP URIs that identify and describe datasets; mechanisms to publish original datasets in RDF, JSON-LD, NT, or TTL							######	45.5%
	1.4.2 Evidence of data transfer protocols	Data is easily available and accessible to various user groups; evidence that the DRRM institution prioritizes interoperability (institutional framework, Data governance officers, stewardship teams, using common classification and vocabularies, presence of semantic/ontologies)							######	9.1%
	1.4.3 Evidence of data policies	Data within the DRRM institution is well-maintained and updated on pre-determined certain frequencies consistent with the data maintenance framework and ensures data quality and currency.							######	45.5%
								Subcomponent Total Score	######	
1.5 Big data Capability	1.5.1 Big data readiness	The DRRM institution realizes the value of big data; users depend on big data from various resources and are actively implementing big data projects throughout the institution							######	54.0%
	1.5.2 Big Data accessibility and infrastructure	Data is organized and architected on a master data management repository (e.g., Hadoop, Map Reduce) to allow high volume and velocity data sharing between systems and across multiple users							######	29.7%
	1.5.3 Big Data management	Big data management is integrated across the DRRM institution on a unified platform							######	16.3%
								Subcomponent Total Score	######	
								Component 1 - Data Access and Sharing - Element Level Specifications	#####	

Sheet 3- Component 2 - Digital Applications and Services- Element Level Specifications

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0										
Component 2 - Digital Applications and Services- Element Level Specifications										
Subcomponent	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
2.1 Application portfolio	2.1.1 Portfolio/business alignment	The DRRM institution has a portfolio of software applications and software-based services (either custom or off-the-shelf), which it uses to attain its strategic goals or objectives and according to an IT strategy and/or common design and development framework							####	75.0%
	2.1.2 Portfolio management & maintenance	The DRRM institution's application portfolio is managed and kept viable through ongoing support and routine application maintenance							####	25.0%
								Subcomponent Average Score	####	
2.2 Software	2.2.1 Procurement	Procurement and decisions of "make, buy, or reuse" of the software are informed by and aligned to the DRRM institution's strategy and driving the best value for acquired the supplies and services							####	10.9%
	2.2.2 Product scalability and integration	The DRRM institution implements an architecture design and a strategy for product integration and scalability that adhere to Zachman Framework (or similar), with clear procedures, criteria, and performance verification							####	20.9%
	2.2.3 Management, maintenance, updates	The DRRM institution applies effective procedures and best practices to manage and maintain its software and application assets to ensure continuity of its operations (i.e., keeps an up-to-date software asset inventory; has well-defined software service level agreement that keeps its software assets up-to-dates; implements a framework and action plans for system administration, database administration, network administration, system security, data backup, security, and restore processes, etc.)							####	10.9%
	2.2.4 Budget and finances	The DRRM institution has an adequate budget for the procurement, operation, and regular maintenance and update of software							####	57.2%
								Subcomponent Average Score	####	
2.3 Tools for Workflow optimization	2.3.1 Automation	The DRRM institution maintains a portfolio of platforms and tools to facilitate enterprise-wide automation of common business processes with defined targets and performance metrics (e.g., automated data extraction, computer-aided dispatch, automated tracking of field works, etc.)							####	27.7%
	2.3.2 Application Program Interfaces (APIs)	The IT strategy of the DRRM institution is API-driven (meaning that the diverse software programs and applications it uses are seamlessly connected and talk to each other to provide a valuable digital experience to all users) and implemented APIs support discovery and provide self-documenting protocols							####	30.5%
	2.3.3. Performance Tracking and Process Improvement	The DRRM institution employs applications and tools (e.g., QA/QC applications) for operating, managing, and documenting processes and tasks and tracking performance to comply with ISO 18091:2019 (Quality management systems — Guidelines for the application of ISO 9001 in local government) and ISO/IEC/IEEE 90003:2018 (Guidelines for the application of ISO 9001:2015 to computer software)							####	30.5%
	2.3.4 Field Support	The DRRM institution uses the latest technologies in support of various field tasks (surveys, GIS field mapping, etc.) that provides instant access to reliable and update data, facilitate real-time data gathering and reporting, maximize the allocation of resources, support effective communication between field and offices, and improve accountability and productivity of field personnel							####	11.3%
								Subcomponent Average Score	####	
2.4 Analytics	2.4.1 Digital Platform	Users at the DRRM institution access all digital resources and tools via a common platform managed in a cohesive (end-to-end) manner							####	49.3%
	2.4.2 GIS and data science analytics	The DRRM institution is equipped with a range of analytical capabilities (GIS, data science, etc.) that serve all its operation and business needs related to gathering and visualizing historical data, identifying patterns and dependencies, creating probable forecasts, providing optimization option, and supporting decision making							####	31.1%
	2.4.3 Big data analytical capabilities	The DRRM institution is equipped with big data analytical capabilities (e.g., machine learning and AI) that are automated or integrated with its business process and operation and can incorporate all kinds of data (structure, unstructured, real-time data, etc.) in decision-making processes							####	19.6%
								Subcomponent Average Score	####	
								Component 2 - Digital Applications and Services- Element Level Specifications	#####	

Sheet 4: Component 3 - ICT Infrastructure - Element Level Specifications

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0										
Component 3 - ICT Infrastructure - Element Level Specifications										
Subcomponent	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
3.1 Computing Infrastructure	3.1.1. Architecture specifications	The DRRM institution maintains and operates a computing infrastructure informed with an architecture design of hardware (servers, storage, desktops, input, and output peripherals), network components, operating system, GIS, etc. that meets its business needs and is kept current with technological trends							######	14.0%
	3.1.2 Sizing and capacity	The conditions and performance levels of the computing infrastructure assets are well monitored and subject to scheduled maintenance and updates							######	18.4%
	3.1.3 Procurement	Procurement and decisions of hardware are informed by and aligned to the DRRM institution's strategy and driving the best value for acquired equipment							######	6.1%
	3.1.4 Asset inventory and maintenance	The DRRM institution maintains an up-to-date infrastructure asset inventory with detailed technical specifications; reports are available for the existence							######	20.3%
	3.1.5 Management of infrastructure	The DRRM institution's computing infrastructure is actively managed against standardized management practices that comply with ISO 13485:2016 (sections that cover process equipment (both hardware and software) and supporting services (communication or information systems)							######	20.6%
	3.1.6 Budget	The DRRM institution has adequate budget and funding for the procurement, upgrade, operation, and maintenance of its computing infrastructure							######	20.6%
								Subcomponent Average Score	######	
3.2 Network Infrastructure	3.2.1 Design and carrying capacity	The design, development, and deployment of networks in DRRM institution comply with ISO/IEC 17568:2013 (Information technology — Telecommunications and information exchange between systems)							######	50.0%
	3.2.2 Performance and downtime	The DRRM institution's networking infrastructure (both wired and wireless) meet the increasing user demand for bandwidth, speed, security, and availability							######	50.0%
								Subcomponent Average Score	######	
3.3 Risk management	3.3.1 Disaster recovery	The DRRM institution implements a disaster recovery strategy for unplanned hardware failure and data loss and restores events						5	3.750	75.0%
	3.3.2 Firewalls and security breaches	The DRRM institution implements cybersecurity controls and techniques that comply with O-ISMS (information security management maturity standard published by The Open Group) and/or ISO 14001 and enables automated security controls to protect the institution from inside and outside threats						5	1.250	25.0%
								Subcomponent Average Score	5.0	
3.4 Computing infrastructure for big data processing	3.4.1 Storage Solutions	The DRRM institution has an enabling computing environment (in-house or cloud-based) optimized for big data storage, access, and retrieval							######	33.3%
	3.4.2 Processing Power	The DRRM institution has an enabling computing environment (in-house or cloud-based) that provides the increased processing power required to run big-data analytics and processing algorithms							######	33.3%
	3.4.3 Networking Hardware	The DRRM institution has robust networking hardware an enabling computing environment (in-house or cloud-based) that facilitates fast data transfer of big data volumes (e.g., 10-gigabit)							######	33.3%
								Subcomponent Average Score	######	
								Component 3 - ICT Infrastructure - Element Level Specifications	#####	

Sheet 5: Component 4 - Staff Competencies - Element Level Specifications

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0										
Component 4 - Staff Competencies - Element Level Specifications										
Subcompone	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
4.1 Competency framework	4.1.1 Data acquisition	Data users within the DRRM institution have strong knowledge of the unique geometric and thematic properties of geospatial data, the factors that affect data quality, and data production technologies, including data collection, data capture methods, and technologies used to collect georeferenced observations and measurements							#VALUE!	30.9%
	4.1.2 Analysis and modeling	Analysts within the DRRM institution have strong knowledge and experience with the application of the analytical functions ("exploratory" analyses as well as model-driven analyses) of geospatial and data software tools							#VALUE!	30.9%
	4.1.3 Programming and development	Developers within the DRRM institution possess the knowledge and skills to design and develop software and applications, including GIS software products, applications for processing, analysis, or adding value to remotely sensed data, and applications to automate routine tasks and customize end-user interfaces							#VALUE!	6.8%
	4.1.4 Management	Technical managers within the DRRM institution have the knowledge and skills of project management, database administration, etc.							#VALUE!	23.8%
	4.1.5 Big data competencies	Users within the DRRM institution at various level understand the benefits of big data and are familiar with the various technical aspects relevant to the job they perform (i.e., analysts know how to run and interpret the results of big data analytics, technical administrators know how to manage big data, decision-makers understand the value of data-driven decisions, etc.)							#VALUE!	7.6%
								Subcomponent Average Score	#VALUE!	
4.2 Training portfolio	4.2.1 Roles and skills alignment with domain	Digital solutions and analysis by the DRRM institution is managed and ran by adequate staff with appropriate professional qualifications, experience, and credentials							#VALUE!	30.5%
	4.2.2 Training plans	Staff have access to ongoing training to maintain and develop their technical and operational knowledge, skills, and abilities							#VALUE!	27.7%
	4.2.3 Training utilization/performance assessment	The DRRM institution routinely executes performance appraisal to assess training effectiveness; decisions for tenure are based on clear criteria for work performance and acquires competencies							#VALUE!	11.3%
	4.2.4 Budget	The DRRM institution has an adequate budget and funding to run and maintain a strong training portfolio for its staff in digital technologies							#VALUE!	30.5%
								Subcomponent Average Score	#VALUE!	
4.3 Decision making support	4.3.1 Evidence-based decisions	The DRRM institution uses evidence-based planning and operating, and its decision-making process relies heavily on products and data provided by digital technologies.							#VALUE!	66.7%
	4.3.2 Technology transformation	The highest levels of the organizational hierarchy at DRRM institution embrace digital transformation and innovation in digital technology as a core value							#VALUE!	33.3%
								Subcomponent Average Score	#VALUE!	
								Component 4 - Staff Competencies - Element Level Specifications	#####	

Sheet 6: Component 5 - Institutionalization and Partnership Programmes - Element Level Specifications

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0										
Component 5 - Institutionalization and Partnership Programs - Element Level Specifications										
Subcomponent	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
5.1 Stakeholder management and collaboration	5.1.1 Internal coordination/collaboration function	The DRRM institution has a DR&T coordination function and/or committee to rationalize frameworks and development, access, and maintenance of DR&T assets							#VALUE!	25.0%
	5.1.2 External stakeholder framework	The DRRM institution embraces collaboration as an organizational-wide culture and has a formal framework or protocol for DR&T strategic partnership and alliance as part of its operational model							#VALUE!	25.0%
	5.1.3 Stakeholder engagement	The DRRM institution adopts standard processes and tools for stakeholder engagement (both internal and external) and different types of partnerships in DR&T; KPIs in place for assessing and improving how DRRM institution effectively manages collaboration opportunities with local, national, and regional partners in the development and operation of data, infrastructure, and applications to leverage benefits and return of investments in DR&T							#VALUE!	25.0%
	5.1.4 Protocols and agreements	The DRRM institution executes different protocols for data sharing, interoperability, license sharing, and other like service and collaboration agreement meant to maintain effectiveness and minimize cost and redundant functions							#VALUE!	25.0%
								Subcomponent Average Score	#VALUE!	
5.2 Communication	5.2.1 Communication plan	The DRRM institution has a formal plan/framework for analyzing, planning, implementing, measuring, and evaluating communication activities and communication value concerning its operation and organizational goal							#VALUE!	50.0%
	5.2.2. Communication performance	Communication activities and efforts are linked to outcomes such as the key performance indicators and impact measurements through qualitative and quantitative methods; the presence of digital trace evidence such as posts, and interaction on social networks							#VALUE!	50.0%
								Subcomponent Average Score	#VALUE!	
								Component 5 - Institutionalization and Partnership Programs - Element Level Specifications	#####	

Sheet 7: Component 6 - Governance (Policies, Standards, Guidelines, and Best Practices)

Digital Disaster Risk Reduction Maturity Model (DDRRMM) - V3.0										
Component 6 - Governance (Policies, Standards, Guidelines, and Best Practices)										
Subcomponen	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
6.1 Governance Frameworks	6.1.1 Legal regulations and policies	The DRRM institution has a legal framework with regulations and policies concerning the ownership and stewardship of its digital resources and technologies, alignment with standards, interoperability, when and how these resources can be used and accessed, privacy, etc.							#VALUE!	36.2%
	6.1.2 Resource allocation framework	The DRRM institution has a progressive resource and capability management process aimed at enabling organizations to optimally allocate & utilize the scarce resources available (human, finances, etc.)							#VALUE!	26.7%
	6.1.3 Technology alignment framework	The DRRM institution aligns DR&T with its business strategy such that the DR&T mission, objectives and plans support and are supported by business processes and operational projects with measures and indictors capturing the degree of alignment and possible gaps							#VALUE!	13.6%
	6.1.4 Governance framework	The DRRM institution adopts a DR&T governance framework for overseeing the implementation of the legal, resource allocation, and technology alignment frameworks and covering best practices in its structure (i.e., presence of a Chief Information Office, committees or workgroups overseeing different dimensions related to DR&T, etc.), published DR&T policies, dedicated resources, and mechanisms for execution and monitoring							#VALUE!	23.5%
								Subcomponent Average Score	#VALUE!	
6.2 Governance Best Practices	6.2.1 SOPs for technology operations	The DRRM institution has formal standard operational procedures (SOPs) that cover all aspects related to DR&T (governance, asset management, training, etc.) with necessary diagnostic tools and feedback loops to continuously improve the efficiency and effectiveness of the processes through incremental and step-function improvements and innovations							#VALUE!	75.0%
	6.2.2. D&RT management support	DR&T management complies with best practices (e.g., the ten practice areas listed in the Project Management Body of Knowledge (PMBOK®)) and management standards (i.e., ISO 21500:2012 - Guidance on project management) with mechanisms in place to measure project effectiveness and efficiency, and continuous improvement							#VALUE!	25.0%
								Subcomponent Average Score	#VALUE!	
								Component 6 - Governance (Policies, Standards, Guidelines, and Best Practices)	#####	

Sheet 8: Component 7 - Alignment with DRR Coordination and Collaboration (National Level) - Element Level Specifications

Digital Disaster Risk Reduction Maturity Model (DDRRMM) – V3.0

Component 7 – Alignment with DRR Coordination and Collaboration (National Level) – Element Level Specifications

NOTE: **If the DRRM institution is only focused on certain aspect of DRRM operations, change the weights of other irrelevant aspects to 0% and give equal weights for the operational areas within the DRRM operational scope. For example, if the DRRM institution focuses only on risk assessment, change the weight for 7.1.1. to 100% and the rest of the weights are 0%. If it focuses on two areas (disaster mitigation and risk assessment), then give 50% to both and 0% to the rest. If it focuses on three, then each element takes 33.33% and so on. Always make sure the weights sum to 100%.**

Subcomp	Element	Description	N/A	Ad Hoc	Recognized	Defined	Managed	Optimized	Score	Weights
7.1 Pre-disaster Phase	7.1.1 DR&T use in disaster risk assessment	The DRRM institution has published guidelines for the use of DR&T in undertaking a disaster risk assessment; a presence of a DR&T toolkit for disaster risk assessment; evidence of clear alignment of the data, tools, and analytics in the DR&T toolkit and disaster risk assessment methods and approaches adopted; measures to check the accuracy of risk assessment results produced by the DR&T toolkit; procedures for consolidation, classification, and analysis of resulting risk information products; assessment of the "utility" of resulting products for decision making, risk reduction, and other development functions							###	9.1%
	7.1.2 DR&T use in disaster risk management, planning, and monitoring	DR&T play a significant role in the development of a comprehensive national DRRM plan, as evidence by risk information products covering major national/sub-national disaster risk areas, vulnerability maps addressing single and multiple vulnerabilities, presence of up-to-date indicators for monitoring the implementation of the DRRM plan and assessing the effectiveness of its different components, and linkage to DR&T models for early warning, risk prevention, response and recovery, and disaster mitigation							###	9.1%
	7.1.3 Disaster mitigation and prevention	DR&T are effectively used in the assessments of past experiences of disaster mitigation through measures and standards used to track evidence of mitigation intervention impact; evidence of how the knowledge created through DR&T is made available for decision-making with the DRRM institution and partnering agencies in support of data-driven decision making							###	9.1%
	7.1.4 Supporting risk-informed planning and development	Evidence that information products by DR&T are incorporated into ongoing development programs and sectoral action plans; DR&T helps prioritize DRRM activities within development programs and inform the allocation of adequate funding and human resources; DR&T offers intelligence and prediction (i.e., via simulation, AI, and machine learning) for scaling up good practices and lessons learned							###	9.1%
	7.1.5 Awareness-raising and dissemination of	DR&T offer mechanisms for the production and rapid communication of risk information products to relevant ministries/departments, as well as the public through mass media, local alert systems, with support from specialized agencies and information networks							###	9.1%
	7.1.6 Performance of early warning systems	DR&T are effectively used to link with international early warning systems and sectoral ministries and emergency centers to ensure rapid dissemination of early warning information throughout the country at various levels; DR&T produce sector-specific impact warning systems, indicators, and alert criteria; DR&T provide intelligence and suggest actions for risk/disaster management (e.g., evacuation, shelter use, etc.)							###	9.1%
	7.1.7 Preparedness (overall and sector-specific)	DR&T inform the development of both national-level preparedness plan and sector-specific preparedness plans; DR&T provide hazard-level evidence for suggested actions; DR&T are used to mobilize resources and relief assistance/technical support (national, international, regional, NGO agencies; DR&T keep track of the status and capacity of shelters and facilities used to protect lives and livelihood assets, and functionality of warehouses, volumes of relief materials (drinking water, foods tents, and blankets) and emergency food storage facilities; DR&T are used to plan logistics (mobilization of health teams and first responders, locations and enumeration of the most vulnerable people (children, elderly, disabled, women, the very poor) and offer criteria to identify evacuation routes; DR&T are used to plan and simulate rapid [illegible]							###	9.1%
7.2 Disaster Phase	7.2.1 Supporting immediate response and/or relief assistance	DR&T provide a reliable alarm system to alert concerned officials and initiate an emergency response when needed; DR&T offer reliable means to inform relevant service providers and, if required, external relief agencies; DR&T offer a platform to manage and coordinate logistics and monitor the performance of relief/assistance operations to ensure the aid reaches those							###	9.1%
	7.2.2 Damage and loss assessment	DR&T offer instruments and standards and streamline processes for situation awareness and establishing a common picture of impact/damage/loss assessment and needs for food, shelter, water, medicines, hospitalization, etc., a platform for managing fieldwork logistics and personnel involved in the damage and loss assessment, tools for standardized reporting, and predictive analytics to inform early recovery efforts							###	9.1%
7.3 Post-disaster Phase	7.3.1 Recovery of services and infrastructure	DR&T offer tools and streamline mechanisms for integrated response and recovery operations, including analytics to inform early recovery efforts and prioritize repair/reconstruction of infrastructure (e.g., roads, bridges wells, schools, and other key buildings) and services (e.g., health, education, agricultural extension, etc.), criteria for paying compensation and insurance, and standards and indicators to monitor the quality and							###	9.1%
	7.3.2 Rehabilitation and economic and social recovery	DR&T predictive analytics, data mining, machine learning, and simulation are used to inform rehabilitation plans, provide the evidence needed for economic and livelihood recovery, estimate costs and support financial planning, and assess performance and extract lessons learned to build resilience to future hazards							###	9.1%
								Subcomponent Average Score		
		Component 7 - Alignment with DRR Coordination and Collaboration (National Level) - Element Level Specifications							###	

REFERENCES

[1] M. Rosemann and T. De Bruin, "Towards a Business Process Management Maturity Model," in *13th European conference on information, Regensburg, 2005*.

[2] O. A. Alrwais, "Towards a New GIS Maturity Model: An Organizational Usage Perspective," *CGU Theses & Dissertations, 100.* [Online]. Available: http://scholarship.claremont.edu/cgu_etd/100. doi: 10.5642/cguetd/100, 2016.

[3] M. Kohlegger, R. Maier and S. Thalmann, "Understanding maturity models results of a structured content analysis," in *I-KNOW'09.* [Online]. Available: https://www.researchgate.net/publication/290265437_Understanding_maturity_models_results_of_a_structured_content_analysis, 2009.

[4] C. F. Gibson and R. L. Nolan, "Managing the four stages of EDP growth," *Harvard Business Review*, vol. 52, no. 1, pp. 76-87, 1974.

[5] "SEI, CMMI® for Development, Version 1.3" Hanscom Air Force Base, MA: Software Engineering Institute, Carnegie Mellon University, 2010.

[6] F. Marx, F. Wortmann and J. H. Mayer, "A Maturity Model for Management Control Systems," *Business & Information Systems Engineering*, vol. 4, pp. 193-208, 2012.

[7] J. Pöppelbuß and M. Röglinger, "What Makes a Useful Maturity Model? A framework of general design principles for maturity models and its demonstration in business process management," in *ECIS 2011 Proceedings*, 2011.

[8] E. Tocto-Cano, S. P. Collado, J. L. López-Gonzales and J. E. Turpo-Chaparro, "A Systematic Review of the Application of Maturity Models in Universities," *Information*, vol. 11, 2020.

[9] "ORR, The Risk Management Maturity Model (RM3)," London, UK: Office of Rail and Road, 2019.

[10] I. Bruno, A. Donarelli, V. Marchetti, A. S. Panni, B. V. Covino, G. Lobo and F. Molinari, "Technology Readiness revisited: A proposal for extending the scope of impact assessment of European public services," in *Electronic Governance* (ICEGOV2020), Athens, Greece, 2020.

[11] IFD, "Societal Readiness Levels (SRL)," Innovation Fund Denmark. [Online]. Available: https://innovationsfonden.dk/sites/default/files/2018-08/societal_readiness_levels_-_srl.pdf.

[12] *SMC, Smart Cities Readiness Guide: The planning manual for building tomorrow's cities today, Smart Cities Council (SMC),* 2015.

[13] A. Shaikh, N. Memon, M. Memon and A. Ahmed, "Strengths and Weaknesses of Maturity Driven Process Improvement Effort," in *CISIS '09. International Conference on Complex, Intelligent and Software Intensive Systems*, Fukuoka, Japan, 2009.

[14] B. Morris, "The case against maturity models," 08 06 2019. [Online]. Available: https://www.ben-morris.com/the-case-against-maturity-models/. [Accessed 8 May 2021].

[15] E. d. Boer and S. Narayanan, "Avoid pilot purgatory in 7 steps," McKinsey & Company, 16 April 2018. [Online]. Available: https://www.mckinsey.com/business-functions/organization/our-insights/the-organization-blog/avoid-pilot-purgatory-in-7-steps#. [Accessed 28 April 2021].

[16] SSC, "Six Sigma: A Complete Step-by-Step Guide," Council of Six Sigma Certification, Buffalo, WY, 2018.

[17] C. Southerton, "Datafication," in *Encyclopedia of Big Data*, L. A. Schintler and C.L. McNeely, Eds. Spriner Nature, 2020, pp. 322-326.

[18] CGDEV, "The Case for Evidence-Based Innovation and Implications for USAID (and Beyond)," Center for Global Development, 25 February 2021. [Online]. Available:

https://www.cgdev.org/blog/case-evidence-based-innovation-and-implications-usaid-and-beyond. [Accessed 4 May 2021].

[19] EK, "Digital: Does evidence-based L&D matter?," Emerald Works, 28 April 2019. [Online]. Available: https://emeraldworks.com/resources/blog/l-d-research/digital-does-evidence-based-l-d-matter. [Accessed 4 May 2021].

[20] ADB and OCED, "Leveraging Technology and Innovation for Disaster Risk Management and Financing," Manila/Paris: Asian Development Bank and Organization for Economic Co-operation and Development, 2020.

[21] UNDRR, "Sendai Framework for Disaster Risk Reduction 2015-2030," *UN world conference on disaster risk reduction, 2015 March 14–18*, Sendai, Japan , Geneva: United Nations Office for Disaster Risk Reduction, 2015.

[22] FEMA, "A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action," Federal Emergency Management Agency (USA), Washington, DC, 2011.

[23] UNSDG, "Leaving No One Behind: A UNSDG Operational Guide for UN Country Teams - Interim Draft," United Nations Sustainable Development Group, 2019.

[24] UNEP, "Discussion Paper: The Case for a Digital Ecosystem for the Environment: Bringing together data, algorithms, and insights for sustainable development, Bandura: The Fourth United Nations Environment Assembly of the United Nations Environment Programme," 2018.

[25] A. Ghazawneh, "The Role of Platforms and Platform Thinking in Open Innovation Networks," in *43rd Hawaii International Conference on System Sciences*, 2010.

[26] S. Opitz-Stapleton, R. Nadin, J. Kellett, M. Calderone, A. Quevedo, K. Peters and L. Mayhew, "Risk Informed Development from Crisis to Resilience," United Nations Development Programme (UNDP) and Swiss Agency for Development and Cooperation (SDC), Geneva, 2019.

[27] M. L. Herr, *An operational guide to Local Value Chain Development*, Colombo, Sri Lanka: International Labour Organization, 2007.

[28] G. Tassey, "Technology Life Cycles," in *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*. Elias Carayannis, Ed., Springer, 2013, pp. 1797-1807.

[29] S. Baas, S. Ramasamy, J. D. DePryck and F. Battista, "Disaster Risk Management Systems Analysis," Food and Agriculture Organization of the United Nations, Rome, 2008.

[30] T. L. Saaty, *The Analytic Hierarchy Process*, New York: McGraw-Hill, 1980.

[31] UN, "Leaving No One Behind: Equality and Non-Discrimination at the Heart of Sustainable Development," United Nations System, Chief Executives Board for Coordination, New York, 2017.

[32] I. M. Zatsmana, O. Y. Inkovaa and V. A. Nurieva, "The Construction of Classification Schemes: Methods and Technologies of Expert Formation," *Automatic Documentation and Mathematical Linguistics*, vol. 51, no. 1, pp. 27-41, 2017.

[33] J. May, "Disaster Loss Data system – Discovery and Needs Analysis (DLD D&NA)," United Nations Office for Disaster Risk Reduction (UNDRR), 2020.