A Comprehensive Framework on Appropriate Technology Choice for Sustainable Development

1. The need for a comprehensive framework in an unsustainable world

1.1. Choosing technologies appropriate to the goals

Today, people and organisations across various sectors, in both developed and developing countries, are committed to achieving Sustainable Development Goals (SDGs). However, despite having goals to work towards, it is still unclear what kind of economic systems, social systems and technologies should be developed and applied to achieve these targets.

From a technological viewpoint, recent developments, such as artificial intelligence, autonomous vehicles, space development and advanced medicine are considered promising, and major research and development resources are allocated towards them. Although these technologies may be attractive and useful, it is doubtful whether the development of these technologies is consistent with the attainment of SDGs. If we consider the primary problems facing the world today–including poverty and inequality, global and local environmental problems, a shortage of natural resources and dehumanisation and alienation–the current choices modern societies are making (both when using and developing technology) are at odds with those they need to make to become sustainable.

In this paper, the term 'technology' is defined as the means or skills used to accomplish a predefined purpose while carrying out a purpose-oriented action. In this commonly understood definition, technology is defined solely as the means for attaining a particular purpose. However, in modern society, technology is often positioned as the purpose itself, rather than the means, which commonly leads to people becoming subservient to technology. The choice to use or develop technologies to create new products and services which will, in turn, expand consumption and drive economic growth in the name of obtaining more profits–or opening new 'frontiers' for the future–often leads to society substantially deviating from what can be considered sustainable.

To achieve SDGs, we should choose, develop and use technologies that are appropriate to these goals.

1.2. The crucial role of appropriate technology and its revitalisation in modern society

When considering what kinds of technologies are necessary for the future, appropriate technology movements–which were primarily active between the mid-1960s to the mid-1980s–provide useful hints and inspiration. Various definitions of the term 'appropriate technology' have been used throughout the decades, giving it a rather broad and vague meaning. In general, the term implies technologies appropriate for local socio-economic and cultural conditions that match well with the needs of local people and create job opportunities while remaining environmentally friendly. At the same time, the term has also been used as an alternative to modern technologies. In other words, based on the perception that modern technologies have been creating serious problems, such as global and local environmental issues, the depletion of natural resources, as well as dehumanisation, the term appropriate technology has been associated with technologies that resolve these issues. Therefore, the targets that are aimed for with appropriate technologies are generally consistent with those of SDGs.

Shortly after the mid-1980s, appropriate technology movements became less active, which suggests that they might have been inadequate. In order to revitalise appropriate technology movements, it is vital to establish where and how they fell short. The process of revitalising these movements may be one of the most effective ways to create a system of technologies capable of achieving sustainable development.

An overview of the history of appropriate technology movements suggests several reasons for their decline, including the dominance of capitalism and modern technology that emerged with the end of the Cold War, an absence of practical business management, a shortage of related human resources, as well as a lack of political support. However, the ambiguous nature of appropriate technologies, and the lack of a framework that can be approved and supported widely by people and organisations across various sectors in our society, can be considered the fundamental reasons why these movements declined. In light of this, this paper aims to develop a Comprehensive Framework on Appropriate Technology Choice for Sustainable Development.[1]

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[1] For this framework, the term 'appropriate technology choice' is used instead of 'appropriate technology' because the latter evokes a wide range of definitions, including limited and stereotyped ones. Also, the term is potentially misleading because it hints at a group of technologies that are inherently appropriate (i.e., they possess a unique property) rather than dependent on the context of their usage.

1.3. An unsustainable world

In exploring the required technologies for sustainable development, it is useful to consider contemporary world issues in three categories: poverty and inequality; environment and natural resource depletion; and dehumanisation. These matters all derive from the same root and all contribute to making the world unsustainable. Because these issues are linked together, they should not be considered and solved separately. For example, if we succeed in solving poverty and inequality problems only, the basic infrastructure of our lives can be destroyed by climate change-related disasters. Also, if we successfully address poverty and environmental problems, but dehumanisation prevails, our lives may lose meaning. Furthermore, dehumanised people are unable to solve problems creatively. It is, therefore, crucial that we investigate the root of these problems, explain the dynamic relationships between the related factors, consider measures to overcome the obstacles, and then effectively implement these measures.

1.4. Poverty and the global inequality crisis

In 2017, 2.2 billion people did not have access to safely managed drinking water services, and 4.2 billion people lacked access to safely managed sanitation services.[2] About 1 billion people survived without access to electricity, and 1.6 billion people lived in inadequate housing.[3] In 2018, on the other hand, the combined wealth of the richest 26 individuals in the world matched the wealth of the 3.8 billion people who make up the poorest half of society.[4]

Poverty conditions should not be defined statically as only a matter of daily income; instead, they should be defined more dynamically and practically by focusing on the conditions that assure people's freedom to pursue the lives they want.

When we consider the causes of poverty and inequality and investigate the mechanism that gives rise to these problems, it becomes clear that it is not a matter of 'backwardness' in developing countries; rather, these issues are created by factors that occur when traditional societies get caught up in the global wave to modernise. Issues also occur when movements in the private sector aim to increase production efficiency in order to gain more profit–despite the limited room available for economic growth in the

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[2] UNICEF/JMP/WHO, 2019, *Progress of household drinking water, sanitation and hygiene, 2000 – 2017.*

[3] OECD/IEA, 2018, *World Energy Outlook 2018* and UN-HABITAT, 2017, *Dialogue on the special theme for the twenty-sixth session of the Governing Council.*

[4] OXFAM, 2019, *Public Good or Private Wealth?*

local context. In other words, poverty and inequality problems are attributable to the development of industrialised societies, with capitalism and modern technologies as essential drivers.

As the trickle-down theory has continued to lose credibility in the middle of a global inequality crisis, policymakers seek solutions for poverty through measures such as the redistribution of wealth, job training and education. Although these measures make sense and are effective in certain contexts, the problem lies in the fact that most of these solutions assume that technologies are given conditions rather than something that people can choose.

1.5. Environmental problems and natural resources depletion: lessons not learned

In the early 1960s and 1970s, crucial warnings about the challenges of our modern industrialised society were issued in the forms of 'Silent Spring' (Rachel Carson, 1962) and 'The Limits to Growth' (Donella H. Meadows et al., 1972). 'Silent Spring' outlines the harmful effects of the indiscriminate use of pesticides on the natural ecosystem by showing how a wide range of animals and plants dynamically interact within that system. In other words, pesticides affect not only insects, but also other living things. 'The Limits to Growth' raised a significant warning regarding industrialised societies' unchallenged pursuit of an ever-growing economy. The report used a computer simulation to show that our society will face various limits in the foreseeable future if economic growth is not subject to proper control. Such growth will result in a sudden and uncontrollable decline in population and industrial capacity.

However, our societies have yet to acknowledge these warnings and their associated lessons. Today, a wide range of waste—including plastics, chemicals, radioactive matters and heavy metals—are discharged and accumulated in increasingly larger quantities in our environment. Most countries still seek limitless economic growth, and climate change has become a reality. Today, super typhoons, catastrophic floods, heatwaves, large scale forest fires and glacier melts warn us, although in a far blunter manner than 'The Limits to Growth.' Despite the serious risks we face, society remains reluctant to take the necessary measures in the required speed and intensity.

1.6. Dehumanisation

When appropriate technology movements were active, the issues associated with dehumanisation were also eagerly discussed. However, as people's interest in appropriate technologies declined, the attention given to dehumanisation lessened. It appears this did not occur because dehumanisation problems were being solved but

because, increasingly, these problems became the norm in our daily lives. Not only does dehumanisation make our work worthless, it also threatens to disturb the development of harmonic human relationships in our society–including those among family.

Fundamentally, human beings are capable of fulfilling their desires in various dimensions and attaining welfare through work; we can produce necessities for our lives, develop our potential and creativity, assist others and develop cooperative relationships. In modern society, however, work has become a means through which to receive wages; no (or very limited) human capacities are developed in the workplace, and poor human relationships are established. Moreover, our industrialised society's driving motivation to seek higher production efficiency often forces labourers to work harder for lower wages.

The rapid development of information and communication technologies in recent years has made it possible to communicate without the restrictions of distance, space or time. These developments have also enabled extremely high-speed data processing and new services in fields such as consumption, transportation, medicine, education and finance. However, these technologies may bring about new types of dehumanisation problems, including a lack of direct human relationships, a transfer of human abilities to machines (which will result in human subordination to them), as well as the emergence of strictly controlled totalitarian societies. Furthermore, the reduction of labour that is caused by increased production efficiency using information and communication technologies can cause severe unemployment problems–especially when the space for further economic growth is limited.

Poverty and environmental issues are related to the primary conditions necessary for our lives. Moreover, dehumanisation creates issues that devalue human life and limit our ability to solve society's problems.

1.7. The necessity of multi-sector dialogue among developed and developing countries

It is clear that the development pattern, implemented by developed countries, has already reached several limits; as such, it is not sustainable. Despite these limits, many developing countries are still following this framework. Nevertheless, even if developed countries insist on alternative development patterns, developing countries would likely consider this behaviour as egoistic and argue that those who have already enjoyed the benefits of a modern industrialised society want to prevent developing countries from doing the same.

This impasse can only be settled by creating a way forward–for each side–that will realise the welfare of all people. It makes sense to use certain modern technology

factors and modify them to fit the local conditions when creating technologies for these new developments. At the same time, developing countries can show developed countries how to consider and relearn what they have lost in the modernisation process, including traditional technologies, an understanding of what humans can achieve through their own abilities, a harmonic way of living with nature, and the importance of human relationships in communities. Furthermore, reasonable critiques of developed countries will be necessary to reform technologies in developed countries drastically.

The framework mentioned above should be developed and brushed up through multiple sector dialogue between developed and developing countries. Such a dialogue would aim to develop a concept for the future in which people share the purpose of creating harmonious, inclusive and sustainable societies while recognising diversity in a concrete form.

2. Appropriate technology choice for sustainable development

Now is the time to make appropriate technology choices, develop them and use them widely in order to attain sustainable development. Such technologies will be characterised and/or oriented as follows:

§Solving poverty and inequality problems

P-1. Choosing and developing technologies that are appropriate for local conditions and directly contribute to poverty reduction

In general, it is challenging to transfer technologies used in developed countries to developing countries in sustainable ways because the socio-economic and cultural conditions are different. It is, therefore, crucial to choose or develop technologies that fit local conditions and fulfil people's basic needs, such as clean water, sanitation, electricity, housing and food.

SDGs related to P-1

P-2. Creating job opportunities appropriate to local context

The redistribution of wealth–the most common measure being taken to alleviate poverty –is necessary for certain conditions. However, if the underlying structure that

causes poverty and inequality does not change, the poor will remain dependent on others. E.F. Schumacher, who pioneered the concept of intermediate technology as the precursor of appropriate technology, defined intermediate technology based on the 'equipment cost per workplace', which means technology should be chosen on the basis of how it creates job opportunities based on particular needs. The solution to the world's poverty problems is to create worthwhile job opportunities while adapting to the context of individual cases and using technologies suited to that purpose.

SDGs related to P-2

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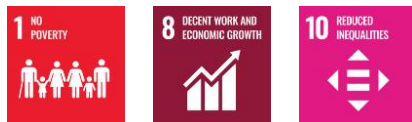
§Solving environment and natural resource depletion problems
E-1. Limited things should be treated as limited things
Schumacher's book, 'Small is Beautiful: A Study of Economics As If People Mattered,' begins with this description: 'One of the most fateful errors of our age is the belief that 'the problem of production' has been solved.' Here, Schumacher severely criticises the modern industrialised society for consuming 'capital' (i.e. limited non-renewable resources, such as fossil fuels) as if they are 'earnings' (i.e. unlimited renewable resources). If we continue to use these non-renewable resources, we will exhaust them. Moreover, without proper treatment, our continuous discharge of waste, wastewater and exhaust gas will cause disorder in, and ultimately destroy, the environment. However, if we use the phrase 'Limited things should be treated as limited things' as a guiding principle for the development of technologies, we can resolve most of our environmental and natural resource depletion problems. This principle can be divided into two sub-principles: natural resource depletion and waste management. These actions involve the following:
E-1.a Refraining from using non-renewable resources to the maximum extent, especially eliminating the use of fossil fuels; and

E-1.b Refraining from discharging wastes, wastewater and exhaust gas without proper treatment and avoiding greenhouse effect gas emissions.[5]

SDGs related to E-1

E-2. Developing a society based on sustainable resources

Modern technologies have been developed based on the assumption that fossil fuels can be supplied abundantly, always. Contemporary movements for promoting renewable energy primarily focus on replacing a part of the existing energy supplied by fossil fuels. However, the current excessive use of fossil fuels is extremely unsustainable because, within a few centuries, it will use all the natural resources that have formed over several hundreds of millions of years. The replacement of such huge amounts of energy consumption by renewable energy is unreasonable. Instead, we should plan and develop our society, industries and technologies, as well as our lives, based on the quantity and quality of resources that can be supplied in a sustainable manner.

SDGs related to E-2

E-3. Not disturbing the balance and cyclical process of the ecosystem

We must distinguish strictly between materials that can be safely returned to natural ecosystems (referred to as "N") and artificial materials which cannot be (referred to as

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[5] Nuclear power plants are often evaluated as an energy source with little greenhouse effect gas emissions. However, this conclusion is based on limited perspectives. Considering the issues of potentially catastrophic damage caused by severe accidents, issues with radioactive waste that can potentially threaten people tens of thousands of years into the future with radiation exposure, as well as the danger of exposing operators or workers to radiation, the technology is inappropriate in all situations.

"A"). N should be recycled or reduced to nature after use, whilst A should be used in separate systems to not disturb the balance and cycle of the natural ecosystem and then be recycled or disposed of safely after use. Complex products that are composed of both N and A should be designed and produced in a way that N and A can be easily separated.

SDGs related to E-3

E-4. Giving priority to small-scale, decentralised systems

Natural energy–which will, in the future, be the sustainable world's primary energy resource –is characterised by its low energy intensity that is present everywhere. For this reason, natural energy is suited to small-scale, decentralised energy supply systems. In harmony with the renewable energy supply, the development of decentralised socio-economic and technological systems–which are highly self-sufficient in supplying basic needs such as energy, water and food and, at the same time, open to interact widely with other regions and countries–will make significant contributions to attaining a sustainable society. In decentralised systems, controllable technologies create job opportunities, are environmentally friendly, lead to unique and attractive production activities and lives, and are more likely to be used than large scale, centralised systems. Moreover, securing local regions' ability to provide for themselves will increase the safety of society as a whole significantly, especially under current conditions in which the world faces severe risks from various sources.

SDGs related to E-4

E-5. Recognising the limits of modern science and technology and respecting nature

Modern science and technology are based on a mechanical view of the world that was developed in the 16th and 17th centuries. This worldview is based on the principle of

reducing an object to certain factors and then defining verifiable laws that these factors obey. The scientific knowledge obtained through this principle can be systematically accumulated in large quantities and added to exponentially. Through the advancement of science and technology, the accumulation of knowledge has led to the idea that we understand most of the world and will perceive everything in the future. In reality, however, the world is unfathomably complex, and despite our attempts to understand it, new questions continually arise, which pushes any hope of ultimate understanding further away, for example, how was the universe created and how did life begin? Furthermore, non-verifiable factors–such as the nature of human consciousness, emotions, the arts and religions–remain prevalent in society. Moreover, no one knows what lies beyond the bounds of human perception; there are most likely things we do not even know exist and will, therefore, never be able to perceive.

The assumption that humans understand most matters in the world, combined with a worldview that justifies human dominance, gives rise to an attitude of superiority over nature; humans see nature as an object to be used. This attitude is the fundamental factor that has brought about the modern world's environmental and natural resource problems. We should change our attitude in order to change the world. We should recognise that what we know about nature is extremely limited–and so are our capabilities. We must respect nature for its mystery, incomprehensibility and immeasurable and irreplaceable value. Also, we must commit to not disturbing or harming nature.

SDGs related to E-5

§ Solving dehumanisation problems
D-1. Appreciating and extending non-commercial production and work
We live in a society in which most products or services and related works are conducted as commercial productions or services and wage labours. In contrast, people used to be able to provide for themselves to fulfil basic needs (such as water, energy, food and housing). People were also able to handle a wide variety of jobs, and they conducted and celebrated a variety of ceremonies and festivals through cooperative and direct human interaction within their communities. The development of the commodity economy

caused interpersonal relationships to suffer as people were now connected, indirectly, through money. This process was furthered as the rise of capitalist economies pushed more goods and services to be supplied as commercial ventures in order to seek a never-ending increase in profit. In the process, many human capabilities that were developed through self-sufficient activities were lost, and people became increasingly dependent on commercial goods and services.

To attain sustainable development, we should give priority to doing things by ourselves rather than depending on commercial services or machines to recover our initiative and develop our creativity in our productive activities and lives. This process implies that non-commercial production and work should be appreciated and appropriately extended.

SDGs related to D-1

D-2. Using technologies controllable by people

In general, the introduction of technology to particular production or consumption systems means the transfer of what belongs to human capabilities or skills to tools, machines, facilities and systems. The process usually increases production efficiency and improves convenience. On the other hand, human beings inevitably become more dependent on things or systems that do not belong to them. The process does not merely involve a loss of human skills; it is significantly more complicated because new skills that are based on using these technologies and/or monotonous work might develop. (At least these new skills are more dependent on external factors and systems than the skills that develop without the introduced technologies.) The best possible technology choice should be made by considering these dynamic changes. Because our happiness and welfare are improved when we use our own initiative and free will, we should give priority to technologies that people can better control.

SDGs related to D-2

D-3. Using technologies that develop human resources

Work gains value and significance when it enables people to demonstrate and develop their capabilities. This kind of work is also worthwhile and rewarding since it can be creative and is likely to foster the development of cooperative relationships between people. Therefore, we should give priority to technologies that bring out and develop human resources.

SDGs related to D-3

3. Epilogue

A technology system based on the above-mentioned comprehensive framework should form the basis of a future technology system for the world. The principles and directions described in this paper are a foundation for more concrete and practical proposals regarding technology choice. Moreover, these solutions keep the local and specific conditions in each case in mind during the development and implementation phases.

Multi-sector and international cooperation–including international organisations, governments, private sectors, universities and NGOs–is indispensable to develop and implement this framework. At the moment, development aid across the globe is carried out based on the idea that developed countries are more advanced than developing countries and should, therefore, take the lead. Nevertheless, it is the development pattern of these developed countries that has made today's world unsustainable. In light of this, developing countries should not blindly pursue this existing development model. Also, developed countries should adapt their socio-economic structures and technologies drastically in favour of sustainable structures. At the same time, developing countries must pursue alternative development patterns. We will succeed in attaining sustainable development when

developed countries' commitment to drastic change and developing countries' dedication to alternative development frameworks proceed cooperatively.

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