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# SUPPLY CHAIN ANALYSIS FOR WATER AND SANITATION TECHNOLOGY RESEARCH PROJECT (Case Study in Morotai Island, North Maluku Province)

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## ABSTRACT

*Indonesia Government Regulation Number 50 Year 2011 stipulated that Morotai island in Nort Maluku as National Tourism Strategic Area (NTSA). As a tourism area, Morotai should be supported with good facilities and infrastructures including clean water and sanitation. Ministry of Public Works and Housing undergoes a replication project as a pilot project of sanitation and clean water technology in Daruba, Morotai, North Maluku. This technology is covering sanitation technology (bio filter, sanitary pond) and clean water (SPC, Reserve Osmose). This technology is ready to be applied in Daruba and all of its technology originated from Java. This study is eager to see to what extent the supply chain of sanitation and clean water technology, from the technology producers which are mostly located in Java and the application location is in Morotai. The study of Supply Chain in Clean Water and Sanitation Technology Implementation using an applied based research approach. This study refers to scientific research and attempt to solve practical problems. The result of this study, any supply chain for four technologies in Morotai. The results consist of identifying supply chain components, determining network dimension structure, that consists of three types dimension, determining type of business chain, and mapping supply chain.*

## INTRODUCTION

Indonesia Government Regulation Number 50 Year 2011 stipulated that Morotai island in North Maluku as National Tourism Strategic Area (NTSA). As a tourism area, Morotai should be

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supported with good facilities and infrastructures including clean water and sanitation. Meanwhile the condition of sanitation infrastructure development and clean water in NTSA Morotai is in a bad state (RD Center of Chemistry Technique Application of Public Works, 2018). In the medium-term projection, one of areas in Morotai Island District which has potentially clean water and sanitation facility is Daruba area. Daruba is a village in South Morotai District that was projected to be the capital city of Morotai Island District in future years.

Given this matter, in the development of tourism area, the Ministry of Public Works and Housing undergoes a replication project as a pilot project of sanitation and clean water technology in Daruba, Morotai, North Maluku. This technology is covering sanitation technology (bio filter, sanitary pond) and clean water (SPC, Reserve Osmose). This technology is ready to be applied in Daruba and all of its technology originated from Java. Figure 1 shows the technology used in Morotai. This study is eager to see to what extent the supply chain of sanitation and clean water technology, from the technology producers which are mostly located in Java and the application location is in Morotai.

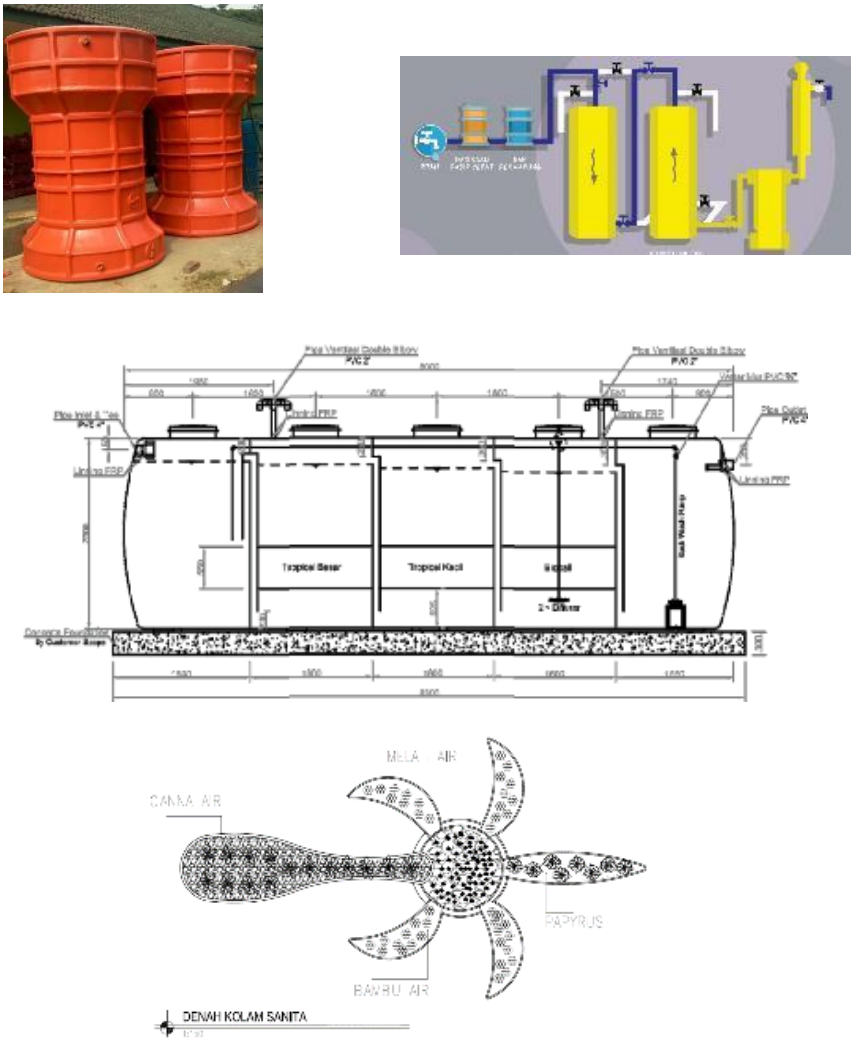


Figure 1. Technologies in Morotai

Supply chain is a set of activities that includes purchasing, manufacturing, logistics, distribution, marketing, that perform the function of delivering value to end customer (Turan Paksoy, 2011 in Kumar & Kurmar, 2013; Casado-Vara, 2018). Now, the term supply chain is commonly used to cover many if not all of the various logistic functions (Rushton, Croucher, &

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Baker, 2014). The concept of the supply chain is really an extension of the ideas nature of logistics. The total logistics concept advocates the benefits of viewing the various elements of logistics as an integrated whole. Supply chain is similar, but also includes the supplier and the end user in the process. This is the major difference between supply chain and traditional logistics.

Then, according to Chopra & Meindl (2016), a supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request, and includes manufacturer, suppliers, transporters, warehouses, retailers, and even customers themselves. It may be more accurate to use the term supply network or supply web to describe the structure of most supply chains, as shown in Figure 2. Each stage in a supply chain is connected through the flow of products, information, and funds.

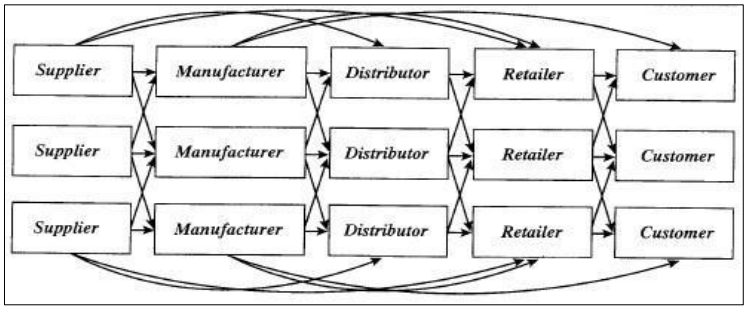


Figure 2. Supply chain stages

The application of the supply chain, mainly in the manufacturing industry, has been successful and has achieved the expected benefits. Some of these benefits are cost reduction, competitive advantages, productivity improvement, value creation, and better relationships between parties. To apply SCM in construction, it is necessary to distinguish some characteristics of construction production system, such as the construction product (for a single most of the times), the place, equipment and methods (change for each project), parts and materials (not all of them can be stored at site), and construction personnel (high rotation index during the construction time and between projects).

Although the construction process is different, supply chain can be useful and effective in construction. A typical construction supply chain is complex as several different trades including consultants, suppliers, and sub-contractors are involved. Figure 2 below shows the complexity of a construction supply chain. It consists of three major flows, as material, equipment, and labour (Cox & Ireland, 2002; O'Briend et al., 2002 in Thunberg, 2016). Also, Figure 3 shows phases in a typical construction project which clients, consultants, contractors, and suppliers positioned as nodes connected by interfaces compromising knowledge transfer, information exchange, financial, and contractual relationships (Behera, Mohanty, & Prakash, 2015).

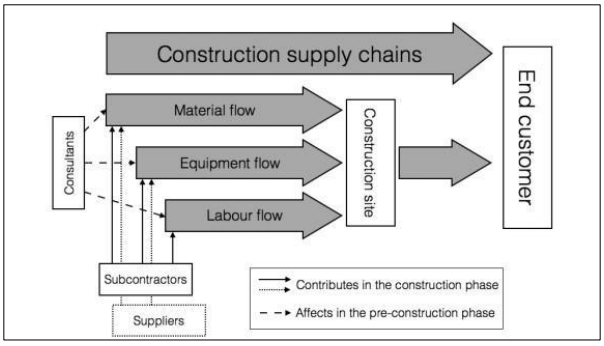


Figure 3. Construction of supply chains

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Widjanarko (2009) in Podungge (2018) stated that globally the construction sector consumes 50% natural resources, 40% of energy, and 16% of water. Beside that, Soeharto (1995) in Podungge (2018) stated that in construction projects, materials and equipment are the largest portion of a project which the value can reach 50% until 60% of the total project cost. Therefore, to reduce some problems in a project and also to improve contractor's performance, construction supply chain can be implemented. Figure 4 shows phases in a typical construction project.

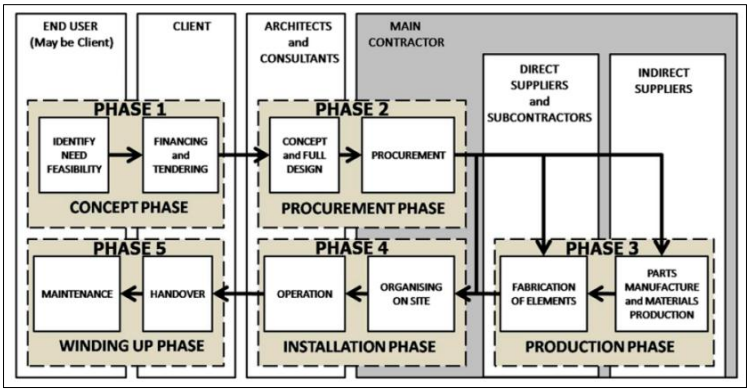

Figure 4. Phases in a typical construction project

According to Pusat Pendidikan dan Pelatihan Sumber Daya Air dan Konstruksi (2017), there are some problems that become obstacles in construction projects, such as material scarcity because of the project location is too far from the construction material supplier, low availability of equipment and skilled manpower around the project location so must be came from outside area, the project location is out of the way so there is no access or there is any access eventhough really minimal, damage or problems of the equipment, insufficient storage capacity, and erratic weather.

The similar things also stated by Hartati et. al. (2019) that transportation and construction material retail location become several factors which affected to the sale of kind construction material (in this study is cement) in construction projects. From the logistic planning point of view, transportation connect between manufacturer, warehouse, and customer. Thus, transportation provide spatial closure and allow specialization. Transportation should become as cost reducing which the expenditure enables greater saving in the manufacturing and marketing process (Bowersox, 1978 in Sutoni & Apipudin, 2019). There are several strategies that can be implemented related to transportation, such as being on time in the shipping process, increase the accuracy of shipping process, and improve the capability of shipping process (Hartati & Misnadesi, 2019).

## RESEARCH METHOD

The study of Supply Chain in Clean Water and Sanitation Technology Implementation using an applied based research approach. This study refers to scientific research and attempt to solve practical problems. Collecting data method is divided into 2, i.e. primary data and secondary data. Primary data is collected from literature studies, field observations, and in-depth interviews with technology manufacturer. For secondary data is taken from Puslitbang Perumahan dan Pemukiman.

In this study, qualitative descriptive is used as analysis method in order to designing supply chain structure. According to Maulani, Suraji, & Istijono (2014), designing supply chain structure consists of 4 steps, such as:

a. Identifying supply chain components, i.e. identifying parties who involved in construction project (main contractor, subcontractor, supplier and other parties who contributed in material and service flow). Basically, subcontractor and supplier must become partner for long term. However, Ballard & Howell (1998) in Herdianti & Abduh (2015) stated that relation between

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parties who involved in construction industry as a project based industry is a temporary relation (temporary multi organization)

b. Determining network dimension structure, that consists of three types dimension, i.e. horizontal structure (the number of tier that pass through the supply chain), vertical structure (the number of supplier or customer in each tier), and horizontal position (organization/company position is in the final customer or in the several places between supply chain end point)
c. Determining type of business chain, that consists of four types, i.e. managing process, monitoring process, not managing process, and non part of process
d. Mapping supply chain. Based on Heizer & Render (2014), there are six strategies that can be chosen to purchase construction materials and services, such as many suppliers, few supplier, vertical integration, kairetsu network, virtual company, and joint ventures

Table 1 summarizes supply chain variables and indicators.

Table 1. Supply chain variables and indicators

| Variable | Indicator |
|---|---|
| **Supply Chain Parties** | Project Owner<br>Contractor<br>Consultant<br>Subcontractor<br>Supplier/Material Manufacturer<br>Construction Equipment Service<br>Manpower Service |
| **Supply Chain Structure** | Horizontal Structure<br>Vertical Structure |
| **Business Chain** | Managing Process<br>Monitoring Process<br>Not Managing Process<br>Non Part of Process |
| **Supply Chain Costs** | Material Price<br>Shipping Cost/Transportation<br>Storage Fee |

## RESULTS AND DISCUSSION

To determine the structure of supply chain network of each applied technology, we need to learn about the supplier of each technology and also its constituent material component. This is in line with the argument of Rushton, Croucher, & Baker (2014) stated that the supply chain concept is an extension of logistic concept. For bio filter technology, there are six certified bio filter suppliers and one of them will be selected as the supplier of the construction project in Morotai area. Those six suppliers are PT Mega Fiber Indonesia, PT Rototama Berlian Plast, PT Cahaya Mas Cemerlang, PT Susti Sarana Mandiri, PT Graha Ksatria Envirotama, and PT Jagad Sanitasi Indonesia. Following are the results of the survey associated to the bio filter technology expedition to the project location from each supplier.

a. PT. Mega Fiber Indonesia

This supplier is located in Tangerang. They design their own product to meet market demand and it is customizable by consumer's request. For several raw materials (such as fiber), are still imported from, among others, Japan, Korea or China. The price of finished product (delivery cost excluded) depends on the specification of used component. The delivery made by this supplier is in the form of unraveled parts sent to the consumer's location then assembled in consumer's location. They are selected this method for the low cost compared to shipping in the form of intact

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form. For comparison, if assembled at the factory, one container will only accommodate below 10 unit bio filters whereas if assembled in site, 1 container may accommodate up to 160 units.

The transportation mode used to ship is truck (by land) and ferry (by sea) since there is no queue, therefore the product can be delivered to consumer's location faster. As for the process of product installation at consumer's site, there is no need for specific equipment or materials. In every product installation guide is attached, therefore no specific qualification needed. For certain cases, the supplier also trains contractors how to install. For this matter, the supplier has their own qualification for its workforce namely minimum High School/Vocational High School and passionate in engineering.

b. PT. Rototama Berlian Plast

This supplier is located in East Jakarta. They deliver their products to the consumers' location in intact form. To avoid operational issues due to sent in intact form, this supplier carries out a product trial before delivery.

c. PT Cahaya Mas Cemerlang

This supplier is located in Central Jakarta. Shipment made by this supplier to the consumers' location is by making use of expedition company and they have sent their products to Papua.

d. PT Susti Sarana Mandiri

This supplier is located in Yogyakarta. For several raw materials (such as fibers), are brought from factory in Bogor. The supplier has many storages including in Manado. For the finished product price (shipping cost excluded) depends on its type, which is Rp2.3 million (for 4 souls), Rp2.75 million (for 5-6 souls), and Rp3.8 million (for type 6-8 souls). They have their own distributor to ship the product to the consumer's location. The shipment cost by boat is 30% of product price. For the product installation process in consumer's site, specific equipment and material are not required. However, if the consumer assembles on their own, the supplier is also able to provide a technician to assist the product installation.

e. PT Graha Ksatria Envirotama

This supplier is located in Yogyakarta and has workshop in Gresik District, East Java. This supplier sells its product in package (including shipment and installation costs). For the shipment of the product to the consumer's location, the supplier ships the product from the factory to the distributor first, hereafter it is heading to the consumer's location by using expedition company. For the product installation process at the consumer's site, it depends on consumer's party. This installation process requires 4 up to 5 workforces.

f. PT Jagad Sanitasi Indonesia

This supplier is located in Serang District (West Java), Gresik (East Java), and Manado. The component of this product constituent is prasedimentation and sludge digester, anaerobic/anoxy aerotic, and clorifier unit with lamella plate settler. The price of finished product (shipment cost excluded) is approximately Rp3.5 million up to Rp320 million. In this regard, the supplier sells its product in package (including the shipment and installation costs). The supplier ships its product in intact form and unraveled parts (divided into parts) assembled in consumer's location.

For assembled product, it is more dedicated to remote areas. The cost of the shipment to consumer's location depends on the area location. The transportation mode used, shipment route, and shipment time are determined by third parties. If the product arrives at the consumer's location, the product will be stored previously in temporary workshop. For the product installation process at the consumer's site, no particular equipment and material are needed. In this regard, the equipment needed is only nuts, bolts and burrs. In addition, no specific qualification is required for the workforce. In some cases, the supplier also provides installation technician which the number depends on the tank number.

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Of those six suppliers, PT Mega Fiber Indonesia was selected as the bio filter supplier at the construction project in Morotai area. Generally, the bio filter comprises of inlet pipe, outlet pipe, settling tub, slurry circulation pump, body part (made of fiber, resin, and catalyst/hardener) as well as filter. PT Mega Fiber Indonesia has a factory located in Tangerang and also has distributors in Jabodetabek area, Bandung area, Surabaya area, Malang, and Manado area. The location of the projects using bio filter from this supplier is almost all over Indonesia. Figure 5 and 6 show construction supply chain structure of clean water and sanitation technology in Morotai and map of distributors and projects applying biofilter from Mega Fiber

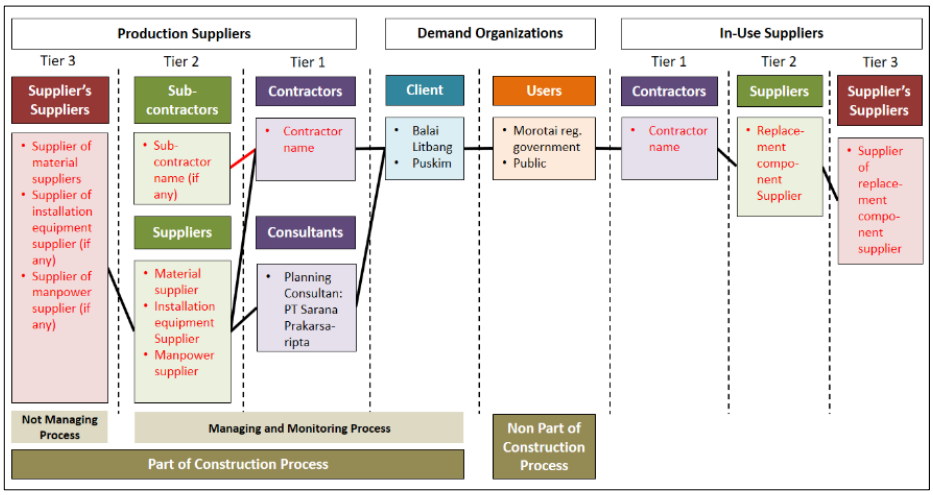

Figure 5. Construction supply chain structure of clean water and sanitation technology in Morotai

Figure 6. Map of distributors and projects applying biofilter from Mega Fiber

The price of the bio filter depends on the specification of its constituent component. For the bio filter that will be applied in Morotai area, this bio filter is a custom (adjusted to the client request) with capacity 43.2 $m^3$/day, the dimension of the length is 16 m, and the diameter is 1.8 m. This custom bio filter is directly brought in from Tangerang with cost Rp350,000,000.00. This price includes with control panel, air blower, installation cost, shipment cost, and other costs. For the shipment to Morotai, the transaction is conducted between contractor and third parties. PT Mega Fiber Indonesia usually recommends the expedition party, but the decision remains in contractors' hand.

The shipment from Tangerang to Surabaya is using PT Proteus Mitra Logistic by land route, whereas from Surabaya to Morotai uses PT TAL Agung Langgeng by sea route. Total shipment

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cost is Rp52,000,000.00. Therefore, the shipment cost takes only 14.86% of total bio filter price. The shipment with route Tangerang-Surabaya-Morotai needs more than 2 weeks (around 19-20 days). For the installation process of bio filter in the project location, no specific equipment and workforce with special qualification are required. Only, PT Mega Fiber Indonesia has attached particular glue for the fibre and there is also a technician to guide the installation process. This is in line with the concept argued by Chopra & Meindl (2016) in which the supply chain captures the party directly and indirectly involved.

To anticipate lack of component during the installation process or replacement of the component in the future, for small parts can be obtained in nearest distributor namely in Manado. For large components, it will be shipped from the supplier factory in Tangerang. Nevertheless, PT Mega Fiber Indonesia is basically willing to accept certain component adjusted to the local material. However, there should be an agreement with PT Mega Fiber Indonesia beforehand to guarantee the product quality, including conducted a laboratory test to the bio filter output (the one using local material) to ensure the quality standard.

In capturing the sanitation and clean water technology supply chain, including Biofilter as the sanitation technology, it also needs to conform to 3 main currents, as argued by Cox and Ireland (2002), O'Briend et al. (2002) in Thunberg (2016). They are Material, Equipment and Workforce. Following are the initial network structure for bio filter technology construction in Morotai area. Figure 6 shows construction supply chain structure of biofilter technology in Morotai.

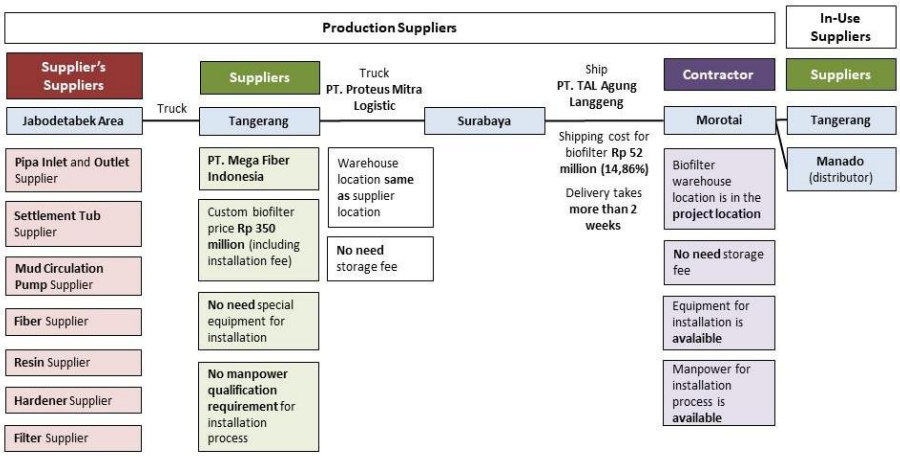


Figure 6. Construction supply chain structure of biofilter technology in Morotai

Hereafter, at the Sanitary ponds technology, the constituent component/material can be retrieved from local suppliers in Morotai. This technology constituent component comprises of filter, orifice pipe, and the sanitary pond itself. The cost incurred comprises of construction cost of sanitary pond tub itself as much as Rp16,957,624.26 as well as piping work and sparing pipe as much as Rp6,220,000.00. Therefore, total cost for the construction of sanitary pond (include shipment cost) is Rp23,177,624.26. Table 2 shows the detail cost for the construction of Sanitary Pond.

The material sent to the project location is by land line and it takes approximately a day to get directly arrive at the location. For the construction process of this sanitary pond, the equipment and workforce required is the contractor's responsibility. Hereafter, to anticipate lack of material or component replacement in the future during the construction, the material/component can be obtained in Morotai local shop. The structure of initial network for sanitary pond technology construction in Morotai area is suggested in figure 7.

For Simple Water Management Installation- Quick Sand Filter, the technology constituent component itself comprises of ground water tank, pump, roof tank, and Quick Sand Filter (made of fibre). This material is brought in from the supplier CV. Lusika in Bandung. The fibre which

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is made as the constituent material of Quick Sand Filter is bought from PT Justus. The cost for the IPAS procurement is Rp117,414,000.00 (installation and shipment excluded). The contractor is in charge of shipment of the material up to the project location in Morotai. The shipment route is from Bandung to Surabaya by land and continued by sea from Surabaya to Morotai (using PT TAL Agung Langgeng).

Table 2. Detail cost of construction

| No | Job Description | Volume | Unit Price (Rp.) | Total Price (Rp.) |
|---|---|---|---|---|
| A. | Job for Building Construction Sanitary Tub | | | |
| 1 | Common earthworks | 25,20 $m^3$ | 80.787,00 | 2.035.832,40 |
| 2 | Landfill work that has been excavated | 25,20 $m^3$ | 26.929,00 | 678.610,80 |
| 3 | Landfill work under the work floor | 2,52 $m^3$ | 342.043,00 | 861.948,36 |
| 4 | Rebate concrete work floor | 1,26 $m^3$ | 1.166.820,00 | 1.470.193,20 |
| 5 | Sanitary tub | | | |
| | - Brick press ½ brick camp 1:3 | 43,50 $m^3$ | 130.735,00 | 5.686.972,50 |
| | - Plastering 1:3 | 87,00 $m^3$ | 71.541,00 | 6.224.067,00 |
| | | | ***sub total*** | **16.957.624,26** |
| B. | Piping and Pipe Sleeves Works | | | |
| | Pipe and Accessories Procurement Works : | | | |
| | a. Procurement of PVC pipe dia. 150 mm | 12,00 m | 75.000,00 | 900.000,00 |
| | b. Procurement of PVC pipe dia. 200 mm | 12,00 m | 110.000,00 | 1.320.000,00 |
| | c. Procurement of PVC pipe sleeve dia. 200 mm | 1,00 ls | 1.000.000,00 | 1.000.000,00 |
| | d. Instalation of pipe and pipe sleeve | 1,00 ls | 3.000.000,00 | 3.000.000,00 |
| | | | ***sub total*** | **6.220.0000,00** |
| | **TOTAL COST OF SANITARY TUB CONSTRUCTION** | | | **23.177.624,26** |

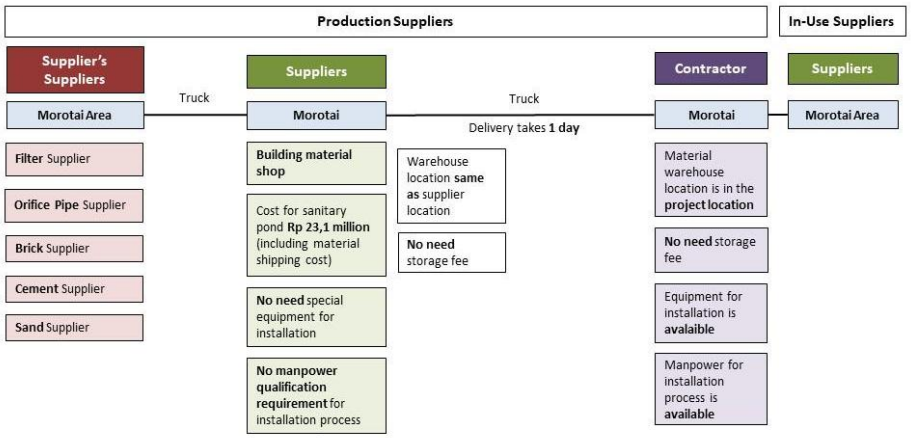


Figure 7. Construction supply chain structure of sanitary pond technology in Morotai

Based on proportional calculation, the material shipment cost for the IPAS construction is Rp41,013,812.28. If calculated thoroughly (with installation cost Rp17,089,088.45), the shipment cost taking 23.37% portion. Likewise with the bio filter shipment, the shipment with route Bandung-Surabaya-Morotai takes time more than 2 weeks (around 19-20 days). For the IPAS construction process in location, there is no need for special equipment and workforce with special qualification. However, there is sometimes improvisation or change on the design on the processing unit to anticipate design that is not fit with the project location. Later, there will be delegation from the CV Lusika also involved in IPAS construction process. Figure 8 shows construction supply chain structure of IPAS technology in Morotai

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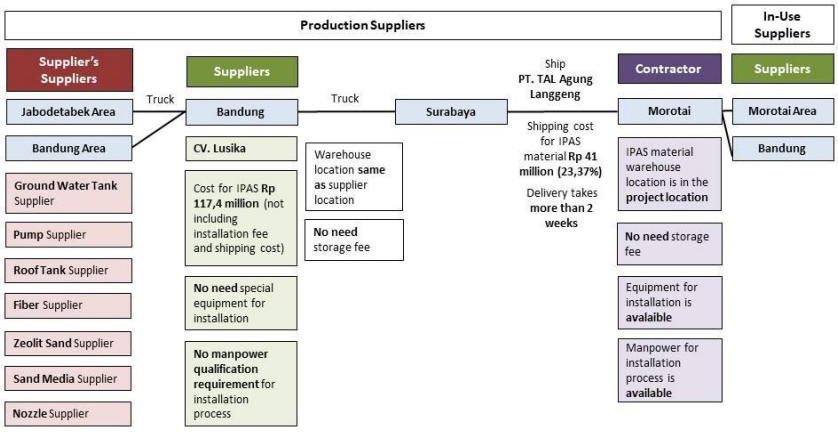


Figure 8. Construction supply chain structure of IPAS technology in Morotai

Next technology will be applied in Morotai is Reserve Osmose (RO). The technology constituent component is quite many comprising of water inlet valve, pre-filter, RO membrane, post-filter, automatic inspection valves, flow blockers, reservoir, faucet, exhaust pipe. RO system unit is brought in from the supplier called PT Zeofilt Water Treatment located in Bandung. The cost for the procurement of this RO system is Rp20,000,000.00 (installation and shipment cost excluded). This RO system has dimension 350 x 430 x 1,060 mm with material stainless steel. Likewise with the IPAS technology, the material shipment to the project location in Morotai is borne by the contractor. The shipment route is from Bandung to Surabaya by land and continued from Surabaya to Morotai by sea.

The proportional calculation indicates that the material shipment cost for RO system installation is Rp6,986,187.72. If overall calculation (with installation cost by Rp2,910,911.55), this RO system unit shipment cost also takes portion 23.37%. Likewise, with the IPAS material shipment, the shipment with route Bandung-Surabaya-Morotai takes more than 2 weeks (around 19-20 days). For the RO system installation process in project location, no particular equipment or workforce with special qualification are needed. Hereafter, to anticipate lack of component during the installation process or component replacement in the future, for small/general component can be obtained in local Morotai. For large/specific component, needs to wait for shipment from the supplier factory in Bandung. Figure 9 shows the initial network structure for the RO technology construction in Morotai area.

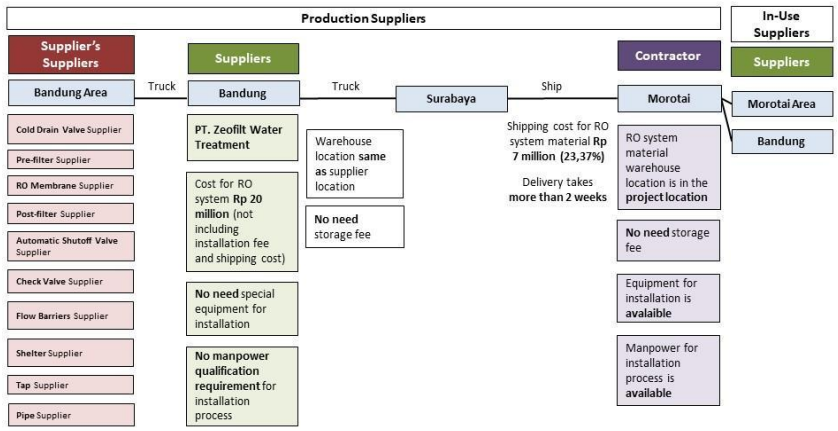


Figure 9. Construction Supply Chain Structure of RO Technology in Morotai

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## CONCLUSIONS

There are 4 technology ready to be applied in Morotai, which are bio filter, sanitary pond, SPC, and RO. For bio filter technology, there are six certified bio filter suppliers and one of them will be selected as the supplier of the construction project in Morotai area. At the Sanitary ponds technology, the constituent component/material can be retrieved from local suppliers in Morotai. This technology constituent component comprises of filter, orifice pipe, and the sanitary pond itself. Total cost for the construction of sanitary pond (include shipment cost) is Rp23,177,624.26. For SPC, the technology constituent component itself comprises of ground water tank, pump, roof tank, and Quick Sand Filter (made of fibre). This material is brought in from the supplier CV. Lusika in Bandung. The cost for the IPAS procurement is Rp117,414,000.00 (installation and shipment excluded). The last is RO. The technology constituent component is quite many comprising of water inlet valve, pre-filter, RO membrane, post-filter, automatic inspection valves, flow blockers, reservoir, faucet, exhaust pipe. RO system unit is brought in from the supplier called PT Zeofilt Water Treatment located in Bandung. The cost for the procurement of this RO system is Rp20,000,000.00 (installation and shipment cost excluded).

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