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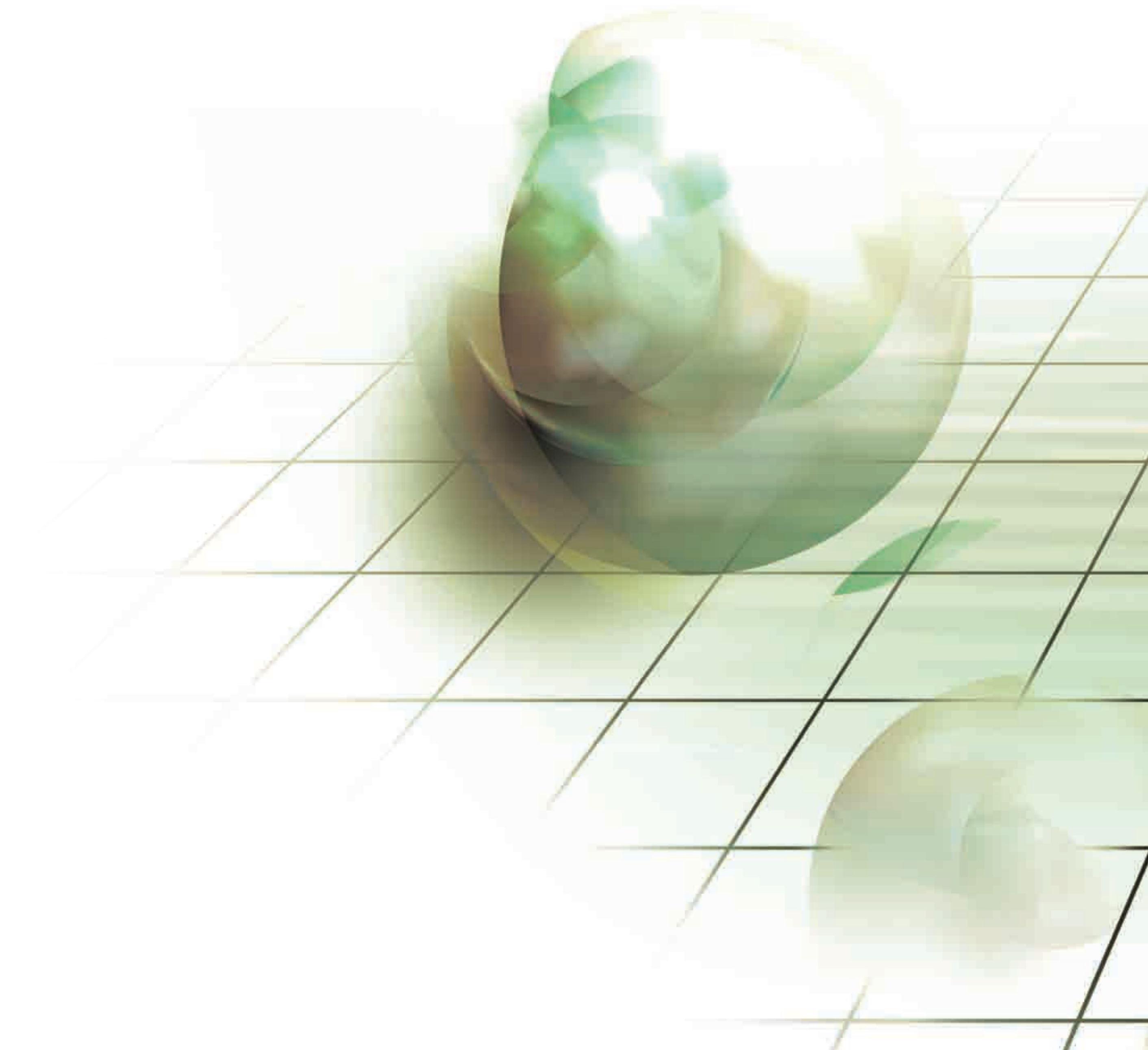

The Water-Energy Nexus and Development of Basic Needs of Urban-Life (BNU) Index
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Working Paper:
The Water-Energy Nexus and Development of Basic Needs of Urban-Life (BNU) Index

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Water, Energy, Nexus, Basic Needs of Urban-life (BNU), Sustainable Development Goals

Sustainable environment is one of the most important topics in the discussion of post-2015 Sustainable Development Agenda. Within MDGs, ensuring environmental sustainability is the goal number 7. Target 7.C is to halve by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation. This target was met in 2010, five years ahead of schedule (WHO, 2013). However, 40 countries in the developing world are still seriously off target, many of which are located in the Sub-Saharan Africa (The World Bank, 2014).

Energy on the other hand, was not featured in the MDGs. But 5 years before the deadline, energy was recognized as the key priority to achieve global development Agenda by the UN Secretary-General, Ban Ki-moon (2010). Addressing this oversight, energy should not be missed in the next SDGs. Emission from energy generation has been the world's challenge and the main cause of climate change acceleration. The focus area of energy should emphasize on increasing the share of clean and low or zero emission energy technologies.

The challenges in energy sector are both in its accessibility and quality. Over 1.2 billion people, or about 20% of the world's population are still without access to electricity. About 2.8 billion people are still using fumes and smoke emitting solid fuel like wood, charcoal, coal and dung for cooking and heating. This practice of open cooking fires cause respiratory diseases and kill about 1.5 million women and children every year (The World Bank, 2013).

This working paper features the important trend and development within the water and energy nexus, discuss the water-energy nexus in urban metabolism, and propose a new monitoring tools on the basic needs of urban-life (BNU). One of the reasons why some goals in the MDG did not perform so well was, there was not enough quantifiable data of progress and outcome for monitoring measurement and feedback to design (Sachs, 2014). At the same time, because more people in the world is now living in the city, the urban development is becoming more important than ever before (UN Department of Economic and Social Affairs, 2011). The proposal of BNU is an effort to answer these SDGs emerging challenges.

1. Water and Energy nexus

Providing water requires energy, providing energy requires water footprint (Schnoor J., 2011). Main sources of energy are coal, natural gas, oil, nuclear, and the renewables. Power generation using these sources requires large water footprints, including the renewable ones because the system and equipment have to be made where involving water is inevitable. On the other hand, extracting and improving water requires energy because water has to be transported and treated so that it becomes safe for consumption.

As coal and oil energy reserve are depleting and the emission of carbon dioxide from the fossil fuel based energy sector is in an alarming stage, human beings look for cleaner sources of energy. Among the renewable energy resources, the growth of hydropower electricity generation is predicted to escalate (IEA, 2013). Hydropower is a glaring nexus between water and energy, where the force of water flow generates electricity.

While people are striving for energy self-sufficiency and technology advancement in improving the efficiency and effectiveness of renewable technologies, the discovery of natural gas trapped in the shale forms in this century lit a promise of having cleaner energy. However, the extraction does not only contribute to more greenhouse gas emission (Stevens, 2012) but also the method of hydraulic fracturing requires millions of gallons of water (Kargbo, Wilhelm, & Campbell, 2010). The nexus between water and energy is very strong that water footprint is unavoidable for any kind of energy generation. To name a few: the need of water in cooling power plant towers (Perry, 2012), the water footprint in fossil fuel extraction drilling process (Chavez-Rodrigues & Nebra, 2010), and in electricity generation from renewable resources (UNESCO-IHE, 2008).

Fresh water distribution in the world is not equal. Some area are blessed with abundant surface water but some have to extract ground water, reuse, recycle or even desalinate the sea water because fresh water is too scarce. But with a forecast of 9 billion populations by 2050, the human race may not be able to use the same volume of water, neither the same way we use it now (UNEP/GRID-ARENDAL, 2008). Despite of the industrialization and improved effectiveness of agriculture, the biggest water consumer is still the agricultural sector. About 75% of the global consumption is in the agricultural activities (UNEP/GRID-ARENDAL, 2008), the remaining is shared by energy providers, residential, industry, and commerce (Figure 1).

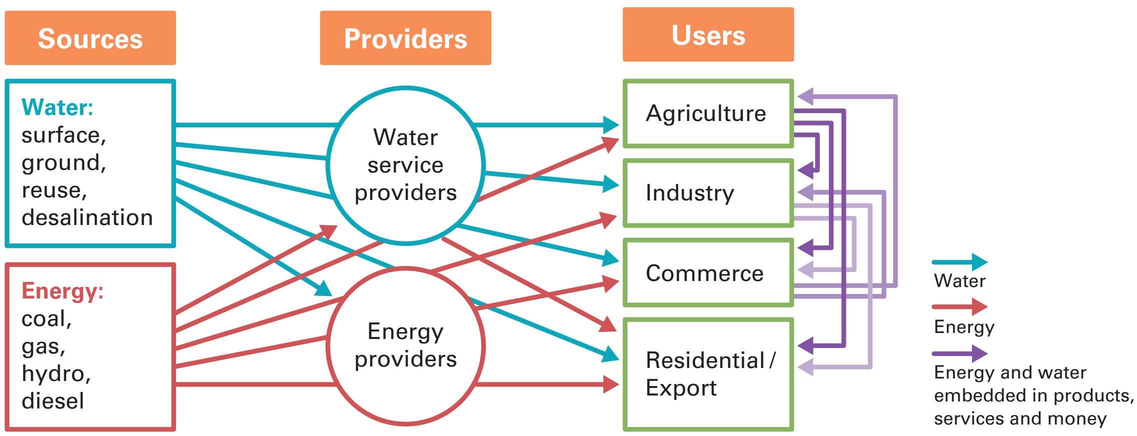

Figure 1. Water and Energy flow. Source: Kenway 2012 (reproduced with permission)

Advanced technologies for water recycling such as the high-pressure membranes and reverse osmosis are still expensive and energy intensive (US EPA, 2014). Desalination also consumes more energy compared to fresh water treatment (Elimelech & Phillip, 2011). But nevertheless, wastewater is increasingly recognized as a resource where one can seek to harvest water, nutrients and energy (Schnoor J., 2011).

2. Water-Energy Nexus and the Urban Metabolism

Urban metabolism is the flows of water, energy and materials through the city that are required to sustain the city's inhabitants (Wolman, 1965). Managing the urban metabolism is more important than ever before because more than half of the world is living in the urban area (UN, 2010). The nexus in water-energy urban metabolism is therefore can be defined as the interconnection between water and energy involved in the flows of water and energy required to sustain a city.

In 2011, already more than half of the worlds' population lives in the urban area (UN Department of Economic and Social Affairs, 2011). The urban areas have significantly higher proportion of energy use. They account for 67%

of global energy use and 71% of global energy-related carbon dioxide (CO_2) emissions (IEA, 2010). Therefore, addressing the issues in cities will significantly affect the overall world consumption of natural resources and green house gas emissions.

Although many parts in the world experience fresh water scarcity, there is a paradox; many cities are in higher potential risk of flooding. A study (Beck, et al., 2012) indicates that the world urbanization leads to potential risk of flooding. This phenomenon is mainly aggravated by the climate change (Nilsson, 2013). Another study shows that although majority of people in the cities have access to water, only a handful of that water is meeting the health and safety standards (Vairavamoorthy, et al., 2008).

The post2015 project held a participatory workshop in Indonesia, Surabaya City, to hear in first hand about the challenges and aspirations of people's life in the developing country's urban environment. The Participatory workshop was held in government housing for rural-urban migrants. Voting result on priority topics showed that water is significantly considered as the most important aspect in their lives. In figure 2, the red area in each bin represent the female answer, and the blue area represent the male answer. Both male and female put their highest concern in the water sector.

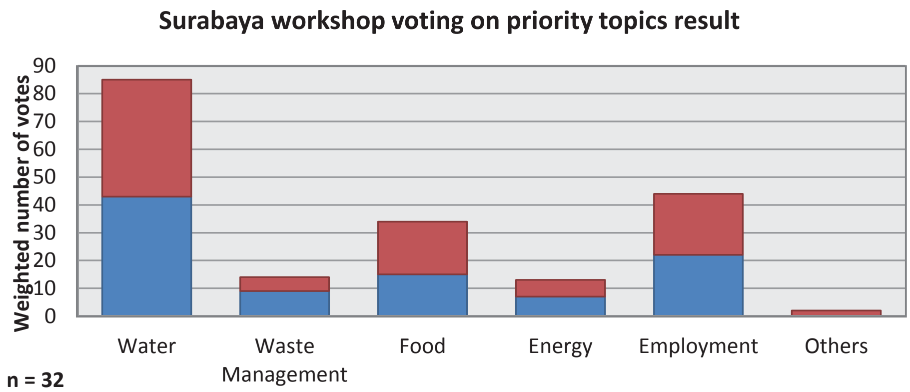

Figure 2 Basic needs of urban life priority topics voting result from Surabaya workshop. (Pandyaswargo, Abe, & Franciscus, 2014)

The main challenges of the water sector faced by the workshop participants in Surabaya are both about the water supply quantity and the quality of sewerage system. Water from the water utility company is delivered daily to a common storage and then distributed to each building by pumping it to another storage tank on the rooftop. Water is then distributed by gravity to each household. Because pumping requires energy and energy price is high, pumping is only done twice a day. Due to this, the housing residents do not have 24 hours access to water supply. This is one evidence that challenges in water is closely related to the challenges in energy sector. In other words, the nexus between water and energy is ineglectible and there is no priviledge for one to only target at one side of the problems because challenges are interconnected.

Kenyway (2012) illustrated the water-energy nexus in the current urban societies as shown in figure 3. The planning, regulation and standards of water and energy are managed in isolation. Quantification of urban performance and targets are still very limited, and the management and monitoring of water and energy is done separately.

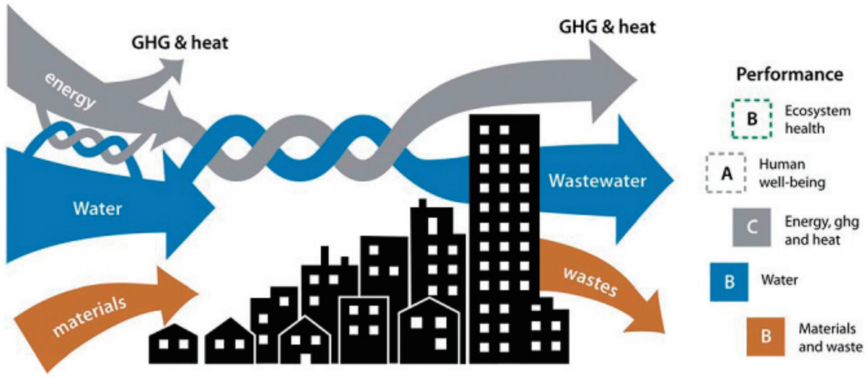

Figure 3. The current paradigm: fragmented urban performance (Kenway S., 2012) (Reproduced with permission)

In the future, cities should manage water and energy in an integrated manner. This proposal is illustrated in figure 4. In this new paradigm, the management of water, energy and related cycles (including nutrients) is done comprehensively and simultaneously. Targets for resource efficiency is being quantified so that the development assessment can strongly inform and influence the overall system optimisation.

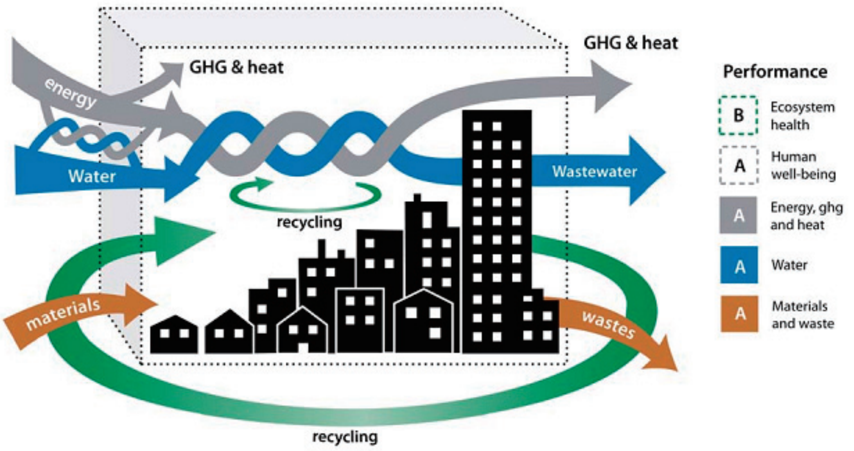

Figure 4. The future paradigm: coordinated performance in sustainable cities (Kenway S., 2012) (Reproduced with permission)

Recyling of water and energy is also very significant in improving the water and energy use efficiency. In the United States, irrigation of the residential urban landscape can vary from 40% to 70% of urban residential use of water. Therefore reuse of water in the urban landscape is one strategy to offset water supply shortages (St. Hilaire, 2008).

Water and energy challenges faced by the cities in the less-developed world is quite different. According to the OECD (2013), cities in the well-developed countries may be in a position to focus on quality-of-life measures, while cities in the less-developed countries may first need to address basic provision of water and energy supply as well as wastewater treatment services.

Appropriate urban designs may help to improve the efficiency of energy and water use in cities. Cities seeking for greater efficiency in water and energy should take significant action, research and policy development especially on the areas of including it in education programs, developing the combined water and energy standards, guidelines and planning process (Kenway S., 2013). Although the management of water and energy metabolism should consider the interaction of the components to overall efficiency (Kenway S., 2012), the water-energy portfolios ultimately must be studied at the local scale because often, the decision making eventually takes places in the local level (Schnoor J. L., 2011).

3. Development of The Basic Needs of Urban-life (BNU) index: time matters

The basic needs for life is traditionally listed as food, shelter and clothing (Denton, 1990). This working paper presents water and sanitation, energy, food, job, and living environment as the extension of this list in response to the urbanization (Figure 5). This list is from now on called as the Basic Needs of Urban-life (BNU). This working paper also suggests that the each of the BNU elements influence each other and the nexus within BNU could be improved through education and proper health care.

Water-Energy nexus is one part of BNU, the other nexus are the connection between each item in BNU; e.g. water-food nexus, energy-food nexus, water-job nexus, energy-job nexus, food-job nexus, and so on. BNU offers a solution to monitor both the overall performance and the specific performace of each of its dimension. In this way, one can easily identify which sector is performing weakly so that the appropriate nexus can be addressed. Shelter dimension is the "roof" of BNU, this implies that the other BNU items are roofed under the human settlement. A shelter has function to protect human being from uncomfortable climate and weather conditions such as extreme temperature, rain, and the wind. Job is placed near to the "floor" of the BNU house because income from employment (or entrepreneurship) supports the affordability of the items above it. Living environment is placed at the bottom of the BNU house because it supports the livability and healthy condition on a person living especially in the urban area to function. Living environment is including the open space and access to various public services including transportation, healthcare and education[1].

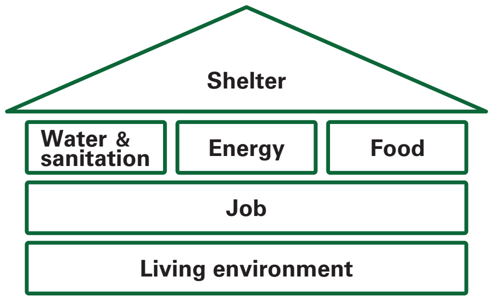

Figure 5. Basic Needs of Urban-life (BNU) "house"

The urban area has better availability of utilities and public services. The benefits gained from urbanization could then be expressed in terms of the length of time where these facilities are available or accessible. Table 1 summarizes the proposed tasks that could be measured in time measuring units such as minute and hour.

Table 1. BNU dimensions, indicators, and unit

BNU dimensions	Proposed measurable Tasks as indicator	Proposed Unit
Shelter	How long in a day someone could enjoy safe and comfortable shelter protecting her/him from severe weather condition	Hours Per Day
Water and sanitation	How long in a day someone could have access to improved water supply, solid waste management service, and proper wastewater treatment	
Energy	How long in a day someone could have access to electricity	
Food	How often someone could easily have access to purchasing safe food	
Job	How long in a day someone could spend quality time with the family / significant others	
Living environment	How long in a day someone could enjoy comfortable living environment (open space parks)	

[1] Indicators used for each BNU could vary, but when comparing for example two different communities, one should be consistent about the selected indicator to secure comparability

By comparing an individual value with the maximum and minimum value from a community or region, one could understand how well or how poorly her or his life condition is in terms of their BNU dimensions[2]. The maximum and minimum value could also transform the indicators into indices between 0 and 1. As the value becomes closer to 1 the higher quality of BNU one has[3]. This approach could be summarized by equation (1) and (2). These equations are modified from the steps to calculate Human Development Index (HDI) (UNDP, 2013). BNU replaces the dimensions of life expectancy, schooling, and income within HDI with the 6 dimensions listed in table 1.

$$Dimension\ index = \left(\frac{individual\ or\ average\ community\ value - minimum\ value}{maximum\ value - minimum\ value}\right) \quad \ldots \quad \text{(eq. 1)}$$

BNU index is the geometric mean of the 6 BNU dimensions indices. This is expressed by equation 2.

$$BNU\ index = \sqrt[6]{I_{Shelter} \cdot I_{Water\&sanitation} \cdot I_{Energy} \cdot I_{Food} \cdot I_{Job} \cdot I_{Living\ environment}} \quad \ldots \quad \text{(eq. 2)}$$

By having such framework, things could be measured and compared easier. This, in turn, could help decision makers to see at a glance, which dimensions require immediate action for remedy. The index also contributes to easier evaluation of a policy and/or program impact by monitoring the change of the index value over time. Another potential benefit is to increase the awareness of urban dwellers in general or to help them make decision when choosing a place to live that could offer them an optimized benefit based on her or his capacity. In the future development of BNU, one would also be able to measure their urban living condition in terms of CO_2 emissions, global warming potential, or energy consumption and cost and benefit equivalent.

4. Hypothetical illustration of BNU application

In order to facilitate an easy understanding of the BNU index, the hypothetical figure of each BNU dimension for the index calculation was made and presented in table 2. The table shows multiple urban conditions for Individual A, who lives in community Z.

Table 2. Hypothetical data for Individual A in Community Z (unit: hours per day)

BNU dimensions	Values for Individual A	Minimum values in Community Z	Maximum values in Community Z
Shelter	24	10	24
Water & sanitation	6	4	24
Energy	12	8	24
Food	24	6	24
Job	4	2	12
Living environment	1	1	5

Given the values in the table 2., the following calculations are necessary to figure out the corresponding BNU index for Individual A in community Z.

2 The application of BNU could be individual, community, or regional.

3 The proposed measurable tasks in table 1 are positive indicators (the longer the time, the better quality of life is). However, one could also measure in terms of efficiency, for example the time required to commute from home to workplace (the shorter the time, the better quality of life is). In that case, BNU closer to 0 would indicate better quality of urban life.

$$\text{Shelter Index} = \frac{24-10}{24-10} = 1$$

$$\text{Water \& sanitation index} = \frac{6-4}{24-4} = 0.1$$

$$\text{Energy Index} = \frac{12-8}{24-8} = 0.25$$

$$\text{Food Index} = \frac{24-6}{24-6} = 1$$

$$\text{Job Index} = \frac{4-2}{12-2} = 0.2$$

$$\text{Living environment Index} = \frac{1-1}{5-1} = 0.25$$

Then,

$$\text{BNU Index} = \sqrt[6]{1 \cdot 0.1 \cdot 0.25 \cdot 1 \cdot 0.2 \cdot 0.25} = 0.323$$

The BNU Index of individual A is 0.323. This implies that the person is in the lower range of BNU index within community Z. The poorest dimension within the BNU of individual A is the water and sanitation index with only 0.1 followed by job index of 0.2. By looking at the BNU index and dimensional index, one could understand the quality of basic urban life in general and the dimension that needs improvement. The variation of BNU index could be developed into the following alternatives, but not limited to: 1) having several comparable indicators for each dimension 2) comparing one community with another 3) comparing one community with a region.

5. Conclusion: some input for the post-2015 Sustainable Development Goals

Considering the water-energy nexus in the urban context of the developed and less-developed world, this policy brief proposes the following goals, targets, and indicators:

I. Improvement of basic needs of urban-life (BNU) and its nexus

a) Ensure the all time accessibility to energy and water
- Optimum sufficiency and efficiency of energy usage in water distribution
- Reducing water footprint in electricity generation plant (by reuse and use of appropriate technology)
- Reducing unnecessary energy consumption in waste water treatment (improving rainwater catchment and reuse of water in urban landscape irrigation)
- Improve connectedness between stakeholders involved in water-energy utility services to join hand in improving water-energy nexus efficiency

b) Ensure the all time accessibility to water and food
- Water quality should meet the minimum safety standard
- Optimum sufficiency and efficiency of water usage in household use including cooking food, drinking, washing, and other basic uses

c) Ensure that there is enough employment and capacity building for urban resident to be able to afford the BNU
- Quality education relevant to the job market
- Availability of decent employment for people to be able to earn and afford the BNU dimensions

d) Ensure that proper sanitation and hygiene is available for urban dwellers to a safe and healthy life
- Availability of proper waste management where: 1) decent number of employment is created 2) enable material and energy recovery
- Availability of proper wastewater treatment and environment maintenance where: 1) sewerage is not clogged 2) urban water body does not become a place where mosquito and other disease carrier animals breed
- Availability of appropriate sanitation infrastructure where human waste is taken care of in a hygienic and sanitary manner so that it will not lead to health deterioration

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