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Disaster loss indicators for reporting to DesInventar Sendai and enabling rapid monetary valuation in Malaysia

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ABSTRACT

Disaster loss indicators compatible with DesInventar Sendai were delineated to facilitate reporting to the Sendai Framework for Disaster Risk Reduction (SFDRR), and enable monetary valuation of disaster impacts in Malaysia. A standard means of collecting disaggregated information to ensure compliance to SFDRR targets is a challenge for many governments. A systematic review of the literature facilitated the extraction of an array of disaster loss indicators, which were compared to four global disaster databases and three national datasets for compatibility. Suitable indicators, validated through focus group discussions, were used to develop a data collection template with embedded models, which enables rapid calculation of disaster loss after an event. The template will support the advancement of evidence-based policymaking and reporting to the SFDRR.

1. Introduction

The Sendai Framework for Disaster Risk Reduction (SFDRR) has introduced seven targets that can be measured and monitored for demonstrating global progress on disaster risk reduction (DRR) over the next 15 years. Countries are called upon to collect data for all scales of disasters in a systematic and standardized manner. Four of its seven targets are related to disaster impact data, requiring national disaster-loss datasets to be disaggregated for countries to report on their progress towards these targets. A set of 38 indicators and minimum data requirement for each critical indicator has been identified, which has to be based on reliable, event-based data on disaster losses (Mizutori, 2020). The use of SFDRR indicators offers an opportunity to progress towards a global disaster loss accounting system (Zaidi, 2018).

Disaster-loss data is essential for supporting informed decision-making on disaster-risk management. Global disaster databases are a major source of information on losses. Examples include EM-DAT operated by the Centre for Research on the Epidemiology of Disasters (CRED) in Brussels; Sigma operated by Swiss Reinsurance Company (Swiss Re) in Zürich; NetCatSERVICE operated by Munich Reinsurance Company in Munich; and an initiative of the United Nations Office for Disaster Risk Reduction (UNDRR) named DesInventar Sendai (DesInventar, 2009; Swiss, 2016; MunichRE, 2018; EM-DAT, 2020). The Global Unique Disaster Identifier Number (GLIDE), University of Richmond Disaster Database Project, and the British Association for Immediate Care (BASICS) are additional databases of this type (Tschoegl et al., 2006).

The global databases contain a variety of information depending on their respective purpose. DesInventar Sendai supported by the UNDRR is a free open source system for managing disaster information, which is accessible to all national governments (DesInventar, 2009; Mazhin et al., 2021). Desinventar Sendai facilitates the reporting of global progress on the SFDRR and Sustainable Development Goals (SDGs) on poverty eradication (Goal 1), sustainable cities and communities (Goal 11) and climate action (Goal 13). Other global databases provide observed disaster-loss data that becomes quite useful when no mathematical risk models are available (Kron et al., 2012). Previous studies have used the number of deaths from global databases to evaluate flood-loss structure, marginal benefit of flood-loss prevention practices, rate of exposure and morbidity, scale of disaster needs, and predictive performance of

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commonly used vulnerable and risk indicators (Chen et al., 2020; Eriksson et al., 2020; Keim, 2020). Information from global databases are also used to analyse spatial and temporal distribution of disaster impact in terms of public health, fatalities, injury, affected people, and property damage on both global and regional scales (Minervino and Duarte, 2016; Hu et al., 2018; Shen et al., 2019; Talisuna et al., 2020); they also are used to assess disaster impact on aspects of society (Datar et al., 2013; Ward and Shively, 2017; Albrecht, 2018). By performing a systematic comparison between two global databases (EM-DAT and NetCatSERVICE) and a national data source, and employing a historical damage function, climate costs have been projected for China (Bakkensen et al., 2018).

Despite their usefulness, global databases do have some limitations. These include data gaps and availability at more granular scales such as the regional, national and sub-national levels (Guha-Sapir and Below, 2002; Gall et al., 2009; Kron et al., 2012; Wirtz et al., 2014; Osuteye et al., 2017; Edmonds and Noy, 2018; Moriyama et al., 2018); differences in the reported damages (Panwar and Sen, 2019; Mazhin et al., 2021); comparability across disaster databases that compromises the quality of research and policy-making (Fakhruddin et al., 2017); lack of coverage of climate change impact of weather and slow onset events (Gall, 2015); and absence of environmental and ecosystem related impacts (Walz et al., 2021). A cursory review of major global databases revealed that only EM-DAT and DesInventar Sendai have an open access policy, Sigma and NetCatSERVICE have restricted access while other databases were inaccessible (Table 1). With respect to the number of records, DesInventar Sendai records a higher number of disasters as it has lower inclusion criteria, which results in having higher rate of incomplete cases and missing observations. All databases cover human and economic damages but environmental loss is not recorded. Other than Sigma, uncertainty checking of the remaining three databases are specified. The databases also collect data from multiple reliable sources although DesInventar Sendai has been criticized for using newspapers and other press as primary sources of data (Nussbaumer et al., 2018; Panwar and Sen, 2019).

Notwithstanding, the strength of DesInventar is that it allows nations to use its platform and methodology to develop customized national databases, which facilitates the collection of more disaggregated data covering both small- and large-scale disaster events, up to the municipal level (Osuteye et al., 2017; Moriyama et al., 2018). Monetary valuation of losses and damages from all magnitude of disasters will serve as baseline information for disaster cost assessment. This will provide an insight on the cumulative costs of small- and large-scale disaster events and reveal the actual impact disasters on the economy the national or sub-national level. Such information is vital for making informed decisions as governments grapple with the impacts of disasters due to climate extremes, which is projected to increase with global warming of 1.5 °C particularly in the tropics and in cities (IPCC, 2018, 2022). The development of national databases is a very challenging feat as it requires agreements at national and sub-national levels as well as the involvement of relevant stakeholders (De Groeve et al., 2014; Dilley and Grasso, 2016). In addition, the experience of New Zealand and Nepal have highlighted the need for a standard means of collecting disaggregated data and delineating suitable indicators using consistent terminologies and methodologies, to make the datasets more compliant to SFDRR (IRDR, 2014, 2017; Tamrakar and Bajracharya, 2020).

The current body of literature has limited coverage of the ability of global disaster databases in serving global frameworks such as the SFDRR. A knowledge gap also exists on how national disaster datasets and disaster loss indicators support reporting to the SFDRR, particularly with respect to monetary valuation of both small- and large-scale disaster events. This is the motivation for conducting this study; to investigate the coverage of disaster loss indicators in the literature as well as global and national databases, and ascertain their use for reporting to the SFDRR targets, whilst enabling monetary valuation for all magnitude of disasters. Data collection practices and relevant indicators are investigated to develop a template (i.e. a piece of data collection format) for gathering information on disaster loss in Malaysia that is compatible with the DesInventar Sendai platform. Available costing information is used to facilitate rapid monetary valuation of disaster losses, which will serve as baseline information for disaster cost assessment. The DesInventar Sendai is selected as it is designed to accommodate disaster event data collection, including losses and damages, to support UNDRR in monitoring the SFDRR targets. Moreover,

Table 1
An overview of four global databases.

	EM-DAT	Sigma	NetCatSERVICE	DesInventar Sendai
Access policy	Open	Restricted	Restricted	Open
Number of records (as of 2021)	25488	12983	More than 28000	272000[a]
Damage type	Direct human and economic damage including economic sector damage	Direct human and economic damage including economic sector damage	Direct human and economic damage including economic sector damage	Direct human and economic damage including economic sector damage
Data sources	UN Agencies, IFRC, World Bank, Reinsurers, Press, news agencies	Insurance claims, UN agencies, World bank, Press, Academia	Insurance claims, UN agencies, World bank, Press, Academia	National governments, UN agencies, private sources, newspapers,
Uncertainty check	Quarterly cross-check for uncertainty	Uncertainty is not specified	Conducts systematic evaluation of uncertainty	Practices quarterly cross-check for uncertainty
Level of accuracy	More accurate as validation process are applied	More accurate as they use insurance data	More accurate as they use insurance data	Higher rate of incomplete cases and missing observations
Languages	English	Multiple languages	Multiple languages	Multiple languages
Spatial Resolution	Country level	Country level	Country level	Sub-national level (up to municipal level)
Threshold for disaster entry	High	Very Higher	Medium	Low, include disaster of all scales
Georeferenced data	Not georeferenced	Not georeferenced	Provides georeferencing	Provides geo-referenced inventory
Disaggregation of data	Human losses are disaggregated but economic losses are not disaggregated	Human losses are disaggregated but economic losses are not disaggregated	Human losses are disaggregated but economic losses are not disaggregated	Data is more disaggregated compared to other databases
Customization	Not possible	Not possible	Not possible	Allows customized data collection in addition to maintaining mandatory data fields

[a] The total event recorded by DesInventar Sendai is the latest reported in the Global Assessment Report 2013. Source: (IRDR, 2014; Gall, 2015; Osuteye et al., 2017; Bakkensen et al., 2018; Nussbaumer et al., 2018; Panwar and Sen, 2019).

Malaysia has started to implement SFDRR as a part of its efforts to reduce disaster risks and impacts (Azimi et al., 2019), and the country does not have a government operated disaster database yet (UNISDR, 2017). The findings of this study could serve as a basis for developing a national disaster database that is SFDRR compliant and facilitates monetary valuation for all magnitude of disasters, which could be adapted by other countries.

2. Material and methods

2.1. Systematic review

A systematic review was conducted using multiple data sources and keywords that formed the basis for an orderly selection of articles, from which information on disaster loss indicators could be extracted for further analysis (Fig. 1). The meta-analysis statement (PRISMA) 2009 checklist was followed as a guideline (Moher et al., 2009).

Data sources for the review considered both peer-reviewed and grey literature. Searches were conducted in Web of Science (WoS), Scopus, ScienceDirect, SpringerLink and Google search engine (for grey articles). Acceptable articles for the review had to have been published between 2000 and 2020; the preferred language was English. The last two decades was considered a sufficient period to capture the body of knowledge on DRR that has been continuously growing. The search strategy focused on using keywords and synonyms that were linked using 'OR' and 'AND' to extend the searches. Keywords used included disaster-loss data, damage data, disaster-damage costing, damage and loss databases and disaster database, among others (see Appendix A, Table SM 1 for the complete list).

The identification phase covered the deployment of the search strategy in various databases (Fig. 1). The records reviewed comprised both the peer reviewed and grey literature. They were delineated using several inclusion and exclusion criteria. Papers that were included used global disaster-loss databases for disaster-impact assessment; discussed the suitability, usability, data recording, database structure, and/or data quality of disaster-loss databases; covered/proposed/compared disaster-loss databases on a national or global scale; evaluated/assessed/calculated disaster-loss from social, economic, and environmental perspectives; explained the methodological procedures of the relevant databases; were written in English and published in a journal indexed in WoS or Scopus. Papers that addressed data collection, Sendai indicators, and policy were also reviewed. Grey literature included open-source material on global disaster databases and their methodology that were published by authorized parties (i.e., CRED, Munich Re, UNDRR). It also comprised reports published by various local departments in Malaysia such as the Drainage and Irrigation Department (DID), National Disaster Command Centre (NDCC) and Public Work Department (PWD). Papers not indexed by WoS or Scopus and grey literature not recognized by authorities were excluded. Material written in a language other than English, or were not published between 2000 and 2020, or did not cover disaster loss or impact assessment issues were also excluded. The title and abstract of each material was read and discarded if they were related to the exclusion criteria. The identification phase yielded 243 documents that were downloaded for further handling.

Further processing involved screening the records to ensure their eligibility to be included for critical assessment (Fig. 1). The screening phase involved a cursory review of titles, year of publication and authorship. Of the 243 downloaded articles, 57 articles were found to be duplicates based on the title, year of publication and author list. Also excluded were eight articles published before 2000, which was spuriously included. The eligibility of the remaining 178 articles was determined by carefully reading each abstract of the full articles. In this round, 109 articles were excluded, as they were not related to the fields of disaster impact analysis. This left a total of 69 documents to be critically assessed.

A critical assessment of the 69 documents revealed the coverage of a wide range of relevant issues, including policy related to the Sendai Framework Monitor, data collection approaches and sources, and

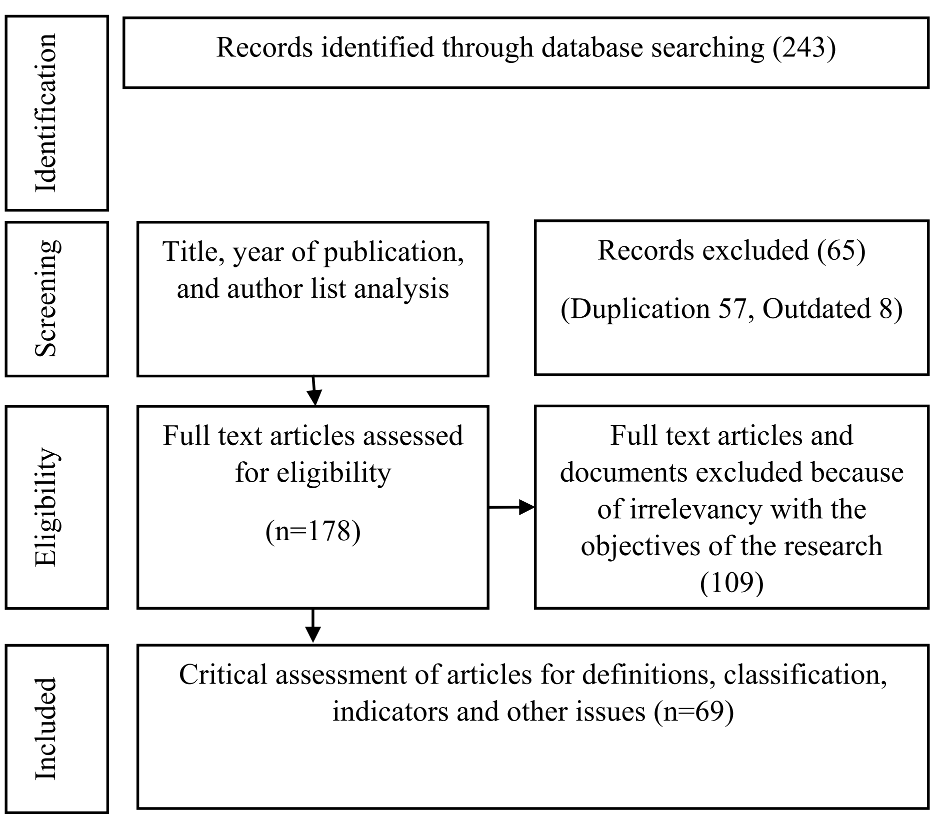

Fig. 1. The PRISMA flow diagram for the systematic review that delineated suitable articles for further investigation.

suitability of indicators in global disaster databases. Nine articles were theoretical, two were damage-assessment reports from two national departments (DID and PWD), and one was a data-collection method from the NDCC. A total of 57 peer reviewed articles of the 69 documents assessed were found to be useful for further analysis.

Data analysis commenced with the extraction of disaster loss indicators in the literature that are commonly used to perform damage assessment (Appendix A, Table SM 2). The indicators were classified into sub-groups based on their common types. This enabled a comparison with existing databases, which only use a standard number of indicators, to identify gaps and areas to focus on for further improvement. Four global databases (i.e. EMDAT, SIGMA, NetCatServices and DesInventar Sendai) and three existing datasets from Malaysian agencies i.e. the Department of Irrigation and Drainage (DID), Public Works Department (PWD) and National Disaster Command Centre (NDCC), were selected for this purpose. Various alternatives that could be used to evaluate economic costs using existing market-based information and current practices in managing disaster data were also examined. The emphasis was to identify adjustments required for disaggregated data and its compilation, to develop a database that is SFDRR compliant and facilitates monetary valuation.

2.2. Models for monetary valuation

An Excel sheet data collection template was used to embed simple models for monetary valuation. The limited number of disaster-damage assessments conducted by the DID, PWD and NDCC revealed the costing information that is currently available in the country (DID, 2003, 2012; PWD, 2009). Several models were embedded into the data collection template to enable monetary valuation using a market-based approach (Table 2). Damage unit values (DUV) were used for various types of physical assets, replacement cost, restoration cost, and appropriate market price, drawing on current practices. The template with its embedded models enable rapid calculation of the monetary value of disaster loss after an event, as disaster-loss information is collected in the field and entered into the Excel sheet for the respective indicators.

The direct and indirect damages of flash floods utilised the widely used market price and restoration cost approach (Balbi et al., 2015; Middelmann-Fernandes, 2010; Rayhan and Grote, 2010). The market price approach determines the value of a property based on the selling price of the property or similar property (Freeman et al., 2014). Restoration cost approach values goods and services based on cost incurred for bringing it back to its original state (Brans, 2005). In this approach different damage unit values (DUVs) for different types of properties as well as repair costs have been used in previous literature (Thieken et al., 2007).

A hypothetical damage/loss information was tested for flood damage in an urban area (Table 3). The cost information was extracted from damage data sets of the DID and PWD loss assessment reports. The data was then inserted in the template for testing its monetary valuation.

Table 2
The models used in the Excel sheet template.

No	Name of the Costing	Equation/Model
1	Death	Number of deaths X Value of statistical life (VSL)
2	Missing	Number of missing X VSL
3	Injured	(Minor injured people X Cost of Minor injury) + (Major injured people X Cost of Major injury)
4	Total affected	(Total affected people X employment rate in the affected area X Per day Productivity per person) *Excluding death and injured people
5	Relocation cost	(Number of relocated family X Relocation cost per family)
6	Evacuation	(Number of evacuated family X Evacuation cost per family)
7	Agriculture	$(CrD \times CrY \times CrP)$ CrD = Crop land damage (hectare) CrY = Crop yield per hectare (Metric ton) CrP = Crop price per Metric ton (RM)
8	Physical damage (House/ buildings)	$\sum(Ht_i \times DUV_i) + (Ht_i \times HUP_i)$ Ht_i = House/Building type DUV_i = Damage unit value for each type HUP_i = House Unit price for each type
9	Other physical assets	$\sum(Pt_i \times PDV_i) + (Pt_i \times PV_i)$ Pt_i = Property type DUV_i = Property damage value per 10000 population or average damage value PV_i = Property value (replacement cost)
10	Livestock	$\sum(LSt_i \times LSp_i)$ LS_t = Livestock type LSp_i = Price of the livestock type
11	Irrigation, water supply, fisheries, and other sector	$\sum(ND_i \times ARC_i) + (NL_i \times AV_i)$ ND_i = Number of damaged items ARC_i = Average repair cost NL_i = Number of lost items AV_i = Average value/replacement cost of the item

2.3. Focus group discussion

Focus group discussions were held to share the findings of the study with key stakeholders that are familiar with various types of information relevant to disaster loss assessment. The purpose was to validate the indicators and models in the template. The stakeholders comprised experts and representatives from agencies that are involved in collecting post-disaster event data, including representatives from DID, PWD and NDCC. The representatives are the officials in charge of disaster data collection in their respective agencies (Appendix A, Table SM 3).

Two focus group discussions were held that were attended by the same representatives. In the first discussion, disaster-loss indicators extracted from articles obtained after the systematic review were compared with indicators used in Malaysia. Each item including the models employed was thoroughly scrutinized. The indicators and their definition were presented to the participants to obtain their agreement. This is to ensure that the relevant data could be collected by the respective agencies in the future. Modification and changes suggested

Table 3
Hypothetical loss information of an urban flood event that was used to test the template.

Indicators	Hypothetical damage/loss	Productivity	Cost (RM)	Source of cost information
Death	10 people	NA	Value of Statistical Life = 1514972	PWD (2009)
Missing	10 people	NA		
Minor injury	5 people	NA	Cost of minor injury = 130000	
Major Injury	5 people		Cost of minor injury = 6000	
Relocation	100 family	NA	Relocation = 5000	
Urban house	10	NA	Damage unit value DUV = DUV 22000	(DID, 2012, 2003; DOA, 2019, 2018, 2016, 2015)
Rural House	10	NA	DUV 15500	
Fruit	100 ha	11.28 Metric ton per hectare	Loss per ton 5729	
Vegetable	100 ha	18.1 Metric ton per hectare	Loss per ton 2413	
Cash crops	100 ha	12.8 Metric ton per hectare	Loss per ton 1813	

were implemented, and the amendments were confirmed in the second focus group session. The second focus group discussion also provided an opportunity to conduct a critical review of the DesInventar Sendai platform, and its ability to serve as a common database at the national and sub-national levels. The concerns and inputs in terms of improvements to the platform were critical to ensure its suitability for Malaysia.

3. Results and discussion

3.1. Overview of disaster loss indicators

The critical review of selected articles culled a wide range of disaster loss indicators for a variety of disasters from both developed and developing countries, as categorised by the United Nations (UNDESA, 2020) (Appendix A, Table SM 1). Disaster loss valuation is most common for floods, followed by landslide/debris flow, drought, and multiple disasters (Appendix A, Figure SM 1a). A similar number of disaster loss valuation has been conducted for floods in both developed and developing countries (Appendix A, Figure SM 1b). In terms of drought and landslide and other disasters, a slight difference can be observed but no generalized conclusion can be drawn. An important observation from the review is that the indicators used for disaster loss assessments are similar for multiple types of disaster events from both developed and developing countries.

The disaster loss indicators were broadly grouped into social, economic and environmental categories and linked to their respective sources for traceability (Appendix A, Table SM 2). The most used indicators are those related to deaths, people killed, casualties, affected people and injuries. Indicators such as homelessness, evacuation, relocation, and displacement are reported less frequently, although these indicators provide a great deal of insight in an assessment of a disaster scenario. Several limitations were observed with respect to the disaster-loss indicators. Many indicators were constructed (constricting a variable), operationalized (using proxies), and conceptualized based on the objectives and scope of a particular study. They include a wide range of social, economic, and environmental elements that can be conceptualized in countless ways by the combination of various sub-elements. Some indicators (i.e., transportation, agriculture, firm areas, electric disruptions, livestock and lifelines) can be used for both social and economic relevance concurrently. It appears that disaster loss assessment can be performed using a multitude of indicators in a variety of combination depending on the purpose.

3.2. Comparison of global databases and national datasets

A comparison of disaster loss indicators extracted from the literature to those reported in the four global databases provided some interesting insights (Table 4). With respect to social indicators, DesInventar only missed out on indicators related to the “homeless” and “displaced”. It appears that EMDAT, SIGMA and NetCatServices are missing some 4–6 disaster loss indicators in the social category. In reporting economic indicators, even though EMDAT and DesInventar include the highest number of indicators (5 each), the number of indicators excluded are higher (7 each). Sigma and NetCatServices have left out the highest number of economic indicators. These include economic indicators for reporting “direct loss of production”, “service disruption”, “restoration cost” and “road destruction”. Environmental indicators are missing in all global databases.

In Malaysia DID is responsible for flood management. Thus, the agency regularly collects, stores and manage flood related data in rural areas. The DID also assesses flood impact and prepare annual reports on flood conditions. Disaster loss information in urban areas are generally not collected or reported as they tend to be small scale flash-floods and water ponding incidents. The PWD generally assess landslide related damage that occur in government managed roads and properties. The reports and relevant data are published in public domain. The NDCC is the national disaster control centre, which maintains a framework for disaster data collection, primarily focusing on major national events. The information in the datasets used by the three departments for recording and reporting disaster loss were separated into social, economic and environmental categories to be compared to the global databases (Table 4).

The Malaysian agencies differ in their consideration and definition of disaster-loss indicators. For example, while PWD includes ‘death,’ ‘injured,’ and ‘relocation’ in their assessment, DID does not include ‘injured’, ‘missing,’ and ‘relocation’. ‘Homeless’ and ‘displaced’ are completely absent in the Malaysian datasets. In addition, disaster loss data in Malaysia does not include important loss indicators such as ‘total affected people,’ ‘homeless,’ ‘evacuation,’ ‘relocation,’ and ‘mobile objects’ (movable properties like vehicles). There is a lack of unanimous agreement about constructing indicators that address physical losses. For example, NDCC utilizes an indicator called ‘infrastructural damage’ and categorizes all physical items under this indicator. The DID and PWD place roads, railways, water treatment, and sewerage under an infrastructural damage indicator category.

Comparisons of monetary losses reported by Malaysian agencies to that of the global databases is challenging because of the aggregated nature of global disaster loss indicators. For example, the EM-DAT includes damages related to forests (ha) and farmland/crops (ha) under the category of infrastructural damage (EM-DAT, 2014). Additionally, physical and sectoral damages are combined and recorded under aggregated disaster loss in the global disaster databases. However, the disaster loss indicators reported by Malaysian agencies can be reclassified into social, economic and environmental categories, and disaggregated to be in line with the requirements of DesInventar. The final classification was based on the need to comprehensively meet the reporting requirements of the SFDRR as well as availability and capacity to collect the information in the country, as verified during focus group discussions.

3.3. Template for national reporting and monetary valuation

Disaster loss indicators and data on costs are available in Malaysia albeit incomplete (Fig. 2). Improvements are required to ensure consistency in definition across agencies, use of features that are common to all hazards, and collection of missing information. A template was developed for this purpose (Fig. 3). In addition to recording the number of deaths (number killed), number missing, evacuation and relocation data, it was proposed that data be collected on the number injured, and directly and indirectly affected people, for the section of impacts on humans. These indicators have additional breakdown items that enable and facilitate the inclusion of disaggregated data. The template also includes several types of houses, public building, and other infrastructural disaster-loss elements in a disaggregated fashion as well as data related to movable properties (i.e., vehicles) with physical damage. Agricultural disaster loss is calculated based on affected hectare areas; livestock is counted in units, and roads and railways are counted in km affected per road class. The indicators encompass items that are relevant and suited to the Malaysian context.

By embedding simple costing equation of disaster loss using information that is currently being collected by agencies, the template enables rapid monetary valuation (Fig. 3). This calls for consistency in use of the indicators. For example, the indicator ‘Killed’ (those who died during or directly after the disaster due to the disaster) and ‘Missing’ (those whose whereabouts are unknown since the disaster occurred, i.e., presumed dead and for whom no physical evidence of death has been found) are mutually exclusive categories and should not be double counted. People who have suffered from physical or psychological harm, trauma, or illness due to the disaster should be counted under the ‘Injured’ category. This can include a new injury or a previous injury that has been exacerbated due to the disaster. ‘Livelihood’ includes adversely affected capacities, productive assets, and activities that are

Table 4
Comparison of disaster loss indicators in global databases and Malaysian datasets (√ = indicators are available; X = indicators are not available).

Social							
Indicators	Global Databases				Malaysian Datasets		
	EMDAT	SIGMA	NetCatSer	DesInventar	DID	PWD	NDCC
Deaths	✓	✓	X	✓	✓	✓	✓
Injured	✓	✓	✓	✓	X	✓	✓
Missing	X	✓	✓	✓	X	X	✓
Homeless	✓	✓	X	X	X	X	X
Total affected people	✓	✓	✓	✓	✓	✓	X
Evacuation	X	X	✓	✓	X	X	X
Relocation	X	X	✓	✓	X	✓	X
Displaced	X	X	✓	X	X	X	X
Education	X	X	X	✓	X	X	X
Healthcare	X	X	X	✓	X	X	X

Economic							
Indicators	Global Databases				Malaysian Datasets		
	EMDAT	SIGMA	NetCatSer	DesInventar	DID	PWD	NDCC
Crop loss	✓	X	X	✓	✓	✓	✓
Livestock	X	X	X	✓	✓	X	✓
Property loss	✓	X	X	X	✓	✓	X
Infrastructure damage	✓	X	✓	✓	✓	✓	✓
Indirect economic loss	X	X	X	X	✓	✓	X
Economic sector damage	✓	X	✓	✓	✓	X	X
Direct loss of production	X	X	X	X	✓	✓	X
Service disruption	X	X	X	X	✓	✓	X
Restoration cost	X	X	X	X	✓	✓	X
Aggregate Economic loss	✓	X	✓	✓	✓	✓	✓
Road destruction	X	X	X	X	✓	✓	X
Fisheries	X	X	X	X	X	X	✓
Mobile object	X	X	X	X	X	✓	X

Environmental							
Indicators	Global Databases				Malaysian Datasets		
	EMDAT	SIGMA	NetCatSer	DesInventar	DID	PWD	NDCC
Agricultural areas	X	X	X	X	X	X	X
Forest areas	X	X	X	X	X	X	X
Damage to biodiversity	X	X	X	X	X	X	X
Others	X	X	X	X	X	X	X

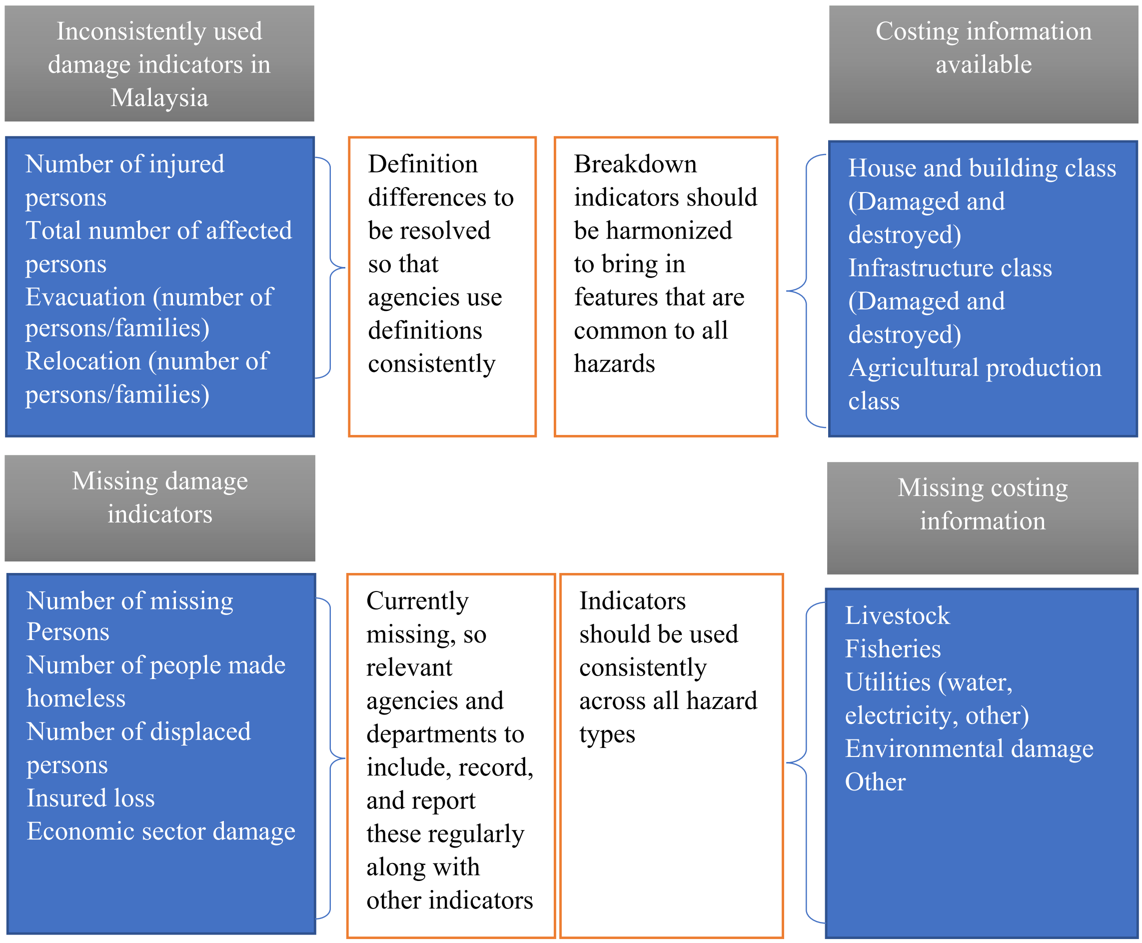

Fig. 2. Availability of disaster loss indicators and costing information in existing datasets.

essential for maintaining a means of living with dignity (UNDRR, 2017). The monetary valuation for deaths and missing persons is calculated using the Value of Statistical Life in Malaysia. The valuation of injury is calculated using the estimate of injury value per person provided in the National Slope Master Plan Malaysia 2009–2023 (PWD, 2009).

'Evacuation' refers to temporary relocation from homes, workplaces, hospitals, schools, etc; 'relocation' refers to permanent relocation. Relevant costing information for the monetary valuation of relocations is currently unavailable. However, the National Slope Master Plan Malaysia 2009–2023 does include a monetary valuation for relocation, which is actually defined as the temporary mobilization of affected people during a disaster situation (PWD, 2009). According to the DesInventar Sendai definition, the temporary mobilization of people actually represents evacuation (UNDRR, 2017). Therefore, in this template, the monetary valuation of evacuation is calculated using the approach of the National Slope Master Plan Malaysia 2009–2023, where the estimated cost of temporary mobilization per family is used.

People who have gone through injury, evacuation, and relocation, and who have suffered direct damage to their homes and livelihoods (i.e., their economic, physical, social, cultural, and environmental assets) are considered directly affected. As the monetary valuation of most of above-mentioned impact indicators is performed separately throughout the template, the template does not conduct monetary valuation for directly affected people, but rather records the number of people affected only to avoid double counting. However, it conducts a monetary valuation for indirectly affected people, i.e., those who suffered disruption to basic services, critical infrastructures, and who have suffered health-related consequences (UNDRR, 2017). In doing so, this template uses per day productivity loss per person for urban and rural areas for Malaysia (PWD, 2009).

Agricultural loss is calculated as the per hectare (ha) area affected by the disaster using prices of agricultural products per Mt/ha collected from Vegetables and Cash Crops Statistics Malaysia 2018, Industrial Crops Statistics 2018, and the Paddy Production Survey Report 2015 provided by the Department of Agriculture Malaysia (DOA, 2015, 2016, 2018, 2019). The costing information for a disaggregated valuation of livestock is currently unavailable, however a proxy can be used to calculate livestock loss per rural family using the relevant estimate in the DID flood report (DID, 2012). Damage to roads and railways are related costs and are calculated using per kilometre road and railroad maintenance and reconstruction costs provided by the PWD (PWD, 2017). Damage to homes, buildings, and infrastructure include disaggregated items in greater detail. For different types of houses, relevant damage unit values are used to calculate monetary loss, which are collected from the DID flood manual (DID, 2003). However, there are various items for which costing information in not available; these are identified by white cells in the template (Fig. 3). Some indicators have either a damaged value or a destroyed value and some have no information for either of the two-damage levels. In such cases, a column headed "estimated monetary value" is provided in the template to facilitate the calculation using an alternative way by putting an estimated value of the damaged or destroyed items. Moreover, for several sectors such as irrigation, power and energy, water supply, communication, fisheries, forestry and wildlife, and other sectors, disaster related damage and destroyed values are yet to be decided.

Hypothetical loss and damage data that is available (Table 3) were inserted in the respective cells to test the template. The template was able to calculate cost of damage as soon as the loss and damage

Disaster Information Collection template

General information

Serial No.		GLIDE No.		Source	
Date (YMD)		District		Block	
Event		Place	Area Type: Urban	Magnitude	
Cause		Discrete cause		Latitude	
Duration		Time of event		Longitude	

Impact on humans

					Major	Minor		
Killed (Auto Sum/Total)	10	Missing (Auto Sum/Total)	10	Injured (Auto Sum/Total)	5	5	Directly affected people (Auto sum/Total)	0
Total killed (When breakdown is unknown)	10	Total missing (When breakdown is unknown)	10	Total injured (When breakdown is unknown)	5	5	Directly affected people (When breakdown is unknown)	0
Men		Men		Men			Number of houses damaged (by people)	
Women		Women		Women				
Children		Children		Children			Number of houses destroyed (by people)	
Elders		Elders		Elders				
Disabled persons		Disabled persons		Disabled persons			Livelihoods disrupted	
Loss (RM)	15149720	Loss (RM)	15149720	Loss (RM)	680000			
Indirectly affected (Auto sum/Total)	0	Total relocation (Auto Sum/Total)	0	Total evacuation (Auto Sum/Total)	0			
Indirectly affected (When breakdown is unknown)		relocation (When breakdown is unknown)	0	Evacuation (When breakdown is unknown)				
Number of families	0	Families	0	Number of families	0			
Men		Men		Men				
Women		Women		Women				
Children		Children		Children				
Elders		Elders		Elders				
Loss (RM)	0	Loss (RM)	0	Loss (RM)	0			

Agriculture (hectares)	
Fruit	100
Vegetables	100
Cash crops	100
Industrial crops	
Rice	
Palm Oil	
Loss (RM)	13150482

Physical damage

	Damaged	Destroyed	Estimated monetary value
Bungalow houses			
Upmarket condos			
Terrace houses (urban)	10		
Terrace houses (suburban)			
Kampung houses			
Urban household articles			
Rural household articles			
Religious buildings			
Shops			
Water sources			
Loss (RM)	220000		

	Damaged	Destroyed	Estimated monetary value
Bridges			
Culverts			
Wells			
Cars/vans			
lorry/buses			
Motorcycles			
Health centers			
Hospitals			
Health posts			
Schools			
Public buildings			
Loss (RM)	0		

Livestock (number of units)	
Poultries / Chickens	
Cattles/Buffalos	
Hatcheries	
Goats	
Pools	
Cages	
OR Number of rural houses affected	
Loss (RM)	0

Railways & roads	Damaged(KM)	Destroyed (KM)
Railways		
Expressways		
Main highways		
Collector roads		
Local roads		
Primary roads		
Secondary roads		
Loss (RM)	0	

Irrigation Sector	Damaged	Destroyed	Estimated monetary value
Flood protection system			
Minor irrigation facilities			
Medium and major irrigation facilities			
Irrigation canals affected			
Total (RM)			
Water supply			
Drinking water sources affected			
Transmission pipe lines			
Distribution pipe network			
Pumphouses			
Groundwater tanks			
Elevated water tanks			
Treatment plants			
Total (RM)			
Fisheries			
Boats			
Hatchery			
Others			
Total (RM)			
Forestry and wildlife			
Wildlife sanctuaries affected			
Forest affected			
Total (RM)			

Power and Energy	Damaged	Destroyed	Estimated monetary value
No. of power stations			
No. of transformer stations			
Damage to H/T power lines			
Damage to distribution lines			
No. of pylons damaged			
Total (RM)			
Communication			
Switching			
Transmission			
No. of towers			
Total (RM)			
Other related sectors			
Heritage site			
Sewerage			
Tourism			
Minery			
Total (RM)			

Total monetary loss (RM)	44349922

Comments	
Collector	
Date	

Fig. 3. The template for data collection that was modified after UNDP, 2006. Indicators in the white cell have no costing information at the moment.

information was inserted. The template was validated by all the major government agencies involved in data collection during the focus group discussion, which was held under the aegis of the National Disaster Management Agency (NADMA) Malaysia. Protocols for standardized collection of disaster loss information is required for the template to be adopted by all agencies at the national and sub-national levels. Once the current data collection system is modified, NADMA could easily use it for reporting to the SFDRR and also obtain rapid disaster loss data for both large- and small-scale events.

3.4. Towards a SFDRR compliant national database

Many of the indicators in the literature are not easy to classify for a data-collection template to develop a national database that is SFDRR compliant (Appendix A, Table SM 2). For example, transportation disruption can be related to aspects of social impact (Damm and Klose, 2015; Hilker et al., 2009; Rilo et al., 2017); whereas costs due to transportation disruption can be related to economic aspects and impact (Hilker et al., 2009; Coates et al., 2014; Carrera et al., 2015; Acosta et al., 2016; Bahinipati et al., 2017; Rilo et al., 2017; Daniell et al., 2018). Similarly, agriculture and forest area loss can be considered as economic when crop areas (Haile et al., 2013; van der Geest, 2018; van der Geest and Warner, 2014), crop production (Hilker et al., 2009; Damm and Klose 2015; Bhattachan et al., 2018; Koç and Thieken 2018) and industrial trees and plantations related cost are available (Luu et al., 2017; Wan and Billa, 2018). The same indicators can be considered as environmental loss by assessing affected area of agriculture, deforestation, plantation and land desertification (Bahinipati, 2020; Kreibich et al., 2010; Luu et al., 2017; Wan and Billa, 2018).

In addition, structural damages in education facilities (Bahinipati, 2020; Velásquez et al., 2014) and the healthcare sector (Minervino and Duarte, 2016; Velásquez et al., 2014) may represent the economic perspective, while disruption to services and routine work in these sectors may represent the social perspective (Velásquez et al., 2014; Minervino and Duarte, 2016; Luu et al., 2017; Daniell et al., 2018; Koç and Thieken, 2018; Bahinipati, 2020). Clearly, the type of information represented by each indicator is purpose oriented. Furthermore, collecting data related to socioeconomic profile, psycho-social stress, and mental stress, might not be possible, particularly for small-scale disaster events, as it would be cost-, time-, and labour-intensive. Such indicators require further investigation to be fixed in a template for a structured national database.

The proposed template calls for very minor modification and change in existing datasets managed by agencies in the country for increasing compatibility to SFDRR. These areas include consistency in the definitions used for both terminologies and damage indicators, and the need to adjust and modify disaggregated items (house and building classes, infrastructural damage, and agricultural production) in terms of costing. Missing indicators and costing information should also be added in preparation for estimating, assessing, calculating and reporting damage (Fig. 3). Moving on, costing information that is appropriate to urban and rural areas can be added for proper valuation of loss. Enhancements could also be made to include an assessment of indirect impact, which involves more dynamic factors. Proxy indicators, rates and values need further investigation to enhance the template.

Both large- and small-scale disaster events can be recorded for rapid damage valuation in the proposed template. The template is intended to record final information after the disaster event has ended. If a disaster event last over several days or weeks, daily stock taking could be done for each indicator. As the template is embedded with active damage calculating formulas, the daily monetary cost could be reported until the end of the event. This would provide vital information for governments to plan the allocation of resources for the recovery phase after a disaster event.

The template that has been proposed is new to the country, where disaster loss data is collected and estimated manually by different agencies using a variety of procedures. Stakeholders must now come together to develop a common data collection protocol for damage assessment. This is vital for improving current processes for reporting national data on disaster loss. Strong leadership is required at the national level to mobilise resources and build capacity to make this happen. As a start, a pilot can be coordinated by NADMA Malaysia, to use the proposed template and determine its effectiveness for improved policymaking and reporting to the SFDRR. Such a pilot would also entail capacity building and deployment of resources for multiple disaster data collection agencies at the national and sub-national levels. Institutionalised use of the template would facilitate streamlined and routine reporting of the country's progress in achieving the targets of SFDRR. This is most relevant to Target A on mortality, Target B on affected people, Target C on direct disaster economic loss with respect to GDP, and Target D on disaster damage to critical infrastructure and disruption of basic services, particularly for health and educational facilities.

The section on 'Impact on humans' in the template contains variables that are directly relevant to Targets A and B. The variables are the number of people killed or missing (Target A) and the number of people who are directly affected i.e. number of people injured, relocated or evacuated, and victims with damaged and destroyed houses (Target B). The template also contains variables for costing information for every relevant damage indicator to estimate economic loss as required for Target C, using the disaggregated numbers that are directly useful for reporting on Target D. Examples of the variables include data on agricultural loss (i.e. crop loss, livestock loss, forestry loss and fisheries loss); damaged and destroyed productive assets (i.e. industrial crops such as oil palm); economic loss in the housing sector (i.e. types and value of houses damaged); damaged or destroyed critical infrastructure as well as associated disruption (i.e. health, education, water supply, power, communication and infrastructure units such as roads, highways, bridges and culverts); and damaged cultural heritage sites. The individual variables in the proposed template could also be easily modified for other countries to suit their national circumstances and existing data collection systems for reporting progress on the SFDRR targets.

4. Conclusion

Indicators used for disaster loss assessments are similar for multiple types of disaster events from both developed and developing countries; a single disaster database on losses is feasible depending on its purpose. Global databases such as EMDAT, SIGMA and NetCatServices are an important resource but are unable to capture a wide variety of data on disaster losses due to their concise structure. These databases are missing some 4–6 disaster loss indicators in the social category, over seven economic indicators, and none have environmental loss indicators. In comparison, Desinventar Sendai, which supports reporting for the SFDRR and SDGs, has the best collection of disaster loss indicators.

The current data collection and reporting practice in Malaysia uses many SFDRR compliant data inconsistently and misses out some indicators completely. The disaster loss indicators can be reclassified into social, economic and environmental categories, and disaggregated to be in line with the requirements of Desinventar Sendai. A template has been proposed to standardize the collection of disaster loss data in the country for Desinventar Sendai, which has been validated by major data collection agencies in the country. The template is also able to facilitate rapid monetary valuation of disaster loss for both large- and small-scale events. A pilot is recommended to apply the proposed template and determine its effectiveness in providing baseline information for evidence-based policymaking and reporting to the SFDRR.

Author contributions

Tariqur Rahman Bhuiyan: Writing- Original draft preparation, Methodology, Data Curation **Ah Choy Er:** Conceptualization, Supervision, Methodology **Choun-Sian Lim:** Data Curation, Writing, Review. **Nurfashareena Muhamad:** Supervision, Review **Arpah Abu Bakar:** Writing - Review & Editing, Supervision. **Joy Jacqueline Pereira:** Writing-Review & Editing, Conceptualization, Supervision & Funding Acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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