Takakura Composting Method (TCM) as an Appropriate Environmental Technology for Urban Waste Management

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Abstract

The term of "Appropriate Technology (AT)", introduced by Schumacher which refers to all kind of technologies including environmental technology, has been since developed into a global discourse on technology advancement and its impacts of implementation on human civilisation as seen from various perspectives. The technology could also relate to the basic, fundamental yet innovative technology. Using this perpective, Takakura Composting Method (TCM) always prioritise to be integrated with the local context to have more efficient and effective implementation of its method. This study aims to understand the implementation of TCM on the case study in Hai Phong, Viet Nam, which is a sister city of Kitakyushu which would provide an important base for formulation of a development model for further appropriate and sustainable implementation. This study firstly examined relevant references and extracted the most important socio-economic and cultural key-factors of AT such as: financial mechanisms and cost affordability; technological adaptability and independence; social and cultural acceptability; local needs, demands, and resources; community participation and involvement; commitment from local government; environment consciousness; and continuity and long-term impact. Authors then utilised series of interviews with the main stakeholders to understand the actual implementation. The information from the interviews were utilised as empirical database for a descriptive analysis based on each key-factor. Finally authors concluded that TCM mainly reflects all key factors within its implementation despite of the acknowledgement of several main challenges. Basic understanding of the development model was succesfully generated and the key-factors were recognised as the main components for the basic model. Yet the structure for the development model is still missing.

Keywords: appropriate technology, Hai Phong, Takakura Composting Method, urban environment, waste

1. Introduction

In the early stages of global civilisation, technology was highly considered as one of the main contributors of urban development. The implementation of technology innovation or advancement was commonly acknowledged as one of the main drivers of any kind of transformation resulting from development activities whether from a social, cultural, or economical perspective. However it takes several centuries for humanity to realise that not all technologies could be appropriately implemented to support the development under all conditions. Conversely, not every context whether it is a city or a country could appropriately provide the opportunity to access or to implement the technology itself. Furthermore, not all technology could offer the same positive impact for each different condition and context, whether this is, for example in developed or developing countries, or in the context of urban, rural, regional, or national setting. For example, incineration technology is being well-developed and widely implemented in Japan, yet on the other hand the same technology has found enormous challenges on its implementation in many developing countries due to various issues, such as the different type of waste, the lack of supporting policies and regulation, etc.

As a result, a number of multidisciplinary studies has set their primary objective to define what appropriate technology actually is. Many parameters and criteria have been discussed, however only very few studies have indentified and reflected on the most important feature of a technology which is its endless ability to be transformed and developed towards its implementation in contextual and sequential manner. Based on this feature, we would elaborate on a hypothesis that a technology would ultimately require a development model in order to be implemented in appropriate and sustainable way. This development model would also reflect on different stages of implementation namely: initial stage, scaling-up stage, and replication stage. Therefore the main purpose of this study is to analyse the appropriate technology itself and to provide a base for formulation of a development model for the implementation of appropriate technology based on the experiences from the case study.
Formulation of a comprehensive development model that is able to be replicated in other case studies with sufficient modification based on each local value would be the novelty of this study.

2. Previous Studies

2.1 Global Discourse on Appropriate Technology

The basic thinking of “Appropriate Technology (AT)” was initially introduced by E.F. Schumacher back in the 60s and 70s, and has been widely discussed since then (Trace, 2016). AT was broadly introduced, covering both the hard element and physical appearance of technology as well as the soft element and non-physical factors such as transfer of knowledge, communication skills, capacity building and others (Murphy, Mcbean, & Farahbakhsh, 2009). By this understanding, the technology itself could be interpreted as one that is high-tech, futuristic, and involves larger capital investment. However, it could also relate to basic, fundamental yet innovative technology. Currently the term AT is also used to refer to all kind of technologies including environmental technology. Furthermore, AT was developed in the context of the global discourse on the appropriateness and impact of implementing technological advancement for human civilisation as seen from various perspectives.

Many studies have already discussed the definition, implementation, development, and evaluation of AT from different backgrounds and perspectives as well as within various settings and contexts. For example, based on a case study in Kampong Sodana, Indonesia, it was concluded that an appropriate technology should be: (1) adaptable, (2) aimed at self help, (3) energy efficient, (4) locally controlled, and should also leading to: (5) a strong community involvement (Putri & Wardiha, 2013). Meanwhile another study suggested that one could consider 16 factors of the purchasing managers’ strategic framework developed by an organisation called the National Health Service (NHS) in order to select and determine appropriate technologies. Four out of those 16 separate factors are applicable to select appropriate waste treatment technologies such as: (1) legal and compliance; (2) sector specific guidelines; (3) mandatory reporting requirements (environment, sustainability, and carbon reporting); and (4) cost of purchased solution (economics) (Lee, Vaccari, & Tudor, 2016).

It was also suggested that the sustainability of technology implementation depends on its adaptability, which is then determined by: (1) technical sustainability, indicated by the accessibility of component parts, the availability of the needed infrastructure, the availability of technical know-how to accomplish such service, and the elapsed time between repairs; (2) economic sustainability, indicated by affordability, reusability, and local availability of required servicing resources; (3) environmental sustainability, indicated by resource consumption, environmental releases, resource conservation, and environmental compliance; and (4) socio-political sustainability, indicated by the level of awareness, acceptability, governmental policy and continuity, and the socio-cultural influence (Dunmade, 2002).

Other finding suggested that generally in order for a technology to be accepted, it should overcome several main challenges such as: (1) identifying the proper drivers (institutional, socio-cultural, technological, and/or financial); (2) alternative financial mechanisms (such as involvement of micro finance organisations); (3) the involvement of community-based organisations; and (4) the active participation of local governments (Uddin, Muhandiki, Sakai, Al Mamun, & Hridi, 2014). Furthermore in the context of technology implemetation in developing countries, some criteria should also be considered such as: systems independence; image of modernity; individual technology or collective technology; cost of technology; risk factor; evolutionary capacity of technology; single-purpose and multi-purpose technology (Wicklein, 1998). Another study concluded that there are important considerations in AT development and implementation such as: (1) meeting the basic needs of users; (2) sound technology; (3) flexible technology; (4) meeting local capabilities by utilising local materials and resources; (5) affordability; (6) sustainability; (7) encourages local participation; (8) culturally/socially appropriate; (9) gender considerations; and (10) appropriate technology transfer mechanisms (Murphy et al., 2009).

After the implementation of a technology by considering the factors above, the next step would be to assess and evaluate whether the technology is appropriate or not. A quantitative Appropriate Technology Assessment Tool (ATAT) has been developed, which employs Multi-Criteria Decision Analysis (MCDA) to generate an Appropriateness Index with 49 independent indicators. The most prevalent indicators are: (1) community input, (2) affordability, (3) autonomy, (4) transferability, (5) community control, (6) scalability, (7) local availability of raw materials, and (8) adaptability (Bauer & Brown, 2014). Having concluded all previous studies above, authors would argue that it would be very beneficial if there was a development model that could cover the comprehensive transformation process of AT from initial stage, scaling-up stage, and replication stage.

2.2 Composting as an Important Environmental Technology

Similar to the above explanation on AT, environmental technology itself could be understood to cover the techniques, concepts, products, and knowledge-based services for environmental protection, conservation, and improvement on issues such as climate change, air pollution, biodiversity, waste management, and others (Weinberger, Jörissen, & Schippl, 2012). Waste management, especially in an urban context, has been regarded as one of the main targets for the implementation of environmental technologies. Composting is one of these environmental techniques (technologies) that could contribute to the improvement of municipal waste management by introducing organic waste reduction by the concept of re-use as often taken as the first step in many cities. It is actually not a new technique yet it has been re-promoted in waste management to address climate change (IGES White Paper, 2008). In the past, composting was proven to be an effective method to achieve high circulation rate of materials and nature resources within an integrated social-ecological system. In Japan, composting was intensively practiced as a major component of Satoyama landscape which is rooted deeply in the traditional Japanese way of life. The Satoyama landscape is a traditional landscape which was developed mainly by human's self-sufficient activities on agriculture and their direct dependancy towards the resources from forestry and water environment to sustain the livelihoods. However in the present time, this method needs to be re-introduced in order to regain its appropriateness in the era of globalisation (Takeuchi, Ichikawa, & Elmqvist, 2016). One recent innovation on composting in Japan is the Takakura Composting Method (TCM), which is the focus of this study.

2.3 Potentials and Challenges of Takakura Composting Method

Takakura Composting Method (TCM), named after its developer, Koji Takakura, was introduced for the first time in the city of Kitakyushu, Japan, and then disseminated to many other cities. Subsequently, within the city-to-city cooperation scheme, TCM has been brought to Surabaya city in Indonesia, a sister city of Kitakyushu, and succesful implementation has been developed over the years (Kurniawan, Puppim De Oliveira, Premakumara, & Nagaishi, 2013). Within 5 years period (2004-2009), there has been 30% reduction on the average amount of waste per day disposed at Benowo Landfill in Surabaya, as shown in Figure 1. Successful implementation of TCM in Surabaya was the result of three important factors. The first factor was the development of one model community to try out the implementation of TCM in their waste management. This development gained its momentum from collaboration activities within the Green Sister City commitment between Kitakyushu and Surabaya. Secondly, the local government of Surabaya City adopted the method practiced by the model community into their composting centres at the city scale, and it enhanced capacity while at the same time supporting the replication of model practices at the community level. Lastly, the city organised a community cleanup campaign called the Green and Clean Campaign, in collaboration with other related stakeholders (Maeda, 2009).

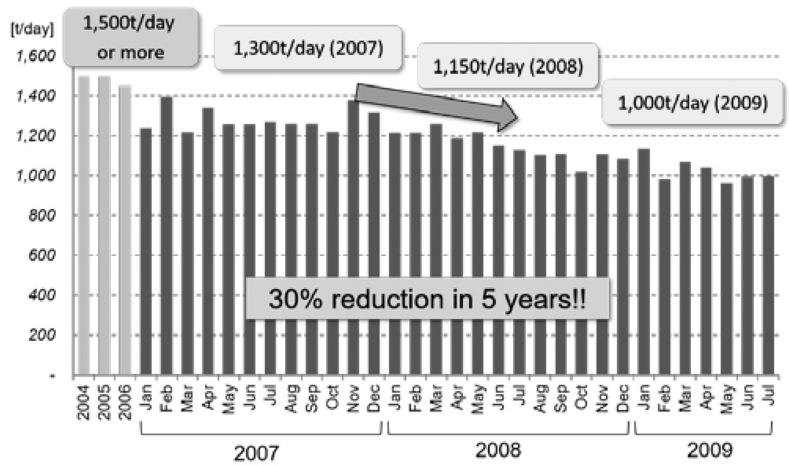

Figure 1. Average amount of waste per day at Benowo Landfill. Source: Maeda (2009)

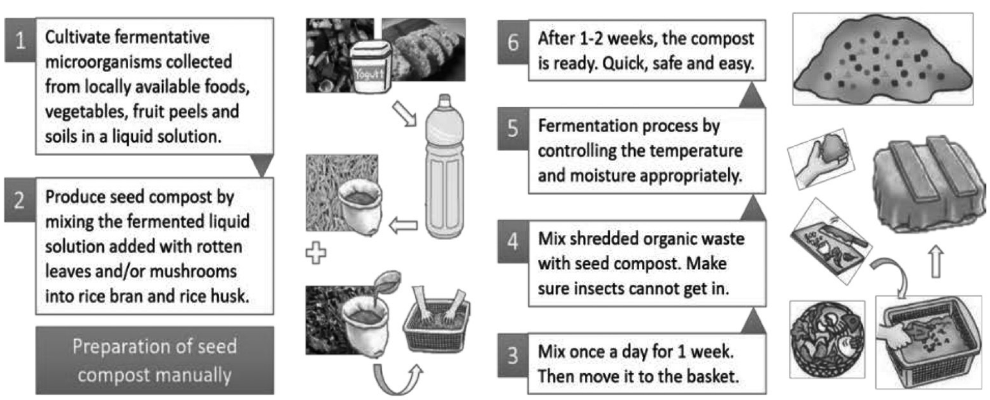

Figure 2. Process of Takakura Composting Method (TCM). Source: Maeda (2009) modified by authors

TCM has been replicated in many cities such as Semarang, Medan, Makassar, Palembang, Jakarta, and Balikpapan in Indonesia as well in other cities in Thailand (Bangkok), Philippines (Bogo, Cebu, Talisay, Puerto Princessa), Malaysia (Sibu), and Nepal (Lalitpur) because of its potentials compared to other conventional techniques (Maeda, 2009). The main innovation of TCM is the utilisation of fermentative microorganisms as seed compost, which were originally cultured from local fermented foods, such as soy sauce, yoghurt, and fermented beans which is called as tempe and tape in Indonesian, fruits and vegetable peels, rice bran and rice husks. Figure 2 shows the overal proccess of TCM.

The first potential is that TCM can be completed in a shorter time period of only one or two weeks. This is much faster than the windrow method or other composting methods which usually take months of production time. Secondly, there is also an advantage on the ability of TCM to be operated over smaller areas of land due to its simplicity and high productivity. Therefore less land is required for building composting centres, resulting in lower costs. In fact, the compost produced by TCM is half-matured, so it completes its maturation in the fields rather than at composting centres. The third potential is that TCM is naturally low-cost due to its use of local resources, non-sophisticated technology, and labour-intensiveness. This labour-intesiveness is indeed one of the important values that makes TCM fitting very well with the needs of cities from the developing countries where the employement rate is very low while the population is still growing. In Japan, this is unfortunately not the case, thus TCM could only be implemented at the household scale in its own home country.

The fourth potential is the safety procedures and working conditions that are carried out through during TCM implementation since it does not deal with any chemical materials. Lastly, as the fifth potential, again due to its simplicity, TCM is applicable at both the household level and at composting centres. The only difference is due to its use of fermentative microorganisms, which can be applied using a small-size ventilated basket at the household level, or in a larger space at the composting centres (Maeda, 2009). Nevertheless, there are also challenges in the implementation of TCM such as the intensity of labour, the dissemination of the method and establishment of a pilot project, the support from cities' stakeholders, and the establishment of a market for the compost produced. Table 1 below shows the potentials and the challenges of TCM.

Table 1. The potentials and challenges of TCM. (Source: Maeda (2009) modified by authors)

Potentials
the labour-intesiveness (low-cost & less hi-tech)
the shorter period of production
the ability to be operated o ver smaller areas
the safety procedures and working conditions
the applicability at both the household level and the composting centres

Challenges
the labour-intesiveness (human resources)
the dissemination of the method
the establishment of a pilot project
the support from cities' stakeholders
the establishment of a market for the compost produced

3. Methods

As explained earlier, this study aims to analyse the appropriate technology itself and to provide a base for formulation of a development model for the implementation of appropriate technology based on the experiences from the case study especially in the urban setting of developing countries. However before formulating a model, one needs to have an overview from different perpectives especially from the socio-cultural and economical point of view in order to identify the main components or key-factors of AT while addressing the sequential character of a development. Only then would one be able to understand whether a technology (i.e. TCM) could be regarded as AT in the sector of urban waste management or not. To that end, this study was designed to perform a qualitative approach with two main steps.

3.1. Literature Reviews

The first step is to examine relevant references and to extract the most important socio-cultural and economic factors from the references. These key-factors would be utilised to construct the development model. Basically the authors carried out literature reviews for the first step. Manuscripts of related scientific publication were selected and content-analysed. Key-factors of each manuscript then were categorised based on the keywords on its findings to reformulate a more representative key-factors.

3.2 Interviews

The second step is to conduct a descriptive analysis based each key-factor within the on-going development of TCM in Hai Phong. For the second step, the authors began with a case study-based approach by conducting series of interviews with the main actors, namely Koji Takakura himself, as the inventor of TCM and a main member of Kitakyushu's team of ezperts who provided technical assistance for the implementation of TCM in Hai Phong, and the representative person-in-charge from the implementing organisation, i.e. Hai Phong Urban Environment Company (URENCO). In regard to the major roles of both respondents, the quality of the obtained information from the interviews are considered highly reliable and appropriate to be used for this study. (Figure 3)

4. Case Study

In the next step, authors utilised the key-factors to discuss the implementation of a technology within a case study. In order to have a concentrated result, the authors also limited discussions to only environmental technology and tried to relate to the concept of Appropriate Technology (AT). Therefore for this study, the authors discuss TCM specifically as an example of AT for cities in developing countries. Hence the case study of Hai Phong city in Viet Nam was chosen.
This method was proven to be successfully implemented in Surabaya, Indonesia and many other developing cities. But, what about in Hai Phong?

One of the biggest environmental issues faced by cities in developing countries is the lack of appropriate waste management. Specifically in relation to urban solid waste management, many cities still cannot provide their citizens with a full service of waste management, encompassing collection, transportation, and treatement. Furthermore many of these cities still depend on open dumping as their final disposal method. Along with urban growth, the amount of waste continues to increase and final disposal areas are quickly exceeding their capacity. The introduction of waste separation and reduction at source is apparently the most common and feasible approach that could be taken by a developing city in order to improve its waste management. It often requires basic and low-cost evironmental technology or techniques to be implemented. Composting is one of the low cost environmental techniques that could effectively cover both objectives — waste separation and reduction — since it focuses on treating organic waste which accounts more than half of total household waste in most cities.

Figure 3. Research development steps. (Source: Authors)

As elaborated in the previous section, in addition to being interpreted as a hard element, technology can also be interpreted as a soft element such as knowledge or methods. Also as explained above, TCM is basically a composting method that introduces composting of organic matter by means of cultivating fermentative microorganisms which suit the soil and are commonly available in the natural environment, in order to shorten the production time while increasing the productivity. Thus TCM always prioritises connections with the local context to have more efficient and effective implementation of this method. This is already indicated as one of the main AT key factors discussed above. By implementing TCM, the effective use of fermentative organisms enables the production of a large amount of compost in a small space within a short time. Moreover the method is safe and economically feasible as it requires readily-available materials only. However there are also other key factors, so TCM needs to reflect all of these comprehensively.

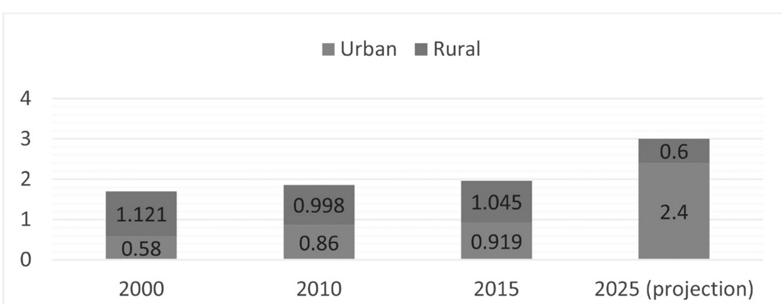

Figure 4. The growth of urban and rural population in Hai Phong (numbers are in millions). (Source: Ministry of the Environment of Japan & IGES (2018))

For this purpose authors would introduce the case study of the implementation of TCM in Hai Phong, Viet Nam, in order to discuss the key factors formulated above. As well as being a sister city of Kitakyushu, Hai Phong is the third largest city in Viet Nam with a population of 1,980,000 inhabitants. The city is located on the coast about 100 km from the capital city of Hanoi and is the largest marine distribution base in northern Viet Nam. The city aims to become Viet Nam's first Green Port City by 2020, with a sustainable, environmentally-friendly port driving economic development. In cooperation with Kitakyushu, Hai Phong developed the Green Growth Promotion Plan (GGPP) in May 2015. Waste is set as one of the four main sectors out of the seven sectors in the GGPP (Ministry of the Environment of Japan (MOEJ) & IGES, 2018). The urban area of Hai Phong is experiencing a continuous increase of population in the last two decades and expected to grow faster within the next decade, as shown in Figure 4 (Ministry of the Environment of Japan (MOEJ) & IGES, 2018).

Currently, waste is landfilled without separation for recycling and intermediate treatment, so there is a concern that the landfill sites (Tran Cat, Do Son, Dinh Vu) in Hai Phong will soon reach maximum capacity. However, due to opposition from residents, it is difficult to establish new landfill sites. There is already a composting facility at the Trang Cat landfill site, but because waste is still rather mixed, it could not produce high-quality compost, which is only being used to cover the landfill. In Hai Phong, 1,600t of waste per day is created by households and business, and only 200t of that is currently delivered to the compost facility (NTT Data Institute of Management Consulting Inc., 2017). Most of the rest is directly landfilled at the final disposal sites. By 2025, the amount of waste generated is expected to increase to at least four times thus creating a major environmental impact if there is no change.

Therefore the authors suggest that one of the most effective strategies to address this issue is to improve the existing composting facility by introducing more appropriate system and method. (Figure 5)

The composting facility is managed and operated by the URENCO as part of its responsibility on municipal solid waste collection and transportation, and final disposal. URENCO collects the total amount of 900t of waste per day and treats 200t of the total amount at the composting facility. The composting facility was also built by URENCO with total construction cost of around JPY 2.1 billion or USD 21 million. The operational cost for this facility is around VND 200,000 or USD 9 per ton, which is subsidised by the city government of Hai Phong. The production of compost using a fermentation process takes about one month (City of Kitakyushu et al., 2015). Collaborative activities on composting were started at the end of 2016 and up to now it have been developed into at least three developmental stages: (1) composting training; (2) pilot project implementation; and (3) scaling-up development. (Figure 6)

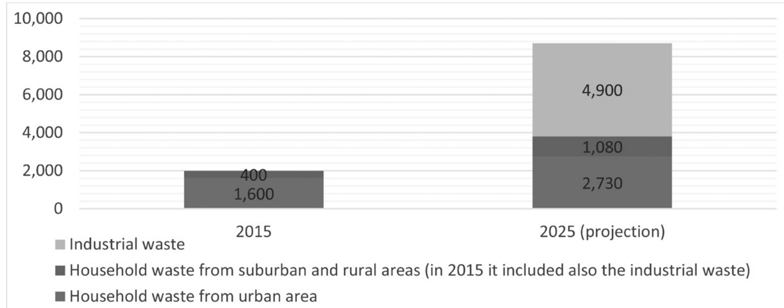

Figure 5. The amount of Hai Phong's waste generation in 2015 and projection in 2025 (in tonnage). (Source: Ministry of the Environment of Japan & IGES (2018))

Figure 6. Trang Cat composting facility: interiors (left) and exteriors (right). (Source: Authors)

5. Results and Discussion

5.1 Content analyis based on the Literature Reviews

The authors collected a number of scientific papers published in international journals as important references for this study, and then selected the most relevant ones as described in the section on previous studies. From the selected papers, authors extracted key-factors by categorising the common factors discussed in the content of each paper. The authors then summarised the common factors under eight key factors:

(1) financial mechanism and cost affordability

For the imported technology from foreign or external entity, the cost should be affordable. There should be potential financial drivers and/or alternative financial mechanisms in order to support and sustain its implementation. Also in the case that the technology comes as a solution with operational cost, it should be fully anticipated and affordable as well. The technology should also be economically affordable within the whole implementation process.

(2) technological adaptability and independence

The component parts of the technology should be able to access easily if not locally. The infrastructure needed to implement the technology should be available. In the case of maintenance service is needed, the technical know-how is available and locally preferable. Thus the elapsed time in-between repairs and/or maintenance process should not be lengthy. The technology should be better (safety, comfort, ease, etc.) compared with the existing technology thus this advancement can be the driver (reason) to use the new technology. The technology should also have the ability to become independence from any other systems. However it should be flexible enough to be implemented either as a stand-alone technology in a remote/individual society or as a collective technology in a cultural group society where everyone contributes. Furthermore it needs to have the evolutionary capacity of a technology so it can be expanded and reconfigured to higher and more sophisticated production when the demand increases. The technology should have multi-purpose applications or at least the potential for variety of applications. The autonomy, adaptability, and flexibility of the technology should be also identified during implementation and it should be locally contextual.

(3) social and cultural acceptability

The level of awareness of all stakeholders towards the technology should be appropriate, so does the acceptability. The socio-cultural influence should either encourage, in harmony, or at least not against the implementation of the technology. The technology should have the acceptance of cultural leaders, religious leaders, school teachers, and/or other community leaders as the socio-cultural driver for its implementation. The image of modernity should also be represented by the technology which means that the technology should be seen as something that can elevate the social status or provide a good image for an individual. It should also fit to the local norms and habits which means culturally and/or socially appropriate. The technology should also be able to be equally accessed by both genders

(4) local needs, demands, and resources

The servicing resources required by the technology for its maintenance such as: technical experts, maintenance facilities, and materials that are specific to the technology needing repair, should be locally available. The technology should also use raw materials that are locally available. The technology should meet the basic needs of its users. It should also meet the local capabilities by utilising local materials and resources. The technology should be self-help during its operation meaning that is directly implemented by local human resources without any external assistances and locally controlled on site.

(5) community participation and involvement

Community-based organisations should be involved in the implementation of the technology. The implementation process of the technology should be open to community inputs. Moreover, it could be controlled by the community. By a strong community involvement, the technology could encourage high level of local participation.

(6) commitment from local government

The implementation of the technology should be supported by the governmental policy and stability. The technology should have at least the potential to be institutional driver. The local governments should be actively participating in the implementation process of the technology. It should also be recognised as a legal matter and compliant to formal regulations at local, regional, and national level. The technology should be equipped by specific guidelines developed by responsible organisations.

(7) environmental consciousness

The technology should include the practice of environment-sound resource consumption. The technology should also be responsible for its environmental releases and resource conservation during its implementation. It should follow the environmental compliances. It should be energy efficient. Lastly, the implementation process should include mandatory reporting requirements on its environmental sustainability.

(8) continuity and long-term impact

The technology should provide reusability. The technology should limit and/or minimise the risk factors on its operational, financial, long-term development, and other implementation components. The implementation of the technology should be also scalable, preferably to be sequentially scaled-up to achieve optimum impact. The technology implementation should be sustainable and continuously improving. Lastly, it should also be transferable and have appropriate technology transfer mechanisms since the initial and introduction process until the dissemination and replication process to other cities.

Table 2 shows the categorisation of the key-factors which will be used as the main framework for analysing the case study.

Table 2. Categorisation of key-factors of AT implementation. (Source: Authors)

No.	Factors of AT implementation and development	Key factors
1	affordability (Dunmade, 2002) financial driver; alternative financial mechanisms (Uddin, Muhandiki & Sakai et al, 2014) cost of technology (Wicklein, 1998) affordability (Bauer & Brown, 2014) affordability (Murphy, Mcbean & Farahbakhsh, 2009) cost of purchased solution (economics) (Lee, Vaccari & Tudor, 2016)	Financial mechanism and cost affordability
2	the accessibility of component parts; the availability of the needed infrastructure; the availability of technical know-how to accomplish such service; the elapsed time between repairs (Dunmade, 2002) technological driver (Uddin, Muhandiki & Sakai et al, 2014) systems independence; individual technology or collective technology; evolutionary capacity of technology; single-purpose and multi-purpose technology (Wicklein, 1998) autonomy; adaptability (Bauer & Brown, 2014) sound technology; flexible technology (Murphy, Mcbean & Farahbakhsh, 2009) adaptable (Putri & Wardiha, 2013)	Technological adaptability and independence
3	the level of awareness; acceptability; the socio-cultural influence (Dunmade, 2002) socio-cultural driver (Uddin, Muhandiki & Sakai et al, 2014) image of modernity (Wicklein, 1998) culturally/socially appropriate; gender considerations (Murphy, Mcbean & Farahbakhsh, 2009)	Social and cultural acceptability
4	local availability of required servicing resources (Dunmade, 2002) local availability of raw materials (Bauer & Brown, 2014) meets basic needs of users; meet local capabilities by utilizing local materials and resources (Murphy, Mcbean & Farahbakhsh, 2009) self help; locally controlled (Putri & Wardiha, 2013)	Local needs, demands, and resources
5	the involvement of community based organizations (Uddin, Muhandiki & Sakai et al, 2014) community input; community control (Bauer & Brown, 2014) encourages local participation (Murphy, Mcbean & Farahbakhsh, 2009) strong community involvement (Putri & Wardiha, 2013)	Community participation and involvement
6	governmental policy and continuity (Dunmade, 2002) institutional driver; active participation of local governments (Uddin, Muhandiki & Sakai et al, 2014) legal and compliance; sector specific guidelines (guidelines) (Lee, Vaccari & Tudor, 2016)	Commitment from local government
7	resource consumption; environmental releases; resource conservation; environmental compliance (Dunmade, 2002) energy efficient (Putri & Wardiha, 2013) mandatory reporting requirements (environment, sustainability & carbon reporting) (Lee, Vaccari & Tudor, 2016)	Environmental consciousness
8	reusability (Dunmade, 2002) risk factor (Wicklein, 1998) transferability; scalability (Bauer & Brown, 2014) sustainability; appropriate technology transfer mechanisms (Murphy, Mcbean & Farahbakhsh, 2009)	Continuity and long-term impact

5.2 Descriptive Analysis based on the Key-factors on the Results of the Interviews

5.2.1 Financial mechanism and cost affordability

The provision of technical advice introducing TCM was first introduced by the Kitakyushu city government to Hai Phong city government represented by URENCO as one of the city-to-city cooperation activities at around November 2015. Once the compost made by TCM met the compost standards regulated by the Ministry of Agriculture and Rural Development of Viet Nam after a test result came out in May 2016, URENCO and the Department of Construction of Hai Phong City allocated a budget for preparing necessary equipment and materials to start the composting training. It began with a 5-day composting training programme which treated 200kg of waste per day in December 2016. Upon completion of the training and analysis (one month), URENCO began a composting pilot project which treated 50 tons of waste per day funded by Hai Phong in 2017. (Figure 7)

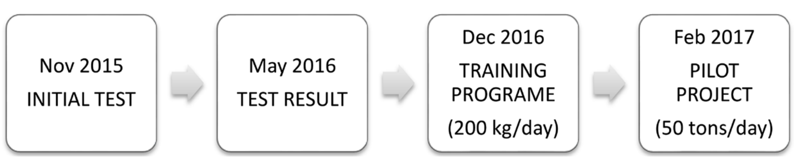

Figure 7. Implementation stages of TCM in Hai Phong. (Source: City of Kitakyushu et al. (2015))

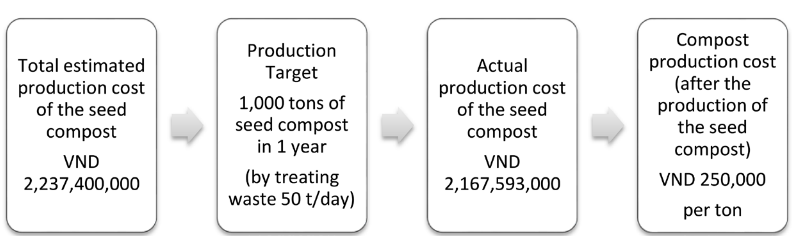

Figure 8. Production cost for the composting pilot project. (Source: URENCO (by interview))

Since the basic idea of the implementation of TCM was to utilise and improve the existing composting facility, it was modified to adapt to the existing facility. Therefore the implementation was assumed to be affordable since no large investment on infrastructue was needed. For the composting pilot project, in the beginning it was estimated that they would require VND 2,237,400,000 or around JPY 11,000,000 (USD 110,000) only to produce the seed compost. The targeted output was approximately 1,000 tons of seed compost in one year. However, currently the actual cost for producing the seed compost is VND 2,167,593 per ton or VND 2,167,593,000 in total which is already lower than the estimated cost. Then after the production of the seed compost, the standard production cost of the normal compost is only at VND 250,000 (around USD 10) per ton. This cost is expected to be further reduced once the compost is in the market. Thus the operation is likely to be very affordable for URENCO. (Figure 8)

The expected revenue from selling the compost product is around VND 950,000 per ton and this revenue will be used to cover the production cost up to VND 950,000,000 with the assumption that all 1,000 ton of compost will be sold out. At the moment, URENCO is only utilising the compost for planting in the experimental garden, the greenery areas of URENCO facility, and the central green line of Hai Phong. (Figure 9)

5.2.2 Technological adaptability and independence

The main principle of TCM is to use microorganisms which are commonly available locally in the natural environment. In Trang Cat composting facility, the same principle was applied in the introduction of TCM within a composting training. The compost was created using the local microorganism as the fermentation agent. The local staff from URENCO were trained on the basic principles and technical knowledge. However since the implementation was mainly using the existing facility and equipment, very little adaptation was required. On the operational side, the operator of the composting facility did not find any obstacles for maintenance or improvement after participating in the training programme. However, in term of production of the compost, the use of the existing facility actually determines the capacity and the efficiency of prodution. Therefore the challenge is how to use the existing facility appropriately in order to optimise production. (Figure 10)

Figure 9. Utilising existing facility for implementation of TCM. (Source: Authors)

Figure 10. TCM training for local staff. (Source: Authors)

5.2.3 Social and cultural acceptability

Composting is a common practice in Viet Nam. However, most of the compost is being used for agricultural purposes and for covering landfill in rural areas. There is no strong evidence that compost is actually used in the urban area of Hai Phong. Thus the implementation of TCM in the composting facility could be a great opportunity to develop a rural-urban linkage in Hai Phong. Another positive point is that it would be easier to gain people's attention and commitment for using TCM since the method was developed in Japan. It seems that citizens have a preference for the quality of Japanese products, methods, and technologies. Therefore TCM would not face any difficulties to be accepted socially and culturally.

5.2.4 Local needs, demands, and resources

The microorganisms required in TCM can be regarded as a local material or resource. Other materials such as yogurt, yeast, natto (fermented soybeans), actinomycetes, mushroom, mold, etc., are also available locally and sold all over the country. For the training, only around 200kg of waste per day was treated. For the pilot project, 50 tons of waste was treated. The next plan is to expand the capacity up to 100 tons of waste per day. Further it is expected that TCM would finally be able to meet to local needs to treat 200 tons of waste per day. This amount is based on the maximum capacity of the existing composting facility. However, the amount of waste collected from markets, hotels, and restaurants is still insufficient. Therefore in parallel, URENCO strives to raise the awareness of waste separation at source and tries to mix septage for compost production in order to reduce the cost of production and improve the capacity of the composting centre.

Local demand comes from the city government that is willing to use the compost product for greening the city in order to be Green Port City by 2020. Currently, the compost is being used for the central line gardens in Hai Phong, the experimental gardens of Trang Cat solid waste treatment complex, and parks at the URENCO facilities. All remaining compost is then used for various public gardens and parks in Hai Phong. From the training activity, local staff were made aware of the importance of TCM. The number of staff assigned for compost production is also increasing so there would be sufficient local human resources for the implementation of TCM in the facility once it is scaled up. Currently at this stage, 21 workers from URENCO are involved in the composting facility. Their work involves a process that includes a waste sorting line, collection, and scavenging for minor inorganics. This work requires many personnel with good working skills. Therefore it is good example of a labour-intensive industry that could help to create more job opportunities for local communities. (Figure 11)

Figure 11. Collection of microorganisms from the surrounding green belt. (Source: Authors)

Figure 12. Discussion and commitment engagement with local business owners and communities. (Source: Authors)

5.2.5 Community participation and involvement

For the composting pilot project, waste was collected from local shops, hotels and restaurants. In June 2017, owners voluntarily committed to cooperate with URENCO and the local government. Moreover for further development and improvement of the TCM, major involvement from the community is required especially to conduct waste separation at the source, which will increase the quality of the compost. Under instructions from the Haiphong People's Committee and Department of Construction of Hai Phong, support was accumulated from the wards, farmers' union, women's union, youth and inhabitants. This top-down approach is more effective in the case of Viet Nam. Recently in order to implement this community participation, two communities were selected as model communities for waste separation. They are the Dang Hai 1 Community (21,911 inhabitants/6,124 households) in the Hai An Urban District, and Lam Son Community (12,580 inhabitants/2,852 housholds) in the Le Chan Urban District. They are both located in the Quan Ward. (Figure 12)

5.2.6 Commitment from local government

The local government of Hai Phong shows a strong commitment on its vision to become a Green Port City by developing a GGPP in cooperation with the City of Kitakyushu. Furthermore based on Hai Phong City Green Growth Strategy Action Plan, the city government already assigned the Department of Construction of Hai Phong to be responsible for two related actions: (1) introduction of construction technology with less environmental impact; and (2) reducing the amount of final disposal by intermediate treatment of waste and recycling. The Department of Construction is the focal unit for supervising the implementation of improvement and compost production enlargement program at Trang Cat Waste Treatment Complex. The budget for the scaling-up of the TCM pilot composting to a capacity of 50t per day will also be provided by the Department of Construction of Hai Phong city.

5.2.7 Environmental consciousness

In addition to the commitment explained above, the city government seems to favour the introduction and utilisation of environment-conscious technology as well. With the typical top-down approach by the city government in Viet Nam as mentioned in the above section, the principle of environmentally-friendly will soon be applied to every aspect of development thereby setting up a perfect environment for the implementation of AET. Moreover this environmental consciousness or awareness is not only visible from the local government but also from the citizens, represented by the owners of local shops, restaurants and hotels. They were voluntarily committed to provide their organic waste for use in the TCM project implementation. Most importantly, the leaders of the model communities, Dang Hai 1 Community and Lam Son Community, will play an important role in boosting the environmental consciousness of citizens. A public hearing was held for each community in June 2018. During this event, the community members were trained on how to separate waste into household waste and other waste using different plastic bags. By conducting surveys and campaigns in the neighborhoods, participants are increasingly concerned about the environment and aware of the importance of waste separation at source. However, there is only limited awareness, and inhabitants still do not have the skills to identify and classify garbage. (Figure 13)

Figure 13. Public hearings to increase the environmental consciousness. (Source: Authors)

5.2.8 Continuity and long-term impact

Amongst other environmental technology, composting has the closest association to the principle of reusability, since it turns organic waste into compost which can be used as fertiliser. Meanwhile TCM is actually more of a soft technology as it does not have the characteristics of a sophisticated tool or high investment. Instead it is a rather innovative method that very much respects the local resources. Thus TCM is also arguably more transferable and scalable compared to the hard element and physical technology. It also ensures a continued process since the compost produced could be used as a starter or seed compost for the next process. However the sustainability of TCM is more likely to be related to the improvement of waste management especially on waste separation and also the availability of appropriate users for the compost. Currently the waste is not separated properly at the source and citizens are more familiar with the use of chemical fertiliser since it is cheaper. The absence of proper waste separation and lack of compost users are the two main obstacles to continiuing TCM development in Hai Phong, Viet Nam.

6. Conclusion

Based on the discussion on each key-factor, authors gained comprehensive understanding of the TCM implementation in Hai Phong, which is still at the introductory level. The activities conducted by URENCO were mainly training and pilot activities. There were also efforts to disseminate TCM practices into the communities as well as the efforts to engage collaboration of other stakeholders. The local government is showing strong commitment for further implementation. Meanwhile from the technical perspective, facilities and infrastructures are still being the subjects of improvement and optimation. The key-factors provided important measures to capture and assess the development processes of the TCM implementation. In comparison with other frameworks from previous studies, authors would argue that the key-factors concluded in this study could provide more socio-cultural and economical perspective in order to foresee the development of TCM at different stages.

Figure 14. Basic development model at the initial stage. (Source: Authors)

These key-factors also serve as main components for the basic development model, as shown in Figure 14. However in order to actually implement the model, the linkage and hierarchy between the components need to be introduced to set up a structure for the model. Currently there is not enough information and evaluation since the implementation is still at the initial stage. Only after gaining more experiences from different stages of the implementation (initial, scaling up, replication) at the case study, authors would argue that the structure of the development model could be better identified and determined. Feedbacks from facilitators, operators, users, and all relevant stakeholders would be the main empirical data to further formulate the development model.

This study summarised and analysed the case study using the key-factors of AT as a framework. These are: (1) financial mechanism and cost affordability; (2) technological adaptability and independence; (3) social and cultural acceptability; (4) local needs, demands, and resources; (5) community participation and involvement; (6) commitment from local government; (7) environmental consciousness; and (8) continuity and long-term impact. The case study of Hai Phong was analysed using each key-factor as the framework within the on-going development of TCM. The above key-factors provide more socio-cultural and economical perspective in order to foresee the development of TCM at different stages. Finally the authors conclude that TCM indeed reflects mainly all key-factors within its implementation despite not yet fully responding to all challenges. Thus TCM could be regarded as an Appropriate Technology (AT) in the sector of urban waste management. However, the absence of proper waste separation and lack of compost users, and lack of skills on how to use the existing facility appropriately in order to optimise production are some of the main challenges for the self-dependance and continuity of TCM development in Hai Phong, Viet Nam. Based on these results, the base for development model was succesfully generated and the key-factors were recognised as the main components for the basic model. Yet the structure for the development model is still missing. Therefore the next step is to introduce the structure and further formulate the development model at different implementation stages based on feedbacks from facilitators, operators, users, and all relevant stakeholders in order to sustain the TCM implementation.

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