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DESIGN AND TECHNOLOGICAL APPROPRIATENESS: THE QUEST FOR COMMUNITY SURVIVABILITY

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Abstract: The extent of exposure to which a societal group is possible to fall into a critical condition or crisis is defined as the vulnerabilities embedded in the group. Vulnerability eradication is then characterized as having particularities in each circumstance. The eradication effort addressed to a vulnerable community with situational limitations is becoming interesting to study. Technology, as an interdisciplinary solution, is potential to be a powerful solution for the eradication. Although vulnerability eradication has been widely discussed, the discussion is rather fragmented that compiled in historical way. This study aims to analyze the quest of community survivability through technological appropriateness and design. Information are gathered from literatures to be properly ordered based on the position of each phenomenon in history. Facts are compared and contrasted to deliver clear understandings on the chronologies. The historical explanations indicate that the pursuit of technological appropriateness was tightly related to the rising of technological independence in Southern hemisphere. Also, design methodologies were developed to address challenges in each own timeframe, yet each one has its own benefits and disadvantages; hence engineers need to carefully choose appropriate methodology to produce an "appropriate" technology. Then, this study gives a notion that the quest is still waiting to have further development of design methodologies for AT.

KEYWORDS: Community, design, sustainability, survivability, appropriate technology.

Introduction

Vulnerability is a crucial issue in the history of societal resilience. Vulnerability in a society is stated as the extent of exposure to which a societal group is possible to fall into a critical condition or even crisis (Bourdelais, 2005; Sianipar *et al.*, 2014b; Turner *et al.*, 2003). Vulnerability is often noted as a critical characteristic of a societal group in either its developing progress and/or recovery context (Eisenman *et al.*, 2007; Mechanic & Tanner, 2007). Eradication of vulnerabilities hence has been an important focus in those conditions. The characteristics of eradication effort are tightly influenced by the characteristics of vulnerabilities and the situated context wherein the vulnerabilities exist. In spite of the facts that vulnerabilities happen in both developed and developing societies in any different societal level, vulnerability eradication taken in a limited circumstance and/or limited access to outside regions is very interesting to study. Such situational limitations could become tough challenges for any vulnerability eradication effort. Furthermore, among many societal levels, community has been one of critical subjects for vulnerability eradication due to its fundamental position as the foundation of societal resilience (Comfort *et al.*, 1999; Leichenko & O'Brien, 2002), meaning that vulnerability eradication addressed to communities in a society could be a vital determinant of the toughness of the society in getting across developing and/or recovery process. A community that has a wide exposure to crisis due to its vulnerabilities combined with situational limitations, therefore, could become a crucial matter for its society and a tough challenge for any effort to eradicate its vulnerabilities in order to strengthen community survivability and develop societal resilience (Few, 2003; Leichenko & O'Brien, 2002). In fact, vulnerability eradication in such kind of communities is becoming more interesting to study when the communities exist in developing countries. Situational limitations in both community and national levels could intensify the challenges.

On the other hand, vulnerability itself is understood as having cross-disciplinary perspectives rather than multidisciplinary (Cutter *et al.*, 2003; Turner *et al.*, 2003), hence the eradication in a vulnerable community with many situational limitations requires an interdisciplinary solution in order to bring a complete problem solving through a single solution by simultaneously eradicating vulnerabilities from different perspectives at the same time. Based on the explanations, technology could highly be possible to be the solution. Technology, including technological changes as its form in continuous process over time, has been recognized as an interdisciplinary solution and a part of societal transformation (Rip & Kemp, 1998; Willoughby, 1990). Looking at the facts that vulnerability eradication needs to be taken as a continuous effort in societal development to maintain its role in surviving community, technology could be both a powerful driver and a strong foundation of the survivability of a vulnerable community in a developing country. In that spirit, technological concepts such as Appropriate Technology (AT) that concerns on contextual solution could possibly become an important construct. Its bottom-up approach and concerns on technological appropriateness in a situational practice have a high potential to overcome situational limitations in a targeted vulnerable community in a developing country (Garniati, 2013; Sianipar *et al.*, 2013b). Roughly-speaking, designing a technological solution and implementing technological changes for vulnerability eradication is a very interesting topic to study due to its critical position in the pursuit of community survivability. The ways a technology is developed are then becoming more and more important for vulnerability eradication in all vulnerable communities in any developing country.

However, discussions on those issues are rarely documented in a packed scholarly literature that explains them in chronological matters. Also, despite their importance as an interdisciplinary approach, they are usually discussed in fragmented discourses. Therefore, in order to gather complete understandings on such issues and their historical roots, this study is organized based on these following questions:

Q1 How did technology arise as a powerful solution in community development process in many developing countries?

Q2 How did people find their ways to develop technological solutions that could completely eradicate community's vulnerabilities without leaving local people behind?

Revisiting History

Eastern Technological Independence

Understanding technological changes for vulnerability eradication in vulnerable communities in any developing countries cannot be detached from the history of those countries in the pursuit of technological independence after achieving their national independence. In the 1960s, Africans and Asians entered the decades of independence (Edoho, 2009). In addition to the growing needs as a result of their newfound autonomy, developing countries attempted to find sufficient ways to solve the problems emerging among vulnerable communities in their jurisdiction. As the moral obligation after long colonialism, positive missions from developed countries attempted to redevelop good partnerships with developing and Third World countries. As a result, the collaboration introduced the idea of community development. Efforts were then undertaken in later missions to introduce the idea of empowerment. The shift from the development paradigm to the empowerment paradigm has shown that empowerment should be treated as the right way in guiding community transformation process

(Cummings, 2001; Diaz-Puente *et al.*, 2009; Ferguson, 2010; Lacy, 2000; Wilson, 1996). After achieving their independence, developing/Third World countries, in association with their partners, also attempted to develop sufficient technology for the processing of materials sources left by colonialism. This was caused by the facts that developing/Third World countries wanted to obtain faster results than ones that would only be possible by using their limited knowledge, which is an effect caused by the long-term colonialism. They also required technology to multiply the result of their transformation process. As a result, developing and Third World countries were quite concerned with the development of sufficient technologies based on their economic limitations (Bourrieres, 1979; Harrison, 1980; Wicklein, 1998). However, problems still arose as the result of technological changes in a low-knowledge community (Narayana, 2003; Teitel, 1978). These problems were caused by many limitations in the local communities, *i.e.* technical, economic, and/or social aspects (Sianipar *et al.*, 2013b). Those barriers were then exert overwhelming effects. Any limitation has its own characteristics but also affects the other ones due to the unstructured nature of the system in vulnerable communities in any developing countries.

At the time, some ideas were proposed to solve such condition. There were ongoing suggestions to balancing scientific technology development from Western and the conscience of local communities. In that spirit, some correlations were proposed to cope with many ideas surrounding community empowerment, as stated by Kaplinsky (1990) and Sianipar *et al.* (2013a), through the idea of technological appropriateness in particular context and timeframe of each of targeted community. As a means for improving the indigenous knowledge in doing local processing activities, technical consideration is interpreted by how local people can use, maintain, and make a technology by themselves, even if using limited resources. Following the spirit of national independence, such considerations provide the locals with opportunities to initiate technological appropriateness based on their own conditions and to avoid a significant amount of foreign forces from outsiders. Such understanding was then taken as the basis of technological appropriateness. Next, economics aspect, as the common issue in any vulnerable community in any developing countries, was becoming another basic consideration in technological independence. By understanding local economic limitations, technologies need to deliver real economic benefits beside common economic outputs such as profit or cash money. Complete economic calculations, therefore, has to provide more prosperities for locals. It is better than only an amount of money with no clear velocity or purpose. After that, environmental aspect (Yanful, 2009) is also considered as a means to support increasing concerns on environmental issues. Even though it is largely approached by using technical knowledge, its merit is distinctly different from other kinds of consideration. Thus, it is interpreted as the environmental effects imposed by a technology throughout its life-cycle, *i.e.*, all environmental impacts imposed by a technology to surrounding environment – which also affects present and future people's health – from its initial sketch to its disposal. Then, some social considerations refer to the seamless integration of a technology to the existing social activities. It is recognized as the ultimate level of technological independence. The support of an autonomous self-reinforcing process is preferred due to the limited knowledge associated with this type of decision making. In some cases (Fritsch & Gallimore, 2007), this is interpreted as the technological acceptance level from the local people to a technology.

Comparing and Contrasting AT Concepts

At almost the same time as the growing independence of Eastern countries, the early thoughts of AT had been increasingly seen as having an important position in such discourse alongside the concerns on technological changes in the empowerment of vulnerable communities. The initiation was first started by a famous sage from the eastern world, Mahatma Gandhi, long time before today's high-technology era. As highlighted by Schumacher (1973), Gandhi stated that mass production is characterized by many activities that are destructive to human life; thus, the answer was provided by reverse production, which is "production by mass." This was similar to the writings by Willoughby (1990) and Lin & Zhang (2009), who noted that the World Bank even needed to choose between heavy investments in mass production or the maintenance of investments at lower per capita, which affects more people in Third World countries. Although Gandhi's words were strongly influenced by his struggle to achieve a self-empowered society against western colonialism (Ganguly & Docker, 2007), the words were continuously spread around the world. First captured by Schumacher, Gandhi's words became the foundation of what we know today as "appropriate technology." During the past four decades, the thoughts have been developed into a broad definition of appropriateness. Of the many proposed concepts, several are mostly respected by other technologists (Table 1). One of the first responses to Schumacher's proposal originated from Morawetz (1974), who proposed a more specific meaning of Gandhi's idea into a balanced condition between the academic world and its implementation among society. The localization of resources using intelligent methods to achieve social welfare originated from his thoughts. In 1978, Dunn thought that the idea of 'production by mass' must be adapted as holistic efforts to achieve a self-reinforcing condition to thus adapt society's development path under dynamic conditions. This is characterized by an increase in the wealth and skills of the society's members, which indicates that they can achieve a higher technical system in the future. A year later, the phrase 'appropriate technology' was suggested by Pellegrini (1979) to broaden the meaning from only one piece of a 'technological bridge' into any efforts that include socio-cultural aspects in a technological innovation. Until the late 20th century, many authors had agreed that an AT must not be limited only to the efforts associated with the localization of the required resources, the exploration of the chances of using renewable energy, and/or the provision of new job opportunities but should be characterized as a compact package of technology with affordable prices, preferably small-scale as a result of the targeted community, associated with a careful decision regarding the utilization of scarce natural resources, able to be fused into existing infrastructures, and with required maintenance capabilities that are as low as possible to achieve sustainability (Carley & Christie, 1993; Dunn, 1978; Darrow & Saxenian, 1986; Hazeltine & Bull, 1999; Jequier & Blanc, 1983; Todaro, 1997).

Table 1: The Early AT Thoughts.

Sources	Key points
Morawetz (1974)	available resources; given environment; social welfare.
Pellegrini (1979)	self-reinforcing process; sustaining local activities; develop indigenous knowledge.
Bourrieres (1979)	technical and financial conditions; existing manpower supply; technology transfer.
Thormann (1979)	locally available resources; small production units; socio-culture environments.
Harrison (1980)	economies of scale of natural resources; proportions between national and social goals; national capital, labor and human skills conditions.
Jequier & Blanc (1983)	low investment and price; takes local socio-culture context into account; expand potential employment; easy to manage and organize; sparing and careful use of natural resources.
Betz *et al*. (1984)	appropriate technological efforts to local economic structure (management capabilities, operation and maintenance ability, financial ability, environmental conditions).

While the development of AT thoughts until the end of 1980s was focused on the specific-characteristics of an "appropriate" technology, since the beginning of 1990s the focus was largely shifted to a more general-principles (Willoughby, 1990) (Table 2). Started by Willoughby himself, the understandings of why does one state that a technology is appropriate began to give a larger portion on the particularity of a technological solution regarding its placement and timeframe of usage. The contexts included biophysical (tangible) and psychosocial (intangible), meaning that a technology would become a significant solution if and only if it has considered particular conditions in supporting local growth. After Willoughby's proposal, Sclove (1995) attempted to correlate technology and the ideology of democracy. He stated that technology choice is dependent to political values applicable in a particular region. His thought was then taken as an important positioning in the pursuit of technological independence for vulnerability eradication in many developing countries. In the discourse of AT amongst AT thinkers and practitioners, following Willoughby's and Sclove's thoughts there was Todaro (1997), an economist who proposed the particularity of an AT at individual and/or communal levels by considering existing and potential changes of social and political constructs in a specified region. After the shift of understandings in 1990s, in the 21st century AT thoughts have been becoming to be more referred as a general-integrated approach rather than only a device with specific specifications. Akubue (2000) refers AT as a developmental approach, meaning that AT is an integral part of local problem solving that empowers local capabilities and resources. Such proposal goes beyond common understanding of a technology for job creation or exploitation of existing resources. After that, Wajcman (2006) takes a more feminist position by suggesting a deeper position of technological solution to local daily routines. Social contexts in a specified location then become a critical consideration in his understanding, and have to be considered in technology development as a means to put technology as a local solution. Next, Lucena *et al.* (2010) begins their proposal by highlighting 21st century's global concerns on environmental issues throughout related activities of a technological solution. Besides social impacts, technology development needs to pay enough attention on potential impacts imposed by AT-related activities in the frame of continuous interactions between the members of specified community to surrounding nature. Then, the second decade of this century marks the next shift of AT thoughts. Following a remarkable notion by Kaplinsky (2011), Sianipar *et al.* (2013b) suggests the meaning of technological appropriateness based on a deeper understanding on the practicalities of its concept, intermediating specific-characteristics of an "appropriate" technology to the general-principles of technological "appropriateness", hence emphasizing both strong conceptual and

Table 2: Thoughts on AT since 1990s.

Sources	Key points
Kaplinsky (1990)	biophysical context; psychosocial context; particular location and timeframe.
Sclove (1995)	social and political constructs; individual/communal levels.
Todaro (1997)	appropriate to existing circumstances.
Akubue (2000)	empowering local capabilities and resources; community productivity.
Wajcman (2006)	existing routines; social context; local considerations.
Lucena *et al*. (2010)	local settings; social impacts; environmental impacts; interaction between communities and nature.
Sianipar *et al*. (2013b)	technological appropriateness: (1) technical; (2) economic; (3) environment; (4) social.

practical levels. They propose the levels of appropriateness stated as basically (technical and economic), environmentally, and socially (cultural, judicial, and political) appropriate, as a means to give a clearer view on the resonances between a specified technology to contextual matters in a specified location.

Critics to Appropriate Technology

However, similarly to many other great ideas, debates always emerge with the development of ATs. One of the first notable strikes to ATs occurred a few years after Schumacher's proposal. Rosenbrock (1979) commented on how people understand technological appropriateness. Because the term AT starts with the debatable word 'appropriate', critics argued that an AT can only be implemented at the time when it was designed. The origins of AT, which originated from Eastern wisdom, were also noted by the Western World, which tended to claim that their own technology will always be too far advanced to be dominated by ATs. This was most likely caused by the reality, which Willoughby (1990) and Kaplinsky (1990) had noted, that the Western countries need to maintain their dominance over the developing and Third-World countries, both in technology inventions and in socio-economic power. Furthermore, the Western countries' critics included sophisticated technologists and Western economic activists (Pursell, 1993). Based on the power of the knowledge-based movement, their statements strongly encouraged standing against the development of ATs (Brooks, 1980; Hazeltine & Bull, 1999; Thormann, 1979). Western countries tend to state that the appropriateness of a technology will decrease the possibility of obtaining an improved solution for society. Thus, the choice of a worse solution for implementation in the field would result in a very vulnerable condition. Inefficiency and the inability to achieve real societal growth have also become hot topics because "appropriateness" would lead to the adjustments and compromises of many developmental factors. From an engineering standpoint, ATs are considered failed products due to their insufficiency to fulfil scientific requirements. However, despite the facts that the critics exhibit a strong influence worldwide, ATs are continuously moving beyond their criticisms. The opposite opinions, which claimed that these technologies originated from field evidence (Bhagavan, 1979; Rybczynski, 1982; Sampat, 1995), could not avoid the facts that their judges were picked up from allegations. Their understanding that ATs cannot provide the best solutions was easily contradicted by evidence that an AT is really the best solution under certain conditions. This also means that an AT will provide real development to its targeted community. In spite of their adherence to engineering expertise, the critics should admit that it is easier to use an AT as an intermediate technology (Hazeltine & Bull, 1999) rather than forcing a community to accept sophisticated technology from developed countries. In the 21st century, the critics are still stood but in different form. Kaplinsky (2011) stated that ATs need to shift its non-for-profit position to become a for-profit solution for private firms by producing "appropriate" technology to be sold to communities. In such understanding, AT is criticized to have critical ignorance to potential adaptation for products from developed countries to be more affordable for people in many developing countries. His suggestion is also supported by James (2014). In spite of his direct critics to Kaplinsky's writing, James supports the basic understanding of Kaplinsky's idea in which AT could be a powerful solution for private firms in many developing countries. However, it has to be noted that the understanding of "appropriate" technology has been shifted from only a product/device to a solution-based approach for vulnerability eradication in a specified developing country. The members of a specified vulnerable community, therefore, are not a market for private firms, or in other words: object of development. Community in technological problem solving is the subject that drives the development of a technology for their own interests and not for parties with higher bargaining power such as private firms. Then, as technologies become more widely implemented for vulnerability eradication in many developing countries, ATs have firmly declared themselves to be a powerful approach, even if it is applied for locations with too many local constraints, by delivering its strongest and only weapon: the powerful ‘appropriateness’.

Towards Technological Appropriateness

Mainstream Development of Design in Engineering

In the pursuit of technological appropriateness of a designed technology, engineers have exerted many efforts in recent decades. Ironically, their efforts had been hardly grappled over time without being sufficiently noticed. Starting approximately five decades ago, industrial and military engineers began to exert efforts in technological adaptation (Lucena *et al.*, 2010). At that time, adaptation meant that the local context shall be taken into account in technological development. The movement was based on previous engineering experiences that tended to overlook indigenous knowledge of each local community, including its autonomous nature and self-supporting traits. The negligence was favored due to the technological battles in the Cold War that spread the superpowers’ influences between the US and the USSR (Mitchell, 1988; Moore, 1994). The increasing battle tension affected the engineers who were pressured to exploit many resources for modernization purposes, such as industrialization and economic capitalization. As a result, indicators of societal improvement were only associated with technological and economic perspectives at the macro level, yet the micro-scale economics, the community’s societal subsistence, and the environmental impacts were disregarded. The legacies of colonialism, which have existed for a long time, have transformed the mainstream technological and economic exploitations that directed all of the engineering perfections in the following decades, even after developing countries had achieved their independence for a long time.

In the wake of the independence of countries in Southern hemisphere, engineers became a vital part of the national stakeholders. Because almost all of the knowledge left by the previous administrative governance(s) were held by engineers, these individuals participated as the transitional bridges for their newborn countries to rebuild all aspects of life and governance. Following an overwhelming cheeriness due to their independence, new governments of developing countries attempted to evade any re-entrance of colonialism by tightening the national involvement throughout their jurisdictions. To strengthen their abilities to meet their own needs, new governments aimed to localize the resource distribution and to achieve equitable development for all citizens. The communities were pulled out from their existences in bounded origins to become a single union with a national government that claims to control their area. Referring national resilience as the reason, communities were brought into an integrated process of development. However, many of technocrats at the time (most were engineers) had a comprehension of the meaning of national development that was very similar to one that was held by the previous governance(s). This made these individuals the continuation of a directed approach in functional orders. All of the communities returned to being objects rather than being invited to work together as the subjects of their own development process. Communities were always ignored as stakeholders and treated only as the national labor to support the construction of infrastructures and/or labor in the name of national productivity.

Following these phenomena, some engineers began to search for a new meaning of technological appropriateness. They started to understand the needs of communities in their new countries and figured out that their communities lacked their basic needs (Rist, 2002). Based on their observations, the engineers attempted to build understandable meanings of technological appropriateness to meet the communities’ demands. They interpreted the communities’ basic needs into parameters that can be fulfilled by technological improvements. They then attempted to convert these needs into technical parameters to fulfil them using their engineering knowledge. Using the limited knowledge left by colonialism, the engineers tended to grasp the local knowledge of communities in a mechanistic way. They thought that any implementation of technologies could be comprehended in a universal way, regardless of the time and place. The fulfilment of the communities' basic needs was still conceived as a way to consolidate the communities as an integral part of the national economy. Due to the limited and complicated control that each new government exerted in its communities, the existence of each community was still observed in the exact same way as the other communities in each newborn country. Technological appropriateness was concluded based only on their basic needs. As the result, the basic needs of the communities were lacking. The communities could not go beyond their existing conditions because they were treated only as objects. Their futures were decided as a single national purpose, regardless of the social goals of each community.

Moreover, the internationalization of the economy since the 1980s had abandoned any efforts to pursue technological appropriateness for local communities (Lucena *et al.*, 2010). The "threats" to developed countries from emerging economies at the time, such as Japan and/or China, brought attention to communities that were far from the engineering mainstream. Technological developments were concentrated on large-scale projects, such as metal foundries and large-capacity electricity generators. Efforts for the fulfilment of vulnerable communities' needs were diverted to technological improvements due to the national concern in gaining international competitiveness. In almost all developing countries, where vulnerable communities mostly exist, the communities were affected as their countries began to enter free markets. Due to previous development efforts by local engineers, which did not develop these communities to become sufficiently competitive, the communities must enter an unequal competition between countries. They were disempowered due to the inability of their country to compete in the international market. Their basic needs were then even diminished because they were previously forced to be involved in the country's integration efforts. The communities were then regarded as barriers and obstacles to the country's competitiveness. Engineers then treated them as burdens due to their ineffective and inefficient workings, including low level knowledge, which, ironically, the communities had obtained from local engineers. They were then forced to become part of the international competition, regardless of their social goals and self-reinforcement natures. They were even coerced to exploit their own area for natural resources and/or be employed in manufacturing activities by leaving the indigenous daily routines that had allowed them to survive for centuries.

The Big Hole: Engineering Design for AT

After much diversion, engineers began to understand that they could not achieve real vulnerability eradication for vulnerable communities in many developing countries through technological changes if they did not address the root of the problems on their own side. In the late 19th century, engineers began to overcome their own problems from the beginning of any process: design. Design, as any of other processes, affects the result of a technological development observed by the targeted users. However, design has a more fundamental effect on the whole development, including the users of a technology. It produces a framework wherein a technology will be used and sustained among its users. It results in the foundation of a technology based on certain circumstances (Pearson, 2006; Young, 2010). At that time, engineers began to refocus their attention to not the products but the design process itself. They engineered their design process to change the behavior of design process based the specific-characteristics and general-principles of technological appropriateness. Based on similar movements in industrial sectors (Bayazit, 2004; Cross, 1984; Pahl *et al.*, 2007), engineers who exhibited concern for communities aimed to obtain an appropriate design processes that would construct substantial technological appropriateness to any technologies designed for a specified community. By targeting the beginning of any process, engineers expected to transform the complete design approach from an industrial-based approach, which focused on mechanistic efficiency, into a community-based approach that aims to produce adaptive technologies based on local conditions (Figure 1).

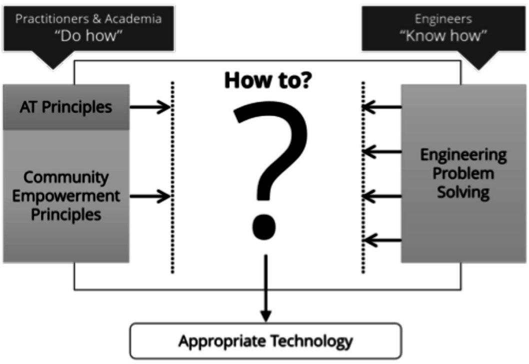

Figure 1: The Big Hole (Sianipar *et al.*, 2013c).

However, as stated by Riley (2008), engineers had already stay stood on their engineering approach so-called EPS (Engineering Problem Solving). In order to design a technology, they had made EPS as a strategic thinking to solve all engineering problems. They picked field problems as a set of inputs for product design and then engineer their design process to fit with an objective function of the process. Their inputs might be given by other multidisciplinary perspectives to give complete overview of the objective function. After they get the inputs, they did separate activities to process the inputs. Some approaches had already included simultaneous involvement of other disciplines into design process, but engineers became the main conductor of design process and the other parties mostly did check-and-balance activities to the process. In short, engineers stood on the closed-engineering standpoint. Problems were given to be solved, involvements are limited on check-and-balance matters. On the other hand, both practitioners as well as academia in AT and community development area had already provided many characteristics of technological appropriateness as the basis of AT development (Lucena, *et al.*, 2010). They also gave notions on how community empowerment should be conducted, and explained critical issues surrounding their efforts. They knew what should be done or not, and they understood that community development was an inappropriate complex way to solve unique problems in each practical area. These conditions became crucial matters which must be embedded into AT.

However, many field collaborations between engineers and practitioners-academia of either AT or community development were still in doubt due to some reasons (Sianipar *et al.*, 2013c). In those cases, practitioners & academia maintained their viewpoint by stating that any engineering process must be taken together with local people; however, engineers strongly kept EPS as their ultimate standpoint. Such counterintuitive requirements had forced engineers to leave their role as industrialists to be field assistants. Engineers, therefore, were being confused to choose between their preconceived knowledge in defining engineering appropriateness (Sianipar *et al.*, 2014a) and the constructs of technological appropriateness for a targeted community (Sianipar *et al.*, 2013c). In order to make a compromise, engineers attempted to intermediate their pure engineering approach and community's needs. They tried to bring technologies from foreign area and adapted them to local basic appropriateness. Looking at above situation, there was a big hole between engineers and practitioners-academia (Figure 1). The EPS approach was arguably rigid hence it is troublesome to incorporate both empowerment and AT principles into its workflow.

Design for "X": Engineering on the Process

One of the most notable of these kinds of efforts was proposed in the early 1990s. Preceded by environmental movements that advocated "Design for Environment", including "Design for Environmental Protection" and "Design for Resource Conservation" (Fiksel, 1996; Amstrong, 1997), "Design for Sustainability" emerged as a promising solution at the time. One of the first initiations was performed by engineers through collaboration between academia from Delft University of Technology (TU Delft) and the United Nations (UN) in the form of Ecodesign (Brezet & Hemel, 1997). Ecodesign was proposed as an attempt to provide a design approach that is focused on environmental issues. It embedded environment as the third addressed issue in addition to economic and technical ones. Ecodesign produced some improvements: the so-called eco-label, eco-efficiency, clean product, and cleaner production. These improvements were famous for their emphasis in the pursuit of considerations related to human health and environmental safety (Lee, 2009), even though it had not yet encoded the social aspect thoroughly. Ecodesign was broadly accepted in industrial countries, but it faced many obstacles in many developing countries. Western-accents design was still inappropriate when it was implemented in contextual projects particularly in vulnerable communities in many developing countries. Ecodesign was more inclined to pay attention to "green" issues rather than specific problems in the communities in which it was put into practice (Hawken *et al.*, 1999; Walker, 2002). It focused on a less-extensive use of resources and promised the sustaining of humankind by implementing a more stringent usage and increased care of Earth. However, communities were not affected until the transformation of Ecodesign.

In addition to the increasing attention on the importance of developing countries in the world's constellation, Ecodesign was criticized to address larger attention on social issues (Brezet & Hemel, 1997; Crul, 2003; Boom, 2005). It was pressured to give a proper portion of considerations on local socio-cultural conditions in addition to the technical, economic, and environmental aspects; this led to the evolution of Ecodesign to become "Design for Sustainability" (Figure 2). This type of design (hereinafter denoted as DfS) was developed in the age of "Engineering to Help" in the 2000s (Lucena *et al.*, 2010). It was proposed by TU Delft in collaboration with the United Nations Environment Programme (UNEP). These researchers attempted to adapt Ecodesign to the conditions in any developing countries by encompassing social aspect as the bridge of technological appropriateness. By including social issues, DfS included all three fundamental principles of sustainability (economics, environment, and social) in the technological development. Furthermore, DfS was not supposed to only focus on the design of technological solutions, but it also proposed how to achieve a certain target of economic growth while simultaneously reducing the contradictive impacts imposed to the environment and social conditions. Thus, it was stated as an effort beyond the "green" issue by pervading a more sustainable approach for the achievement of improvements in many developing economies (Clark *et al.*, 2009). Then, the DfS program was implemented in many developing countries, such as Latin American, African, and Asian countries. It was implemented as a solution for the encouragement of innovation in an environment with a low degree of engineering expertise. SMEs in many developing countries had successfully proven that DfS was able to achieve its objective (Diehl & Kuipers, 2008; Evrard *et al.*, 2009; Haffmans & Winthagen, 2009). It became the accelerator of innovation in the exploration of sustainable opportunities. With respect to sustainability issues, it has contributed to the growth of supporting economics through a holistically and life-cyclical emphasis in many technological improvements.

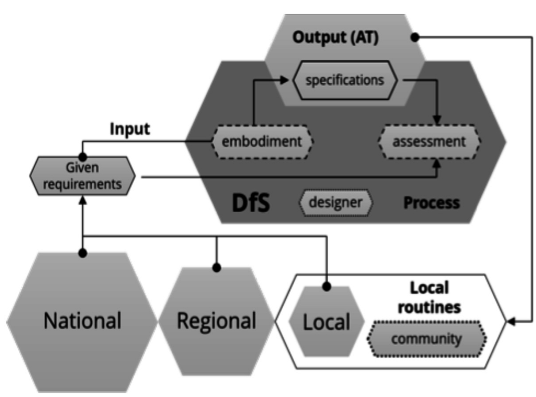

Figure 2: Design for Sustainability (DfS).

However, like previous design approaches, DfS was again trapped. It became an economic-based technical design approach that attempted to include environment and social issues as impacts rather than the main concerns. Engineers remained focused on their previous approach of Engineering Problem Solving (EPS) with its inflexible approaches (Riley, 2008). The later implementations of DfS became demonstrations on how DfS can become a solution for profit-based organizations rather than local communities. In DfS, local communities were treated as the consumers of the technological improvements. Engineers came to a developing country by bringing such technologies and adapting them to the given local conditions, but this resulted in the production of low-level inexpensive technology. DfS became a hard approach (Figure 2) to the community, which indicates that the engineers treated the social issues as something that "negatively" impacts technological development. In other words, which were rarely admitted by engineers, communities were observed as contributing "negative" impacts that must be reduced. Even if the engineers have aimed to "listen" to the communities' needs, their listening was directed to information gained from communities as the lack thereof. Engineers still treated communities as entities with many discrepancies rather than capacities (Lucena *et al.*, 2010). DfS then became similar to the other approaches that have been previously attempted. It focused on economic growth by implementing new technologies, and the engineers then attempted to consider a reduction of environmental and social impacts to achieve larger opportunities for selling their technologies. Thus, the more-sustained party was business/private firms but not communities. Although some opinions claimed that there was a wealth balance between stakeholders, large technological interventions to the communities' routines in the name of modernization endangered the indigenous knowledge, which, as have been previously explained, had survived for centuries without any major human-caused environmental/social issues.

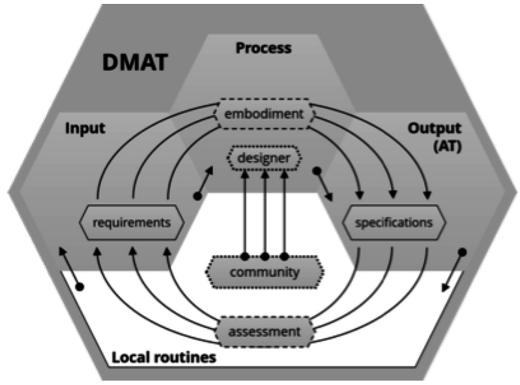

Figure 3: Design Methodology for Appropriate Technology (DMAT) (Sianipar *et al.*, 2013c).

Those explanations have given a clear notion that the big role in research on technological development in any developing communities still largely open due to the lack of a set of engineering design processes that incorporates substantial AT and community empowerment principles in order to achieve real technological appropriateness of a designed AT. In order to fill such big hole, Sianipar *et al.,* (2013c) had proposed a new design methodology that is dedicated for designing AT. So-called the Design Methodology for AT (DMAT), it was developed as the guidance for engineers in doing design and development process of AT, from scratch to be a readily-to-use socio-technical artifact. The main idea of DMAT was the integration between bottom-up community problem solving and top-down engineering problem solving approaches (Figure 3). Design process of an AT was constructed as a set of intercorrelated activities between community members and engineers, oscillated throughout the process to ensure the technological appropriateness of an AT. Some responses to the DMAT indicated that the work had precisely targeted the main concerns of technological development for developing communities: a dedicated design methodology to avoid poor outcomes due to inadequate approach in doing design process. Feinblatt (2013) stated that it is considered as an important and systematic design methodology that is strongly required for designing and developing appropriate technology in the contexts of technical development in any developing communities. Besides, Goodier & Moseson (2013) stated that it is the methodology wherein communities are formally encoded and moved to the center of design process of AT, meaning that the axiom of a human-centered design process has been precisely addressed.

However, there are some limitations in the DMAT. Limitations that become the barriers in both conceptual and practical levels (Goodier & Moseson, 2013). First, there is a clear intention in the whole impression on DMAT to dismiss the value of technological adaptation to developing communities. There is nothing wrong with it; however as previously discussed, technological adaptation must not be ignored due to the fact that it is a common approach in implementing technical advancements in many developing countries (Sianipar *et al.*, 2014b; Willoughby, 1990). Besides, technological adaptation allows any application of AT "to learn from history and contemporaries, and avoids the reinvention of the proverbial wheel" (Goodier & Moseson, 2013). Second, multi-criteria proposed in the ninth step of DMAT has to be put earlier in the process, meaning that there is a need to include some assessments in the beginning of design process to build a stronger foundation of the whole process. Although there is an informal Q&A as the technique to put the foundation of assumptions, engineers from developed countries seem interested to have more contributions since the beginning of design process. The last limitation is the position of social factor both in its concept and practice. As emphasized in the DMAT that social factor is "the ultimate level of technological appropriateness" (Sianipar *et al.*, 2013c), the fact that there is only a few detail to define social factors indicates that such kind of factors needs to be further tweaked and derived into more operationalized understandings. In spite of the proposed idea in which social aspect refers to some more intangible factors such as cultural, judicial and political (Sianipar *et al.*, 2013b), the specified limitation has indicated that such kind of factors are really getting attention from engineers.

Summaries: The Common Threads

Looking at the history of technological independence experienced by countries in Southern hemisphere, technology came up as a powerful solution in community problem solving as a means to support national independence and at the same time preserving the rights of communities to survive by eradicating their vulnerabilities. At first, newborn countries aimed to boost national growth by processing natural resources left by colonialism. Knowledge for such purpose, in fact, were held by engineers that had ever been educated in the colonialism era. Engineers then attempted to capture such opportunities by implementing their approaches in developing sophisticated technologies. However, their approaches intersected the existing existence of communities surrounding the locations of natural resources. By taking the reason of national unity to local communities, engineering approaches were forced to communities. Technologies were developed as a means to only delivering mechanistic purpose yet technologies were ignoring both local needs and existing local problem solving approaches that had survived communities throughout their existence. Inappropriateness of such kind of approaches had widen the exposure of local communities to instability. The situation acted as the cause of vulnerabilities in vulnerable communities and also the trigger of worse vulnerabilities at the future. Technological appropriateness was then being a subject in question, and the quest of technological appropriateness was then become a highlighted issue throughout the history of both engineering problem solving and vulnerability eradication.

In that spirit, the concepts of AT first emerged as the consequences in the pursuit to provide technologies with more technical performances at affordable prices for vulnerability eradication in "underdeveloped" communities in the developing countries. Despite the debatable engineering values of AT, the concept was continuously spread to have a distinguished merit among other technological concepts. AT was recognized as either intermediate or alternative, and also had become a holistic solution due to its contextual approach in capturing technological appropriateness for a particular vulnerable circumstance. Before 1990s, the concept of AT was focused on the specific-characteristics that exhibited the intention of AT in providing a technical artifact to improve a targeted local process. In other words, the early thoughts of AT referred to the concept of technology as a device. After that, the focus of AT concept was shifted from specific-characteristics to general-principles. The shift began in the 1990s, and bring a new understanding of AT from only a device to a package of solutions. The general-principles refer to the impacts of a technology to surrounding system in addition to technical and economic considerations previously indicated in specific-characteristics as embedded specifications in a device. Then, the development of AT concepts was further transformed to the combination between specific-characteristics and general-principles. Acts as the today's school of thought of AT, the combination highlighted that technology design and development need to address as high as possible level of specific-characteristics and general-principles of a technology. Such latest school of thought indicates that the technological concept of AT has transformed from only a technical artifact to become a socio-technical one. In short, AT has become a powerful technological solution that addresses both suitable internal specifications and potential impacts to surrounding routines in a contextual way.

However, engineers were still trapped into a dilemma in choosing whether a technology has to be developed based on universal engineering appropriateness or contextual appropriateness in a specified circumstance. Engineers hence began to address design process as the crucial way in providing technological solution for vulnerability eradication in a vulnerable community with situational circumstances. In history, engineers first address technology development by using EPS as the ultimate standpoint. After that, they attempted to include some other issues beside technical and economic ones. Ecodesign was one of the notable approaches in that spirit. Ecodesign was noted as success in some ways, yet the emerging notion of sustainability transformed it to become DfS. DfS met with success and had been stated as having the most suitable techniques to capture appropriateness of a technology. In spite of its widely recognized usefulness, DfS was misled to again put communities as market for commercial goods, and neglecting vulnerability eradication of the community itself. Such gap was then filled by DMAT. The latest methodology has been noted as the first formal encoding of communities in the center of design process. It has been recognized as an emerging and dedicated methodology to design AT in the pursuit of community survivability. The quest, therefore, has begun to be precisely fulfilled.

Insights: Suggestions and Implications

It is clear that technologies could have an important role in vulnerability eradication due to its nature as an interdisciplinary solution. By reorienting technology from only a technical artifact to a socio-technical one, vulnerability eradication through technological solution is becoming more holistic to cover issues other than technical and economic ones, such as environment, social, *etc*. Looking the historical explanations in this study, engineers have to honestly admit that they need to use a more appropriate approach to develop a technological solution that is appropriate for a contextual circumstance. Some of the methodologies in the history have suggested that each of them has its own benefits, yet engineers have to be aware of the disadvantages embedded in the characteristics of each methodology. In particular, vulnerability eradication in a developing community with situational limitations requires a design methodology which can produce an "appropriate" technology in the pursuit of community survivability. The selection of methodology is then become very crucial in the success of a technological solution.

By using historical explanations in this study, engineers can distinguish between design methodologies that looked like very similar yet each of them offer different view and standpoint. Every engineer then has a possibility to come up with a technological solution that is appropriate with each own situation in vulnerability eradication in a targeted vulnerable community. Particularity of each contextual case, therefore, is possible to enrich the knowledge of other engineers in other vulnerability eradication efforts. In other words, precise technological appropriateness of each case can give a notion for other future cases, yet the appropriateness of a technological solution has to be taken as having a distinguished merit than must not be directly taken as a given solution for other cases. Moreover, the limitations of DMAT have given a notion that the quest of community survivability through design and technological appropriateness is still on its way to both strengthening the concepts of design methodology for AT and perfecting the practices of AT design and development. The dynamic changes of vulnerabilities in a recovery context after a social conflict and/or natural hazard are also waiting to be incorporated to ensure the survivability. Thus, it is not a transient process to develop a perfect design methodology for AT. The changing circumstances, dynamic challenges, and particularities of vulnerability eradication through technological solutions all around the world would always require further fine-tuning over time on the present methodology or might require another one that fit with different set of challenges.

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