ASM Sc. J., 12, 2019
https://doi.org/10.32802/asmscj.2019.319

A Data Integration Model for Multi-Agency Assets in Disaster Logistic Management

Noor Haryantie Noor Sidin, Khalina Abdan and Hazreen Haizi Harith*

Department of Biological and Agricultural Engineering, Universiti Putra Malaysia, Serdang, 43400 Seri Kembangan, Selangor, Malaysia

The complexity of disasters occurred in recent years demands for a sound and effective disaster management. Since logistics accounts for 80% of the overall cost for disaster management, it requires specific management of its own embedded within the existing disaster management mechanism. This study focuses on the existing disaster logistics management mechanism in Malaysia and how the assets component can be integrated to optimise the utilisation of available resources. This study revealed that there is no linkage between government's disaster responding agencies on their disaster logistics management systems; hence there is no quantifiable way to ascertain how much resources are allocated for the purpose. The objectives of this study are two-fold; understanding the current disaster logistics mechanism and proposing a data integration model for existing multi-agency disaster logistics management system. This study employed a systematic approach for empirical studies until data analysis. The methodology used to develop the proposed data integration model is based on the System Development Life Cycle principles, whereby a common data storage approach for data integration was adopted; followed by the Extract, Transform, Load architectural pattern for the model. Subsequently, a conceptual data integration model and logical data integration model were developed. The logical data model comprises of four modules; logical extract, logical data quality, logical transform and logical load module. Further expansion of this study could incorporate location intelligence into the system, and also include resources available from other entities, such as non-governmental agencies and private companies. It is hoped that this study will pave the way towards a comprehensive disaster logistics management in the country.

Keywords: disaster logistic management; data integration model; multi-agency asset; System Development Life Cycle

I. DISASTER AND LOGISTICS MANAGEMENT

Annual economic loss due to disaster has significantly increased over the years with a total of USD1.5 trillion in damage worldwide between 2003 until 2013, according to a study by the United Nations Food and Agriculture Organization. Although the losses are understandably increases due to the magnitude and severity of disasters, it can also be considerably reduced through effective disaster management practices. Disaster management practices generally refer to activities associated with handling or coping with disaster; prior, during and after its occurrence. This is apparent in the dominant concept of disaster management cycle, which typically consists of four phases; prevention and mitigation, preparedness, response and recovery. This concept has been widely accepted due to its thorough approach in managing disasters as well its ability to correlate the relationship between disaster and development (Guzman, 2001).

In disaster management, logistics is the largest and most complex element of relief operations (UNDP, 1993). Logistics accounts for 80 per cent of the overall relief operation and usually consumes the largest share in

*Corresponding author's e-mail: hazreen@upm.edu.my

funding in overall disaster response operation (Wassenhove, 2006; Jahre, 2016). Therefore, efficient logistics management can be considered as one of the critical success factors in disaster management. A well-organised disaster logistics management can deter the negative impact of disaster and subsequently reduce the loss due to disaster.

Disaster logistics management consists of delivering appropriate supplies in good condition, in the quantities required, at the places and time they are needed (UNDP, 1993). At the same time, it also encompasses the relocation of disaster victims, and the movement of the relief supplies and workforce. Therefore, disaster logistics management is inherently present in all the four phases of a typical disaster management cycle but is most prevalent in the response phase. Each element of disaster logistics management is expected to integrate seamlessly to serve as the backbone of the entire disaster operation.

In recent years, Malaysia has been hit by back-to-back incidents; ranging from natural disasters to human-made disasters. As a result, disaster management has become more complex due to the intertwining nature of both natural and human-made disasters, the frequent occurrence and the increasing severity and complicated response effort which affects the community as well as the government.

During the 2014 flood, victims were trapped at Sekolah Kebangsaan Manek Urai Lama for almost a week with minimal logistics supplies. The situation worsened when the existing supplies were rapidly depleting, but additional resources could not be delivered as the area was completely inundated. Additionally, almost 8,000 Orang Asli from 67 villages were trapped in their areas and had to endure two weeks of inadequate food supplies. Though seemingly a supply shortage problem, these two instances are manifestations of poor logistics management. Supplies were abundant in surrounding the inundated area and kept arriving from various locations all over the country, but the distribution of the said supplies was hampered by ineffective logistics planning and preparation.

It is hypothesised that the crux of the above problem lies within our local disaster logistics management, which is currently being handled by multiple government organisations with different objectives and stakeholders. While each agency has a working logistics management system, there is no one integrated system. General information such as the number of assets allocated to a state and district can only be acquired through conventional means of communication such as in a meeting, phone calls, emails or fax, but the data could not be obtained in real-time, and may be inaccurate. Furthermore, this traditional method of information sharing consumes valuable time and subsequently hampers the overall response to a disaster. This will subsequently delay the requirement of additional resources, as there is no system with integrated data on the availability and current location of allocated resources and assets.

Therefore, this study aims to develop an integration model for multi-agency disaster logistics management, focusing on the assets. To chronological objectives were established as follows:

1. To review the existing government's mechanism on disaster logistics management.
2. To develop a data integration model for assets from responder agencies for disaster logistics management.

Since disaster logistics management is present in all three phases: pre-disaster, during disaster and post-disaster, the scope of this study includes the activities within all three phases but limited to the asset component in disaster logistics management. The scope of this study is as follows:

1. Pre-disaster activities include strategic planning in terms of pre-positioning of assets and evacuation plan. Activities during disaster consisting of carrying out evacuation and mobilisation of assets to support delivery of supplies. Post-disaster activities include the earlier part of recovery such as delivering relief aids to evacuation centres and areas which are not accessible through normal means of transportation.
2. Since this study was specifically done on Malaysia as its case study, the scope of agencies and mechanism are limited to those within the country, namely disaster management agencies such as National Disaster Management Agency (NADMA), Fire and Rescue Department Malaysia (FRDM), Civil Defence Force (CDF) and Royal Malaysian Police (RMP). The scope of mechanism in this study was limited to the National Security Council (NSC) Directive No. 20 and its accompanying Standard Operating Procedures as the sole policy and mechanism for disaster management in the country.

Moreover, this study focused on the asset component of disaster logistics management; namely transportation (ground, water and air), and equipment (search and rescue equipment and generator sets).

II. IMPORTANCE OF DISASTER LOGISTIC MANAGEMENT (DLM)

Disaster or emergency logistics management can also be characterised by the following main features: the urgency and unpredictability of its requirement, the uncertainty of demands, the shift in focus towards efficiency of operations instead of cost involved, and the complexity due to the number of entities involved in the process (Yang and Yan, 2010). In this regard, it is important to remember that disaster logistics activities are typically carried out by various entities, the most prominent being government organisations and relevant NGOs. To achieve the objective of disaster logistics management, the relationship between the various entities is highly dependent on coordination (Yang and Yan, 2010). This not only holds for disaster management as a whole, but it is particularly prevalent in disaster logistics management.

In disaster logistics management context, coordination together with elements of control can be defined as the process that directs and coordinates all activities encumbered in the responses to a disaster and in preparedness for a disaster which needs to be established by the government before the occurrence of an event. Proper coordination and control will provide the structure for all disaster management functions, and its main role is to assure that the responses meet the identified needs of the affected society (6. Coordination and control, 2014).

Effective coordination within the government is apparent in the way resources, and logistics are managed. A proper plan and well-coordinated implementation of logistics management contribute towards efficient disaster management to ensure that mobilisation of resources is done cost-effectively with timely response (Abulnour, 2014; Thompson, 2015). Even in the face of unpredictable and uncontrollable conditions, logistics should continue to operate, and initial logistic evaluation of a disaster-stricken area is highly necessary. Evaluating the logistical capacity of the affected area and surroundings and seeking all necessary and relevant information such as access routes and locations will enable the relevant agencies to understand the specification of the urgent needs and the consequent efficient management of those needs (Jensen and Jahre, 2010).

Since 1996, international humanitarian organisations have begun to recognise that logistics is the most expensive part in an operation, and is crucial to the effectiveness and speed of operations (Wassenhove, 2006). Logistics also serves as a bridge between disaster preparedness and response, between procurement and distribution and between headquarters and field (Thomas and Mizushima, 2005).

III. CRITERIA FOR EFFECTIVE DLM

Disaster logistics have different characteristics than traditional business logistics in terms of its high volatility and overall purpose. While business logistics strive to deliver goods at the most economical approach, disaster logistics endeavour to save lives by ensuring aids are distributed to affected areas. Efficient disaster logistics management centres around anticipating and recognising problem, and providing specific supplies at the right time where they are most needed (Beamon and Balcik, 2008). The criteria for efficient disaster logistics management can be characterised into the following categories;

A. Proper Assessment of Requirement

Assessment of requirement gives insights into the actual necessities from the ground. The initial assessment will provide a strong basis for the establishment of the supplies and assets components in disaster logistics management. The establishment of a proper and effective supplies component is necessary to cater for uncertainties and irregularities in demands and may involve high volume of items (Cheng and Lu, 2008). The process begins with the acquisition and procurement process which has to address the suitability and durability of the items, as well as the point of origin of the items. This, in turn, should be strongly supported by appropriate relief facilities and inventory management.

On the other hand, a similar establishment of transportation and distribution mechanism needs to be set up as it is a core part of an emergency logistics system (Cheng and Lu, 2008). The setup should consider the movement of supplies including suitable transportation method (by air, water or ground), selection of route and distribution mechanism.

B. Agility and Leanness

Agility and leanness are commonly associated with supply chain management. The agile principle is used when there is unpredictable demand that has to be fulfilled in a short duration of time, while the lean principle is used for predictable demand, through continuous replenishment when time is short, and planning and optimisation when time is ample (Cozzolino, Rossi, and Conforti, 2012). In other words, agility correlates with speed, while leanness correlates with cost, in which both speed and cost would ultimately result in more lives being saved and helped (Wassenhove, 2012). Both principles bring efficiency to disaster logistics management; with agility being more prevalent in the response phase and leanness dominates the recovery phase (Wassenhove, 2012).

C. Robust Governmental Structure and Multi-agency Collaboration

The government's role in disaster logistics management is vital to provide an organised mechanism from the various actors that emerge during a disaster operation (Cheng and Lu, 2008). The overall structure should be robust but still provide ways to elicit cooperation from various agencies. This is where establishing command and control is necessary, and coordination between agencies is essential despite the different capabilities. Research on disaster aid models and systems for logistics revealed that the presence of multiple decision-makers which can be classified into local, national and international levels might provide difficulty in logistics management (Ortuño *et al.*, 2013). Therefore, the establishment of governmental multi-agency structure must come with strong coordination.

C. The Utilisation of Information Technology

The utilisation of information technology has significantly increased communication through exchange of information during disaster logistics operation (Cheng and Lu, 2008). However, communication issues are seldom addressed which has resulted in an overall poor disaster management system. In the event of a large scale disaster, the local telephone network including mobile phones is typically affected. Therefore, there is a need to identify a suitable form of communication such as through radio networks (Timoleon, 2012).

In addition, response operations hinge on the availability of data, particularly spatial data, which can significantly help in decision making (Alamdar, Kalantari, and Rajabifard, 2016). The importance of real-time disaster monitoring and response systems have increased in recent years because of the high number of casualties, victims and the devastating impact of large scale disasters on economy and environment (Bayrak, 2010). Therefore, proper utilisation of information technology will allow rapid response which demonstrates the need for a well-structured and functional information technology system to support initial assessment, information flow, decision-making process, monitoring tool and archive all relevant records.

D. Strong Continuity of the Process

Disaster management is often treated as a one-time process, on the basis that each disaster is unique, thus requiring different responses. Nevertheless, it is important to remember that the structure, mechanism and planning of response generally remain the same. Therefore, it is crucial to treat disaster logistics management as a continual process (FEMA, 2000). Recognising logistics management as a continual process would allow disaster logistics planner to identify and respond towards hazard vulnerability and changing capabilities in both workforce and equipment. Although proper planning may be demonstrated in written documentation such as action plans and policies, the continuity part of the plan is demonstrated by the implementation of the plan, which should also include capacity building of the relevant entities, as well as coordination between the said entities. Lastly, it is of equal importance to evaluate and learn from past disasters for future improvements.

E. Competent and Knowledgeable Personnel

A study by the Fritz Institute highlighted a significant lack of logistics professionals in disaster management internationally (Thomas and Mizushima, 2005). This is supported by another study which highlighted an increasing demand in professional logisticians in disaster management, but the lack of properly developed training and education are the main causes of the shortage. The study then proposed that the training and curriculum for logistics management be customised according to the condition and existing framework in certain countries (Bolsche, Klumpp, and Abidi, 2013).

IV. MAIN APPROACHES IN DLM

There are multiple ways to approach disaster logistics management. The most prominent are approaches that are useful in understanding the concept relevant to coordination and command and control. In this regard, even though many literatures focus on coordination during disaster response, its importance in other phases should not be overlooked. Understanding the level of coordination and cooperation in disaster logistics management requires one to comprehend the prominent approaches in the field, summarised as follows:

A. A Centralised and Decentralised Approach

In a centralised approach, a single agency has the authority to direct the overall disaster logistic process through a command system, whereby it will have control over the resources, flow of information and instructions to the collaborating agencies. This will facilitate effective coordination and control, which are important attributes in disaster logistics. Centralising elements also facilitate pooled decision-making, eliminating duplication of efforts and financing efficiency (Dolinskaya, Shi, and Smilowitz, 2011).

On the other hand, the decentralisation approach is based on consensus whereby agencies involved are empowered to make own decisions. This allows for capacity building at the sub-regional level, which adds diversity to the overall logistics system and improves response time (Dolinskaya *et al.*, 2011). Decentralisation allows more flexible and potentially more resilient operations, but it may result in loss of capacity for strategic action. A disaster response plan should not be rigid in its approach, as it needs to be as dynamic as the disaster situation surrounding it. Therefore, an effective disaster response plan should outline roles and responsibilities and prescribes a command structure that is as decentralised as necessary and as centralised as possible.

B. A Vertical and Horizontal Approach

According to the Cambridge Dictionary, horizontal integration is a situation in which an entity procures another entity that has similar activities while vertical integration is a process where one entity procures another entity that supplies it with goods or buys goods from it to control all the processes in production. In the context of disaster logistics management, a horizontal integration approach is an act of integrating similar infrastructures, assets or supplies which usually results in an expansion of its operation. Vertical integration in disaster logistics is the act of expanding into new operations in order to reduce its dependency on existing logistical components. This is supported by a study by Jahre and Jensen in 2009 which describes the vertical approach as the overall process of logistics management consisting of sending items from the originating location to its intended delivery location, whereas the horizontal approach can be described as having two different entities delivering similar service in the same area (Jahre, Tore, Jahre, and Jensen, 2010).

A study on both vertical and horizontal approaches revealed that the vertical organisational structures in most disaster agencies contribute to a poorly integrated response, especially when collaboration, information sharing, and coordination are required. However, horizontal organisations have assisted traditionally vertical civilian and military agencies by enhancing their capacity to operate successfully in complex humanitarian emergencies and large-scale natural disasters (Burkle and Hayden, 2001).

Fundamentally, the vertical approach is dependent on existing structures, particularly structures that are well established and permanent infrastructures, whereas the horizontal approach allows for emerging solutions to be considered and implemented. A combination of both approaches would work well to fill existing gaps and complement its shortcomings.

C. Cluster Approach

The cluster concept is defined functionally in terms of areas of activity whereby in large disasters, responding organisations often coordinate in clusters based on major sectoral activities, such as logistics, health and shelter. This approach pays particular emphasis on information management whereby the information collection, management and sharing are often targeted to the specific cluster's activities (Sokat *et al.*, 2014; Jensen and Jahre, 2010). This is because the cluster system enables the sharing of information at all level, notwithstanding the location or the hierarchical position. However, the disadvantages of this approach are apparent when valuable information needed by a specific cluster is held by another cluster. The approach would work well if the coordination between clusters is strong, and sharing of information is done freely between clusters.

V. METHODOLOGY

This study was performed based on a systematic approach for empirical research, which utilises knowledge based on real-world data and observation. It aims to include multiple case studies from past disaster incidents occurring within the country. Detailed information on each incident regarding the disaster logistics management was used to verify the earlier established hypotheses. For information gathering, survey which relies on self-reports of factual data and opinion was implemented. The aims for the data collection method and data analysis are (1) to study the current mechanism on disaster logistics management, which was also used to wither support or nullify the hypotheses made in establishing the theoretical foundation, and (2) to gather data from the multi-agencies database to serve as the dataset for the development of a data integration model for multi-agency assets.

For primary data collection, the methods employed were structured interviews with the subject matter expert, i.e. the person-in-charge for disaster logistics in each agency. Additionally, ethnographic interviews were conducted at Pahang and Kelantan with the personnel involved with logistics operations during the flood. The secondary data collection was derived from two main sources: information from a multi-agency database and relevant literature, in order to establish a baseline of the state of knowledge on disaster logistics, both substantive and methodological (Majewski and Heigh, 2010). The literature review focused on analysing the documentation for disaster logistics management, namely the National Security Council Directive No. 20 and also various journals articles on disaster logistics management. The literature review also focused on analysing existing models in disaster logistics management to support the earlier hypothesis. In summary, the need to optimise existing resources through integration of multi-agency assets was emphasised.

The second objective of this paper is to develop a data integration model for multi-agency assets. Data integration is a process whereby information from multiple databases is consolidated for a single application. Users of a data integration model would be provided with a homogeneous logical view of the data that is physically located over multiple data sources. Any data integration project typically consists of assessing the data, integrating the data and delivering or displaying the integrated data. Therefore, based on the dataset procured from all four agencies, a data integration model was developed. Based on the findings from the case studies, the most suitable approach is Common Data Storage. This is due to the different datasets, as each agency has a unique method to store and maintain data. Common Data Storage permits combination from various data sources and does not disrupt the source system.

Furthermore, this approach allows simpler implementation for future upgrades and future changes to the source system will not affect the data integration process.

Based on the data acquired from the agencies, the most suitable architectural pattern was Extract-Transform-Load (ETL) implemented with the Common Data Storage approach. Similar to the approach selection, this architectural pattern was chosen due to the way the existing data are maintained by each agency. The data accumulated from these agencies have different frequencies of the update, file formats, and attributes, hence needs to be aggregated into a common file format before they can be used. The data integration modelling was then carried out based on the Systems Development Life Cycle (SDLC), which describes the stages involved in a data integration development project. For this project, data integration modelling was divided into conceptual data integration modelling (Figure 1) and logical data integration modelling (Figure 2). For the latter, a high-level logical model was developed, which consists of four sub-modules, namely the logical extract model, logical data quality model, logical transform model and logical load model.

VI. FINDINGS

A. Existing Mechanism for DLM

In Malaysia, the preparation for disaster logistics management is done in accordance with NSC Directive No. 20. The nature of the directive is such that it is highly compartmentalised in terms of roles and functions of each agency. Therefore, the approach for disaster logistics management in Malaysia can be categorised into two, the cluster approach and the centralised-decentralised approach.

The cluster approach can be seen in the government disaster management meetings whereby the Central Disaster Management Committee (CDMC) members would present and discuss the available assets to be used during the disaster, before flooding season. The meeting occurs at the federal and also state levels, chaired by the Minister in the Prime Minister's Department and the State Secretary, respectively. Meanwhile, the cluster approach is visible in government disaster logistics in the way the assets are categorised. The assets are categorised into land transportation, water transportation, air transportation and equipment such as mobile kitchen, generator set, mobile toilet, water purification system, life jackets and others. These assets are usually deployed as the monsoon season is nearing, especially for states expected to be hit with the disaster (usual flooding). Disaster logistics assets in the country are common assets, and they are not specifically designated for disaster purposes only. Although this is an efficient way to manage resources, it has some weaknesses in terms of their suitability for more complex disasters.

The centralised and decentralised approach in disaster logistics management can be seen in the way each state manages disaster. Generally, each state manages disaster differently. Although disaster management of the country is centralised at the federal level through CDMC, it is decentralised at the state level as it includes the involvement of State Department as well as different entities that are present in different states. This approach works best due to the different stakeholders in the state as well as the different development growths and financial capabilities.

B. Proposed Data Integration Model

In order to develop a data integration model, an understanding of how the data is being stored within the respective agencies is required. As stated earlier, each federal agency has a unique way of managing data. The logistics assets data of CDF for disaster management purposes are handled by the Disaster Management and Operations Division through the "myAPM" web portal. The logistics assets for FRDM are managed through an online system "e-LOG Operasi". The system is accessible by all FRDM personnel with a limited view of the data based on the administrator's setting. The logistics assets for both RMP and NADMA are managed through an online government asset management system, "mySPPA". The system consists of ten (10) modules including the asset registration module and the asset location module.

As stated in the methodology, it is important to determine the data integration approach and architectural pattern before developing the actual data integration model. The data integration architectural pattern chosen for this study was the Extract, Transform, Load (ETL) using the Common Data Storage approach. The selection of the approach and architectural pattern was based on the nature of the existing data from the agencies. In general, the data have different update frequencies and attributes, requiring some form of standardisation before they can be utilised efficiently by the user. Based on this architecture, three layers were required, namely extract layer, transform layer and load layer. However, between the extract layer and transform layer, there needs to be a data quality layer to ensure that the data can be used for its intended purpose.

The conceptual model (Figure 1) identifies the main subject areas of a data warehouse, which in this case comes from the entities that hold the original data; namely all the responder agencies (CDF, FRDM, RMP and NADMA). Since the data have different formats and structure, they must go through a module before being stored in the data warehouse. Therefore, an ETL module was developed to ensure data availability and reliability in the data warehouse. This process is necessary to provide a guideline for the next layer in the data integration model, which is the logical data integration model. The data source comes from the four aforementioned agencies, while the target for the envisioned data integration model system is the overall data for disaster logistics assets.

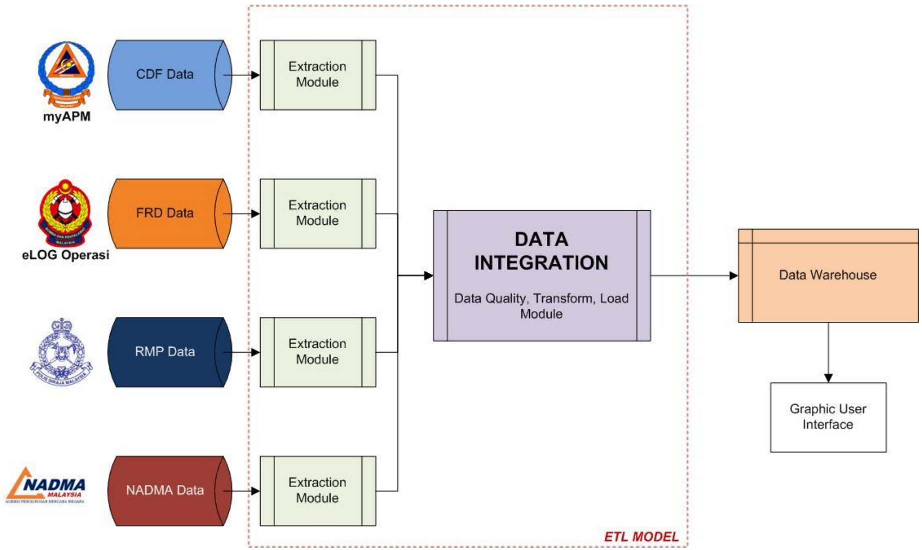

Figure 1. The conceptual data integration model provides an overview of the complete data integration process. The model demonstrates the relationship between each entity that all responder agencies play a prominent role in disaster logistics management. Although the logistic capabilities vary, the significance of each agency remains the same in this conceptual model.

Taking the above context, a conceptual high-level data integration model was developed, as shown in Figure 2. In the high-level logical data extract model, all NADMA and CDF assets are used in disaster logistics management, but not for FRDM and RMP due to the nature of the assets. Data analysis for the extracted model also validates the findings from the case study, whereby disaster logistics assets comprise of common assets, which are also used for other purposes. The outcome of this model is to identify the type of assets to be extracted into the subject area files. All extracted data are formatted into pre-determined subject area files.

The aim of the data quality module is to produce reliable and effective data for the next module, the transform module. While there are many ways to measure data quality, this study focused on the quality of the extracted data, mainly because the expected number of data in the data warehouse is less than 100,000 and through incremental extraction, issues on latency would be reduced significantly. For this project, the data quality module should be able to distinguish data types and ensure that correct data resides in the intended type. Technical Data Quality Check is used to identify invalid data and missing data, while Input Data Quality Check checks for inaccurate data and inconsistent definition.

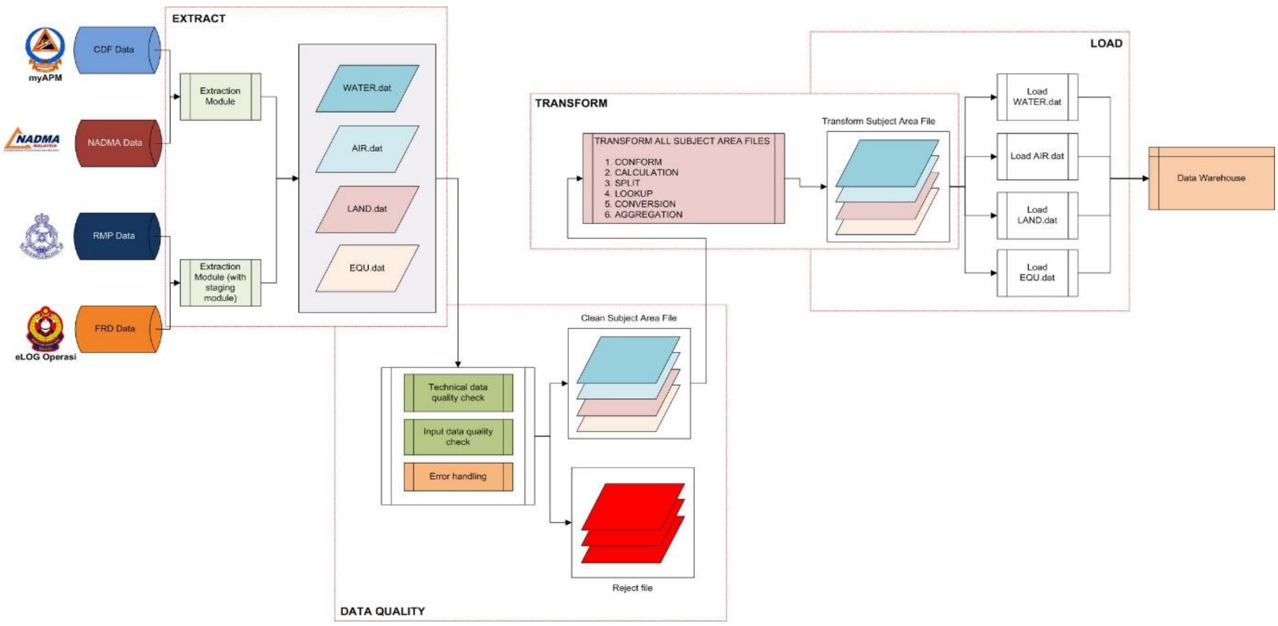

Figure 2. Details of the four logical models, namely logical extract, logical data quality, logical transform and logical load models required for the high-level data integration model.

The logical transform model identifies the transformation required by the extracted data in order to meet the end user's requirement. In this model, the type of data transformations involved are conversion, split, aggregation, calculations, lookup and conforming. The logical load model is fairly straightforward and simple as it concerns loading the predetermined subject area files into the data warehouse. The design of this model is aimed at reducing future maintenance, whereby the load processes are designed by the target and the subject area within the target allows any future changes to be encapsulated in the source data.

VII. CONCLUSION

Disaster management in Malaysia, similar to other countries, is managed through the coordination between government agencies, namely National Disaster Management Agency (NADMA), Fire Rescue Department (FRDM), Royal Malaysian Police (RMP) and Malaysia Civil Defence Force (CDF). Therefore, the success of managing disaster depends highly on the coordination between these agencies, particularly in information sharing on available disaster logistics. Disaster logistics has and always been an integral part of disaster management, as logistics are involved in every phase of the disaster management cycle. During preparedness, logistics assets are prepositioned according to disaster forecasted area to ensure swift mobilisation during response. During recovery, logistics provides support to the recovery works during the initial stage such as when victims are allowed to return to their disaster-stricken homes. Prevention and mitigation phases involve re-evaluation of disaster logistics requirement and procurement of additional assets if necessary. Therefore, it can be concluded that disaster logistics management should not be separated from the disaster management cycle as it is integrated into the cycle.

Currently, the country still relies on the NSC Directive No. 20 as a guideline in disaster management. However, the directive does not specifically mention about joint management of disaster logistics. This has resulted in redundancy in response and recovery effort, and in worst cases, absence of logistics in an area due to miscommunication between involved parties. Through case studies reports by four main agencies and three different states represented by the northern zone (Perlis), east coast (Terengganu) and Central and Southern Zone (Melaka), it appears that each case study has different ways of interpreting disaster logistics management. State disaster logistics management differs between states, accompanied by specific issues and challenges.

Taking all of these into account, it is essential to develop a cohesive data integration system regarding disaster logistics information to enable better coordination between government agencies. Data integration would enable the user to find out the location and specification of asset to determine its suitability for the intended purposes. Having a complete data warehouse on the available asset and resources at district, state and federal levels will improve current disaster logistics management. However, data integration from various sources has their challenges in terms of managing the different data format. Therefore, the top-to-bottom development approach in this study has detailed out each phase of the data integration model; beginning with the conceptual data integration model up to the logical model. The outcome of the conceptual model revealed that all responder plays an equal role in the proposed data integration system, irrespective of their asset capability.

The high-level logical model aims to identify the attribute of each entity that will describe the requirement for the data integration process. Subsequently, the four logical data integration model that has been developed addresses the heterogeneous challenge of the data source by providing subject area files from the beginning of the extract module. The logical extract model aims to identify the relevant type of assets to be included in the data warehouse; whereas the logical data quality model manages data reliability and effectiveness. The outcome of the logical transform and logical load is to identify the transformation required by the extracted data such that they can be utilised to meet the end-user requirement and can load the predetermined subject area files into the data warehouse respectively.

The current mechanism on disaster logistics management at the federal level is carried out through NADMA as the main disaster management agencies. However, due to its role as a coordinating body, it does not possess strong logistics capability and is dependent on other sources. Hence it will have to communicate continuously with other responder agencies for an updated status of assets. With a data integrated model database or system, effectiveness in communication can be increased as the complexity of the overall process is reduced. This will, in turn, improve response time. A study by Hristidis, Chen, Li, Luis, and Deng in 2010 discusses data management and analysis in disaster situation, which focuses on Information Extraction (IE), Information Retrieval (IR), Information Filtering (IF), Data Mining (DM) and Decision Support (DS). Their data flow model acknowledges the need for data integration and addresses pertinent issues in data integration, which is the heterogeneity of the overall disaster data, which was also one of the considerations in developing the proposed data integration model.

Since disaster management in the country is a joint effort, the assets involved are the common asset that is also used by the respective agencies for their daily tasks. Nevertheless, using the proposed data integration model, automatic data extraction can occur at each of the agency-specific logistic systems as each agency maintains and updates their original system, without having to inform the main stakeholder of the data integration system.

VIII. REFERENCES

[1] '6. Coordination and control' 2014, *Scandinavian Journal of Public Health*, vol. 42(14_suppl), pp. 56–75. https://doi.org/10.1177/1403494813515102.

[2] Abulnour, AH 2014, 'Towards efficient disaster management in Egypt', *HBRC Journal*, vol. 10, no. 2, pp. 117–126. doi:10.1016/j.hbrcj.2013.07.004.

[3] Alamdar, F, Kalantari, M, & Rajabifard, A 2016, 'Computers, Environment and Urban Systems Towards multi-agency sensor information integration for disaster management', *CEUS*, vol. 56, pp. 68–85. doi:10.1016/j.compenvurbsys.2015.11.005.

[4] Bayrak, T 2009, 'Identifying requirements for a disaster - monitoring system', *Disaster Prevention and Management*, vol. 18, no. 2, pp. 86-99. https://doi.org/10.1108/09653560910953171.

[5] Beamon, BM, & Balcik, B 2008, 'Performance measurement in humanitarian relief chains', *International Journal of Public Sector Management*, vol. 21, no. 1, pp. 4–25. doi:10.1108/09513550810846087.

[6] Bolsche, D, Klumpp, M, & Abidi, H 2013, 'Specific competencies in humanitarian logistics education Specific competencies in humanitarian logistics education', *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 3, no. 2, pp. 99–128. doi:10.1108/JHLSCM-08-2012-0019.

[7] Burkle, FM & Hayden, R 2001, 'The Concept of Assisted Management of Large-Scale Disasters by Horizontal Organizations', *Prehospital and Disaster Medicine*, vol. 16, no. 3, pp. 128–137. doi: 10.1017/S1049023X00025875.

[8] Cheng, W, & Lu, J 2008, 'Operational Analysis on Emergency Logistics System and Emergency Response Model', in *IEEE International Conference on Service Operations and Logistics, and Informatics*, Beijing, pp. 1323–1328. doi:10.1109/SOLI.2008.4686605.

[9] Cozzolino, A 2012, 'Humanitarian Logistics and Supply Chain Management', in *Humanitarian Logistics*, SpringerBriefs in Business, Springer, Berlin, Heidelberg, pp. 5-16. doi:10.1007/978-3-642-30186-5.

[10] Cozzolino, A, Rossi, S, & Conforti, A 2012, 'Agile and lean principles in the humanitarian supply chain The case of the United Nations World Food Programme', *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 2, no. 1, pp. 16–33. doi:10.1108/20426741211225984.

[11] Dolinskaya, IS, Shi, ZE, & Smilowitz, KR 2011, 'Decentralized Approaches to Logistics Coordination in Humanitarian Relief', in *Proceedings of Industrial Engineering Research Conference*.

[12] FEMA 2000, *Chapter 9: Preparedness For Emergency Response*.

[13] Guzman, EMDe 2001, *Towards Total Disaster Risk Management Approach United Nations Office for the Coordination of Humanitarian Affairs-*, pp. 1–17.

[14] Hristidis, V, Chen, S, Li, T, Luis, S, & Deng, Y 2010, Survey of data management and analysis in disaster situations', *The Journal of Systems & Software*, vol. 83, no. 10, pp. 1701–1714. doi:10.1016/j.jss.2010.04.065.

[15] Jahre, M, Pazirandeh, A, & Wassenhove, L Van. 2016, 'Defining logistics preparedness : a framework and research agenda', *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 6, no.3.

[16] Jahre, M, Jensen, L-M & Listou, T 2009, 'Theory development in humanitarian logistics: a framework and three cases', *Management Research News*, vol. 32, no. 11, pp. 1008-1023. doi:10.1108/01409170910998255

[17] Jahre, M & Jensen, L-M 2010, 'Coordination in humanitarian logistics through clusters', *International Journal of Physical Distribution & Logistics Management*, vol. 40, no. 8/9, pp. 657-674. doi:10.1108/09600031011079319.

[18] Majewski, B, & Heigh, I 2010, 'A Peek into the Future of Humanitarian Logistics : Forewarned Is Forearmed', *International Journal on Supply Chain Forum*, vol. 11, pp. 4–19.

[19] Ortuño, MT, Cristóbal, P, Ferrer, JM, Muñoz, S, & Tirado, G 2013, *Decision Aid Models and Systems for Humanitarian Logistics: A Survey*, in Atlantis Computational Intelligence Systems, Atlantis Press, pp. 17–45. doi:10.2991/978-94-91216-74-9

[20] Sokat, KY, Zhou, R, Dolinskaya, IS, Smilowitz, K, Chan, J, Sokat, KY, ... Chan, J 2014, *Capturing Real-Time Data in Disaster Response Logistics*.

[21] Thomas, A, & Mizushima, M 2005, 'Logistics training : necessity or luxury', *Forced Migration Review*, vol. 22, no. 22, pp. 60–61.

[22] Thompson, DDP 2015, *Disaster logistics in small island developing states: Caribbean perspective*. doi:10.1108/DPM-09-2014-0187.

[23] Timoleon, C 2012, *The Logistics Chain of Emergency Supplies in Disasters*, Athens University.

[24] UNDP 1993, *Disaster Management Training Programme - Logistics* (1st Edition).

[25] Wassenhove, V 2006, 'Humanitarian aid logistics: supply chain management in high gear', *Journal of the Operational Research Society*, vol. 57, no. 5, pp. 475-489. doi:10.1057/palgrave.jors.2602125.

[26] Yang, C, & Yan, X 2010, 'Emergency Logistics Management and Its Operations Reference Model', in *International Conference on Management Science & Engineering*, pp. 570–575.

[27] Official Statement By: H.E. Tan Sri Muhyiddin Mohd Yassin, Deputy Prime Minister, Third United Nations World Conference On Disaster Risk Reduction 2015, viewed 5 April 2016, <http://www.preventionweb.net/files/globalplatform/ministerialstatementmalaysiafinalre.pdf>

[28] Utusan Online 2014, 400 terperangkap di SK Manek Urai Lama selamat, viewed on 9 September 2016, <http://www.utusan.com.my/berita/nasional/400-terperangkap-di-sk-manek-urai-lama-selamat-1.40818>