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An Integrated Information System Design for Managing National Hazardous Waste in Indonesia: A Proposal

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ABSTRACT

Managing an information system of hazardous waste (HW), residual of business activities of hazardous materials, needs to be addressed as hazardous waste management (HWM) is one of crucial issues in global perspective. The waste directly and indirectly, can pollute or harm the environment, or endanger the environment, health, and survival of humans and other organisms. HWM is a set of activities which include reduction, storage, collection, transportation, utilization, processing and landfill. These activities involve waste generators, waste collectors, waste transporters, waste utilizer, waste processors, and waste landfill disposals. The paper aims to propose an integrated information system design of national HWM in Indonesia. The study was started by gathering requirements (by literature study, stakeholders' interview, and focus group discussion with business people or workers related hazardous waste management), requirements analysis, established system requirements, and designed the information system based on the requirements. The study produced requirements of an integrated information system and system design which modelled using UML (unified modelling language). The design can be used as a foundation of detail design of processes, data, interface, and networks of a working prototype or working system.

Keywords: information system; hazardous waste; hazardous waste management; UML; waste management.

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1. INTRODUCTION

Environmental is a global issue as it involves the survival of humans and other organisms. It also becomes a crucial issue in Indonesia. Therefore the government and parliament established a law to protect and manage the environmental.(Law Number 32 of 2009 Concerning Protection and Management of the Environmental (Undang-Undang Nomor 32 Tahun 2009 Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup), 2009) As a follow up to the law, five years later, the government issued a government regulation which concerns to hazardous and toxic waste management (Government Regulation of the Republic of Indonesia Number 101 of 2014 Concerning Management of Hazardous and Toxic Waste (Peraturan Pemerintah Republik Indonesia Nomor 101 Tahun 2014 Tentang Pengelolaan Limbah Bahan Berbahaya Dan Beracun), 2014). The law and the regulation are foundations and rules in managing hazardous waste management (HWM).

Law Number 32 of 2009 in article 62 expressly instructs the government and regional governments to develop environmental information systems to support the implementation and development of environmental protection and management policies. The environmental information system is carried out in an integrated and coordinated manner and must be published to the public(*Law Number 32 of 2009 Concerning Protection and Management of the Environmental (Undang-Undang*

Nomor 32 Tahun 2009 Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup), 2009). Because environmental problems are also related to HWM, an information system that can be used for supporting the implementation and development of HWM policies is also needed.

In terms of waste management (WM) in Indonesia we found studies by Meidiana, Irianti, and Widyatmoko. Meidiana's research about municipal solid waste management that is one of the factors causing the low service of solid WM in many Indonesia's cities are insufficient of information about the exact amount of waste produced by waste generator, collected at transfer point, and delivered to final disposal sites. Improper information regarding the WM elements drives inefficient municipal WM planning of majority cities in Indonesian. If there is a system in managing waste transfer and weighing, the local government can take advantage of landfill area estimation. The accurate estimation of landfill area can minimize the number of overload landfills which currently occur in many Indonesian cities(Meidiana & Gamse, 2010). It is a similar condition with HWM.

Irianti concluded that in healthcare waste management (HCWM) there were many hospitals did not comply with Ministerial Health Decree No.1204/2004 in terms of safe HCWM as addressed by Government Regulations No. 18 and 85/1999 concerning Hazardous Waste Management, including HCWM. Her studies revealed that there was an unclear policy framework that governs the implementation of safe HCWM. The availability of relevant laws and regulations has not been kept by companies with relevant policy and guidelines(Irianti, 2013). However her studies finding has been ruled by the Law number 32 of 2009 and the Government Regulation number 101 of 2014.

Widyatmoko specifically studied HWM in Indonesia by collecting data from PT Prasadha Pamunah Limbah Industri which has integrated waste management facilities. His study concluded that groundwater and rainfall are potential to transport contaminants leached from the facility offsite to agricultural areas downstream and create potential health hazards. Therefore, the company needs special engineering barriers to isolate waste stored in the landfill. The negative correlations of the COD (chemical oxygen demand) concentrations of primary and secondary leachates indicate a possible failure of primary leachate liner system, which required corrective action in preventing groundwater contamination. Negative impacts of waste treatment plants to surrounding areas comes from over capacity, insufficient knowledge of geological structure, risk of existing faults, groundwater flow system to aquifers(Widyatmoko, 2017).

There are many studies on HWM and information systems of HWM. In a review of efficient WM practices Halkos stated sustainable WM required the combination of skills and knowledge of engineering and physical sciences together with other aspects: ecology, economics, human behaviour, entrepreneurship and good governance. His paper discussed extensively the policy framework and the legislative background around waste and WM in the EU and worldwide. His study focused on the treatment options for waste under the economic cycle approach having the idea of closing the loop with consequently achieving a more efficient resources use(George Halkos, 2014). HWM in emerging countries with especially emphasis on industrial HW, medical waste, and household HW. He found that there were lack systematic approaches to administer WM programmes, inability to collect effectively and manage wastes to reduce the negative effects of those activities. He insisted that frameworks of regulatory and regulations did not address properly HW treatment and final disposal. There was also lack in the implementation of the regulations associated with HWM inconsequence of disintegrated responsibilities between government departments and local government(Mmereki et al., 2016).

Deswal developed and designed a GIS application for municipal solid waste (MSW) in India. The system has capability to handle both spatial and non-spatial data. The software provides query capability as well. Using the system is a technology to manage MSW and support the users to manage could help in jumping over the management technology in emerging countries especially in India(Deswal & Laura, 2014). Thompson also developed GIS for Nigeria as a system that enhances waste management authority in planning and combating the menace of improper solid waste disposal. The developed system solves the problem of allocation and relocation of waste bins, no separate bins for recyclable waste, and no direct communication means between citizen and waste management authority(Thompson et al., 2013).

One country that has a concern in the HWM is Turkey. A study conducted by Akkoyunlu analyzed the processing time of HWM in Turkey. According to them there needs to be a thorough evaluation of a country in its HWM program in theory, practice, problems, and solutions. In 2010 786,418 tons of wastes were produced in Turkey and 81.4% was sent to controlled landfills while the rest was burned and stored(Akkoyunlu et al., 2017). The other country which has a great attention to

the HWM is India. Due to economic development and growth, industrialization and changes in lifestyle, it has increased the amount of waste in India especially in big cities with large populations and high growth. The HWM has become very ineffective due to limitations including governance systems, inappropriate treatment facilities, regulatory limitations, and low levels of knowledge of the parties involved. Therefore we need a technology that can support the mitigation of various hazards caused by the HWM(Karthikeyan et al., 2018).

In regards to information system, based on our interview the stakeholders regard to hazardous waste management and focus group discussion with business people or workers related hazardous waste management in Indonesia, currently the Ministry of Environment and Forestry already has two information systems for handling HWM: SIMPEL (sistem informasi pelaporan – reporting information system) which be used by stakeholders to report their environmental activity including HW and Festronik (Electronic Manifest of Hazardous and Toxic Waste Materials) for pinpoint HW movement tracking between stakeholder's site. However, these systems are not integrated so that stakeholders must enter the same data into different systems as a result is very inefficient and potentially inaccurate. These systems also cannot monitor the actual amount of waste circulating in the industrial environment. Furthermore, for real time waste movement tracking the government has access rights to geographic information systems (GIS) from GIS providers of stakeholders. The government is not the owner of the data. Other than that, the stakeholders keep using their legacy system without any interface with the government system which makes multiple entries individually to the systems.

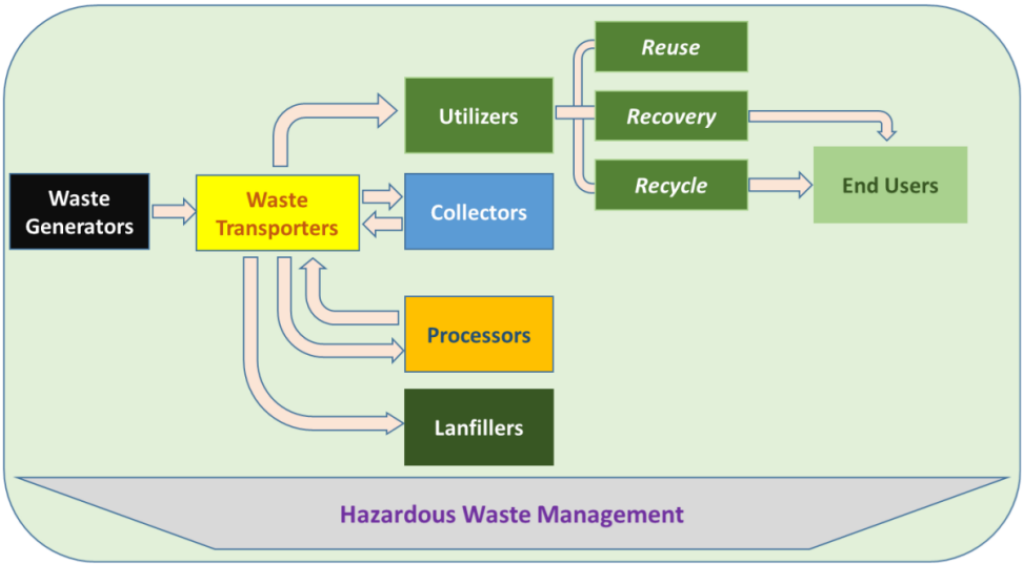

Fig 1. Scope of Waste Management Control in Indonesia

We cannot find any research which particularly and deeply studies an HWM information system (HWMIS) for Indonesia case. The purpose of this study is to analyze the system requirements of a HWMIS named and design an architectural information system which include global design of process, data, interface, and network design of this information system(Kendall & E. Kendall, 2011). This design must allow all stakeholders and regulators (governments) for each level to collaborate in using this system. The specific purpose of this research is to create a HWMIS software application. This system is very urgent to manage and monitor the generation of HWs by waste generators and their movements up to the utilizers and landfill disposals so as to ensure the control of their effects on the environment. The system is proposed to the government in order to easily manage and control HW performance indicators of all locations of the country as at Figure 1. The system does not only make the governments easier to manage and control HWM but more than that the system is more user friendly.

2. RESEARCH METHOD

The study applied a research for developing an information system software application. User requirements were gathered by literature study and interviewing stakeholders as well as FGD. Use cases as part UML (unified modelling language) is used to develop system requirements(Kendall & E. Kendall, 2011)(Whitten & Bentley, 2007)(Andi Saputra et al., 2020). Based on the requirements we design global

processes, data, interfaces, and networks for the system. Processes were designed process modelling by rich picture and data was using data modelling by class diagram.

3. RESULTS AND DISCUSSION

The research yielded system requirements and system design. System requirements developed to describe needs, functional and non-functional requirements while system design to depict process design, data design, interface, and networks(Imamuddin, 2007b).

In regard to system needs we state that it is an end-to-end system that integrates movement/status information of hazardous waste from waste generators to processors or final disposals carried by transporters. The system is able to be interfaced to stakeholders' legacy system as well.

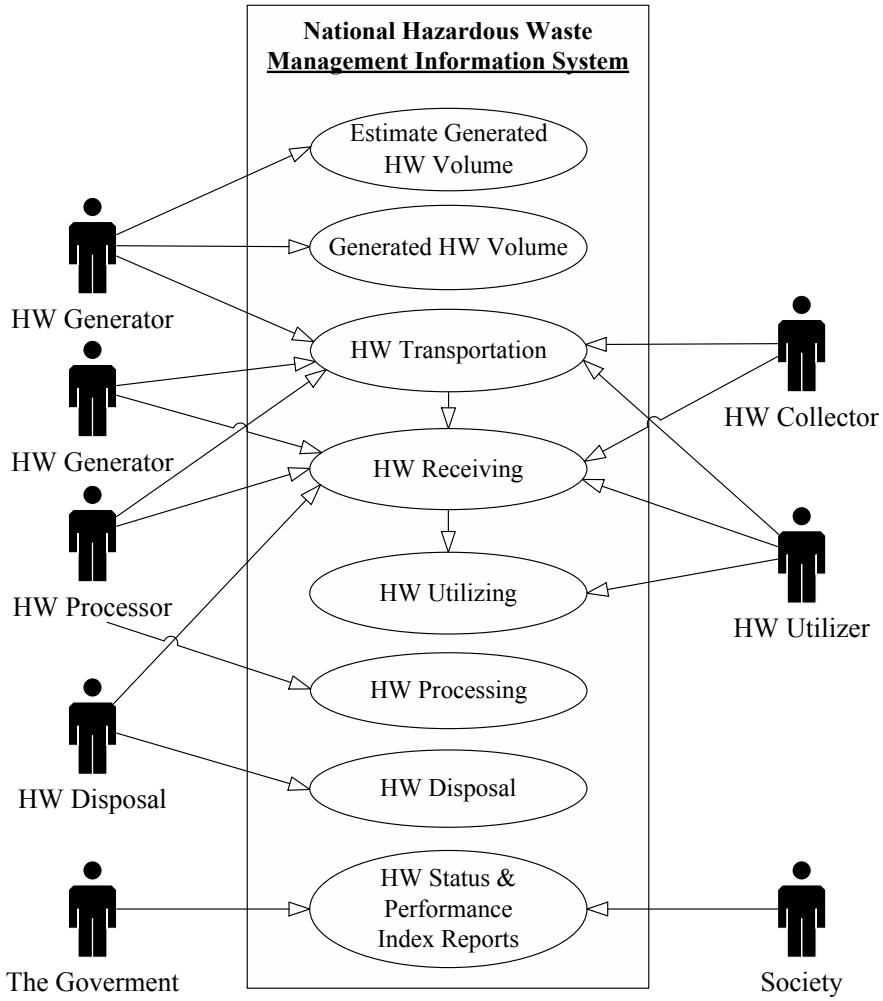

Fig 2. Use Cases Diagram

As at Figure 2 functional requirements depicted using use cases diagram, the system is able to:

1. manage information of generated waste estimation, actual generated waste, temporary storing, and reducing processes by waste generators;
2. track waste transportation from waste generators to processors or final disposals by waste generators, transporters, and waste receivers by the government for each level and related stakeholder of the waste;
3. manage, track, and monitor waste reusing/recycling, waste processing, and waste disposal; and
4. provide graphical/statistical/spatial information of status or performance of hazardous waste management of the country;

Non-functional requirements comprises that the system is:

1. accessible around the country using internet by desktop/laptop computers or mobile devices;
2. able to be interfaced to stakeholders' legacy systems;
3. limited access rights depends on authentication and authorization of users; and
4. secured from outside attacks;

The requirements are foundations of system design. A system has 3+1 pillars: process, data, interface plus networks. We used a rich picture to figure processes of the system and association between users/actors and processes. Using the rich picture as Figure 3, the system is clear and understandable.

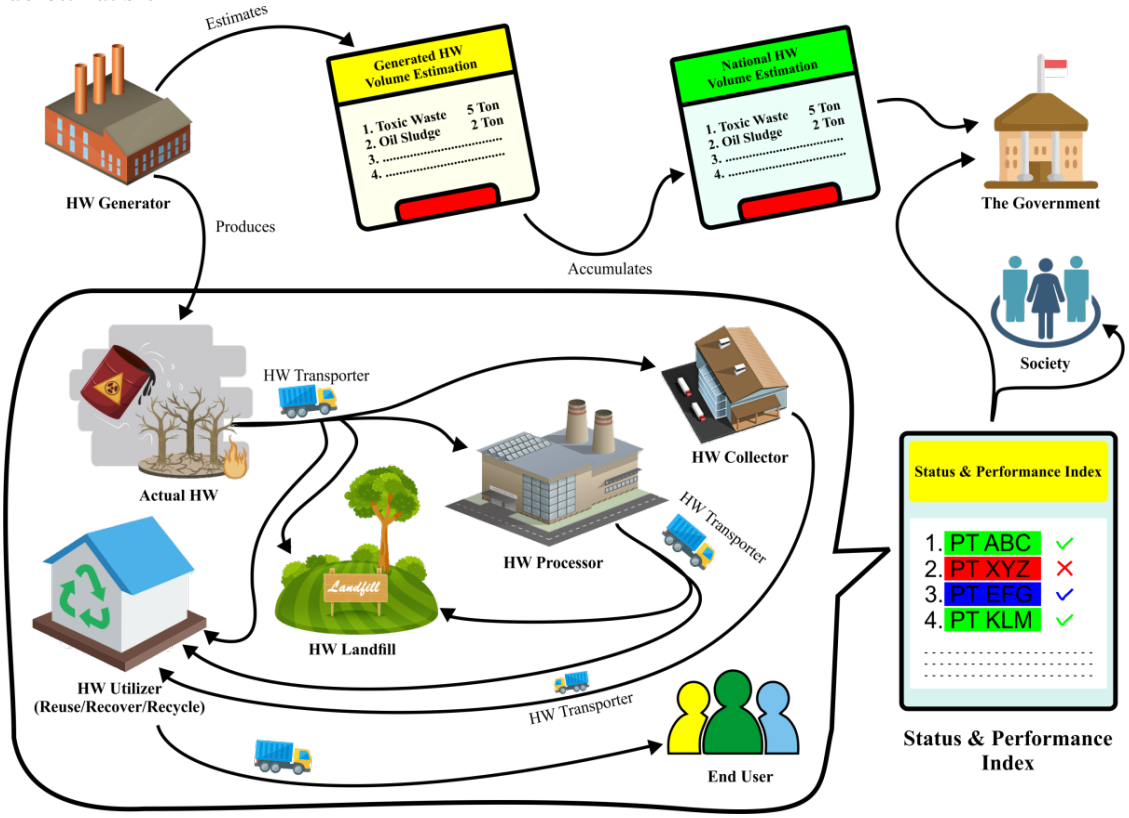

Fig 3. Rich Picture

Based on the use case diagram and rich picture diagram we developed data modeling using a class diagram as in Figure 4(Imamuddin, 2007a). There are eight entities plus for specialization entities: Generators, Volume Estimations, Wastes, Treatments, Deliveries, Transporters, Destinations, and Geography Locations. Destinations entity is generalization of entities: Collectors, Processors, Landfill, and Utilizers.

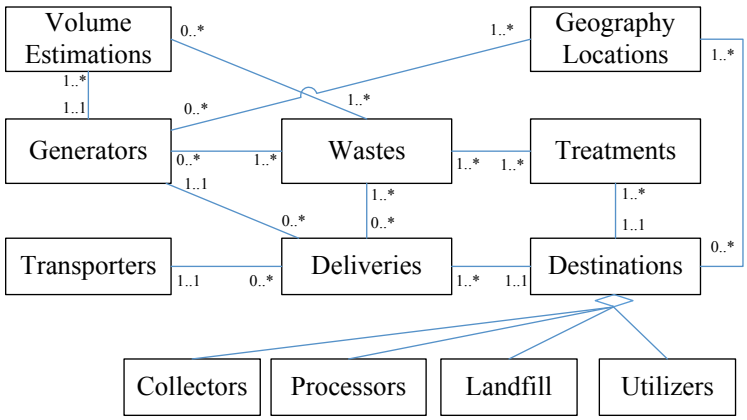

Fig 4. Conceptual Class Diagram

In this section we will discuss each item of requirements and/or designs. Firstly, waste generators are required to record estimated generated wastes and publish the information to transporter companies and utilizer/disposal/processor companies in order to get competitive price and services. Accumulated information of estimated generated wastes addresses the government to plan waste management properly. Actual generated waste, temporary storing, and reducing processes lead the government systematically determines index and performance of HW generator companies by the system.

Transporting HW is a critical issue on HWM while the HW reduced by fraud on the road between a waste generator company as sender to waste processor/disposal company as receiver. HW transportation tracking is a mandatory process in the system. The government can immediately detect and trace waste volume discrepancy and deviation on the road. This way drives waste transporters to be more responsible in waste delivery.

HW processor/disposal/utilizer companies are responsible to record reusing/recycling/recovery, processing, and disposal of HW consistently. Aggregated number of HW shows information how effective waste management in the country is and which processes of disposal are mostly used in the country. Eventually, providing information about hazardous waste status and performance index using graphical/statistical/spatial information figures describes easily to understand current situation of HWM in the country. The government can immediately take actions in order to react for stabilizing the situation and the societies can also control the circumstance.

As HWs are generated institutions around the country, the system must be accessible around the country using the internet by desktop/laptop computers or mobile devices. The system should fit in mobile devices to maximize and enlarge a number of users. Thus, reliable internet connectivity must be available at remote spots of the country to serve the system.

Interfacing to stakeholders' legacy systems is important in order to avoid user resistance to the system. It will remove double works on the user side and cut-cost in making reporting to the government. They do not need to add more man power to execute the system as it has interfaces with stakeholder's legacy system.

Access rights are to limit access rights depending on authentication and authorization of users. Each stakeholder accesses their HW data only. Central government users have access rights to all information of the country, province government users have access rights to all information of their province, and city government users have privilege access to all information of their city. The system provides other public information which is accessible by the societies or public as well. Security issues also need to be addressed to the system design. Database server, application server, and web server needs to be separated. Each server needs to be secured from outside attack, transfer data from a server to other servers and from each stakeholder terminal to the server must be safe.

In terms of data modelling we have Geography Locations entity to accommodate the requirements that we have local (province/city) government who are responsible in managing environmental issues on their own territory. This will support them to localize their issue regarding

misappropriation of handling waste by each point of waste generations, transfers, and disposals. The data is beneficial for tracking of hazardous waste movement.

4. CONCLUSION

The study produced system requirements and architecture system design of the software. The design can guide other researchers or software developers to develop a working prototype or a working system. To be more operational the requirements and the design need to be detailed and enriched with survey more stakeholders.

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