

Technological solution for vulnerable communities: How does its approach matter?

CPM Sianipar^{1,2,*}, K Dowaki², G Yudoko¹

¹ School of Business and Management (SBM), Institut Teknologi Bandung (ITB), Jl. Ganeca 10, Bandung, West Java 40132, INDONESIA

² Department of Industrial Administration (IA), Tokyo University of Science (TUS), 2641 Yamazaki, Noda-shi, Chiba-ken 278-8510, JAPAN

* Email: morgana.sianipar@sbm-itb.ac.id; <http://morganasianipar.com>

Abstract. Vulnerability is an emerging term for both scientific communities and practitioners. Vulnerabilities attributed to a particular community are then aggregated to state it as a vulnerable community. Vulnerability-related study is recognized as an interdisciplinary one due to the complex characteristics of vulnerabilities in each contextual situation. In common understandings, technology is recognized as an interdisciplinary solution, making it possible for supporting any activity in eradicating vulnerability. This study aims to observe such possibilities. Literature survey is taken to investigate the interconnection between vulnerability eradication and technology. Brief comparison between several developing countries and particular focus on Indonesia become a medium of further investigation to reveal issues surrounding technology-related efforts for vulnerability eradication in vulnerable communities. The study reveals that developing countries, particularly Indonesia, tend to adopt approaches from Northern hemisphere, including transferring technologies from developed countries without proper propagation. It means that local knowledge and power are largely ignored in the pursuit of local problem solving for vulnerability eradication. These facts become a signpost to emphasize that approach in implementing technological solution for such purpose is the critical mechanism to ensure the success in every contextual situation. Then, looking at the results of this brief study, its emphasis indicates further requirements to shift the paradigm of typical community development to contextual community empowerment in order to ensure the continuity of every technological solution for a consistent eradication of local vulnerabilities, including possible changes of required approach alongside the shift.

1. Vulnerability: An introduction

Vulnerability has become an important term in today's society. It is used by people across disciplines, including different scientific traditions in seeing and treating a particular phenomenon. From proposals on psychological vulnerabilities to engineering ones, from economics vulnerabilities to ecological ones, the term "vulnerability" has become a contested meaning [1]. Each discipline and scientific tradition has tried to incorporate vulnerability in their own contexts, and has theorized vulnerability as they deal with it from their own perspective in every contextual vulnerable situation. While those disciplines and scientific traditions have proposed their understandings on vulnerability with interconnected meanings, there is no single agreed definition of vulnerability, meaning that the concept of vulnerability itself is rather contextual than general, and diverse rather than converged. The term itself, as a word, is defined as the extent of an observed entity to which it is exposed to potential



harm due to its fragile foundation in facing challenges, particularly a shocked one such as natural hazard [2]. The fragile foundation refers to the fundamental factors of an observed entity regarding its capabilities in delivering response, either natural or artificial, for external as well as internal challenges, both natural and artificial. Besides, the exposures are stated as the opportunities of an observed entity to experience possible future harms as the results of either past experiences, present circumstances, or possible future changes. In such understanding, vulnerability itself is the cause of future vulnerabilities as vulnerability is tightly related to fundamental factors of an observed entity, meaning that when a vulnerability produces weak responses to a challenge, the weak responses will accumulate previous vulnerabilities related to the challenge to be bigger vulnerabilities at the future in facing further challenges. Vulnerability, therefore, is highly possible to bring an immediate destruction of an entity [3]. Looking at the diverse definitions of vulnerability, including different approaches in dealing with vulnerability as well as the multi-facets condition of a challenge due to accumulated effects of a vulnerability, understanding vulnerability is rather an interdisciplinary than an isolated thought. Vulnerability can be stated as having multidisciplinary concepts from different perspectives yet almost useless in providing clear answer to overcome a challenge, or incorporated to other concepts as a basis thought in dealing with human-environment interaction [4,5]; however, vulnerability itself is standing as an independent understanding that waits to be approached from all facets of its complexity.

2. Vulnerable communities

2.1. Standing on a fragile foundation

In society, vulnerability is also becoming one of critical concerns in societal development. Recognized as the weak foundation of the extent to which an individual or group of people able to face challenges in surviving their existence, study on vulnerability is particularly focused on community level due to the importance of communal actions in incorporating global movements to regional and local practices [6,7]. Vulnerabilities attributed to a specified community are then aggregately taken to state the community as a vulnerable one. Vulnerability, therefore, is known as a basic characteristic of a specified community in developing and/or recovery contexts. In developing context, vulnerabilities of a vulnerable community refer to exposures experienced by a specified community that cause instability of internal communal system or interactions between members of a community in the development process, meaning that fundamental factors supporting the community or the system have not reached a firm position and cannot support each other when changes of challenges occur due to progress of development (Figure 1). On the other hand, vulnerabilities of a vulnerable community in recovery process refer to the results of a crisis caused by disaster or war/social conflict that affect fundamental stability of a community (Figure 1), including its access to outside world. The instability causes exposures of a community in their process to recover internal condition and its connection to other regions. Instability in a recovery process is highly possible to cause next crises. In the middle of either developing or recovery context, there is an intermediary one which is prevention context. In the context of prevention, vulnerabilities of a developing community are the extent of exposures to which the community that is in a development process is possible to fall into a crisis. Either in a development progress or in recovery process after war/conflicts or natural disasters, including prevention context, vulnerabilities occur as the result of unstable circumstances, an unbalanced state between fundamental factors in a community [8-10], among local/regional entities that construct the foundation of local/regional resilience. Roughly-speaking, at community level vulnerabilities happen as the products of developing and/or recovery contexts, and vulnerable communities exist due to the vulnerabilities deeply-rooted in a community that is critically live in an unstable circumstance caused by continuous treats of natural disasters or uncondusive conditions for supporting strong growth and fundamental stability [11-14].

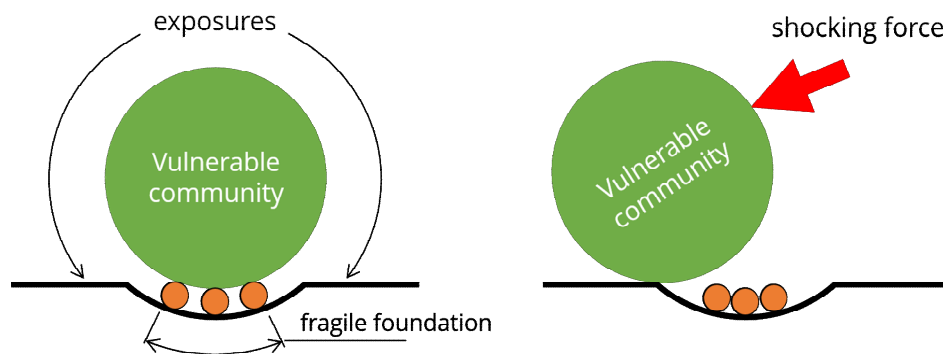


Figure 1. Standing on a fragile foundation.

2.2. *In developing countries: A major part of the world*

Looking at the conception, vulnerable communities arguably exist in both developed and developing countries. As indicated by the understandings of vulnerability, each of developed or developing has its own vulnerabilities that cause the exposure of either national development progress, national recovery process, or national crisis prevention system. Such reason has become the root of widely-accepted argument in which any country can be stated as vulnerable [15-18]. Furthermore, the causes of vulnerabilities can be distinguished to five different conditions [19]: destructive growth, poverty, political rigidity, dependency, and geographic isolation. Those conditions are possible to happen in any community, in any of developing and recovery context, and either in developed or developing countries; however, those indicators in Woodward's study have indicated that vulnerabilities, in other words: vulnerable communities, are most likely to exist in developing countries. Such statement is based on the considerations in which each of those factors strongly exist in developing countries as the result of the developing state and are supported by instability of fundamental factors. While in developed countries fundamental factors of a nation or communities such as economic power or social resilience are firmly founded on solid resilience and can support each other in facing challenges, developing countries still struggle to stabilize their fundamental factors due to fragile foundation. Moreover, in fact 82.5% people all around the world in the year 2013 live in developing countries [20]. Even if China is excluded due to its potential to become a new superpower country, the rests still cover 63.5% of the world population. By looking that those statistics and the highly supported consideration in which vulnerable communities are mostly likely to exist developing countries, therefore, vulnerable communities are one of the world's major entities and a very important facet of the future security of mankind [21-22]. However, the diverse and contextual understandings of vulnerability itself has become a problematic discourse for authorities and/or local bodies of developing countries in coping with vulnerabilities of a vulnerable community in their own area. Fundamental instability also causes more difficulties in eradicating vulnerabilities of local communities. Such barriers in eradicating vulnerabilities of vulnerable communities are worsened by accumulated vulnerabilities that produce other vulnerabilities in the future and are highly possible to bring crisis to local as well as surrounding area. In other words, eradicating vulnerability is a now-or-never deal, meaning that a failure in treating present vulnerabilities will cause much wider exposure in the future; on the contrary, right treatment will close the gate for other vulnerabilities by strengthening and stabilizing fundamental factors of a vulnerable community.

3. Technological solution for vulnerability eradication

3.1. *Technology: An interdisciplinary solution*

Based on above discussions, by considering the interdisciplinary perspectives of vulnerability, instability of fundamental factors of vulnerable community, and wide exposure of developing countries to fall into crisis, vulnerable communities require a cross-disciplinary solution that can

support growth, vulnerability eradication, and strengthening local resilience. In that spirit, technology comes as a powerful answer in delivering those purposes in a single solution. Despite the contextual characteristic of vulnerability-related studies, technology itself has been recognized to have critical position as one of the essential concerns throughout the world [23], and has gotten a unique placement as one of the cornerstones of vulnerability eradication in today's society [24]. Particularly since the Industrial Revolution in the late 18th century, technology has changed human perspectives on their ways of doing things [25]. After such phenomenal history, whatever the object is, wherever and whenever people, as individuals or human institutions such as communities, governments, or business, require a booster to their effort in the pursuit of vulnerability eradication and reinforcing resilience, technology would be a common choice among other ones [26,27]. Of course, there are people whose sentiments have been reluctant in supporting those facts. They are ones who state that the belief in the capacity of technology in providing answers for the reduction of vulnerability even if in its smallest form must not be posited as the ultimate and an only reason to put technology above any other counter facts. Those kinds of people have also toughly pointed their finger to technology as the main cause of future human vulnerability problems such as environmental and health [28-30]. However, people with negative perspectives on technology are unable to refuse the fact that, even if technology has many negative effects imposed to surrounding space and environment, the answer of their concerns would be mainly provided by technological advancements [31,32]. The concerns, therefore, have changed to become only a rhetoric in any effort of vulnerability eradication. In practical level, the use of technology in vulnerability eradication is frequently focused on environmental issue as the response or prevention to natural phenomena surrounding a community [33-35], yet later approaches have begun to cover other kinds of vulnerability such as social, political, and/or economic vulnerabilities [1,4,26]. In short, the incorporation of technological advancements in eradicating vulnerabilities has changed the whole movement. Since technology is posited as a comprehensive solution produced from interdisciplinary perspectives, the implementation of vulnerability eradication has become much robust for strengthening fundamental factors of a specified community, and stabilizing cross supports between those factors in supporting the resilience of the community, including the deal with undesirable impacts of technology itself.

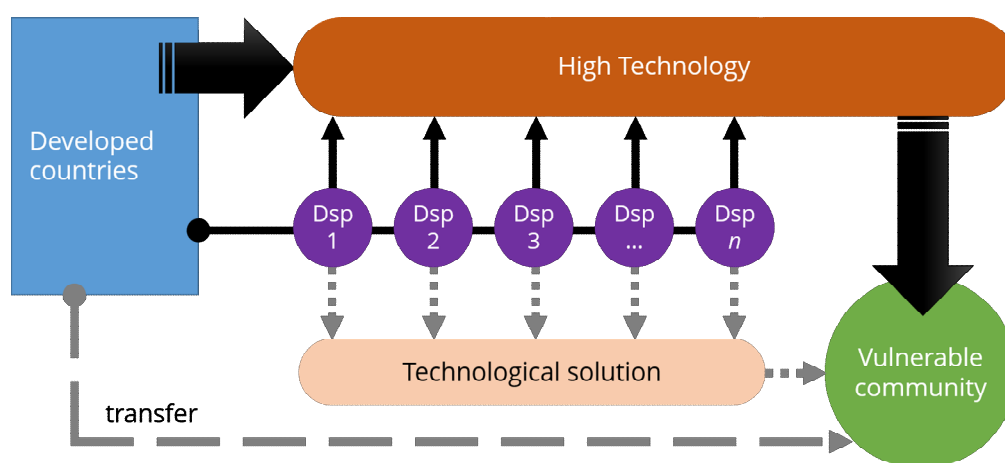


Figure 2. Technology as an interdisciplinary solution. Advancing through transfer.

3.2. Common technological solution: Advancing through transfer

Furthermore, as their attempts to eradicate their vulnerabilities and stabilizing fundamental factors for national resilience, including the pursuit of international recognition to become developed ones, developing countries begin to adapt many approaches from Northern hemisphere in implementing their strategies [36]. Following the terminology transformation of technology from only an artifact to be a more systematic technical enhancement of related processes [23], developing countries have

begun to incorporate such understanding into their development strategies. Approaches and solutions for technological advancements in vulnerability eradication, therefore, are adapted from developed countries to enhance practices in developing ones. In that spirit, technological transfer has become a recognized approach to massively bring technologies from developed countries (Figure 2). In technology transfer, technologies, usually ones with high technical specifications and are common kinds used in the Northern hemisphere, are brought from developed countries. In developed countries, a technology is seen as a universal solution for a certain extent of problems; hence each scientific discipline related to the purpose of a technology (Figure 2, Dsp_n) contributes its expertise in developing the technology in order to unifying the specifications of the technology. In that scheme, a technology is supposed to be a multidisciplinary solution, meaning that each scientific discipline becomes a separated part of solutions embedded in the technology. While the technology is brought to be a technological solution for a vulnerable community, the multidisciplinary approach is consequently brought together within it; however, vulnerability eradication is rather cross-disciplinary than multidisciplinary, meaning that every technology from developed world is not suitable enough to eradicate vulnerabilities from all directions simultaneously due to universal technical specifications to cover the extent of problems in some distinctive scientific disciplines to which the technology needs to solve in developed countries. Also, massive technological transfer in order to support vulnerability eradication in vulnerable communities do not practically obliterate all of obstacles in its implementations in developing countries. Even if some alternative concepts such as appropriate technology (AT) [37] and grassroots innovation [38] have been incorporated as the intermediaries in adapting approaches from developed countries, some difficulties are triggered by unsuitable conditions in developing countries that are left behind in many essential aspects compared to the profile of necessary supports in developed countries in which many approaches were first developed.

4. Situational limitations in technology transfer for vulnerability eradication

4.1. Fundamental differences of developed and developing countries

In fact, developed countries have already had strong national resilience as the result of stabilized fundamental factors (Figure 3) such as economic prosperity, social welfare, *etc.*, which then affect the correlation between widely-accepted constructs of national growth and wealth distribution to the choice of technology. Such conditions happen as the results of some applicable assumptions taken in developed countries. For example, on economic side, developed countries don't have much problems in the economies of scale compared to developing ones [39]; or, people in developed countries have low variations of the definition of social capital, meaning that people tend to act correspondingly with the direction of any other citizen in achieving social goals [40]. Although in developed countries there are diversities of conditions and trade-offs, including critical vulnerabilities that are possible to make them fall into crisis, fundamental factors in developed countries would support each other in facing worst challenges, meaning that a weakness in one factor would be overcome by improvements in other ones. Therefore, the steady condition, as stated by Kaplinsky [41], refers to the time when there is a homogeneity of behaviors between fundamental factors of a country. Such perfect condition also affects any technological choice. Due to the overwhelming supports both from government and the civilized society, technological changes are enormously concentrated at capital intensive techniques [42] by interpreting environmental issue through the rate of impacts imposed per contribution to market needs [31]. In that term, technical qualities become the main goal of technological advancements due to accessible resources for reaching any purpose. On the other hand, developing countries arguably exist in different settings. Circumstances and national capabilities in their own situation are not strong enough compared to which developed countries have achieved in order to eradicate vulnerabilities and supporting national resilience [43-45]. Huge varieties (Figure 3), *i.e.* in economic capacities and/or social goals, have decomposed developmental efforts in developing countries into detached entities, from an integrated national strategy into separate works in each targeted area. Such huge disparities have made some approaches focusing on unique conditions in

each area to be an essential medium to deal with any existing diversity. Still, the problem in direct adaptation of approaches from developed countries to developing ones, including advances of technology through technological transfer, remains same [46]. Enormous diversities that commonly occur in developing countries are not adequate to do an extensive application of approaches from Northern hemisphere due to different basic mentalities to the original ones [47]. Different with developed ones, developing countries, with all of their limited capabilities, are unable to get adequate control on all of discrete entities throughout their governance in order to ensure vast vulnerability eradication in all of its interdisciplinary focuses. In terms of technological changes, they obsessively attempt to overtake technical capabilities of developed countries by, ironically, neglecting the needs of their own citizens. Also, such fascinating effort is also very dangerous because of huge potential technological disasters [48]. The application of technological advancements for vulnerability eradication, therefore, is affected by those mentalities.

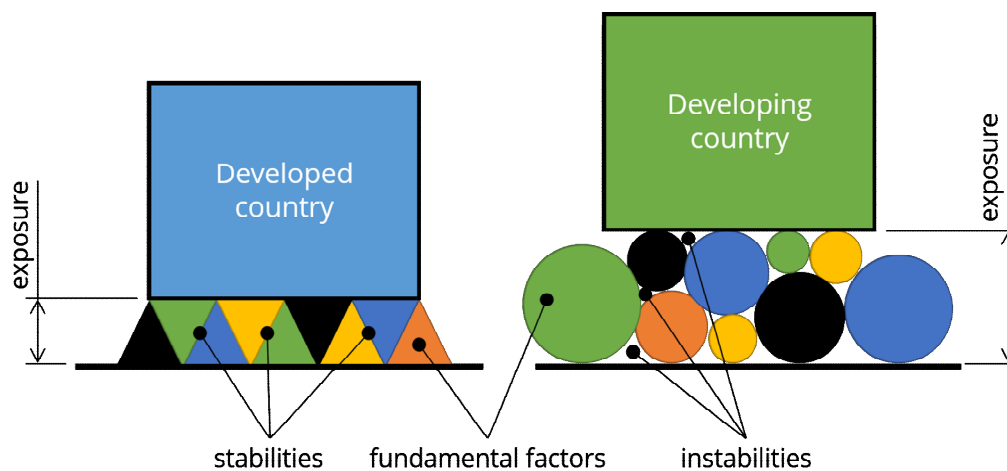


Figure 3. Distinguishing developed and developing countries.

4.2. In brief overview of some developing countries

An example for such condition comes from the world's fourth most populous countries and also the third biggest developing countries: Indonesia. With its 249.5 million population, it covers almost 3.5% of world population [20]. While others big developing countries are continuously showing its substantial growth in conjunction with significant development of its technological advancements for vulnerability eradication, the story of Indonesian remains stagnant due to huge exposures to crisis as the result of fundamental instabilities and social inequality. Countries such as China, India, Brazil, and Mexico have even massively had to interchange their growing potentials to technological transfer for vulnerability eradications both in their own area and in their respective partners of developed countries [49]. In China and India, there is a significant decreasing of dependencies to single directional aids from developed countries due to rapid growth in economic prosperity and technological changes. While China is recognized as new world's economic superpower and followed by its radical advances in technologies, on the contrary, India has its widely-spread technological development from advances to social innovations that strongly affects its ongoing economic growth. Besides, Brazil and Mexico have already had low technical vulnerabilities and good technological capabilities, including growing strategic industries and relatively similar culture to their partners of developed countries, which then produces smooth transfer of technologies despite of social inequalities. On the other hand, technological change for vulnerability eradication in Indonesia is arguably stagnant despite of the growing of industries. In Indonesia, vulnerabilities occur due to both natural disasters and developing state, two conditions that strongly affect many facets of people's life [50-53]. Also, the term vulnerable communities is particularly attributed to people live in rural area, especially for those who

work in low-tech industries such as traditional or transitional farming. In fact, of the Indonesian population, more than half live in rural area, and they are largely work as farmers or in water-related jobs. Such kind of communities is then becoming more and more important due to the widening inequalities between urban and rural area. Their massive portion of Indonesian population gives a notion that they have big influences to national competitiveness, meaning that Indonesian authorities have to take opportunities to target any vulnerable community as a means to develop societies' capability in order to reach higher national growths. To do so, some approaches have been proposed. On one side, technological transfer from developed countries is posited as the booster in achieving sustainable growth [54,55]. On the other side, Appropriate Technology (AT), as a promising technological approach to deliver a comprehensive technical solution in a limited condition, is posited to provide a technology with sufficient technical performance at affordable price [53,56].

4.3. The problems arise

However, the practices of those approaches do not reflect the real form of vulnerability eradication. Huge numbers of advanced technologies are purely imported, *i.e.* by Indonesia, from developed countries without proper adaptation, meaning that technologies are taken for granted to pursue rapid economic growth but ignoring indigenous capabilities of local people; besides, AT is becoming important but is implemented through a laboratory-based development process in a workshop behind closed doors with least participation of targeted community members [47,53,55,57] (Figure 4). Those conditions have made technology designers to: often ignore community empowerment, including local context and values; tend to have an exclusion of traditional ways of knowing; have a denial or devaluing people relationships; and strong commitment to industrial (military-like) working styles [58], by which implementation of technological changes and AT in Indonesia is increasingly difficult due to: (1) questionable technological appropriateness; (2) top-down approach to local needs; (3) low technological diffusion; and (4) weak support from local entities [59,60]. Looking at above facts and conceptions, the real problems in the implementation of technological change and AT is not on the vulnerabilities of targeted communities. The problem is the approach consisting methods or techniques to do technological change and developing AT. In current practices, each of them neglects the existence of another, yet field implementation requires intermediation of those approaches in contextual matter as a means to eradicate vulnerabilities and strengthening local resilience through technologies; thus technological solution for vulnerability eradication needs further development of its approach to strengthening the concept and perfecting the practices of vulnerability eradication.



Figure 4. Present technological approach for vulnerability eradication.

5. Conclusions: The common threads and further researches

Hence, conducting technological advancements and AT in a single timeframe and place needs to incorporate local practices and has to empower local people. Problems discussed above have given notions to intermediate two counterintuitive approaches: technological changes through technology transfer and technology development based on AT approach. Also, there are at least two things that have to be rigorously explored in order to do technological changes for vulnerability eradication. At conceptual level, technological changes for vulnerability eradication requires a clearer understanding to empower people rather than only giving technology to do local development. To do so, scientists need to revisit the concepts of technological changes for vulnerability eradication in vulnerable communities, including an early form of framework to theorize research gap. In terms of its practice, a new framework is required to intermediate the mentality of technology transfer and the spirit of local problem solving; thus technologists could expand the theoretical framework to be a practical framework to conduct technology development for vulnerable communities. Therefore, some pivotal questions such as “what kind of technological changes suitable for vulnerability eradication in vulnerable communities?”, “how do anyone can systematically produce a technology for a vulnerable community based on both technological transfer and local problem solving?”, and “how to apply such guidance in a field application?” would be very important in order to achieve the success of vulnerability eradication through technological changes at both conceptual and practical levels. The first pivotal question is purposed to deeply investigate the basic model of technological solutions overtime to ensure the continuity and persistency of vulnerability eradication. After that, the second question is supposed to be the initiation of further development of the basic model produced from the first question to construct a new systematic technological approach which combines typical technology transfer and local ways of problem solving. Then, the third question is taken as the basis of testing process of the new systematic technological approach produced based on the second question to investigate the validity and reliability of the new approach directly in field applications. In addition, the intention of bottom-up approach in implementing technological changes for vulnerability eradication in a vulnerable community may also affect the choice of developmental paradigm taken as the basis of any concept and practice. Looking at the previous discussion, there is a need to shift the paradigm from typical development to empowerment. The shift is required to ensure the incorporation of local problem solving to any developmental work, including technology-based vulnerability eradication. Finally, the shift may also further affect some related issues. Empowerment-based technological solution for a vulnerable community may become the entrance point of deeper diffusion of the technology to local process as a means to maintain the continuity of technological changes and the consistency of vulnerability eradication; thus technology acceptance – on community side – and technology suitability – on technology side – have to be carefully taken as the interconnected attributes to push the diffusion further in order to seamlessly integrate the technology to be an integral part of local daily routines.

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